UNIVERSITÀ DELLA CALABRIA

UNIVERSITA' DELLA CALABRIA

Dipartimento di FISICA

Scuola di Dottorato ARCHIMEDE

in co-tutela di tesi con **MASSACHUSETTS INSTITUTE OF TECHNOLOGY**

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XXVIII

URBAN MAGNETISM: UNDERSTANDING CITIES THROUGH THE LENS OF GEO-TAGGED PHOTOGRAPHY

Settore Scientifico Disciplinare ICAR 20

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Declaration

Hereby affirm that this submission is my own work and that, to the best of my knowledge, contains no material previously published or written by another person nor material which significantly has been accepted for an award of any other degree or diploma of University or other institutions of higher learning, except where due acknowledgments has been made in the text.

Index

Abstract…….....5
Introduction…….....7
- Objectives…….8
- Materials and methods……..8
- Applications and expected impacts……10
- Structure……..10

Chapter 1.
A framework on the new complex city
Abstract……13
Introduction……..14
1.1 How city is evolved……...18
- From egyptian city to the medieval one: the evolution of the human need to be part of a community……..……19
  - Eqyptian city……..……19
  - Grecian city……20
  - Roman city…….……21
  - Medieval city…….……22
- The baroque city: a theatre-city……..…….23
- The industrial city: the birth of the social cities…….…….24
- Modern urbanism……....25
- The American dream vs Europe: the ideal city towards contemporary city……...26
- Smart City……...28

1.2 New urban planning approach for the complex city…….....47
Conclusions……..53
References……55

Chapter 2.
Open Data from Social Media as tool for better understanding complex territory

Abstract……59
Introduction……..60
2.1 The use of Open Data for the complex systems……64
2.2 Mapping Open Data with GIS……...68
2.3 The use of open data for the analysis of tourist flows……...71
Conclusions……79
References……...83

Chapter 3.
Urban Magnetism through the lens of geo-tagged photography
Abstract……87
Introduction……..89
3.1 Data…….....92
3.2 Definition od user home cities and countries…….93
3.3 Attractiveness…….....95
- Global Attractiveness ……95
- Local Attractiveness ……...108
Conclusions ……...121
References…….....126

Chapter 4.
Temporal Distribution
Abstract……..……131
Introduction……133
4.1 Data……..134
4.2 Temporal Distribution……..137
4.3 Spatio-temporal Attractiveness……149
Conclusions……156
References……..159
Attached Timeline

Chapter 5.
Barcelona Smart City: Application Case Study
Abstract……..166
Introduction……168
5.1 District 22@…….171
5.2 El Raval……186
5.3 Materials and methods: Urban success story told from geo-tagged photography…….....…….....190
- Method…….....190
- Materials……..193
- Application and results……195
Conclusions…….....201
References……..203

Conclusions …….....208

Abstract

This research work presents a method for a new mapping process, based on social networks (especially geo-referred pictures downloaded from the websites of photosharing) to work alongside the maps commonly used in spatial planning. In the vast world of social, I choose to consider in particular the photographs, because people choose to photograph specific places or times that they consider important for some reasons. This would allow a truly innovative reading of the territory, making the concept of smart city in its dual aspects: the technological (because they take into account the social networks by creating dynamic maps of the territories) and human (because it takes into account the actual participation and objective citizens and more generally of land users, without the burden of being directly involved, but only through the daily activities that each of us carries on social networks). In this way it is possible to monitor urban areas that should be protected, managed, potentiated, discovered, making liveble and lived all the city and the territory to have smarter and safer city.

Keywords:

complex systems, smart city, mapping, big data, urbanism, gis

Introduction

"With cities, it is as with dreams:
everything imaginable can be dreamed,
but even the most unexpected dream is a rebus
that conceals a desire or, its reverse, a fear.
Cities, like dreams, are made of desires and fears,
even if the thread of their discourse is secret,
their rules are absurd, their perspectives deceitful,
and everything conceals something else."

Invisible Cities – Italo Calvino

City is where everything happens. Where we breath, where we travel, where we work and meet people. We build our life in the city and with our life we contribute to(towards) building the city. Everyone wants to breath, travel, work, meet people and, in general, live better. This is not the first time in which cities are so interesting for people and research, including so many fields of human knowledges, but cities have never proliferated as much as in these last 20 years and more than half of the World's population now lives in urban areas. In this critical period for all the world, it's clear we cannot overcome crisis if, first of all, we don't re-think cities.

Objectives (Why this study)

[smart city, technology, urban planning]

Although for years the European scene and the world are open to the discussion about *smart cities*, even today the city cannot become really smart in the sense of being completely at the service of citizens. There are many initiatives, but still struggling to take off future. Someone consider smart city just as technological cities, those ones critique them because "too" technological. The proposed method is an objective method, such as human and technological participatory, to be used for planning a really smart cities.

Materials and methods (How this study)

[big data, gis, mapping, visualization, complex systems]

Always more, scientific research is talking about city as complex system. This is because in a city we can find all the features of a complex system: networks, self-organizations,

power laws describing the behaviours in the city. But these phenomena need data from mathematical and physical perspective. Obviously data is not the only one and the best way for understanding city, that is an alive body changing any time, made of people, habits, complex relationships that no data can explain: but data is surely the best way for studying them and identifying patterns, trying to improve first of all city in general and then going deeper in any city. In particular the research is always more interested in big data. So it is important to understand the challenges that big data in general can give to the city science, in particular regarding GIS and geo-localization, considering their applications in many fields such as urbanism, risk management, and so on. With all this preparedness and successful applications, the research, design and implementation of GIS around activities of smart cities and daily considerations of human social needs will lead to very active scenery in the next several years.

Applications and expected impacts (What this study is for)

[environment, urbanism, culture, society, economics, tourism]

The method also has potential applications in various fields: planning (reading area, big events, traffic, etc...), research (because data was provided to create behavioral models, prevention models, etc...), economy (because you can determine which are the most attractive/most photographed places and events, locate where people prefer to go, the links between the different cities to help you determine the prices of air travel, in which place territory agrees or not to open a business, tourism, etc...), security (prediction of disaster damage, streams, etc...), and so on.

Chapters structure

The structure of the thesis is articulated in the following way:

1. First Chapter is about the macrotheme of cities and urban planning, in a temporal travel telling city

evolution during the history, until the new concept of smart city;

2. Second Chapter is about the materials used in the research, explaining why they are useful tools for planning and research: GIS Mapping and Big Data as new challenges for better understanding the complex territory;
3. Third Chapter is about the model of mapping geotagged photography in spatial dimension, illustrating reasons, results and applications;
4. Fourth Chapter is about the model of mapping geotagged photography in temporal dimension, illustrating reasons, results and applications;
5. Fifth chapter is about a case study of urban perception in Barcelona, one of the smartest city in the world, in which the model was really applied.

At the end there are the conclusions of this three years PhD research work and the exposition of applications already started or that will start.

Chapter 1

Picture by Patrick Nouhailler - Flickr

Chapter 1

A framework on the new complex city

Abstract

City is where everything happens. Where we breath, travel, work and become part of a network. We build our life in the city and with our life we contribute to build the city.

This is not the first time in which cities are so interesting for people and research, but they have never proliferated as much as in these last years as more than half of World's population lives in urban areas. The goal of this study is accompaigning the readers in a *temporal* travel in the *spatial* change, arriving to the new city concept: the smart city, underlining how complex theory can be the best approach for better understanding and

changing cities, in which we reflect crisis (economic dimension), digitalization (scientific dimension) and globalization (social dimension). These aspects are actually strongly related each others: economy, science and sociology are all convergent in the macro-topic of the city.

Keywords: [urbanism, smart city, complexity, city evolution, urban planning]

Introduction

Urbanism exists for more than 5,000 years to identify guidelines and rules in the process of city making.

It’s difficult to attribute the urban planning to only one of the two opposing worlds (artistic and scientific), but it is probably correct saying that urban planning is half science and half art. Instead own town planning can represent an easy example of a discipline that, without disintegrating between the one and the other of the two worlds cultural, belongs to a new cultural world, dialectically tending to solve the contradictions of the old one

[1]. In fact, geographers, historians, economists, urban planners and political scientists have incorporated the points of view of their respective disciplines into diverse definitions of the city, this is the reason why we can define a complete definition without excluding no one disciplines, no one capabilities, no one different lecture of the territory. Another important thing to clarify is the relationship between Urbanism and Industrialization. The rise of cities in the modern world is undoubtedly not independent of the emergence of modern power-driven machine technology, mass production, and capitalistic enterprise. But different as the cities of earlier epochs may have been by virtue of their development in a preindustrial and precapitalistic order from the great cities of today, they were, nevertheless, cities. Cities represent a fertile ground for developing science and technology, culture and innovation, for individual and collective creativity, memory of the past and new opportunities for the future, also for mitigating the impact of climate change. However, cities are also places where segregation and poverty are concentrated, despite the intercultural approach to the city life and a better distribution of

the richness. We need to better understand challenges and study solutions but the speed of the transformation processes, the presence of phenomena apparently belonging to different sectoral areas, the spread of technology products that change the location of activities in towns changing its shape, increase more the difficulty of reading and interpretation of urban phenomena.To this regard, the best approach to interpretation and management of a well organized system is complex. As complex systems, the cities are made up of many components, in turn complex: people, insects, roads, buildings, cars, electromagnetic fields. The research, in fact, is talking about city as a dynamic complex system. This expression is equivalent to saying that the city is due to a set of components relative to each other (system), the system processes are not manageable and controllable by means of deterministic (complex system) and, finally, the future development of the city-system is not predictable based on knowledge of the initial conditions (dynamic complex system). The dynamics governing the system-cities are almost always the result of causes not easy to read, which is accompanied by an inability to control and manage complex phenomena, not only

due to the inadequacy of the procedures adopted but also the lack of effective tools [2]. If we consider the city as a "system", characterized by the presence of numerous elements (tasks and functions) and held together by interactions and relationships among its components (communications channels), complexity theory and the analytical approach used for study of complex systems, make it possible to develop a vision of the city as a whole, because the city can be read not only as "physical phenomenon" but also as "functional phenomenon".

The result of the interaction between man and nature which he lived is the world we inhabit today, determined by the complex of events related to the special physical situations, historical, cultural, economic and social own of every place and time [3]. Men have fought to defend and extend their territories. Those who wished to do so now would be in the exciting position of those who must give shape not only material needs but also psychological, combining its own expertise and sensitivity to the needs of others, living in the same time all the difficulties related to the confusion of tastes and styles and the fact that you have lost cultural references and compositional models. On the other

hand there must be a reasoning based on logical reasons and clever thoughts as to be used as a yardstick to judge what we inherited and what you are doing and thinking about the future. Alongside the answers that involved over the centuries, the political, economic and urban, that have changed spatially urabane our reality, today the individual response can only come about by a change in aspirations and popular models: the beauty that interests us is daily, is that of the landscape "home" made up of the inside and outside of our homes, the streets that we walk normally, places that are usual and loved ones. It, when it exists and is enjoyable to all, is a symbol of great democracy in this sense is a human and social value incomparable and perhaps holds the indisputable power that distinguishes the city of the past.

1.1 How city is evolved

[4-11]

From egyptian city to the medieval one: the evolution of the human need to be part of a community

Man is a social animal and from the beginning of the time he has the need to live with the others and to be part of something with others men. Civilization is a complex way of life that came about as people began to develop urban settlements. The earliest civilizations developed after 3000 BCE, when the rise of agriculture allowed people to have surplus food and economic stability. Agricultural populations advanced beyond village life, and many people no longer had to practice farming at all. Civilizations first appeared in Mesopotamia (the actual Iraq), then in Egypt. Civilizations thrived in the Indus Valley by 2500 BCE, in China by 1500 BCE and in Central America (the actual Mexico), by 1200 BCE. Civilizations developed on every continent except Antarctica.

Eqyptian city

Egyptian cities appeared as consequence of the development of agriculture and they imposed themselve as unifying and predominant form of political organization. Cities consisted of regional capitals linked to the population centers of smaller administrative districts.

During the New Kingdom, the Egyptian word for "city" was niwt. That term refers to "settlement". Settlements and cities were located on the floodplain, with a preference for proximity to the Nile, in order to receive goods by boat and for its source of water. Generally, there was not a real urbanism, but that urbanism is considered as the hieroglyph for "city" with houses arranged rather haphazardly around the crossing of two major roads. But in a number of cases attempts at rational planning seem to have been made.

Grecian city

“Polis” is a famous word from which we derive our term “politics,” is usually translated as “city-state”, the principal reason is for emphasizing its difference from what we today normally think of as a city. As in many earlier states in the ancient Near East, the polis included not just an urban center, often protected by stout walls in later centuries, but also countryside for some miles around with its various small settlements.

Roman city

Urban design of Roman cities follows clear laws for the development of public and military services. Roman city is basically composed by a number of identic components, disposed in a special way -parallel and equal-distant separated by streets. The whole forms a unit of rectangular design surrounded by a perimetral wall with watchtowers. All the streets are equal except for two: the North-South one -*kardo maximus*- and the East-West one -decumanus-. Both are wider and they end at the four doors of the exterior wall. At the cross of both streets is the city's forum and the market. These urban rules were developped during nearly 10 centuries in order to create the different cities. In these cities, kinds of housing could be divided into *house*, *domus*, insula and villa. There also were casae or housings for slaves and low classes. Because of their weak systems of building they have all dissapeared in our days. Indeed, there were also great communitary buildings as basilicae, termae and the very important social and

cultural systems called forums. In Roman Hispania there was a lot of capital cities.

Medieval city

In the Middle Ages a new urban culture is developped. City became a small self-sufficient entity which restructured the territory of all Europe in tiny aggregations of towns and countries. The life fervor of this period is reflected in the urban structure, which translates in practice this dynamism exalting with paths and meeting places.

The medieval town, with its own statutes and regulations, creates a small microcosm. This kind of city presents itself as an autonomous entity, circumscribed by walls, inserted in a particular agricultural landscape and recognizable for the profile of towers, roofs and spiers that summarizes the city as a collective symbol for all citizens.

Fig. 1.1 - Medieval Bologna Map

The baroque city: a theatre-city

During two centuries (from 400 to 600) we can retrace the first radical transformations in the city concepts, but it is between 700-800 that actually a new defined city idea started to move on, introducing the need of an urban design. This is the birth of the baroque city, characterized by:

- theatre;
- museums;
- concert halls;
- a park;
- a zoological garden;
- poor hygiene;

- expansion of affluent residential neighborhoods at the expense of the poorest ones.

With the baroque city we assist to the definition of a new spatial model: the city is a theatre.

The industrial city: the birth of the social cities

The industrial revolution corresponded also to an urban revolution.

First of all, the steam machine represented the biggest discovery after the discovery of the wheel for the transportation field. It means that city order should have be completely upset to respond to this huge improvement of communications and transports. Due to this improvement, it was born the phenomenon of Inurbation: people started to LEAVE campaigns because they want to LIVE in the city, the place of innovations and scientific developments.

In the industrial city the changes are really fast.

But the phenomenon have a double face: the fast growth of the industrial city underly also the social differences. Different social classes have to live in different spaces, that have to reflect these

differences in everything. Also speculators built everywhere to take the maximum gain.

Problems and crisis of the industrial cities are:

- overcrowdings;
- increased poverty;
- epidemics.

It is during this period that the concept of SLUM has born.

All these problems pointed out the need of a new kind of urbanism, a modern urbanism.

Henceforth urbanism will be never more detached from social conflicts that take place within it. It will be forever full of social meaning: endeavoring to distribute progress to all the sections of population.

Modern urbanism

Modern urbanism is scientific and moralist, characterized by utopianism and functionalism. From Waterloo (1815) to the revolution (1848) technical and political aspects of urbanism are so close to be confounded to each others.

Fig. 1.2 - Barcelona (Cerdà)

Fig. 1.3 - Florence (Poggi)

The American dream vs Europe: the ideal city towards contemporary city

During the Modern Movement, two of the most important architects in the history, like Le Corbusier and Wright,

elaborated ideas about a new kind of city. Even if they are basically opposite in their intentions, La Ville Radieuse [12] and Broadacre City [13] have the same conceptual pattern. In both materials, ubications and insediative principles have a new strong importance, with emphasis in identifying the correct dimensions and distances between activities and estabilishing the connections. In both, building the city like a park is essential for the city architectural. Urban space is a lattix, with two hortogonal grids, rotated 45° each other, while residential areas are connected with a smaller infrastractural network. Finally, there is the requirement of a new kind of architecture, pure and closer to nature. But in a different way. In Le Corbusier, the city architecture offres a different design from nature, while Brodoacre city is completely part of the nature. This is due to a different basic reflession: Le Corbusier is based on the big 800th city, like the Plan Voisin for Paris or better on the reflessions about La Ville Verte in 1930. Instead in the Wright background there is an illuministic conception, the jeffersonian grid, based on the dream of a great form of democracy and freedom born in the big territories of the new world. In “The Living City” Wright

highlights aspects like:

1. Electrification, consenting to cancel the distances, favoring human communications;
2. Mechanical mobility, enlarging human contact possibilities;
3. Organic architecture, introducing the concept that nature is not an element to struggle but an element to conquer in the architectural project.

Even if these ideal cities are not “smart cities” in the meaning we give it today, there are contact elements. Le Corbusier wrote : “The machine civilty has to find its architectural expression”. We are in the same conditions, but as the “digital civilty”. Our “ideal” city, the smart city, is intrisecally related to contemporaneous man and the ideal is evolving with the digital revolution.

Smart City

Modern cities are more complex systems and engines for the acceleration of human society development. At the same time, cities are consuming resources from nature and producing wastes to environments at a much higher rate than other living styles.

The problems of the contemporary city are:

- Environmental pathologies;
- Congestion and pollution for cars;
- Environmental resources not protected;
- Lack of security;
- Urban sprawl;
- Areas of exclusion and segregation (slums).

All of these problems are strongly related each others: for example, the climate changes and social problems are causing high risks of disaster and unsustainable development to cities. These issues are also generated, because, as we already said, urban areas have been accommodating more and more inhabitants. In particular, it is expected that by 2050, urban dwellers will become 67% of the world population, which is approximately 6.3 billion [14]. But, from the other hand, this faster urbanization processes and growing population densities reinforce people's concerns on better understanding, planning and managing their city, taking care about infrastructure, economy and society to achieve liveability and sustainability. Every urban planners, geographers, economists and citizens, all

together have the need to think and re-think the cities and their use. This context, in the period of the ICT (Information and communication technologies) revolution, couldn't be not related to technology. Due to the high degree of complexity of urban issues, ICTs have long been used to facilitate scientists and practitioners to manage cities and improve the efficiency of many working procedures in the territories governance, or, simply, to help in many urban problems.

In particular, since a high percentage of information, especially in the planning science, is geo-referred, geographical information systems (GIS) have gained their popularity very soon in urban planning, transportation modelling, risk management and geo-demographics. As an essential part in a much wider scope of ICTs in urban management, GIS have been pioneers of many revolutionary changes in the last half century becaming a basic tool for the treatment of urban issues, like traffic flows and so on. It is possible to analyze or predict people movements also with the use of open data that we continuously left on the network, as twits [15] or pictures [16] and so on. It is very important to understand that technology should be just a service for people, it

cannot be considered a goal, as it is just a good and strong mean in people hands. “Smart city” it's used to describe the level that every city wants to reach and is playing a more and more important role. It is a kind of ideal city. For this reason it is hard to define what a smart city is.

As suggested by Holland [17], part of the problem concerns the variety of ways the term “smart” is employed. The term “smart”, in fact, can be related to IT, technology, internet and so on. But it cannot be reduced to just this.

The concept was born during the last decade as a fusion of ideas about how information and communications technologies might improve cities, enhancing their efficiency and competitiveness, providing new ways in which problems of poverty, social deprivation, and poor environment might be addressed [18].

Universities have developed prototypes and solutions for intelligent cities. *MIT Smart Cities Lab [19]* focuses on intelligent, sustainable buildings and mobility systems (GreenWheel Electric Bicycle, Mobility-on-Demand, Citycar, Wheel Robots); the *IntelCities [20]* research consortium developed solutions for electronic government, planning systems

and citizen participation; URENIO has developed a series of intelligent city platforms for the innovation economy [21] focusing on strategic intelligence, technology transfer, collaborative innovation, and incubation, and in the meantime is offering, through its portal, a global watch on intelligent cities' research and planning [22]; the *Smart Cities Academic Network [23]* is working on e- governance and e-services in the North Sea region. Furthermore, influential IT and telecommunication companies such as CISCO, IBM, MS have developed new solutions and initiatives for intelligent cities. CISCO, launched the *Global Intelligent Urbanization* initiative [24] to help cities around the world using the network as the fourth utility for integrated city management, better quality of life for citizens, and economic development. IBM announced the aim of its *SmarterCities [25]* is to stimulate to stimulate economic growth and quality of life in cities and metropolitan areas thanks to the introduction of new ways of thinking and acting in the urban ecosystem.

But, rather than believing that IT itself can actually transform and improve cities, real smart cities must be based on the human

capital. This means that IT is a relevant side but the aim is to enhance democratic debates about the kind of city it wants to be and what kind of city people want to live in.

Also, smart city needs to create a real shift in the balance of power between the use of information technology by business, government, communities and ordinary people who live in cities [26] as well as seek to balance economic growth with sustainabilities. Finally, cities, can only be smart if there are intelligence functions that are able to integrate and synthesise IT to some purpose, ways of improving the efficiency, equity, sustainability and quality of life in cities [27].

Usually the new ideal city, "SMART CITY" is considered a technological city. But it is not the case: city could be technological, but, to be really smart, it is first of all human.

There are many different meanings of smart cities. Smart cities can be identified (and ranked) along six main axes or dimensions [28]. These axes are: smart mobility; smart environment; a smart people; smart economy; smart governance; smart living.

Smart mobility

Innovation and modernization of cities and territories is strongly related to mobility, that should be smart in the meaning of: highly technological, easy for citizens and green. The innovative system of smart mobility represents a new frontier for not only reduce waste and pollution, but also to create scale economies on the movement of people and goods, improving logistics through the use of technology and then saving time and costs. It is important to start thinking about mobility and shifts smoothly to make the standards of everyday life and the related behaviors more environmentally respectful and virtuous. Moving cleverly includes a public transport really efficient and environmentally friendly means for the territory protection. Smart mobility include more livable solutions with consistent and timely updates, safe cycle tracks and continuing for long stretches, park and ride facilities that avoid congestions. Smart mobility should in fact ensure a city centers access regulation, the adoption of advanced mobility management and mobile information to manage

the daily commute of citizens and exchanges with neighboring areas. Smart mobility solutions for all empowering the individual condition of having easy moving, good availability of public transport and sustainable innovative eco-friendly means. To obtain these results they need trip planning systems, route optimization and intermodal transport systems that allow the payment or reservation in mobility technologies Car-to-Car Communication (C2C) and Car-to-Infrastructure (C2I) but also integrated management of car sharing, bike sharing, van sharing.

Smart environment

Citizens are not only involved in the creation of the smart city, but also with individual actions, they become active participants in the process of city designing. This view is particularly significant in the creation of a smart environment, or in making cleaner the environment around. The single can intervene in this improvement process thanks to the single daily actions ranging from a

correct and efficient collection avoiding waste and not eco-friendly behaviors to the choice of alternative means for moving, for a less impact on CO2 emissions. Particular attention to recycling plans should also be paid by the Public Administrations, which should encourage good practice. In the constitution of a respected and respectable environment must also intervene individual companies, for example with business plans that optimize emissions, but also the public administration, adopting a series of behaviors of optimal management of public affairs, as saving lighting systems energy, air quality monitoring to highlight in the presence of critical situations and protection of urban green with specific actions for parks and natural areas improvement, as well as outreach activities to citizens. The renewable energy sources play a major role in the development of smart environment necessary to promote sustainable development. The building, in particular, needs to be rethought in an ecological and rationalization key that must converge more

about efficient buildings, with the consequent heating and air conditioning impact reduction.

Smart people

The smart city is created with the active participation, commitment, adherence to the territory. If it is true that a smart city must be built around the city, it is even more true that the citizens themselves must be the soul of the change of its territory with a smart view, sharing knowledge, ideas and creativity. The public and private stakeholders will choose in a smart city to put the citizen first, they are the heart of every project for the smart city. The centrality of the citizen and his civic participation has increased, especially in the case of the youngest so that enhance the human side of the city: smart citizens who inhabit a city smart. The conscious participation of those living on the territory to the life and decisions that change makes the citizens themselves protagonists of their own change. People are the which ones who choose to rethink a smarter city. A newfound awareness and participation in

public life, high levels of qualification of citizens, peaceful coexistence of different stakeholders and communities are some of the smart features that can be found in a "smart city".

Smart economy

The economy changes thanks to science and technology: the new concept of smart economy changes the global scenario. The city becomes the center of the investment and financial development; new technologies help to orient the production system to better behaviors, meeting the needs of citizens, businesses and land.

In an increasingly complex situation in terms of economic and financial, the smart economy interacts with innovative features such as business incubators for the creation of innovative start-ups, which support the growth of entrepreneurship as the creation of new ideas and their subsequent development thanks to the use of technology, the economic key and social future. The smart economy throws interesting ideas related to growth and innovation:

the window is open on competitiveness and growth, to look to the future. The smart economy must point on innovative spirit that distinguishes the smart city, with high flexibility of the labor market, productivity and entrepreneurship. The international spirit is accompanied by the ability to transform, typical of an economy "smart".

Smart governance

Changing relationships between public administration and citizens with a view to smart governance institutions, bodies, territory and individual residents can communicate in simple and functional with tools that can extend the opportunities for conversation and democratic participation. Dialogue and participation are the key elements of an administration that chooses to be technological. The smart governance pursues administrative simplification, making an important contribution to the strategy of smart city and makes the city center in their mechanisms. The Smart Governance uses the technology to make life easier for citizens: the

case of administrative simplification, necessary for the purpose of the intelligent city, which provides a virtualization of all the steps and processes. The benefits are visible both in direct service to citizens and businesses, both in the back-office management activities. A smart government has a strategic vision of their own development and knows defined according to this choices and courses of action, is able to engage citizens in issues of public importance, promote advocacy and use technologies to scan and shorten procedures administrative.

Smart living

A smart city is a place that knows how to speak to people through the latest techniques and technology applied. Even in tourism smart power components are improving the environmental and landscape enhancement of an area and creating a more sustainable use of the sites. As it is expanded and strengthened the security of the citizen, the center of technologies that assist him in the city. Valuing history, culture, art and traditions in the eyes of all: to do

this, you need to reorganize the resources and tools available to cities and at the same time creating new local services and shared through a more effective network of telecommunications and electronic communications. The contents of the smart city then become virtual to give an opportunity to everyone for enjoying city. The watchword becomes multimedia to create a digital network of orientation and a network of geo-referenced multimedia content that provide a better knowledge of the area and its peculiarities. A smart city in fact bases its growth on respect for its history and its identity: through the use of technology, it is possible to promote its tourist image on the web, by virtualizing the heritage of the city. Thanks to advanced techniques can also create paths and "mapping" issues of the city and making them easily accessible as a "common good".

SMART ECONOMY (Competitiveness)	SMART PEOPLE (Social and Human Capital)
▪ Innovative spirit ▪ Entrepreneurship ▪ Economic image & trademarks ▪ Productivity ▪ Flexibility of labour market ▪ International embeddedness ▪ *Ability to transform*	▪ Level of qualification ▪ Affinity to life long learning ▪ Social and ethnic plurality ▪ Flexibility ▪ Creativity ▪ Cosmopolitanism/Open-mindedness ▪ Participation in public life
SMART GOVERNANCE (Participation)	**SMART MOBILITY (Transport and ICT)**
▪ Participation in decision-making ▪ Public and social services ▪ Transparent governance ▪ *Political strategies & perspectives*	▪ Local accessibility ▪ (Inter-)national accessibility ▪ Availability of ICT-infrastructure ▪ Sustainable, innovative and safe transport systems
SMART ENVIRONMENT (Natural resources)	**SMART LIVING (Quality of life)**
▪ Attractivity of natural conditions ▪ Pollution ▪ Environmental protection ▪ Sustainable resource management	▪ Cultural facilities ▪ Health conditions ▪ Individual safety ▪ Housing quality ▪ Education facilities ▪ Touristic attractivity ▪ Social cohesion

Table 1.1 - Smart city levels (www.smartcities.eu)

For FORUM PA 2010 [29], smart cities are identified in 5 dimensions, that anyway can be grossly assimilated to the previous ones:

1. Mobility: a smart city is a city in which the transport is comfortable, innovative and substenible. There is an incentive of public transport and pedestrian areas,

ecological means like bikes and ITS to inform about the movement in the city.

2. Environment: a smart city is a city in which the sustainable development is very important, that means a new strong attention to improve the separate collection of rubbish and in genearl to reduce rubbish, significantly reducing gas emissions and control the energy, the building construction, the green areas and, in general, the management of urbanism.

3.Tourism and culture: a smart city is a city with an important touristic imagine, a good promotion in the web, valorising culture and territory with advanced techniques, paths and thematic maps, clear and interesting for all kind of tourists.

4.Economy of knowledge and tolerance: a smart city is a place in which you learn continuously in innovative ways, promoting arts, culture and creativity with the right dimension and method for everyone. The knowledges have to be open and free.

5.Urban transformations for life quality: a smart city has a

strategic vision about its development, identifing the right actions to earn the objectives, valorizing the territory and enhance its identity with the help of all the citizens, thanks to a new social cohesion, without barriers between different conditions.

The smart city addresses the supranational planning policies, such as the European Cohesion Policy, that influence national planning policies and prioritize transportation networks and accessibility, entrepreneurship, education and training, and sustainable growth. Smart cities and Urban planning are closely linked to each other because both end-users and stakeholders of the smart city's User layer are obliged to follow the planning rules and to consult in cases of framework's construction to better understand and use the territory [30]. Thus, the user layer is influenced by all planning dimensions. For these reasons, the smart city's infrastructures have to conform to planning rules and not to charge the local environment or the local protected areas, while planning has to uniformly develop smart cities across the regions for coherent development. This means that the smart city's data layer must be kept up to date with accurate planning

information, in order to deliver efficient and effective e-services to the local community.

Smart cities can be classified in various approaches and can be evaluated according to their sophistication. All alternative approaches deliver emerging types of services to the local communities with the use of natural and/or of virtual resources. Urban planning supports sustainable local growth, it consists of four dimensions that were recognized according to the European Regional Policy Framework and they are:

- Environmental protection that deals with qualitative criteria such as: livability, environmental quality, quality of life and respect on biodiversity. In this context planning delimits the urbanization zones, the seashore and streams;
- Sustainable residential development that covers the urban viability timeline since it "meets the needs of current generations without compromising the ability of future generations to meet their needs and aspirations";
- Resources' capitalization that concerns both natural and human resources' capitalization with means of optimal demographic allocation and decen- tralization, water and

other natural resources' use, residential and farming allocation etc;

- Coherent regional growth support that embraces the urban history and landscape and it is based on various Government programs' planning and implementation, which respect traditional settlements, archaeological areas, forests and parks.

We can also affirm that planning's dimensions can be affected by smart city's stakeholders via participatory policy making, while the smart city's infrastructure has to be recognized and capitalized. The future challenge is try to interrelate the physical and the digital space of a smart city with tangible measurement.

In conclusion, a city can be considered smart when it is able to improve the its citizens lives, to meet their needs, those of enterprises and institutions in the technology, communication, mobility, environment and energy efficiency fields.

Even at European level [31], initiatives are born with the aim of transforming an urban community in a smart efficient and socially innovative one, where there are supported and implemented projects ranging from ecosostenibility of urban

development to the energy waste and pollution reduction through better urban and transport planning. Smart city is a city easy to use, technological and for citizens. Only starting to build smart cities we will be able to have a smart world, to change it [32].

1.2 New urban planning approach for the complex city

With smart cities, we are building a new equation with space, people and technology.

The urban project consists in complex processes correlating to mathematic and geometry, in fact the complex systems theory is the right way to understand and measure form evolution and wholeness of our cities. The complexity, developped from Seth Lloyd, a phisicist from MIT and Santa Fe Institute, left a mark in the scientific culture, ranging from informatics, biology, economics and engineering applications. The big intuition is the method, studying not the single parts of a system, but directly the whole system. This concept introduces the essential elements of complexity: chaos, fractals and networks, so we can study the

elements of a system and their connections with themselves and with the rest of the environment.

This ‘new mathematic’ is easily adaptable to describe and study architecture and urbanism. From the beginning of ‘60, there are many studies about these relations between mathematics and city in general, with emphasis in wholeness and Pattern Language [33-35] while the new studies, in ’90, are more about the fractal geometry descripting the urban models [36] and the relations between the different components of the urban system [37-38].

It’s possible to define 3 principles on which should be based the urban structure:

1. activity vertices;
2. connections;
3. hierarchy, garanteeing the components will be grouped progressively from the smaller to the bigger ones.

From these principles, Salingaros elaboretad a framework rules about the urban project [39]:

1. urban components should be standardized to universal laws for the dimensions intercourse, with attention to protect the ‘small’ elements, closer to human scale, to the

invadence of the ‘big’ elements;

2. city works with flow networks, so it’s very important to structure well transportation networks and connections between the activity vertices in the city and with other cities;
3. city should encourage intermodal transportation;
4. neighborhoods should re-define their streets, enhancing vivibility in thier spaces (a good example in this sense can be the woonerven in The Netherland);
5. where communications lines intersect each others it’s important to improve and reinforce the weaker components (like pedestrian crossing);
6. office buildings shouldn’t be isolated, but re-inserted in the urban contest and reachable by the pedestrians thanks to pedestrians areas;
7. more mixed-purpose buildings;
8. building facades should be a connection elements in the urban contest and not a forced separation between the spaces;
9. big open spaces aren’t urban space, so built elements

should define the urban space, avoiding isolated buildings;

10. a neighborhood is a place in which each point inside it can be reached in 15 minutes walk. Each barriers (big parking areas, highways, etc…) should be outside the neighborhood, defining a confine for it.

In addition, many times quantitative indices are not well integrated with qualitative parameteres, perceived from city users [40]. We have to consider many elements when we study the city [41-42]. In fact, for Bettencourt, cities are not only concentrations of people, but better concentrations of social interactions (friendships, work relations, etc…). In the Bettencourt model, cities are a complex system different from organisms or river networks, because city evolves not only to minimize the energy waste, but also to maximize social interactions. For these studies, we know there are two important factors characterizing the city: dimension and specific identity. Big city has advantages respect a small city: there are better infrastructures, efficiency and new ideas and developments are faster to assert, but also the criminality. The behavior is super-linear, that means when the number of citizens becomes double,

each citizen earn 15% more, is 15% more innovative, but he has also more 15% possibility to be a crime victime. People want to move in big cities to improve their productivity and enahance their social interaction, even if life is more cahotic or expensive. Also, when city dimensions become double, it needs only 85% of resources more. But there are some cities that don't follow this rule. The gap is explicable with the specific identity of the city, its particular history.

Calling G the variable indicating the socio-economic interaction levels in a territory.

If $G_{min} = 0 \Rightarrow$ there aren't social interactions, and then there isn't any city.

Calling $G^* = G_{optimum}$:

- If $G < G^* \Rightarrow$ city can improve quality of life, because that means the city doesn't realize its socio-economical potentiality;
- If $G > G^* \Rightarrow$ city is victime of its own success, because its energy waste increase super-linearly with a bigger tax respect to the socio-economical output.

Invariants of urban complexity that characterizes the modern city and, above all, that of the technologically advanced countries can be traced to particular phenomena that spread with increasing intensity and that mark the difference between the organization of the current city and that of the city's past. These phenomena refer specifically to three conditions connoting the current city [43]:

1. the concentration,
2. the specialization,
3. the integration.

The first condition refers to the high concentration of physical activity in urban and metropolitan. The second refers to the increasing specialization of urban activities and subways that can also be read as a direct result of the high concentration. The first two conditions require, therefore, the strong functional integration between assets and groups of assets. The concentration, specialization and integration of generating such synergies in urban and metropolitan system to characterize the city as the "place of complexity" because the complex is the

system of relationships and activities and, therefore, the organization of the city.

Conclusions

The interesting challenge in the new urbanism is re-thinking the methodological approach for the urban planning, that should be based on the complex systems, considering urbanism consists in social processes strongly connected to the geometrical component. We have to interpretate the urban space like an human body, with its dynamics, its history, its evolution.

In this study we made a temporal travel with an excursus of the city evolution. The analysis of the planning's dimensions and of the city's architecture layers shows various meeting points with the new city concept. Nowadays city is one of the most important and discussed topic in so many the research fields. We are living an historical radical change about city structure and concept, but we are not able to understand and stand up to it if we don't know why this change is happening: to know why, we have to learn from the past, from the historical city evolution.

In conclusion, the city is a system characterized by an inextricable complementarity between "phenomena disordered" and "phenomena organizers", that self-regulate a subsequent state of equilibrium.

As occurs in natural systems, to govern a system of this type is necessary to understand the overall structure; you have to know what they are and how they interact with the parts of the system, the differences are transformed into oppositions and complementarities in antagonisms.

In other words you need to know the elements of a metro system and the laws that regulate the mutual relations to identify the many dysfunctions and serious internal abnormalities.

The systemic functional conception of the city can be traced back directly to the general systems theory, which, applied to the urban phenomenon, allows the construction of a model of relevant inquiry to interpretation and decoding of urban complexity. In this sense, already in reading and analyzing system-city you need to combine the characteristics of individual parts of a system to the characteristics of the system, trying to

find the interrelation that binds the individual parts to the whole and vice versa.

Complexity is the new outer reach in the urbanistic research and it's the basic way to understand and plan the smart city, our new city. But what actually is a smart city? There are different meanings for smart cities that we tried to put together. What we can say is that with smart city we are going to define a new equation with people, space and technology and the planning science has to be prepared to build this equation with the complexity.

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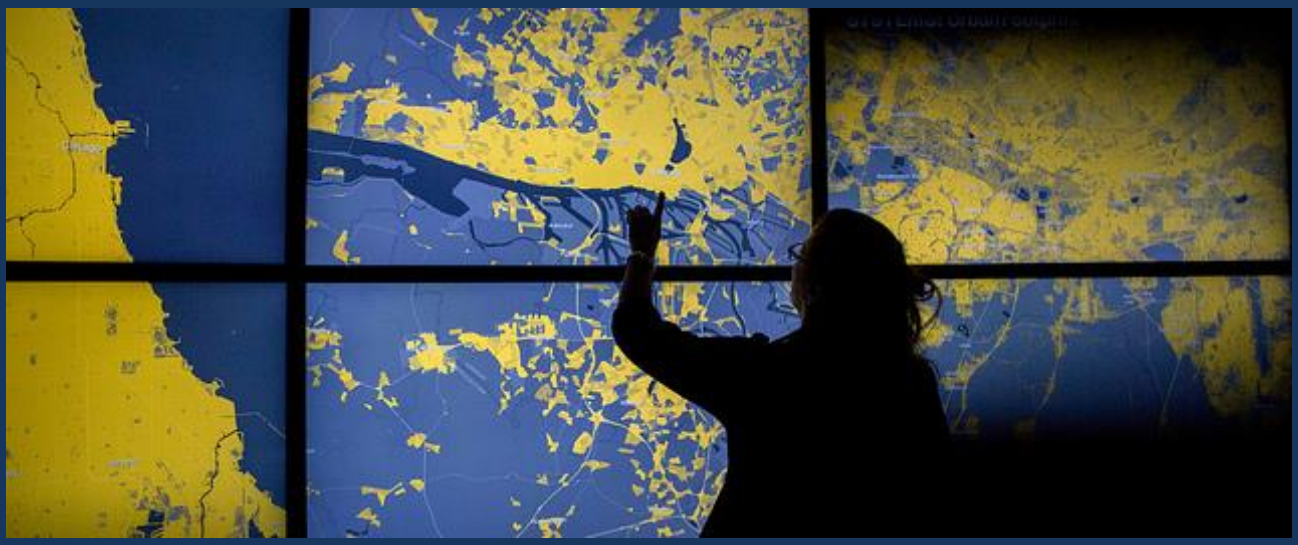
Chapter 2



Picture by Kris Krug - Flickr

Chapter 2

Open Data from Social Media as Tool for Better Understanding Complex Territory

Abstract

Data are becoming increasingly important nowadays, because they represent a concrete and inexhaustible source of information, which could be transformed into knowledge. Then, knowledge is synonymous with resource, because it represents a source of personal and community enrichment and, at the same time, it allows to accomplish more aware actions and to take advantage of every moment of freedom that comes from it. Thanks to today's technology, that creates services in response to the growing needs of citizens, public administrations and companies, the value of these data is finally disclosable in simple

and immediate ways. An important tool, particularly with regard to more precise issues, such as security, economy or quality of life, is Geographic Information System, since it allows not only to represent the collected data in an immediate way, but above all to provide it with georeferencing, and, then, to spread it through mappings, easily interpreted also by non-experts.

Keywords: [Big Open Data; collective sensing; community; territory]

Introduction

The meaning of Open Data can be clarified by using one of the commonly accepted definitions provided by the Open Data Manual, the "Bible" for anyone who wants to embrace this philosophy, which describes it as:

"[...] data that can be freely used, reused and redistributed, with the only limitation - at most - of the request for allocation and the

redistribution of the author in the same way, so without any change."

As highlighted above, we talk about "open" data, i.e., freely transmitted and distributed information, that is exchanged in the network in ways that provide for the total absence of forms of control (such as copyright and patents) and other restrictions that may limit the use, integration and reuse.

Starting from the concept of open knowledge as outlined by the Open Knowledge Foundation (a no-profit foundation founded on 24 May 2004 in Cambridge with the aim to promote open content and Open Data), Open Data can also be characterized by the same principles:

- availability and access: data must be available in a convenient and modifiable form, preferably by downloading it from the Internet. Data must be available in a useful and editable format;
- reuse and redistribution: data must be provided so as to allow its reuse and redistribution, this includes the ability to combine it with other databases;

- Universal participation: everyone should be able to use, redistribute and reuse data, without any discrimination towards application areas or people or groups.

Open knowledge is a prerequisite for collective intelligence, through which it is possible to implement the main practical advantage of the opening that is to exponentially increase the ability to control, certify, explore and combine different databases and then develop new products and services [1].

The use of Open Data is also connected to the tools used for its cataloguing, processing and representation. Since most data are equipped with a system of coordinates that make the data itself georeferenced, it is logical to connect the subject with the Geographic Information System (GIS), a system designed to receive, store, process, analyze, manage and display data geographically; GIS, in fact, allows to work on maps and to show, through an endless series of layers, all the features that are highlighted in a given territory.

But why should research about urban planning be so much interested in these technologies?

1. Because, in the short period, the distance between the digital and the real world becomes shorter and shorter;
2. Because researchers have been very good in the last few years at talking about new technologies, but not as good at understanding how these technologies can actually improve our lives.

It is time to explore these issues, so, the question should be: How can we extract added value from these datasets that are constantly increasing? Everything comes together for creating abundance of data.

Collective sensing is focused on the human aspect that can be drawn from this data, and it would be quite interesting to understand how data can be representative of some collective phenomena, such as mobility, transportation, tourism, etc.

One area that has much interest in Big Data and Collective Sensing is, in fact, tourism. As it will better explained later, tourism in Italy represents 10% of the national Gross Domestic Product (GDP). However, nobody knows how many tourists are present at a given time in a specific area of our nation. These details can be retrieved only with great expense in terms of time

and costs, and after a certain period; it is the same case of a company that does not know who its users are, it is unfamiliar with its production cycles, and that, by working in this way, is bound to fail [2]. Big Data can help in this situation, providing knowledge about what happens and also analyzing it.

The work presented is divided as follows: Section II explains the importance of Big Data to analyze complex cities and to help decision makers to invest in and improve this kind of cities; Section III describes how GIS can be used as a tool to mapping Open Data, Section IV provides an example of the application is presented, and Section V concludes the work with some considerations.

2.1 The use of Biga Data for the complex cities

“Big Data” is a huge collection of such complex datasets as to require the use of different tools as compared to traditional ones in all phases of the process: acquisition, also through sharing, analysis and visualization. The increasing size of the dataset is related to the need to analyze a single dataset, with the aim of

extracting additional information as compared to what could be obtained by analyzing just small series of data, for example, the analysis to gauge the "mood" of the markets and trade, and thus, the overall trend of the company and the flow of information travelling and passing through the Internet.

Big Data also represents the interrelationship of data from potentially disparate sources; these are structured set of data, such as databases, but also unstructured ones, such as pictures, emails, Global Positioning System (GPS) data, as well as information taken from social networks. So, we can talk about "Big Data" when we have a large dataset which requires unconventional tools to extract, manage and process information within a reasonable time [3]. This issue is ever changing because machines are getting faster and datasets are getting bigger. According to a 2001 study [4], the analyst Doug Laney defined the growth model as a three-dimensional one (model of "3V" [5]):

- *volume*: is the size of the data set;
- *velocity*: is the velocity of generation of the data; there is a tendency inherent in making analysis of the data in real time or nearly so;

- *variety*: refers to the various types of data from different sources (structured and unstructured);

This model, summarized in Fig. 3.1, is still valid, although in 2012 the model was extended to a fourth variable V to indicate the *veracity* of the data [6], i.e., the informative value that you can extract.

Over time the model was extended, adding the following features:

- *variability*: this feature can be a problem because it refers to the possibility of inconsistency of data;
- *complexity*: the huge size of the dataset increases the complexity of the data to be managed; the most difficult task is to link the information to obtain interesting outputs.

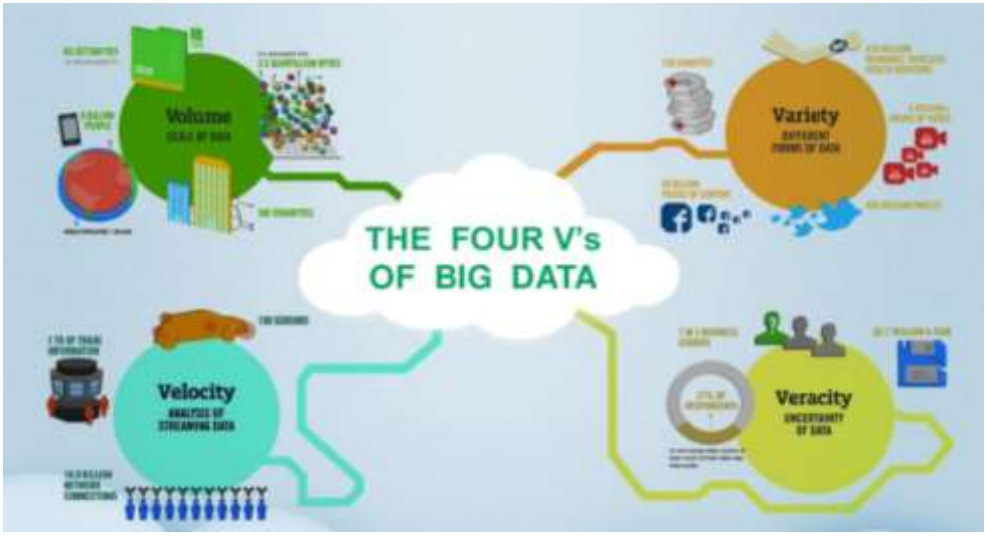


Fig. 2.1 - The four V's of Big Data, source IBM.

With 7 billion people on the planet, who access about 1.2 billion personal computers and 1.5 billion smart phones, growing at a rate of about 30% annually, the scale of data being generated by these devices is daunting [7], but it is important that Big Data are not turned into Bad Data [8]. In fact, the possibility to collect digital traces on a massive scale could be transformed from a tool of potential liberation — the fuel that drives Open Data initiatives in cities and states across the world — into an instrument of abuse, surveillance and asymmetrical control.

Yet, Big Data still hold many promises, not only for the private but also for the public welfare. In cities, Big Data is making a tremendous impact across a broad spectrum: it is helping to imagine a more efficient mobility [9], reducing pollution [10], showing humanity patterns [11]-[13], from energy [14] to waste [15]; moreover, understanding city patterns is a useful instrument for urban planning in general [7]. It is a silent tool that can promote new forms of civil engagement. Nonetheless, a new way to frame the relationship between individuals and Big Data is urgently needed, to move beyond today's pseudo-feudal system of trading personal information for a service.

The challenge, of course, is that Big Data will shortly provide new ways to analyze topical issues of the world, offering new immediate solutions.

Big Data is certainly enriching our experiences of how cities function, and it is offering many new opportunities for social interaction and more informed decision-making with respect to our knowledge on how to better interact in cities. However, it is important to use it properly and respecting everything, keeping in mind that citizens are essentially people and not only data.

2.2 Mapping Open Data with GIS

GIS is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. The acronym GIS is sometimes used for geographical information science, or geospatial information studies to refer to the academic discipline, or career of working with geographic information systems, and it is a large domain within the broader academic discipline of Geoinformatics [16]. In a general sense, the term describes any information system that integrates, stores, edits,

analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations [17]-[19]. Geographic information science is the science underlying geographic concepts, applications, and systems [20]. GIS is a broad term that can be referred to a number of different technologies, processes, and methods. It is attached to many operations and has many applications related to engineering, planning, management, transport/logistics, insurance, telecommunications, and business [18]. For this reason, GIS and location intelligence applications can be the foundation for many location-enabled services that rely on analysis and visualization. GIS can relate unrelated information by using location as a key index variable. Locations or extents in the Earth space–time may be recorded as dates/times of occurrence, where x, y, and z coordinates represent, longitude, latitude, and elevation, respectively. All Earth-based spatial–temporal location and extent references should, ideally, be relatable to one another and ultimately to a “real” physical location or extent. This key

characteristic of GIS has begun to open new avenues of scientific inquiry. The GIS tool allows to map the territory and to have a complete visualization of the overall situation of a determined phenomenon.

The importance of the localization component, i.e., the possibility to have geographical knowledge and information detailed up to the urban level, is often an essential element of the knowledge base of businesses, institutions, local administrative bodies, and public and private operators, providing services in many areas; moreover, with the greater interest in economic, social, political and environmental issues, the availability of data and information, that could be traced on a geographical basis, is increasing.

For example, GIS is a fundamental tool for smart cities, as explained in the book "Geographic information systems for Smart Cities" by Professor Vinod [21], focusing on how the future development of GIS will be triggered by Smart City challenges. In order to explain how GIS system performs, GIS experiences in conjunction with Smart Cities from many countries are shared by GIS experts who have designed and maintained it for several years. GIS is employed for sea erosion issues, urban resilience

issues, slum rehabilitation (for example in India where slums represent one of the most important social aspects to be considered in the urban planning) and state perspective; GIS is also used for smart growth and transport planning, for land use allocation and also for community planning and so on.

The investigation about smart cities requires an integrated approach through innovative, sustainable and inclusive dimensions with knowledge across green energy, sustainable transportation, quality environment and smart building, risk and resilience and many other different domains in which geospatial data and GIS are fundamental elements.

2.3 The use of Open Data for the Analysis of Tourist Flow

As discussed in Section III, the availability of digital geographic information at different scales (national, regional and urban) has produced a crucial transformation in the use of spatial data in recent years, with important benefits for organizations, institutions, governments, public and private operators in the different sectors of economy and services.

It is sensible to assume that the possibility of operating in a relatively simple way with geographically related information, i.e., “geo” information linked directly to the territory, and “graphic” information based on the effective graphical representations of digital mapping, can produce benefits in several application areas, with research or operational purposes, resulting from enhanced possibilities to integrate databases and from their use “on site” (by their direct acquisition), and/or “on line” (through the construction of databases that make information available on the web immediately accessible).

GIS applications are those traditionally used for the production and use of digital maps, such as monitoring and mapping territorial, environmental protection, urban planning, design and operation of road networks, stations and, more generally, technological networks.

Recently, the use of GIS and spatial data has become more popular and widespread; therefore, GIS applications, often integrated with simulation and visualization tools, are covering new areas, such as telecommunications, but little has been done in the cultural and tourist sector so far.

Our country is universally recognized for its great cultural heritage: 3.609 museums, nearly 5.000 cultural sites (including monuments, museums and archaeological sites), 4.000 entertainment places, 49 UNESCO sites, hundreds of festivals, traditions and cultural events.

Tourism is a key sector for our economy (10% of GDP), but beyond figures and statements about our tangible and intangible heritage, the truth is that culture is not considered as a priority in the political choices for the development of the country [22].

For several years, the cultural sector has been suffering due to a serious decrease in resources, that was the consequence of a substantial absence of active investment policies for the development of cultural, creative and artistic activities, and of a renunciation to an effective protection and enhancement of our heritage. Moreover, the interest people have in heritage and cultural activities in general, is progressively increasing, surely thanks to a medium level of culture, that has improved considerably as compared to the past, but also thanks to an instinctive attraction to beauty, which leads us to approach, look at and understand it.

These statements are supported by data provided by the National Statistical System (SISTAN) and Statistical Office of the Ministry of Heritage and Culture (MIBAC); from the analysis, it is clear that the number of museum visitors (including also monuments, archaeological sites, etc. in this category) is steadily increasing. In fact, cultural tourism remains a key segment of the tourism industry, which accounts for about 35%; moreover, 17.6% of the Italian and foreign expenditure in our country in 2012 (i.e, 12.6 billion euro), was represented by expenses made for cultural activities.

The increasing diffusion of social networks, internet, the use of new technologies and strategies of digital communication, have generated deep changes and imposed new rules, new speed and new spaces. Essentially, we have created new ways of interaction and relationship with end-users, users themselves and between users and cultural institutions; a new communication space, made not only of exclusive content, created ad hoc, but mainly based on sharing, discussions, constant feedback and interaction with users, before, during and after the experience of enjoyment [23].

Therefore, we should reconsider everything. And we should do it fast.

Based on the data provided by Globalwebindex 2014, Fig. 2.2 shows the daily hours spent on social media by the people who use them in different countries. Italy, with 2.5 hours / day, perfectly ranks in the middle between the minimum value of 0.7 hours / day in Japan, and the maximum value of 4.3 hours / day in Argentina and the Philippines.

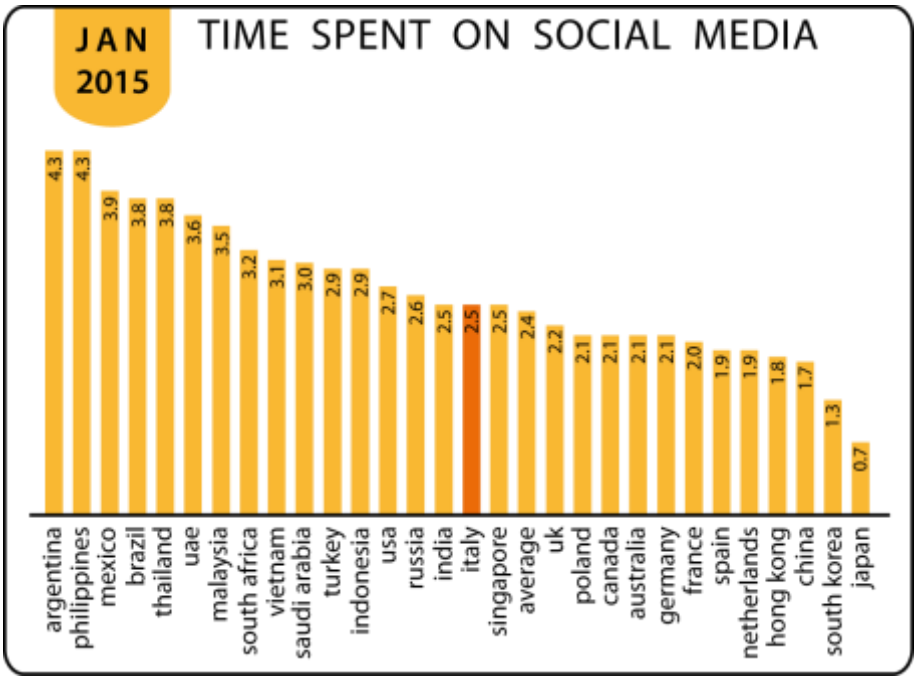


Fig. 2.2 - Average number of hours / day spent by users on social media (this figure only applies to people who use social media, not who do not use them), source Globalwebindex 2014.

Although our country has the highest concentration of cultural heritage, certainly it does not stand out for a promotion activity

able to communicate with the new generations, exploiting the full potential of digital channels, starting with the name of the museum that we seek in the web. The *Uffizi Gallery*, for example, is one of the most famous museums in the world, but on the search engine Google it ranks third among the research results; first of all, the name of the website is *polomuseale.firenze.it*, the website is translated in English only, the graphical interface is not attractive, the Facebook page has only 28.794 "likes" and only 117 people who "are talking about it", nothing as compared to the *British Museum*, that has 468.747 "likes", and 12.057 people who "are talking about it" [24].

Heritage and cultural activities, by their nature, are perfect candidates to support an effective endogenous development, however, art can help the economy grow if a proper strategy [25] is conceived.

The convenience to invest in the cultural field, therefore, lies not in an immediate economic advantage, but in the utilities flow generated by the use, research, and propagation of the heritage and territory where cultural heritage is located.

It is clear how much social media can help promote a territory rather than another. In fact, people buy through the social and choose clothes, shoes and accessories for the car through Facebook and Twitter, and of course, they also plan their vacations by using the same media. So, we can say that by studying social network information, it is possible to have a general idea of people perceptions.

The big novelty of this study does not only lie in mapping Big Data in GIS, since there are many examples of that in the literature, but in the particular kind of data considered.

In the large variety of social networks, we have chosen Flickr, the most famous social for picture sharing. We focused on geo-tagged photos because photography is a disciplined way of viewing and investigating landscapes, able to inform about design and planning in a more "qualitative" way. Residents and visitors take photos in particular places they consider important for some reasons. It could be very useful to understand what we like in our cities, in our territories, what we are interested in, or also where residents or tourists want to go. In turn, understanding this could provide important indications for urban innovation. For this

reason, photography is already considered a good mean of inquiry in architecture and urban planning, being it quite useful for understanding the landscape [26].

As we can see in Fig. 2.3, for Globalwebindex, in 2014, Flickr has been the first social network dedicated to sharing photographs.

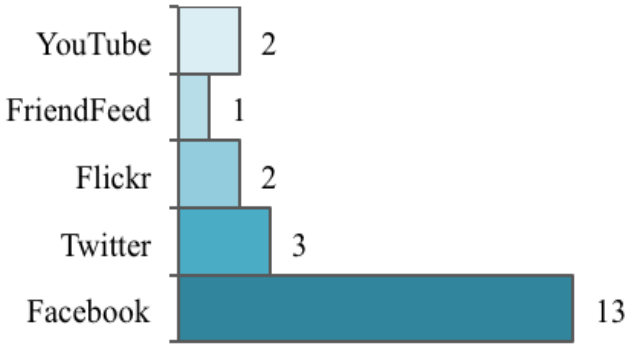


Fig. 2.3 - Main social networks used, source Globalwebindex 2014.

This kind of data can be considered as representative of the popularity rating of people, who, satisfied after visiting a place, want to preserve the memory, and then take a picture and share it on the social.

Through the downloaded Data, the origin of the users can be traced, information for year can be classified, and the geographical coordinates of the place where it was taken can be

associated to each photograph; thanks to this approach it was simple to recognize the most popular tourist sites, the months of the year when tourist flows are greater, and to try to create attractions that enhance tourism itself; but above all, it becomes clear the need to analyze the deficiencies of the territory, which are immediately visible by the mapping of the area, and suggest strategies to overcome the gaps found.

Conclusions

This study introduces and explaines two new tools that are becoming fundamental in the new approach to observation of cities and territories in general: Big Data and GIS. These tools are also mutually related, because the term Big Data also indicates Open Data, the latter are most of all georeferred data, particularly in the cases we are interested in, like cities. With them it is possible to conduct analyses applying the complex theory that better responds to city descriptions, revealing patterns and predicting phenomena that can allow to improve everyone's life. These geotagged data can be spatially visualized on maps to have

a complete and immediate vision of the situation we are talking about, thanks to the GIS.

Both tools are rapidly becoming necessary in space and territory related researches. However, we are quite at the beginning of such explorations, therefore research has to advance more and more in order to improve and maximize the huge potential of these instruments minimizing the controversies and the problems that a wrong use of the same can generate. Therefore, it is correct to affirm that GIS and Big Data suggest a future in which experiences of common citizens, and of true tourists, can be used for better understanding people's taste. Data give a "safe surprise", i.e., information about a reality away from home. Predicting that consumers will prefer a place instead of another one, or eat more in a restaurant rather than a pub, does not sound like a Big Data issue; nevertheless, by giving exact information about the favorite places, seasons, or hours of the day, it represents a new and powerful tool for fine-tuning and maximizing the tactical brand decisions. For instance, the capacity to adjust prices, mobility, services, in a quick and competitive way and in response to an analytically predictable

change in tourist vocations, is clearly a significant tactical power. Thus, also through these predictions, Big Data will greatly enhance the capabilities of travel companies, tour operators and urban planners.

Previous studies on tourism, retrieved from the Internet or from scientific articles, are mostly based on surveys and interviews with experts carried out by the Ministry of Industry, Energy and Tourism, the main public organizations, or private companies; in this particular case this indicates that the industry does not have real data about tourists and it can only take samples from the population as a whole. In contrast, the innovative approach achieved and proposed through this study, specially through the use of photos and GIS for localization, is to introduce data based on real actions of users and not on surveys. In other words, real actions have been analyzed instead of stated intentions or answers to questions, that can be interpreted through a subjective vision and can be, therefore, less useful for business and development.

This study has involved many different indicators, useful to carry out more precise contributions, such as:

- Visitors' main country of origin;

- Geographical position.

Based on the conclusions drawn from data analysis, the study ends with a series of tactical and strategic recommendations for managers. These recommendations focus on:

- Attracting more customers and pinpointing the countries where it is recommended to focus on marketing;
- Detecting areas of the city in which commercial transactions are carried out, specially, those referring to accommodation;
- Ensuring an attractive product suited to customers' true needs (ideal length of package offers, information about complementary services demanded by nationalities, etc.).

It is realistic to believe that a new frontier of social, territorial and economic retraining, could be based on open source data and geographic information, along with the use of information technology-based GIS.

The analysis of the vast amount of data produced by digital activities, opens up a wide range of opportunities for companies, for enhancing the services they offer and for the management of their business. For sure digital traces we leave every day on social

media will increase, providing a very accurate representation of what we do. Social media are a kind of expression of people and crowds participation because they reveal interests, tastes and perceptions of the community. Therefore, we can use these data to know, understand and analyze our collective behavior and, as a function of them, we can imagine better spatial planning in the territories where we live, by taking into account what each of us spontaneously shares and expresses on social media every day.

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Chapter 3

Picture by Moe Jalala - Flickr

Chapter 3

Urban Magnetism Through The Lens of Geo-tagged Photography

Abstract

There is an increasing trend of people leaving digital traces through social media. This reality opens new horizons for urban studies. With this kind of data, researchers and urban planners can detect many aspects of how people live in cities and can also suggest how to transform cities into more efficient and smarter places to live in. In particular, their digital trails can be used to investigate tastes of individuals, and what attracts them to live in a particular city or to spend their vacation there. In this paper we propose an unconventional way to study how people experience the city, using information from geotagged photographs that

people take at different locations. We compare the spatial behavior of residents and tourists in 10 most photographed cities all around the world. The study was conducted on both a global and local level. On the global scale we analyze 10 most photographed cities and measure how attractive each city is for people visiting it from other cities within the same country or from abroad. For the purpose of our analysis we construct the users' mobility network and measure the strength of the links between each pair of cities as a level of attraction of people living in one city (i.e., origin) to the other city (i.e., destination). On the local level we study the spatial distribution of user activity and identify the photographed hotspots inside each city. The proposed methodology and the results of our study are a low cost mean to characterize touristic activity within a certain location and can help cities strengthening their touristic potential.

Keywords: [city attractiveness, big data, human mobility, urban planning, tourism study, smart city, complex systems, collective sensing, geo-tagged Flickr]

Introduction

The traces of communication and information technologies are currently considered to be an efficient and consolidated way of collecting useful and large data sources for urban studies. There are in fact various ways to electronically track human behavior and the most diffuse one is collecting data from mobile phones [1], [2]. It was already demonstrated that this technique can be used as an accurate method for understanding crowds [1] and individual mobility patterns [3], [4], [5], to classify how the land is used [6], [7], [8], [9] or to delineate the regional boundaries [10], [11], [12]. Moreover, it was shown how to identify some of user characteristics from mobile call patterns, for example how to determinate if a user is a tourist or a resident [13]. However, when it comes to studying human mobility patterns, exploring detailed call records is not the only possibility – other sources of big data collected from digital maps [14], electronic toll systems [15], credit cards payments [16], [17], Twitter [18], circulation of bank notes [19], vehicle GPS traces [20] and also using geotagged photographs [21], [22], [23] can be successfully

applied.

The focus of this paper is on geotagged photographs that provide novel insights into how people visit and experience a city, revealing aspects of mobility and tourism, and discovering the attractions in the urban landscape. In the past, photography was already considered as a good mean of inquiry in architecture and urban planning, being used for understanding landscapes [24]. Moreover, Girardin et al. showed that it was possible to define a measure of city attractiveness by exploring big data from photograph sharing websites [25]. They analyzed two types of digital footprints generated by mobile phones that were in physical proximity to the New York City Waterfalls: cellular network activity from AT&T and photographic activity from Flickr. They distinguished between attractiveness and popularity. Regarding attractiveness they defined the Comparative Relative Strength indicator to compare the activity in one area of interest with respect to the overall activity of the city. They measured the attractiveness of a particular event in New York City. In this study we consider the attractiveness in the overall area of the city during three years, comparing the attractiveness and spatial

distribution of activities in different cities.

Discovering how to increase the global city attractiveness or the local attractiveness of hotspots requires knowing the differences in the visits made by residents and tourists. While both residents and tourists take photographs at locations that they consider important, the reasons why they are taking photographs are different. This knowledge helps us to understand the different usages of the urban infrastructure in people spare time. The overall goal is to find the ways how passively collected data can be used for low cost applications that inform urban innovation. These information trends can be of interest for planning, forecasting of economic activity, tourism, or transportation [26]. Finally, a comparative study of cities from different parts of the world is a relevant objective to discern how the patterns of human behavior largely depend on a particular city [27].

In this paper we define city global attractiveness as the absolute number of photographs taken in a city by tourists, while local attractiveness of hotspots within a city is defined by the spatial distribution of photographs taken by all users (either local residents or tourists). In our analysis we are using a dataset that

consist of more than 100 million publicly shared geotagged photographs took during a period of 10 years. The dataset is divided into 8,910 files denoting 3,015 different locations (e.g., cities or certain areas of interest such as Niagara Falls) where for almost every location three different labels are given: *resident*, *tourist* and *unknown*, to denote people who are living in the area, visiting the area or are uncategorized.

3.1 Data

For each photograph in the dataset, which is publicly available on the website sfgeo.org, the following data is given: user id, timestamp, geo coordinates and link from which the photograph can be downloaded. From the given dataset we omitted duplicates (9.33% of the dataset in total) together with the photographs with incorrect timestamps (0.01% of the dataset in total). In the end we were left with more than 90 million photographs. Fig. 3.1 shows how the number of taken photographs and users changed over the period of 10 years. We can see that almost 75% of the photographs were taken from

2007 until 2010. In the further analysis we are thus considering only photographs taken during those three years (about 70 million of photographs in total).

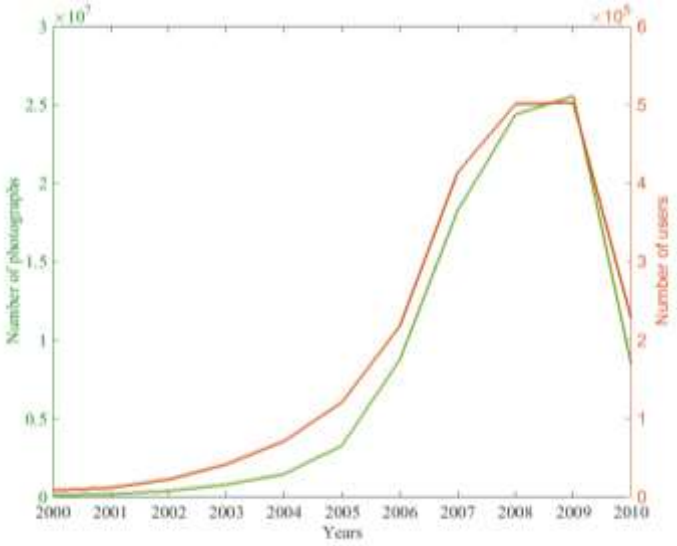

Fig. 3.1 - Number of geotagged photographs (green line) and users (red line) from 2000 until 2010.

3.2 Definition of user home cities and countries

In order to determinate if there is any difference between how residents vs. tourists are attracted to a certain location, for each user in the dataset we have to determinate his/her home city and country. Even though the dataset has tags for: *resident*, *tourist* and *unknown*, the given categorization is not comprehensive and in some cases is not consistent. For instance, for more than 85%

of users in the dataset their home city is not defined (i.e., their photographs are always in *unknown* files). In addition, for almost 25% of users for who their home city is defined at least two or more cities are listed as their home cities making the proposed categorization inconsistent.

Due to the aforementioned reasons, we used our own criteria to determinate if a person is living in the area where he/she took a photograph or not. We are considering that a person is a resident if at that location he/she took the highest number of the photographs (at least 10 of them) over the longest period of time (at least longer than 180 days) calculated as the time between the first and last photograph taken at the location. Once when we determinate a user home city, he/she is automatically becoming a tourist in all other cities in the dataset. A category "tourist" in this sense denotes many different kinds of visitors including business visitors. However, most of people taking photographs at locations other than their home cities in fact act like tourists during this particular instance of time.

From almost 1 million users that took photographs between 2007 and 2010, for only 11% of them we were able to

determinate their home city and country using our criteria. However, these users took more than 40% of all photographs (i.e., almost 30 million). Our classification was not consistent with the initial categorization (i.e., users whose photographs were listed in only one *resident* file) for only less than 2% of users. Moreover, for every city in the dataset we identified its country code allowing us to classify tourists as domestic or foreign ones, where domestic tourists are coming from the same country as the considered city, while foreign tourists are all the others – visitors from different countries. Finally, for every city all the observed activity is assigned to residents, domestic tourists or foreign tourists and for each of these categories, we keep the following data: user id, geo coordinates and for tourists their home city id together with their country code and continent id.

3.3 Attractiveness

3.3a Global Attractiveness

Considering our original question what attracts people to a certain location, we start our analysis looking at different

locations and their absolute global attractiveness that is quantified by the number of photographs taken in them by either domestic or foreign tourists, leaving out the contribution that was made by their residents. Once we determined user home cities and countries, in order to calculate global attractiveness for different locations, we ranked locations by the total number of photographs taken in them by tourists (i.e., people residing outside the considered city) from all over the world. We find that the first 10 ranked cities by photographs are: New York City, London, Paris, San Francisco, Washington, Barcelona, Chicago, Los Angeles, Rome and Berlin. In order to see how strong might be the impact of short-distance domestic visitors on this ranking on this classification, we compared it with the ranking built based just on the activity of foreign users in a city. Surprisingly the difference is not that high – New York and London are still the two leading cities (just switching order), Paris and San Francisco are still within top 5, while Rome having the lowest place in this new ranking among all the cities mentioned is still the 23rd world most photographed city with respect to the activity of foreign tourists. That is why the cities we picked up are the

important destinations not only for all (including domestic), but also for the foreign visitors. This ranking is also highly consistent with the one presented in [22] – all of our top 10 cities happen to be among the first 15 cities they mention. Another two global rankings of city visitor attractiveness worth mentioning in that context are the ones presented by Euromonitor[1] and MasterCard[2]. Although one should not really expect them to be consistent with our ranking, as those rankings are built on diverse (and sometimes heterogeneous) sources of data trying to include all the visits and not necessary only tourists who are willing to take photographs as we do it in our study, we will compare them against our ranking. One could often expect one city to attract more people, but another one, attracting less, being more picturesque, and motivating those fewer people attracted for taking more photos, which would result in a higher total photographic activity. However, all 10 of our top cities are included in Euromonitor's top destinations list. Worth mentioning is that this is already not the case for a newer version

[1] http://blog.euromonitor.com/2010/01/euromonitor-internationals-top-city-destination-ranking.html
[2] http://newsroom.mastercard.com/wp-content/uploads/2014/07/Mastercard_GDCI_2014_Letter_Final_70814.pdf

Euromonitor's ranking from 2015[3] – for example Washington falls out of the top 100 world destinations according to their recent estimate. This serves as a good example of how dynamic the world is, while it is not too surprising that our ranking built based on the data before 2010 happens to be more consistent with the older version of Euromonitor's report. Morover we found that our top 3 cities – New York, London and Paris - are also the top 3 (the order is different however) in MasterCard's ranking, while in total 7 of out top 10 cities (besides Berlin, Washington and Chicago) are mentioned among the "Global Top 20 Destination Cities by International Overnight Visitor Spend" in 2014. Further, we focus this study on the global attractiveness of these 5 US cities and 5 European Union cities (EU), and add together the remaining information as the rest of Europe, the rest of the US and the rest of world. From the aforementioned ranking we were able to extract the origin-destination (O/D) network between 10 most photographed cities, the rest of the US, and Europe as well as the rest of the world. Fig. 3.2 shows O/D flows among the top 10 city-to-city estimated flows of visitors. Colors

[3] http://blog.euromonitor.com/2015/01/top-100-city-destinations-ranking.html

of the ribbons correspond to destination cities and origin cities are marked with a thin stripe at the end of a ribbon (visualization method based on Krzywinski [28]). With this visualization it is evident that the most attractive cities are London and New York City, followed by San Francisco, Washington and Paris. It is interesting to point out that the most important flows happen exactly between these cities and New York City (New York City – Washington, New York City – San Francisco, New York City – London, New York City - Paris), while London and Paris have the strongest flow between each other. The less active cities are Berlin and Rome.

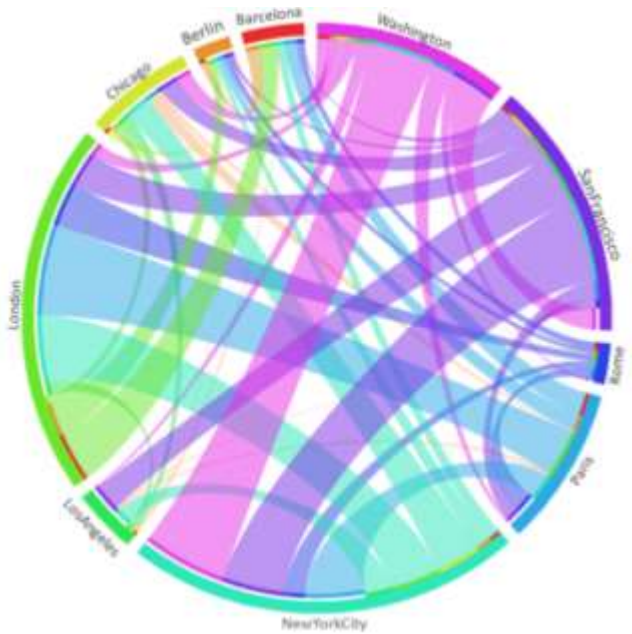

Fig.3.2 – Origin-destination (O/D) network among the top 10 city-to-city estimated flows of visitors. Ribbons represent "outgoing" fluxes on each side. For example, following the ribbon between London - New York City, on London side it represents people living in London who visit and take photographs in New York City.

The dependence between the number of users and the number of photographs they took is quite close to linear, having $R^2 \cong 0.87$ for the linear approximation. Therefore, the analysis based on the number of taken photographs is to some extent also a good proxy for the number of active users; further we will use the number of photographs as the main measure of attractiveness. However, using this measure one should also be aware of the heterogeneity of Flickr activity belonging to users coming from different parts of the world. As shown in Table 3.1 this heterogeneity is quite noticeable – number of photographs taken worldwide by users originating from different cities across the globe varies from 1.16 for the rest of the world to more than 1000 for San Francisco. In many places across the world people are almost never using geotagging location services (e.g., Flickr) and are not sharing their photographs publicly because of different reasons: e.g., technical, cultural or even political ones. Among the top 10 ranked cities this activity varies in a magnitude of 20 times between people living in San Francisco (the most active population) and Rome (the least active).

Table 3.1 – Heterogeneity of Flickr usage: total number of photographs taken worldwide by residents of different areas versus their official population in 2008.

City	*Population (mln)*	*Photographs taken*	*Photographs per 1000 residents*
New York City	8.36	1,026,199	122.75
London	7.81	1,151,799	147.48
Paris	2.23	534,092	239.50
San Francisco	0.81	851,425	1,051.14
Washington	0.59	525,313	890.36
Barcelona	1.62	255,038	157.43
Chicago	2.85	412,246	144.65
Los Angeles	3.83	289,810	75.67
Rome	2.71	126,011	46.50
Berlin	3.43	182,325	53.16
Rest of EU	4,82.61	8,637,148	17.90
Rest of the US	2,87.61	7,347,003	25.55
Rest of the world	5,905.14	6,877,894	1.16

In order to use the O/D flows of geotagged photography as a proxy for actual human mobility between cities across the globe, the appropriate normalization for the above heterogeneity is required. One way of doing it is by normalizing the O/D flows shown in Fig. 3.2 by the number of photographs taken per 1000 of residents of the origin location reported in Table 1. However, this would require further assumptions about the homogeneity of the dataset representativeness for different modes of people travel behavior that would be a questionable assumption given the dataset sparsity and heterogeneity. Therefore, in the further analysis we will refrain from extrapolating the original values of O/D flows defined by the actual number of photographs taken to

represent actual human mobility. In this way we will focus our analysis on the actual photographic activity of the users, keeping in mind that flows of the activity from different origins might actually have different representativeness across the entire human population and might not represent the entire variety of types of human activity from the considered origins in the considered destinations. However, we believe that photographic activity by itself is an important component of visitor behavior and might serve as a relevant proxy for measuring city visual attractiveness for the visitors.

The cumulative incoming flow for each destination in the O/D network from all the origins other than the considered destination represents the destination's total global attractiveness in terms of geotagged photographic activity of tourists. Normalized by the population of destination, this measure becomes a relative global attractiveness of the destination stating how much visitors per capita of residential population the location has.

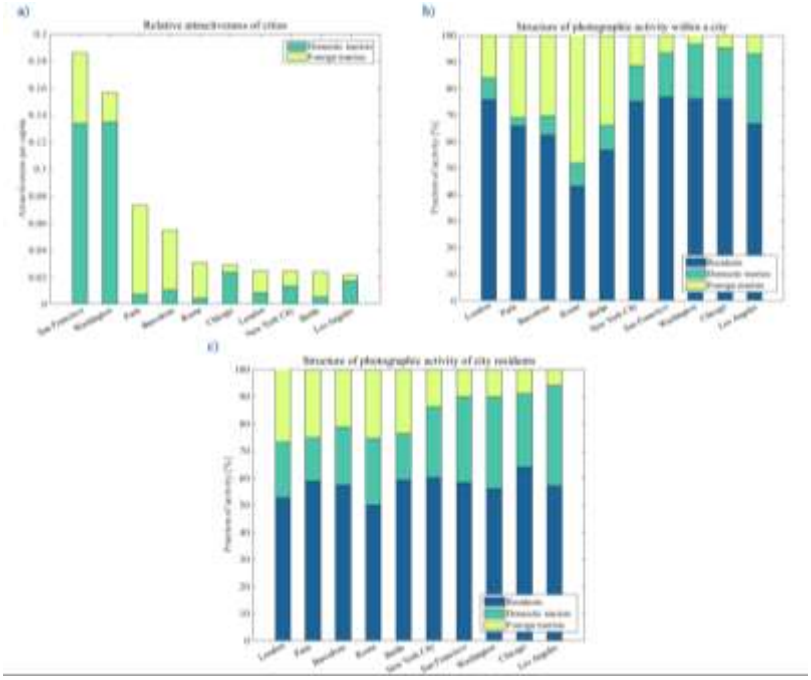

Fig. 3.3 – Relative attractiveness. (a) A relative global attractiveness of top 10 cities measured as the estimated amount of touristic activity per capita of urban population, it is plotted in the decreasing order of total attractiveness, (b) the structure of photographic activity within a city and (c) the structure of photographic activity of city residents. Figure 3 (a) shows the number of domestic and foreign photographs divided by the city population (i.e., attractiveness per capita for domestic and foreign tourists). Figure 3 (b) shows the percentage of photographs within each city depending on the type of user, while Figure 3 (c) shows the share of activity type of users that reside in the particular city. For example, as depicted in Figure 3 (b), Rome receives the largest amount of foreign tourist activity and Washington the smallest. And as depicted in Figure 3 (c) people living in Washington have the largest share of domestic tourists while Parisians have the smallest.

Fig. 3.3a shows the relative global attractiveness in relation to the population of the city (with additional distinction by domestic and foreign tourists). This gives a completely different city ranking from the initial one (e.g., New York City, London, Paris, San Francisco, Washington, Barcelona, Chicago, Los Angeles, Rome and Berlin) – now the top relative attractiveness is observed in San Francisco and in Washington for domestic

tourists, while the top destination by relative attractiveness for the foreign tourists is observed in Paris. Zooming into the relative structure of photographic activity within each city (Figure 3.3b), a clearly distinctive pattern between European and American cities can be observed. Namely, in American cities the city residents take most of the photographs; followed by the domestic tourists mostly taking the rest, while in EU cities the activity within the cities is much more diverse showing a higher fraction of touristic and specifically foreign touristic activity. The borderline cases from both groups are London and New York City, the former having the highest fraction of residential activity among European cities making it more similar to the American cities, while the latter has the highest fraction of foreign activity among American cities, making it more similar to European ones. One of the possible explanations could be that the observed pattern is attributed to the cultural similarities going back in the history of British-American ties.

Additionally, for every city we can define a measure that shows how mobile its residents are (i.e., if their activity is home-oriented or not) by looking at the ratio of loop edges to the total

outgoing weights from the O/D matrix (i.e., user activities in their home cities compared to their total activities). We depict these results in Fig. 3.3c. Although this ratio is nearly flat varying between 50-60%, an interesting pattern appears when looking at the destinations of activities. Again, American and European patterns are surprisingly distinctive – while the American tourists seem to be mostly engaged in domestic tourism, EU citizens' travel more abroad. This difference can be explained because the US is much bigger and at the same time much more geographically diverse when compared to the EU countries of our studied cities. American users thus have more options when engaged in domestic tourism and are consequently less likely to travel to foreign destinations. When considering the strength of each particular O/D flow $a(i,j)$ between the origin i and destination j (i.e., a number of photographs taken by the residents of i when visiting city j), one should expect that the number of people travelling between larger or more significant cities is higher. Therefore, in order to estimate the qualitative strength of each particular O/D flow beyond just the effect of scale, we compare all the non-loop edges of the normalized

network versus the homogenous null-model where all the outgoing mobility is distributed in the relative proportion to the destination attractiveness, i.e., for each non-loop edge ($i \neq j$) the null model is:

$$model(i,j) = \frac{w^{out*}(i)\, w^{in*}(j)}{\sum_{k \neq i}(w^{in*}(k))}$$

where $w^{out/in*}(i) = w^{out/in}(i) - a(i,i)$, $w^{in}(c)$ is the total number of photographs taken in city c and $w^{out}(c)$ is the total number of photographs taken worldwide by city c residents. Using the aforementioned model, we compute the fraction $a(i,j)/model(i,j)$ (see Table 3.2) in order to see how qualitatively strong the links between each pair of cities are, i.e., how people from each origin are attracted to each destination beyond just the effect of scale.

Table 3.2 – Relative strength of the links between each pair of cities, normalized by the null-model estimation.

O / D -->	*New York City*	*London*	*Paris*	*San Francisco*	*Washington*	*Barcelona*	*Chicago*	*Los Angeles*	*Rome*	*Berlin*
New York City	-	0.99	0.88	1.11	2.08	0.32	1.60	0.79	0.61	0.53
London	0.92	-	1.57	0.73	0.35	1.59	0.31	0.44	1.50	1.37
Paris	0.76	2.44	-	0.60	0.21	1.60	0.13	0.24	1.41	1.60
San Francisco	1.58	0.83	0.44	-	0.86	0.45	1.46	2.43	0.41	0.32
Washington	1.70	0.38	0.77	1.40	-	0.75	1.07	0.89	0.67	0.51
Barcelona	0.67	2.40	1.29	0.20	0.05	-	0.12	0.19	1.24	3.32
Chicago	1.25	0.77	0.78	1.37	1.62	0.58	-	1.37	0.41	0.34
Los Angeles	1.31	0.56	0.24	3.31	0.39	0.50	1.07	-	0.31	0.31
Rome	0.76	1.63	1.70	0.21	0.29	2.25	0.36	0.07	-	1.69
Berlin	0.64	1.79	1.15	0.61	0.37	2.15	0.16	0.09	2.22	-

One clear pattern, which can be immediately recognized, is a high level of attractiveness between pairs of American cities, as well as a lower level of connectivity between American cities and EU ones (see Fig. 3.4a). This pattern was rather expected, as trans-Atlantic links are likely to be weaker than more local ones. To a certain extent it could be attributed to a general decay of links with distances (similar to Krings [29]) – indeed the overall trend is well approximated by an exponential function (Fig. 3.4b) going sharply down once when crossing the ocean. However, an interesting finding shown in both Figures 4-a and 4b is that the links going from the US to EU are stronger than same distance links going in the reciprocal direction from EU to the US (see Fig. 3.4a). According to this, Americans are more attracted by EU destinations than Europeans are by the US cities.

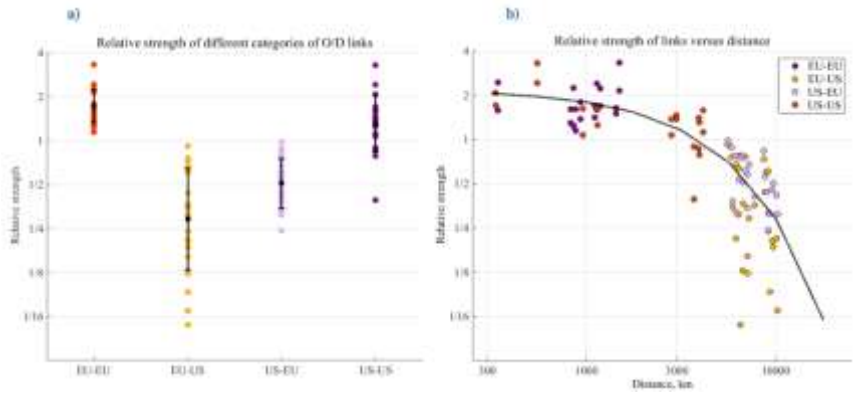

Fig. 3.4 – Relative strength of different types of links (a) grouped by continents, (b) ordered by distance.

3.3b Local Attractiveness

Until this point, cities have been considered only as aggregated spatial units. However, cities all around the world are not spatially homogenous and there are always relatively more attractive areas within them to which one can refer as “hotspots”. Moreover, attractiveness of different locations across the city could vary for different categories of users. In order to investigate this local attractiveness, we identified spatial distribution of photographs taken by users belonging to resident, domestic or foreign tourist groups. Visualizing them on the map, where each dot represents a photograph taken, Fig. 3.5 shows different spatial patterns of how different categories of users take photographs in New York City, which was taken as an example. As expected, tourists in general take more photographs in central areas within the city while residents take photographs at locations that are much more spatially distributed – scattered all over the city. By putting those dots onto the map, we can create “maps of attractiveness” for every city and for its residents and tourists.

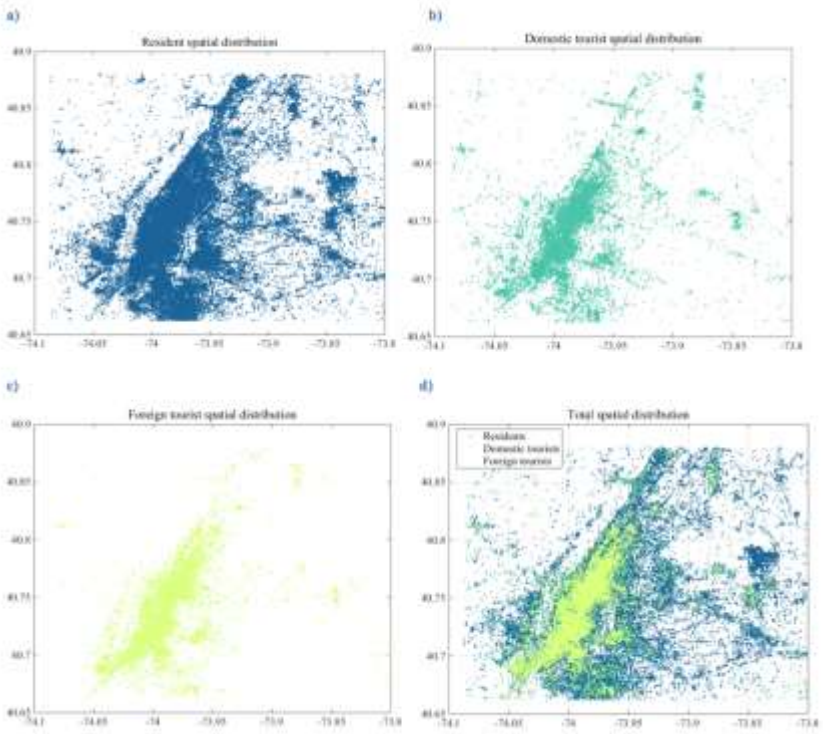

Fig. 3.5 – Spatial distribution in New York City. Dots represent photographs taken by New York City (a) residents, (b) domestic tourists, (c) foreign tourists creating a map of attractiveness for three different categories, while (d) is the map of attractiveness for the three contributions together.

In order to analyze the spatial activity we use 500x500m rectangular grids covering each city. First we start with a standard analysis of the distribution functions of the activity density values across the grid cells for different categories of users – residents, domestic and foreign visitors, as well as for the total activity. All of activities can be fitted to truncated lognormal distributions (distribution truncation is an important consideration from a technical standpoint as by its definition the

cells covered by user activity cannot have less than one photograph taken inside of them) as shown in Fig. 3.6 for New York City. We took New York City just as an example as patterns for the other cities are similar with the only difference in the relative position of the curves corresponding to the foreign and domestic visitors.

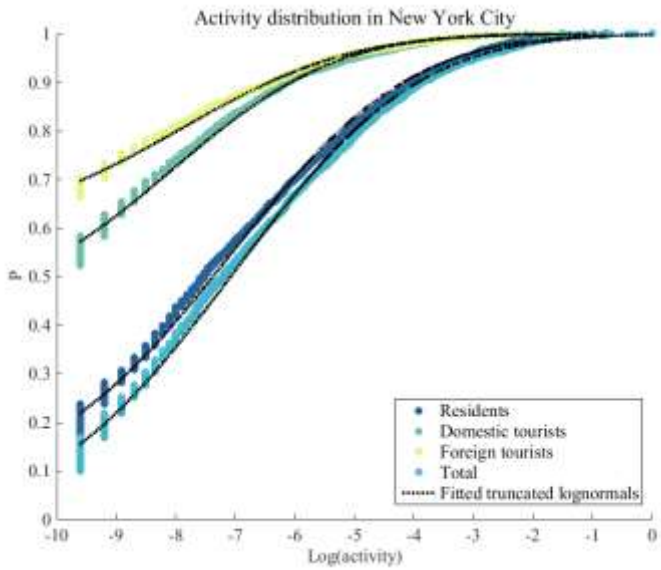

Fig. 3.6 – Cumulative distribution functions of activity density. The plot shows the cumulative distribution functions of activity density over 500x500m grid for city residents, domestic and foreign visitors as well as the total activity in New York City fitted to truncated log-normal distributions.

Log-normal distribution is characterized by its mean and variance. While means vary for different types of users due to the differences of their total activity level, variance characterizes how broad or narrow the distribution is, i.e., how strongly the

activity density varies over the area of the city covered by the considered user activity. The values of variance for all 10 cities and different categories of users reported in Table 3.3 show a consistent pattern – with the only exception of Los Angeles variance of domestic visitor where their spatial activity is always the lowest one, while variance of the foreign activity is higher for all the EU cities compared to the residential activity and lower for all the American cities. Variance of the total activity is usually the highest one with the exception of three EU cities – London, Barcelona and Rome.

Table 3.3 – Variance of the fitted lognormal distributions. Variance of the fitted lognormal distributions to the activity density is shown in 500x500m grid for city residents, domestic and foreign visitors, as well as for the total activity in the different cities.

City	*Residents*	*Domestic tourists*	*Foreign tourists*	*Total activity*
New York City	2.37	2.17	2.26	2.44
London	1.86	1.89	2.22	1.92
Paris	2.24	1.62	2.33	2.39
San Francisco	2.19	2.07	2.09	2.22
Washington	2.21	2.10	2.17	2.22
Barcelona	2.20	1.77	2.42	2.38
Chicago	2.17	2.03	2.08	2.23
Los Angeles	1.86	1.84	1.71	1.91
Rome	2.04	1.88	2.95	2.39
Berlin	1.86	1.78	2.04	2.07

Another perspective of user activity spatial distribution across different cities can be expressed by considering the dimensions of the areas covered by different quintiles of the top density cells.

Fig. 3.7 visualizes the shape of the curve characterizing those distributions (normalization is performed by the number of cells covering 50% of the total activity in order to bring different distributions on the same scale) in all 10 cities for all types of users (i.e., residents, domestic and foreign tourists). The curve shows how large is the most photographed area covering a given quintile of the total activity within the city in relation to the total area covered. Interestingly, curves for all 10 cities and three different types of users nearly follow one single shape which seems to represent a universal pattern of spatial distribution of the photographic activity across the city.

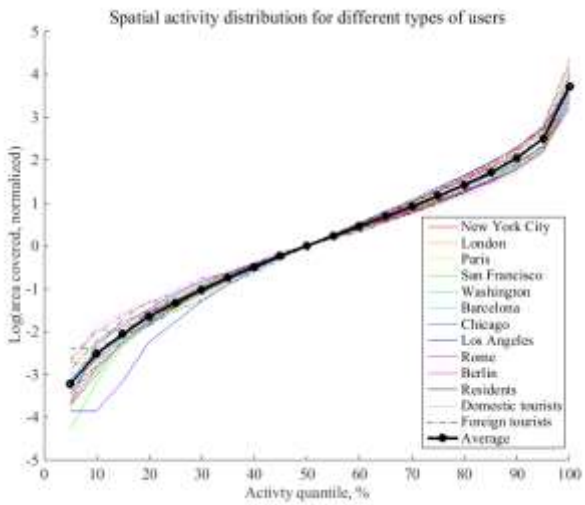

Fig.3.7 – Normalized spatial distribution. Normalized spatial distribution of city attractiveness is shown for city residents, domestic tourists and foreign tourists – normalized total area of most photographed locations is covering a given quintile of the entire photographic activity (area covered by 50% of activity counted as a unit after normalization).

However, quantitatively the areas covered by the activity of city residents, domestic and foreign visitors within each city are quite different. Considering an average ratio between the size of areas covered by different activity quintiles (given the similarity of the spatial distribution shapes) for domestic/foreign tourists vs. the corresponding areas covered by the activity of residents for each city, we can see that these values vary largely from one city to another (see Table 3.4). The pattern is always the same – foreign tourist activity (in any given quintile) covers smaller areas compared to that one of domestic (the only exception is Berlin where those are almost the same) and, with the only exception of Los Angeles, the areas covered by both types of visitors are always smaller compared to the areas covered by the activity of residents. Once more, a very clear difference between the US and EU cities can be noticed – tourists visiting the US cities (with the exception of Chicago) explore more extensively the area compared to the ones visiting EU cities.

Table 3.4 – Top photographed area. Relative size of the top photographed area is covered by the activity of domestic and foreign visitors versus the corresponding area covered by residents in the different cities.

City	*Domestic tourists*	*Foreign tourists*
New York City	0.47	0.35
London	0.40	0.25
Paris	0.33	0.27
San Francisco	0.64	0.48
Washington	0.45	0.32
Barcelona	0.45	0.26
Chicago	0.37	0.21
Los Angeles	1.32	0.74
Rome	0.47	0.33
Berlin	0.25	0.26

The existing spatial activity coverage in each city is not homogenous as people are often initially attracted by its main destinations that become “must visit” locations consequentially getting the highest photographic activity. For city residents those locations, which are often called “hotspots”, include parks, squares or sport facilities, while tourists are usually more attracted to the key places for the city identity (e.g., Times Square in New York City, Big Ben in London). The overall tourist activity in the New York City is visualized in Fig. 3.8 by grouping coordinates of taken photographs into cells and creating a 3D map of the city perception. Our findings of New York City “hotspots” are similar to those previously identified in [22].

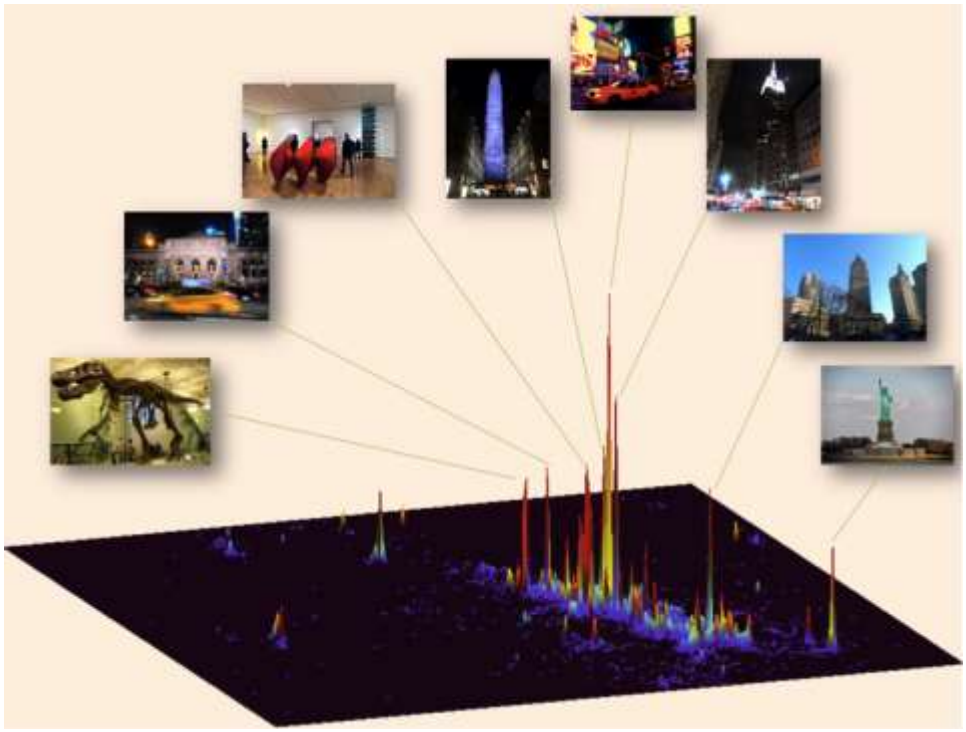

Fig. 3.8 – A tourist density attractiveness map of New York City. The most photographed place in the city is Times Square. In Bronx, which does not attract many people, tourists are mostly taking photographs of Yankees stadium.

Further we give a definition of the hotspots as spatially connected areas on the rectangular grid which consist of the high-density cells and possess the highest cumulative activity. The given algorithm allows us to define a given number of spatial hotspots in all types of user activity, ordering them according to their cumulative activity level. Specifically we identify the top n activity hotspots within each city using a following algorithm:

1. Consider top n density cells in the grid and let a be the lowest activity level among them.
2. Select all the cells with activity higher or equal to a and divide them into spatially connected components (considering cells having at least one common vertex to be connected).
3. If resulting number of connected components is equal or higher than n (could be higher if a number of cells has the same activity level a) stop the algorithm defining selected connected components as the hotspots.
4. Otherwise, if the number of components is $t < \mathrm{n}$, select $\mathrm{n} - \mathrm{t}$ top activity cells from the remaining ones (not covered by selected components) and let a be the lowest activity level among them. Repeat from Step 2.

Fig. 3.9 reports the average total percentage of activity covered by n hotspots in our 10 cities depending on n. In the further analysis we will be considering $n = 12$ hotspots for each city on average covering around 30% of the total photographic activity of all users in the city, as a reasonable trade-off between having enough hotspots to represent important locations across the city

and draw reliable conclusions from one hand, and the intent to have those hotspots cover just the major areas of interest across the city, but not majority of them from the other.

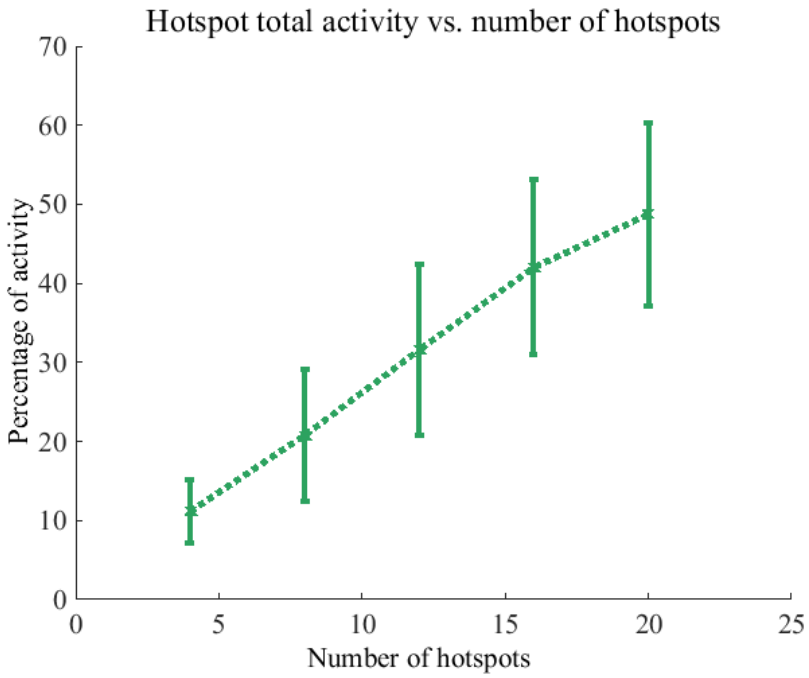

Fig.3.9 – Hotspot activity coverage. Average (together with the standard deviation) total hotspot activity per city depending on the number of hotspots.

In Fig. 3.10 we show examples of the resulting maps for the total user activity (including residents and tourists) in one US city (i.e., New York City) and one EU city (i.e., Rome). In both cities the most active area is their downtown and moreover, one hotspot represents their stadiums – Yankee Stadium in New York City and Olimpico in Rome. Another similarity is that in both cities among their top 12 hotspots are their squares and parks,

meaning that outside of their downtowns and besides their most famous attractions, people take photographs and spend their time at locations where they can meet and talk with other people. The only two cultural hotspots outside the downtown of Rome are the Church San Paolo Fuori le Mura and the Capitolium. Similarly, in New York City hotspots that are outside downtown are two museums located close to Central Park – the Metropolitan Museum of Art and the American Museum of Natural History. Table 3.5 gives the complete list of top 12 hotspots in Rome and New York City.

Fig. 3.10 – City maps of (a) New York City and (b) Rome.

Table 3.5 – Hotspots in New York City and Rome.

Hotspot rank	*New York City*	*Rome*
1	Downtown	Downtown
2	New York City Hall	San Giovanni in Laterano square
3	Metropolitan Museum of Art	Olimpico Stadium
4	Union Square	Auditorium Parco della Musica
5	Citi Field	Caio Cestio Pyramide
6	Yankee Stadium	IED – Istituto Europeo di Design
7	American Museum of Natural History	Papillo Hotel
8	Penn Station	Capitolium
9	Grand Central Terminal	Villa Torlonia
10	Javitz Center	Church San Paolo Fuori Le Mura
11	Brooklyn Bridge	Parco dei Caduti
12	Central Park	Passeggiata del Gianicolo

Once that we identified the first dozen of the most photographed spatial hotspots for each city for all types of users, we define the cumulative activity within each of them separately for residents, domestic and foreign visitors and rank them in the decreasing order by the number of photographs taken. We then plot that number vs. the hotspot rank (similar to the approach used in González et al., 2008). Approximating these rank plots with power law dependences $hotspotActivity(rank) = c\, rank^{-q}$ (by doing so we get R^2 above 90% on average) gives us another important quantitative relative characteristic of how concentrated or distributed between the key destinations across the city is the activity of different types of people. Fig. 3.11 shows those distributions on an example of New York City where the

distribution is more flat (i.e., lower q) for the residents and sharper for domestic and especially foreign tourists (i.e., higher q).

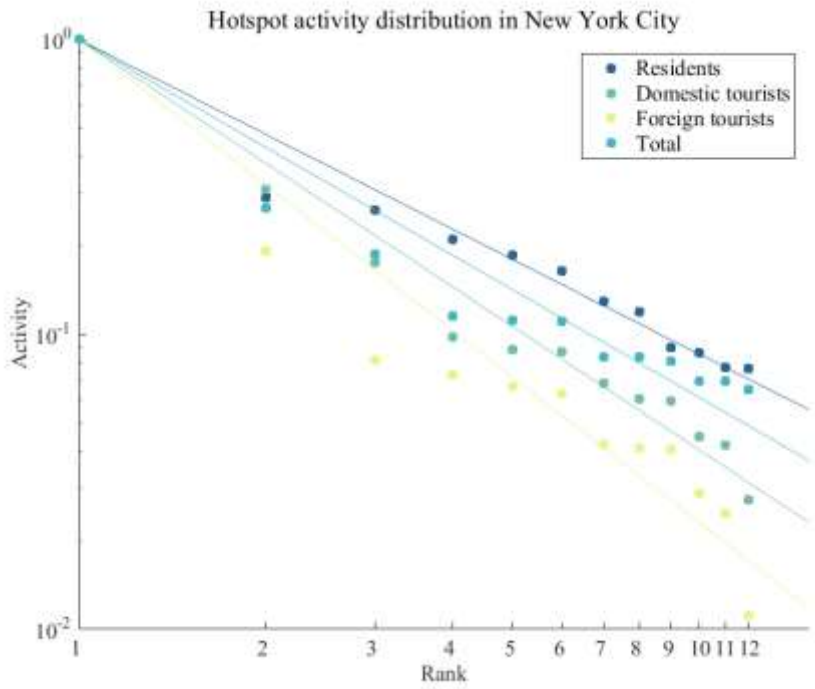

Fig. 3.11 – Log-log rank plot of 12 hotspots relative attractiveness in New York City fitted to power-laws. The top hotspot attractiveness is considered as a unit for each type of users.

Detailed comparison of q exponents for different cities is presented in Table 3.6. From the values of q we can see how concentrated or distributed resident and tourist activity is within them. If the value of q exponent is higher, then it means that people are more focused on just visiting the major attractions, while a lower exponent means that people attention is more

equally distributed among different attractions. By quantifying q separately for residents, domestic and foreign tourists, we can conclude that their values largely vary from one city to another, corresponding to the unique city spatial layout. However, we can still discover additional strongly consistent pattern in human behavior across different cities: the distribution always becomes sharper for the visitors and especially for the foreign visitors with the only exception of Berlin where foreign activity has almost the same exponent as the activity of the city residents.

Table 3.6 – Values of q exponents for residents and tourists in the different cities. q exponent is a measure of how concentrated or distributed people activity is across different "hotspots". Namely, a higher value means that people are more focused on just visiting major attractions.

City	*Residents*	*Domestic tourists*	*Foreign tourists*	*Total activity*
New York City	1.06	1.39	1.63	1.21
London	1.29	1.35	1.61	1.25
Paris	1.25	1.38	1.43	1.23
San Francisco	1.10	1.12	1.21	1.02
Washington	1.21	2.51	2.81	1.42
Barcelona	1.65	2.18	2.26	1.69
Chicago	1.48	1.91	2.71	1.54
Los Angeles	1.25	1.46	1.84	0.92
Rome	2.37	2.77	3.17	2.61
Berlin	1.60	2.19	1.60	1.56

Conclusions

The importance of cities in our society is well founded and it is evident that cities play a crucial role as more than half of world population lives in them. “Rethinking” cities is thus the key component of the world sustainable development paradigm. The first and the most direct way of doing that is by rethinking the way we plan them. In order to become a better planner, one needs to start considering people needs. Not only do people need efficiency, better transportation and green energy, but also do they need a better experience of living in cities enjoying the things that they have interest in and that they find attractive. In this study we thus conducted an analysis of cities through the city attractiveness and derived patterns. The novelty of the study is in the kind of data that was used in it: geotagged photographs from publicly available photograph sharing web sites (e.g., Flickr).

Over the last decade big data analyses have being increasingly utilized in urban planning (e.g., analysis of cell phone records for the transportation planning). However, information from geotagged photographs was not very often analyzed although

they can provide us with an additional layer of information useful for the urbanism in general. Namely, taken photographs indicate places in cities important enough for people to visit them and to decide to leave their digital trails there. By analyzing the global dataset of geotagged photographs we identified 10 most photographed cities, which happened to be distributed evenly between the US and EU. Focusing on the top 10 selected destinations, we studied spatial patterns of visitor attraction versus behavior of the residential users together with analyzing people mobility between those 10 cities and other places all around the world.

Although intercity origin/destination fluxes in a rather predictable way depend on the distance between two cities, links between American and European cities are surprisingly asymmetric. Namely, links going from American origins to EU destinations are on average stronger than the ones going in the opposite direction. Another clearly distinctive pattern between EU and American cities is related to the structure of the photographic activity within them. The results showed that in the US cities their residents take most of the photographs while the

domestic tourists mostly cover the rest leaving not much for foreigners. The activity that happens in the EU cities is much more diverse showing a higher fraction of touristic and specifically foreign activity. Finally, when investigating the qualitative structure of destinations, again American and EU patterns are surprisingly distinctive – while Americans seem mostly engaged in domestic tourism, the Europeans travel more abroad than within their own home countries.

Moreover, we extracted the photographic activity at the local scale comparing attraction patterns for residents, domestic and foreign tourists within a city. Spatial distribution of photographic activity of all those user categories follows the same universal pattern – activity density distributions of all types of users follow log-normal law pretty well while the shapes of the curves for area size vs. activity quintile appear to be strongly consistent. However, the areas covered by tourist activities are always smaller compared to the areas covered by residents with the only exception of Los Angeles where domestic tourist activities cover larger areas compared to city residents. The ratio between areas covered by tourists and city residents is different for domestic

and foreign tourists and is always higher for domestic tourists with only exception of Berlin where those factors are almost the same.

Once again, we find the activities within American and European cities are different from the quantitative standpoint. First, tourists visiting American cities (with the exception of Chicago) explore them more extensively, covering more of the areas of residential activity. More strikingly, the variance of the foreign activity density distribution is always higher for all the European cities compared to the residential activity and lower for all the American cities. Finally, we identified the hotspots in each city focusing on the most photographed places of each city. We noted that hotspot attractiveness follows a power-law distribution where the exponent of this distribution serves as an indicator of how focused people's attention is on the major attractiveness compared to how distributed it is among a number of objectives. For all cities with the exception of Berlin, activity of the tourists and especially foreign tourists appeared to be more concentrated on the major attractions.

To conclude, by showing differences between people visiting the US and EU cities our study revealed interesting patterns in human activity. The results of our study are useful for understanding of what has to be enhanced in cities and where it can be appropriate to increase services targeting different categories of users. In past those questions were traditionally answered by analyzing different available datasets such as hotel information or survey data. However, collecting or getting the access to such datasets usually requires significant efforts and/or expenses, while geotagged photography is publicly available while providing a unique global perspective on addressing many research questions at both global and local scale. In future work we will also consider the longitudinal perspective of data analysis by showing how the observed human patterns evolve over time.

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Chapter 4

Picture by Paul VanDerWerf - Flickr

Chapter 4

Temporal Distribution

Abstract

We live in a world where digital trails of different forms of human activities compose big urban data, allowing us to detect many aspects of how people live and experience the city where they live or come to visit. In this study we propose a way to enhance urban planning by taking into a consideration individual preferences using information from an unconventional big data source: dataset of geo-tagged photos that people take in cities at different times which we then use as a measure of urban attractiveness. We discover and compare a temporal behavior of residents and visitors in ten most photographed cities in the

world. Looking at the periodicity in urban attractiveness, the results show that the strongest periodic patterns for visitors are usually weekly or monthly. Moreover, by dividing cities into two groups based on which continent they belong to (i.e., North America or Europe), it can be concluded that unlike European cities, behavior of visitors in the US cities in general is similar to the behavior of their residents. Finally, we introducing two indices, called “dilatation attractiveness index” and “dilatation index”, that tell us the spatial and temporal attractiveness pulsations in the city. The proposed methodology is not only important for urban planning, but also does supports various business and public stakeholder decision processes, concentrated for example around the question how to attract more visitors to the city or estimate the impact of special events organized there.

Keywords: [big data, collective sensing, geo-tagged Flickr, tourism, temporal distribution]

Introduction

Outputs of analyses on digital footprints can provide novel insights into how people live and experience the city, revealing important aspects of human mobility including tourism. The most widespread way of extracting information from digital traces is to use mobile phone records[1-2] which helped scholars to develop accurate methods for understanding human mobility patterns [3-5], land use classification [6-9] or regional delineation [10-12]. Nevertheless, other sources of big data are also becoming increasingly useful, such as digital maps [13], electronic toll systems [14], credit card payments [15], [16], online social networks like Twitter[17], circulation of bank notes [18] and vehicle GPS traces [19]. In particular, besides Twitter there is a plethora of online social networks, used by a huge number of people every day to share for example their interests, opinions, perceptions, photographs, resulting in the emergence of very large datasets reflecting human behavior. The focus of this paper is geo-tagged photographs shared by users through online social media platforms (e.g., Flickr), as publicly shared

photographs present a feedback on urban design and planning in a qualitative way and almost in a real time which can be a significant addition to more traditional methods, e.g., surveys [20]. Namely, it has already been shown that the number of geo-tagged photographs taken in a particular city serves as a good proxy for studying city attractiveness [21-25]. Although perhaps they do not always share the same reasons why, both residents and visitors take photographs at the places they consider important and that is useful for understanding what people like in cities, what they are interested in or where they like to go. As those insights provide important directions for urban innovations, our goal is not only to measure urban attractiveness at a certain moment or aggregate it over a longer period of time, but also to detect how its patterns change over time.

4.1 Dataset

In our study we use publicly available data from the website sfgeo.org, which collects records about photographs shared on the most popular photograph sharing websites (e.g., Flickr and

Picasa).From this dataset, which contains in total more than 100 million publicly shared geo-tagged photographs taken during a period of 10 years, we omitted duplicates (9.33% of the dataset in total) and photographs with incorrect timestamps (0.01% of the dataset in total). Then, similarly to our previous paper [24], we limited our analysis to only those photographs that were taken between 2007 and 2010 as these compose almost 75% of the entire dataset or about 70 million of photographs in total. Finally, we ordered cities by the number of photographs taken in them (see Table 4.1) and chose to consider ten most photographed ones: New York City, London, Paris, San Francisco, Washington DC, Barcelona, Rome, Chicago, Los Angeles, Berlin.

Table 4.1–Heterogeneity of Flickr usage: total number of photographs taken worldwide by residents of different areas versus their official population in 2008.

City	*Population (mln)*	*Photographs taken*	*Photographs per 1000 residents*
New York City	8.36	1,026,199	122.75
London	7.81	1,151,799	147.48
Paris	2.23	534,092	239.50
San Francisco	0.81	851,425	1,051.14
Washington	0.59	525,313	890.36
Barcelona	1.62	255,038	157.43
Chicago	2.85	412,246	144.65
Los Angeles	3.83	289,810	75.67
Rome	2.71	126,011	46.50
Berlin	3.43	182,325	53.16
Rest of EU	4,82.61	8,637,148	17.90
Rest of the US	2,87.61	7,347,003	25.55
Rest of the world	5,905.14	6,877,894	1.16

We found that among ten most photographed places there are 5 US and 5 European cities. Since the raw dataset does not contain information about user home locations, which is important to distinguish between a resident and a tourist, we used the following method to infer where people live: residents of a certain city are considered to be those users who have the highest activity (expressed as the number of photographs taken) in that city for the longest timespan (calculated as the number of days between first and last photograph taken there) [28]. Once we detected a home city for a user, he/she automatically becomes a tourist in all the other cities visited in the dataset. Moreover, we distinguish between foreign and domestic tourists where the latter are tourists visiting some city in their home country, while the former are travelling abroad. As the relationship between the number of users identified as residents and the number of photographs is linear ($R^2 \cong 0.85$) [24], to a certain extent, the number of photographs taken can be used as a proxy for city attractiveness.

4.2 Temporal distribution

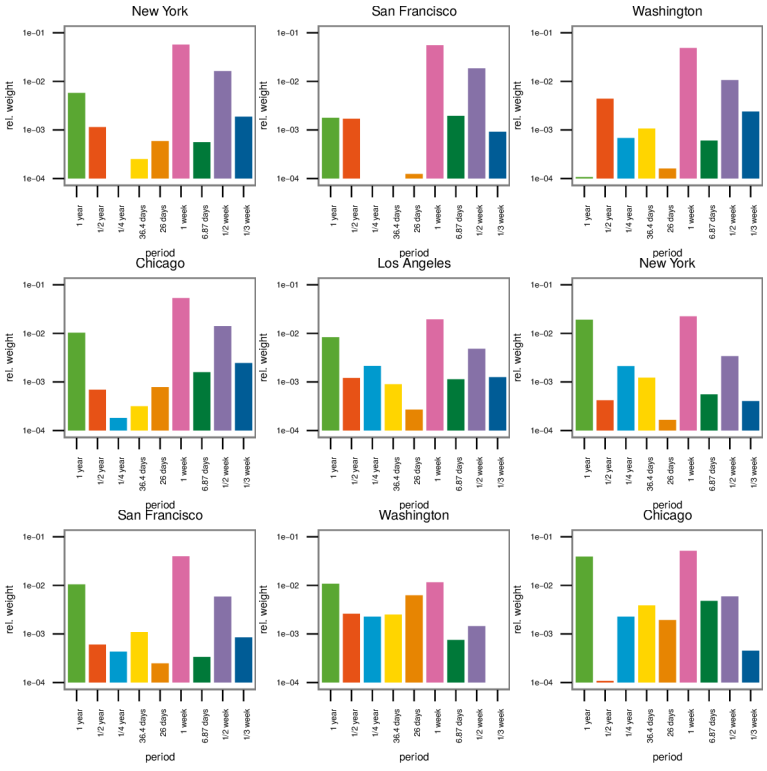
Rather than concentrating only on aggregated urban attractiveness as done in [24], in this paper we focus on temporal aspects where temporal distribution is studied at three different scales: daily, weekly and annual ones, distinguishing among residents, domestic and foreign visitors (Fig. Attached). A common pattern that is present no matter of the temporal scale is that in the US cities residents' behavior is similar to the domestic visitors' behavior, while in EU cities their behavior is more similar to the foreign visitors'.

When zooming in into different scales, daily scale shows the general behavior of the three categories (residents, domestic visitors and foreign visitors) on an average day. Apart from the similarity between categories mentioned above that we find on all three scales, what looks also interesting at this scale is the general trend that in all cities we have a peak between 12.00 and 18.00. Also it is interesting that there is a peak at 1.00 in the night. It is not only from visitors, but also from residents, particularly elevated in Barcelona, Rome, Chicago and Los

Angeles. Moreover, for the weekly scale we can conclude that in all cities and for all categories of users the most active day is Saturday, followed by Sunday, except for foreign tourists visiting New York City, San Francisco and Paris and for domestic visitors in Barcelona, where the most active day is Sunday. Overall, the trend for foreigners is much more flat compared to residents and domestic visitors, meaning that their behavior does not change substantially during weekends and weekdays. This could be explained as they traveled longer distances to come to the city and want to experience as much as they can during their visit. It could also mean that Flickr dataset captures more of the activity of foreign visitors who came for their leisure time than of those who came for business. Finally, the yearly scale shows how behavior ofdifferent types of users changes on a month-to-month basis.

A really good way to detect periodicity in a regular series of data is to inspect its power spectrum. The power spectrum is the discrete Fourier transform of the auto covariance function of the data series. The power spectrum plots the power versus frequency, so the seasonal patterns show up as large spikes

located at their frequencies [26]. In our case, the periodgram shows the most active periods in which visitors and residents take photographs denoting the periodicity of the attractiveness in the city. Applying the aforementioned process to residents', domestic and foreign visitors' activities in all ten cities, we found the main periodicities as shown in Table 4.2.



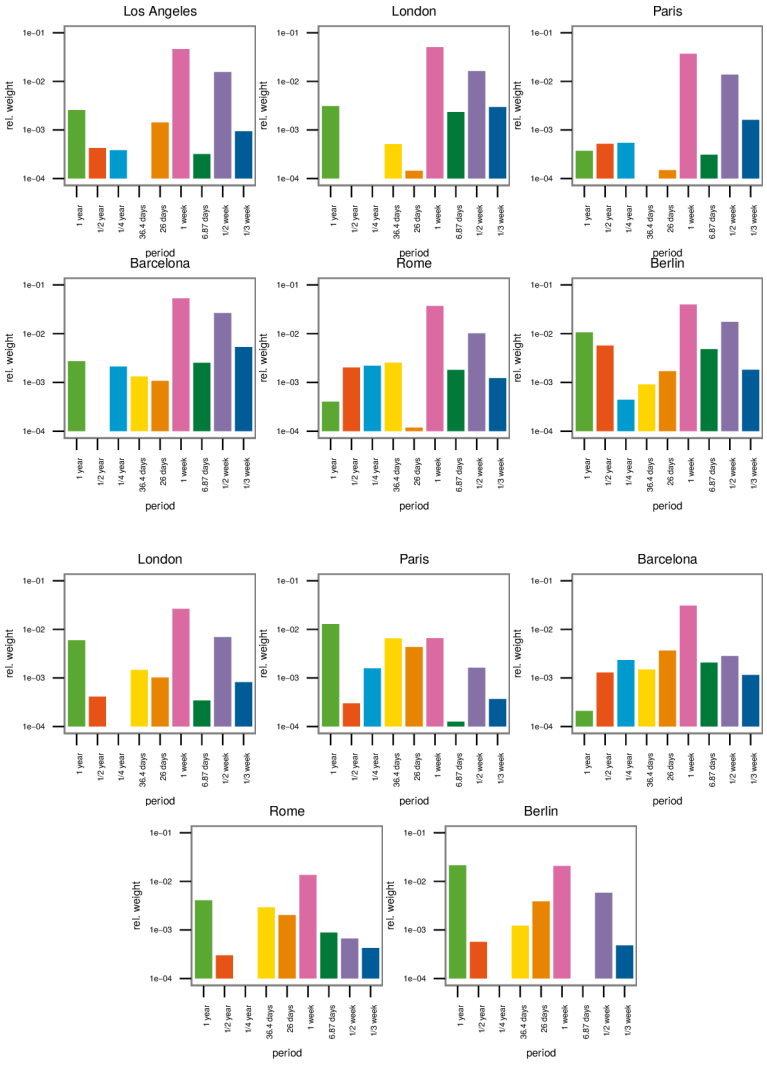


Fig. 4.1 Relative importance of periodicities from the power spectrum; the nine most common frequencies are shown for each city separately for residents and tourists. From top to bottom: residents in US cities, tourists in US cities, residents in European cities, tourists in European cities. Note that the y-axis scale is logarithmic.

As expected, for both types of visitors this cycle is either yearly (365 days) or weekly (7 days), while for residents it is always weekly, excepted for Washington DC (i.e., 3.5 days) and for Los Angeles that does not show any periodicity (i.e., it is 1095 days). However, the results for domestic visitors are rather surprising as

there is not a visible pattern for cities in Europe. Finally, foreign visitors' periodicity is in most of the cases yearly and weekly with the exception of Los Angeles where it is 11.5 days. To be able to better compare periods, we display the relative importances of the most important periods in Fig. 4.1. The general pattern we see there is that for residents the weekly period and periods shorter than a week seem to be more important relatively, while for visitors, longer periods are more pronounced. This is in accordance with the observations made previously on the aggregated time series (Fig. Attached) and the general assumption that for residents, the weekly cycle plays a more prominent role where several harmonics with periods shorter than a week contribute, while the number of visitors is expected to have an important yearly pattern with more variation, the shape of which can be made up of the significant harmonics with periods larger than a week.

Table 4.2– Periodicity of the data for ten considered cities.

	Periodicity			
	Residents	Visitors	Domestic	Foreign
New York City	7	365	7	365
London	7	7	7	7
Paris	7	365	19.5	365
San Francisco	7	7	7	365
Washington DC	3.5	7	7	7
Barcelona	7	365	7	365
Rome	7	7	64.4	7
Chicago	7	365	365	365
Los Angeles	1095	7	7	11.5
Berlin	7	365	3.5	365

In order to have a general picture about variations in photograph activity, we look at the distribution of daily number of photographs for each city, again distinguishing between residents and visitors. For all ten cities, we get that the distributions can be well approximated by a lognormal distribution (note: for residents and all cities: $p > 0.05$, i.e., we cannot rule out the null hypothesis of a lognormal distribution with 95% confidence; for tourists, p values are smaller but the distribution still fits well visually). An example for New York City is shown in Fig. 4.3.

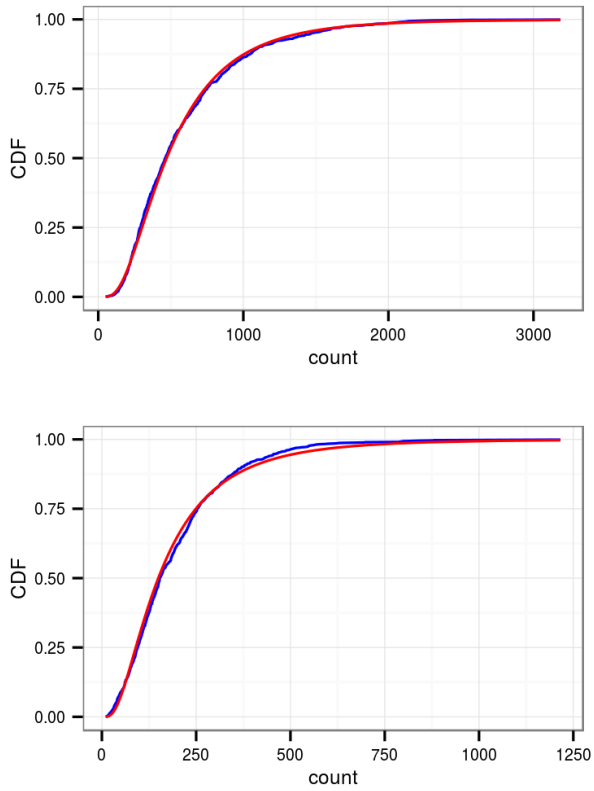


Fig. 4.3 - Distribution of daily number of photos made by New York City residents (left) and tourists (right). The blue lines correspond to the empirical data and the red lines are the fitted distributions. The fit was estimated by calculating the mean and standard deviation of the logarithm of daily picture numbers and using a lognormal distribution with those as parameters. The associated p-values for fits are 0.244 and 0.049, respectively.

For a deeper analysis of temporal distribution, we look at how time series of daily photograph numbers can be decomposed into the combination of deterministic and stochastic components. We use the following two options to describe the temporal attractiveness:

$$A_t = f(t) + u_t$$

$$A_t = u_t f(t)$$

where A_t denotes temporal attractiveness, $f(t)$ is a deterministic sequence and u_t represents options of models with additive and multiplicative noises, respectively. Further, the deterministic sequence consists of two parts: trend (d_t) and seasonality (s_t): $f(t) = s_t \times d_t$, while the stochastic sequence is representative of the random variations. To carry out the decomposition, we need to specify the periodicity in the seasonal component; based on the power spectrum, we chose this to be one week. Illustration of this procedure for New York City is shown in Fig. 4.4 and Fig. 4.5 for the additive and multiplicative cases respectively. We consider the noise as the most interesting component because it may represent the special events in a city. To quantify the importance of the noise, we report average relative weights in Table 3. These are computed as the normalized residuals, i.e. as $< \varepsilon > = < \frac{|u_t|}{(A_t + f(t))/2} >$ in the case of additive noise and as $< \varepsilon > = < |u_t - 1| >$ for multiplicative noise, giving the relative importance of noise when compared to the real activity and the deterministic component. Looking at values in Table 4.3, we see that they are relatively large, the noise is comparable to about 30%-60% of activity on average, while the trend shows that

noise decreases as total activity increases (in accordance with what we expect based on the central limit theorem).

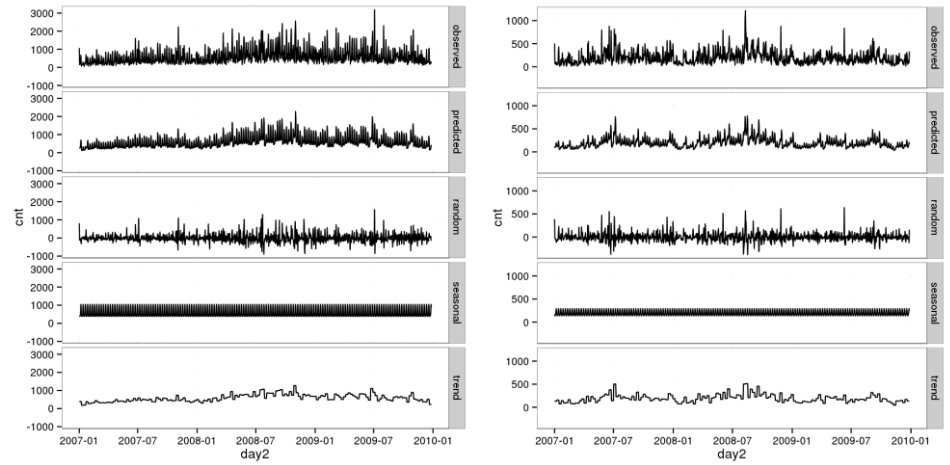
Table 4.3. Average normalized noise for different types of decomposition and different models.

	Residents		***Visitors***	
	Additive noise	Multiplicative noise	Additive noise	Multiplicative noise
New York	0.3026359	0.3062597	0.3894293	0.3597991
London	0.3178385	0.3146551	0.4035543	0.3880250
Paris	0.3626344	0.3537219	0.4374607	0.3916178
San Francisco	0.3270483	0.3283090	0.4709700	0.4354612
Berlin	0.4953906	0.4751745	0.5729734	0.5173991
Washington	0.4761626	0.4550284	0.5677503	0.5191039
Barcelona	0.4322980	0.4200787	0.6452356	0.6013710
Rome	0.5695353	0.5461870	0.6448882	0.5690575
Chicago	0.4131704	0.4029115	0.6433112	0.5797068
Los Angeles	0.5194782	0.5004668	0.5874662	0.5491432

Looking at the distribution of individual components, we get that in the case of a multiplicative noise, the random component can also be described with a log-normal distribution for residents and gives a good approximation in the case of tourists for most cities. The trend distribution can also be approximated by a log-normal distribution; here, it gives a good fit in the case of tourists in London, Barcelona, Chicago and Los Angeles and residents in New York, while for the other cases the null hypothesis can be formally rejected, but the distribution is still rather close to a log-

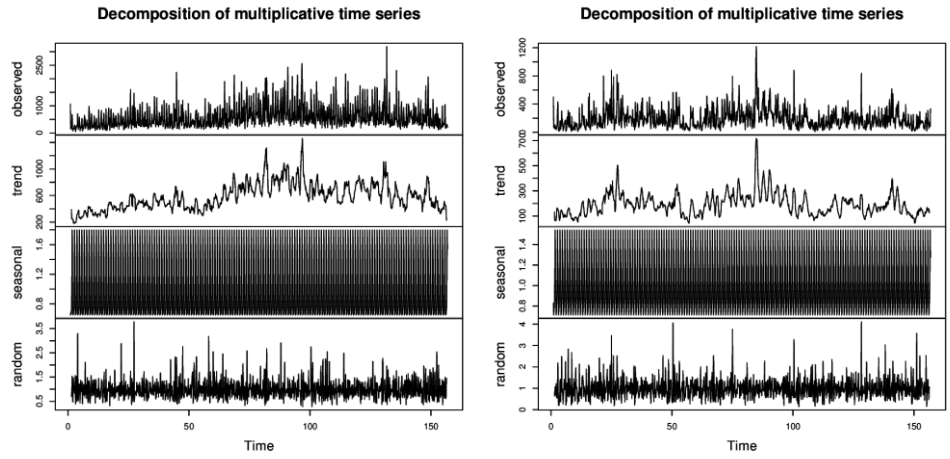
normal (see Fig. 4.4 – 5 - 6). To quantify to quality of fits, we give the associated p-values for all cases in Table 4.4.

We also extracted a list of what we called “outliers”, for each city. Particularly interesting in this sense are the outliers relative to the random variations, because it is supposed to be able to retrace special events. It is generally more interesting in this case detecting the activity of residents. Regarding the American cities, we noted that, in fact, from the outliers of the residents it is possible to retrace the main important events for the population. In particular, in each city (except Los Angeles) there is a trace of the 4th July. This seems to be the most photographed event for the American people. Furthermore, in New York City, we found outliers related to the Thanksgiving Day for each year. [Check Europe]For example, we found an interesting outlier for residents in Barcelona on 27 May 2009, when the soccer team won the Champions League.



(a) **(b)**

Fig. 4.4 - The decomposition of the time series of attractiveness in New York City considering additive noise for residents (a) and visitors (b). The first row is the observed data, the second is the deterministic part (i.e., trend and seasonal), the third the random component, while the 4th and 5th rows are the seasonal (cyclic) part and the trend respectively.



(a) (b)

Fig. 4.5 - The decomposition of the time series of attractiveness in New York City considering multiplicative noise for residents (a) and visitors (b). The first row is the observed data, the second the general trend, the third the seasonality (cyclic events) and the last one is random (special events). Note that the random component here is a scaling factor which multiplies the deterministic part.

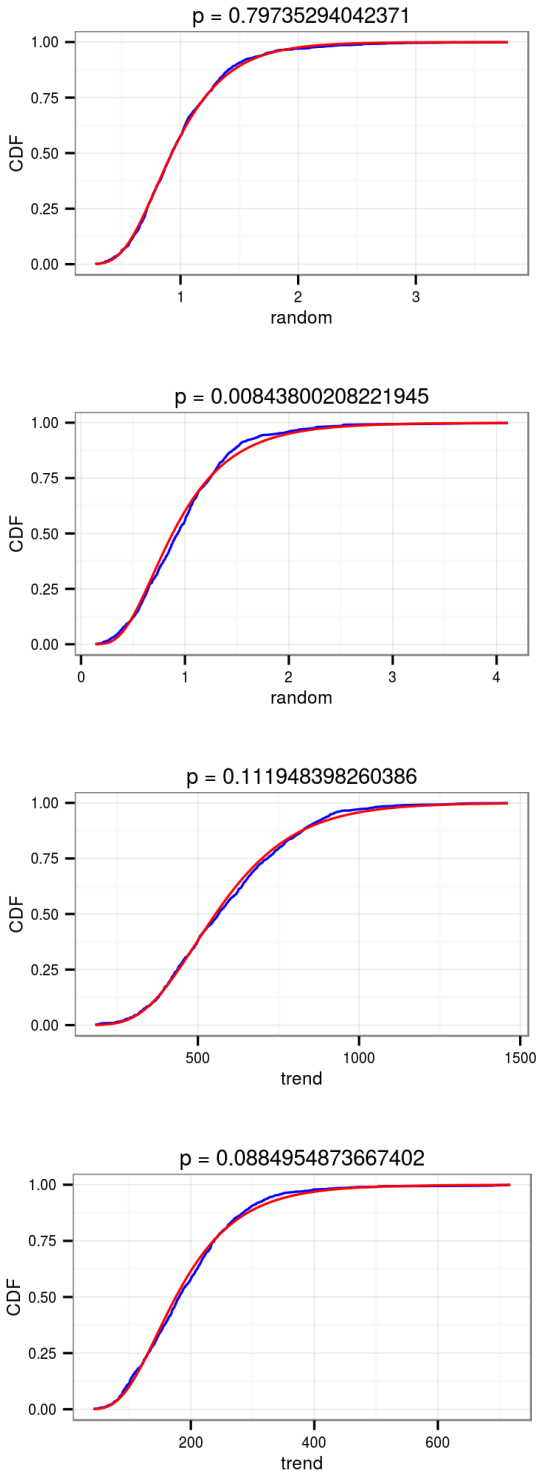


Fig. 4.6 - Distribution of the random component (top) and trend (bottom) for residents (left column) and tourists (right column) in New York City. Blue lines are the empirical data and red lines are the fitted distributions. With the exception of the random component for tourists, all can be considered a log-normal distribution according to the formal Kolmogorov-Smirnov test.

Table 4.4 - p-values for fitting the distribution of daily events with a log-normal distribution for the model with multiplicative noise (values under 0.05 would allow the hypothesis of a log-normal distribution to be rejected with 95% confidence, under 0.01 would allow rejection with 99% confidence, etc.; for most cases, the log-normal distribution cannot be rejected)

	raw numbers		***random component***		***trend***	
city	*residents*	*tourists*	*residents*	*tourists*	*residents*	*tourists*
New York City	0.24372	0.04895	0.79735	0.00844	0.11195	0.0885
London	0.08872	0.03826	0.2358	0.16964	0.0045	0.14844
Paris	0.78324	0.01057	0.14576	4.41E-05	0.00943	0.000294
San Francisco	0.25023	0.00566	0.62568	0.0111	0.00792	0.03389
Berlin	0.41281	0.00372	0.02391	0.00108	0.00843	0.00124
Washington DC	0.14779	0.00957	0.01697	0.0045	0.000258	0.04245
Barcelona	0.57475	0.00943	0.12524	0.000114	0.00709	0.36675
Rome	0.4739	0.00591	0.00103	0.000977	0.03103	0.00026
Chicago	0.71942	0.01429	0.49014	0.000119	0.0154	0.78193
Los Angeles	0.504	0.08066	0.15015	0.00781	0.001165	0.08973

4.3 Spatio-temporal attractiveness

More generally, in order to check ifurban attractiveness is distributed equally across the city or rather concentrated in only a few of its major areas, one can use dilatation attractiveness coefficient, based on the calculation of dilatation activities [26]. However, attractiveness is not static and that is why our focus is also oninvestigating how this quantity changesover time making a dynamic signature of city internal attractiveness distribution. Similar to [26,27], we considered “Venables index”, defined as:

$$V = \sum_{i \neq j} s_i s_j d_{i,j}$$

where, in our case: $s_i(t)$ denotes the number of shared photographs in cell i at time t and $d_{i,j}$ is the distance between cells i and j.When all the activities are concentrated only around one single point, the value of *V* is equal to its minimum, i.e., it is zero. By normalizing *V* with the densities of activity in each cell, we obtain the weighted average distance D_v (the "Venables distance"):

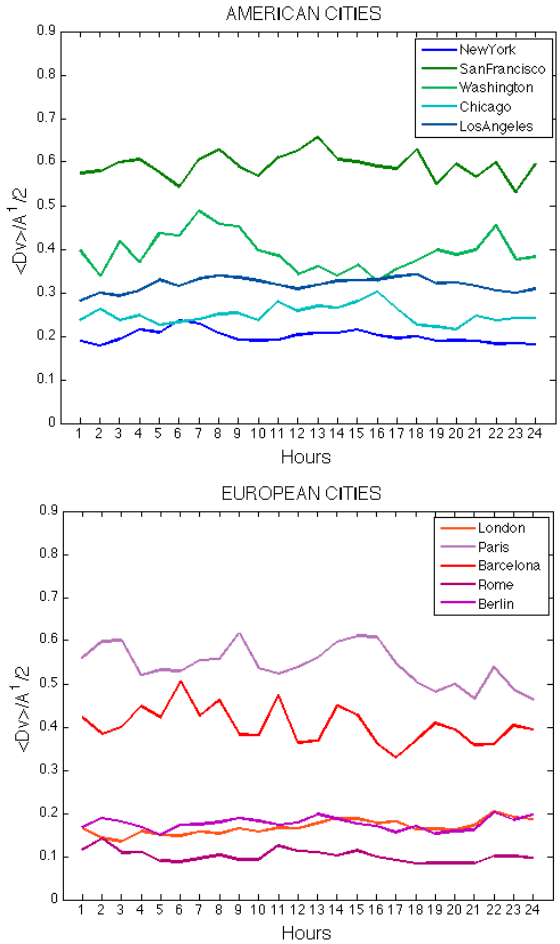
$$D_v(t) = \frac{\sum_{i<j} s_i(t) s_j(t) d_{i,j}}{\sum_{i<j} s_i(t) s_j(t)}$$

In a monocentric city we expect a large variation of the average distance D_v during the day as attractive places are spatially "segregated".For more polycentric cities, where places are spatially less separated, we expect a smaller variation of $D_v$than the one observed for monocentric cities as places are more "mixed". In order to make sure that values of $D_v$are comparable amongdifferent cities, they should be normalized by the city dimension:

$$Dil = \frac{D_v}{\sqrt{A}}$$

where: *A* denotescity official area in km^2. In this way, we computed the attractiveness evolution in an average day for visitors in the considered cities. For a deeper analysis, we distinguished an average weekday and an average weekend day, as shown in Fig. 4.7.

Weekday



Weekend day

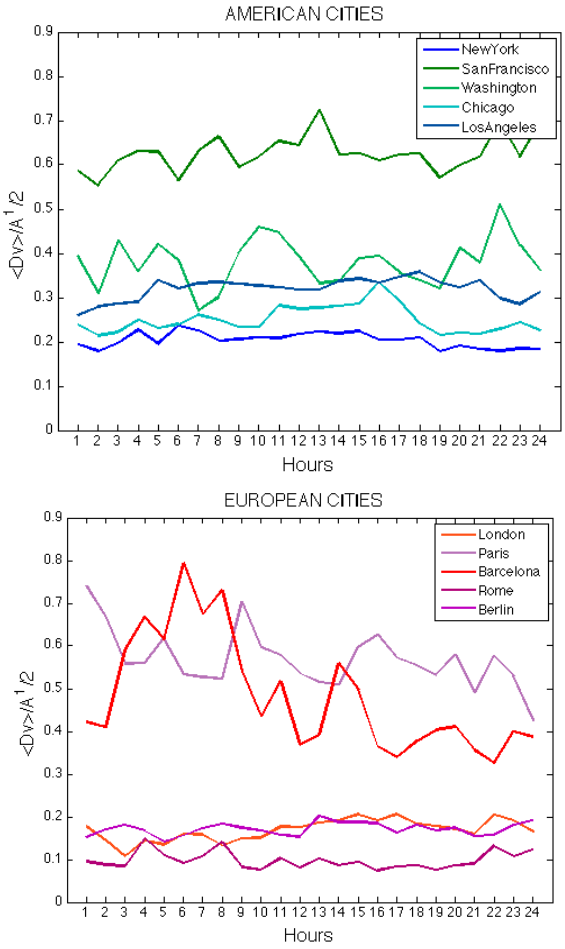


Fig. 4.7 - Dilatation of attractiveness.These figures show the dilatation attractiveness, evaluated with the explained method, for the 10 most photographed cities, considering the American cities and the Europeans ones in an average weekday (a-b) and in an average weekend day (c-d).

When the value for dilatation attractiveness *Dil* is lower that means the attractiveness of the city is not equally distributed in all city areas, but it "collapses" in few places that are close together. We can conclude that generally European cities are characterized by lower values of dilatation (i.e., lower than 0.2),

with the exception of Barcelona and Paris, unlike more "dilatated" US cities that show several peaks on weekends. The US cities are in general characterized by higher values of dilatation (i.e., 0.2-0.6), but their curves are flatter than for the European ones with San Francisco being the most "dilatated" US city. The most interesting difference between a weekday and a weekend pattern can be observed in a case of Barcelona in the morning. There are several possible explanations for that – one of them being people who queuing in front of many monuments, churches and museums located across the city. Moreover, one can also notice an interesting invert peak of dilatation in Washington DC around 7 AM when on a weekday everyone is getting up in the morning, while on weekends everyone is still sleeping.

From these curves, we can extract another feature: the dilatation index, as the ratio between the maximum and the minimum $D_v$during the day that gives a measure of the maximum spatial spread of high density locations:

$$\mu = \frac{\max_t(D_v(t))}{\min_t(D_v(t))}.$$

In Fig. 4.8 we show the rank plot of the cities according to the dilatation index μ.

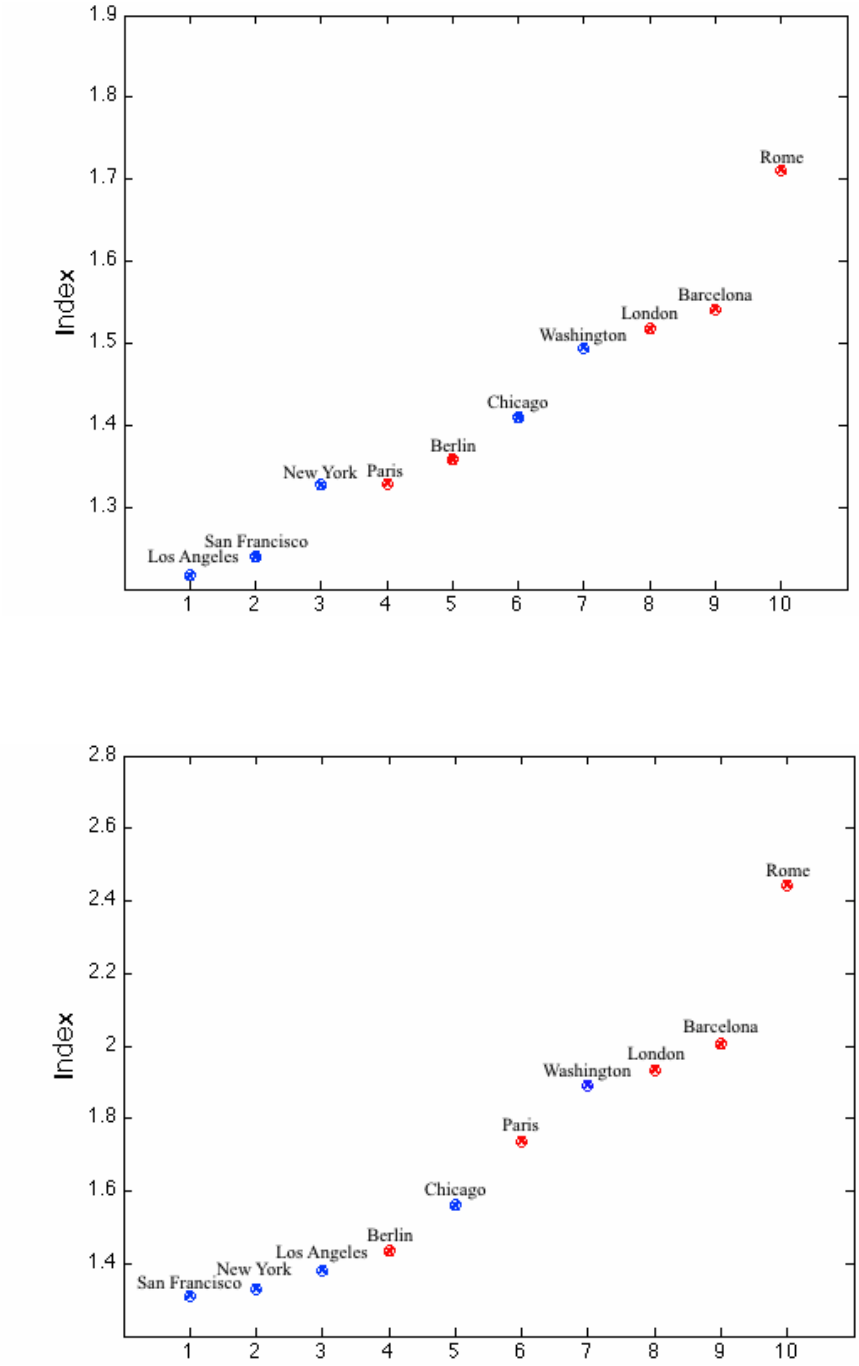


Fig. 4.8 - Cities ranked by the dilatation index, distinguishing average weekday and average weekend day.

Table 4.5 - Cities ranked by the dilatation index, distinguishing average weekday and average weekend day.

	Weekdays			Weekends	
1	Los Angeles	1.22	1	San Francisco	1.31
2	San Francisco	1.24	2	New York City	1.33
3	New York City	1.32	3	Los Angeles	1.38
4	Paris	1.33	4	Berlin	1.44
5	Berlin	1.36	5	Chicago	1.56
6	Chicago	1.41	6	Paris	1.74
7	Washington DC	1.49	7	Washington DC	1.89
8	London	1.52	8	London	1.93
9	Barcelona	1.54	9	Barcelona	2.01
10	Rome	1.71	10	Rome	2.44

When comparing values of dilatation indices for the US and European cities, we can notice a tendency for former ones to mostly have a smaller dilatation index that the latter ones. Lower values of parameter μ denote that the average distance D_v stays approximately the samethroughout the day, meaning that no matter which hour of the day it is, the spatial spread of the high density locations does not change significantly. When places of activity are more entangled, then we talk about more "mixed" cities. In the opposite case of large values of μ, the spatial

organization of the different high-density locations changes significantly along the day.

Conclusions

The common reason why people travel and visit new cities, as either domestic or foreign visitors, is to experience new things they feel attracted to. A very direct measure of this attractiveness is the number of publicly shared photographs that people take in cities all around the world. However, a measure of urban attractiveness is not static as it evolves over time, sometimes resulting in considerable variations over the course of a year or even over a single week or a day. In this study we thus conducted an analysis of these temporal variations, providing and comparing longitudinal characteristic for urban attractiveness patterns. The novelty of our study is in the kind of data considered: geotagged photographs shared using the most popular photograph sharing platforms (e.g., Flickr). Different sources of big data have been used in planning science for a long time now (e.g., mobile phone records for the transportation

planning), but photographs can give us something more useful for urbanism in general – information about what people consider important in the city. For top ten most photographed cities in the world (i.e., five US cities and five EU ones), we showed the general temporal distribution comprehending the daily, weekly and month-by-month variation to detect behavior of residents, domestic and foreign visitors. Results of our analysis on temporal distribution showed that for the US cities the total visitors' behavior is more similar to the domestic visitors' behavior, while for EU cities the total visitors' behavior is more similar to the foreign ones. We also looked at the Fourier spectrum to identify the most important periodicity of attractiveness; our results suggest that for residents, the weekly pattern is most pronounced, while for visitors the yearly pattern is more important. We considered the time series activities for residents and visitors, extracting trend, seasonality and random events. We found that on average, the random component constitutes about 30%-60% of activity (where the exact number depends on the overall volume of activity); this also means that in the case of a special event, it can be much higher. This method

could be very interesting in particular for small cities, where special events are not so frequent as in metropolitan areas and thus it is possible to really take in account the impacts of them compared to the normal trend. Although in all cases we showed results only for our ten cities, the same methodology can be also applied to other cities as well. Moreover, we defined two spatio-temporal indices: the dilatation attractiveness and the dilatation index, which give us measures of how the attractiveness is distributed across the city area, by combining spatial and temporal distribution. Those indices help us to detect even more of differences between European and US cities. Namely, by looking at the "dilatation attractiveness" index, we found that the US cities in general have higher values of dilatation attractiveness and less variations compared to European cities. This means that the US cities are more policentric and "mixed" cities, perhaps because of the fact that on average they are bigger than European cities. In fact, for a higher value of "dilatation attractiveness" city is more "dilatated", more active in all their space. This is also true for the second index, which is the ratio between the maximum and minimum value of "dilatation

attractiveness" during the day. Finally, our conclusion is that when looking at dilatation index, the US cities have in general smaller values compared to the European ones, which means the latter ones are more segregated and monocentric.

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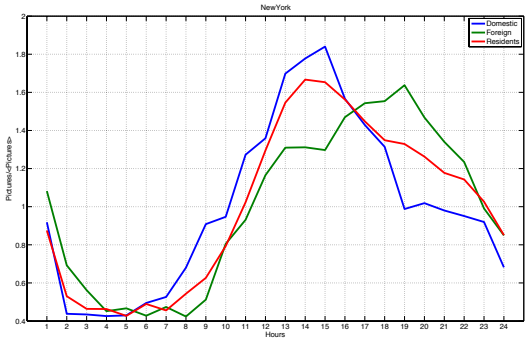
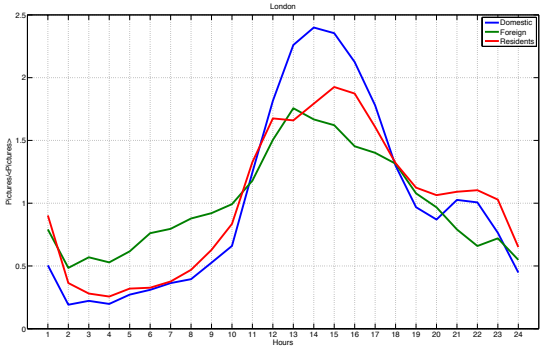
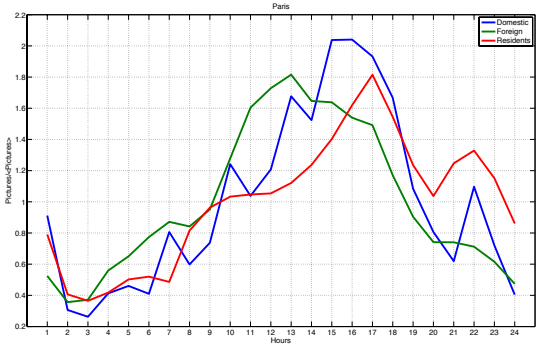
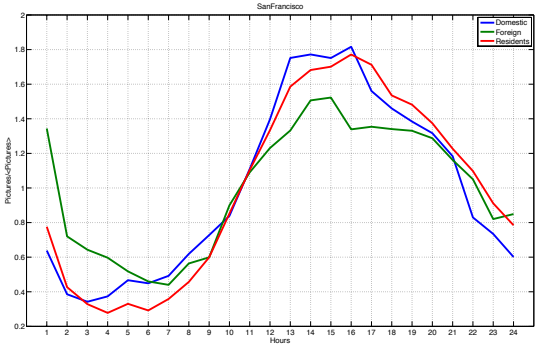
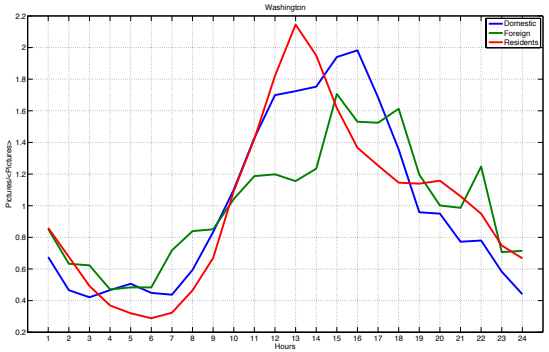
Daily

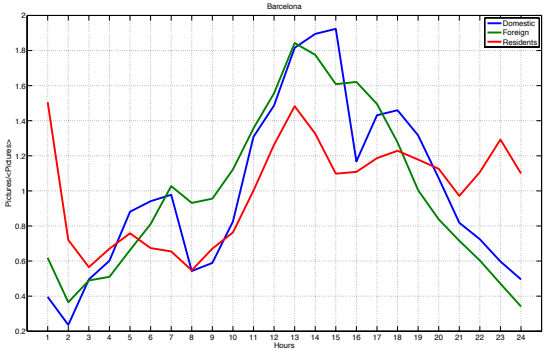


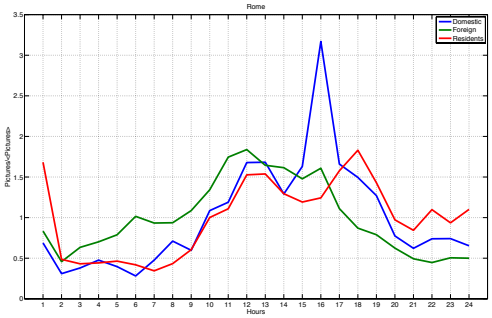


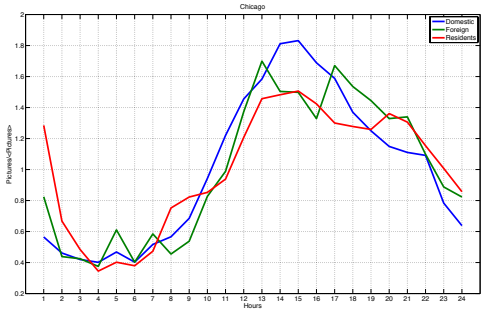


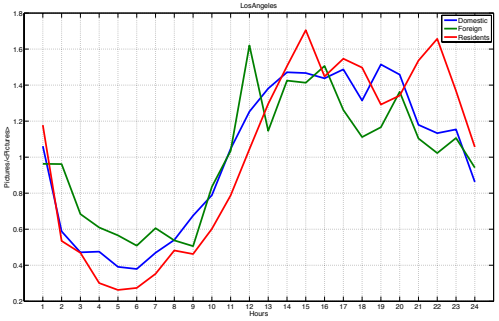


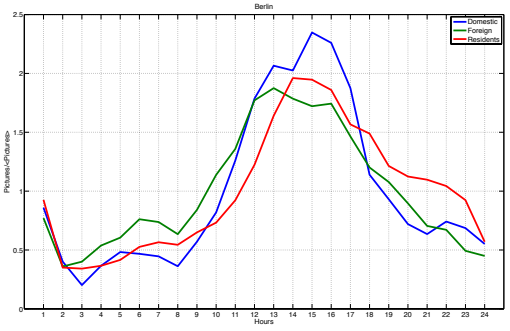












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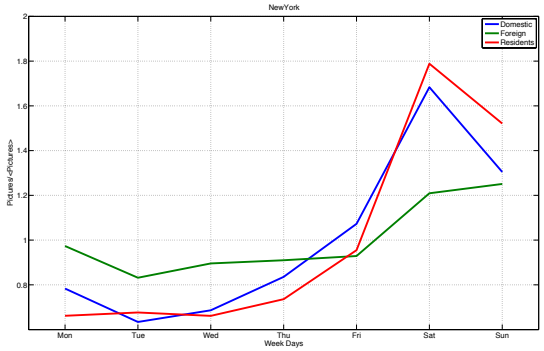

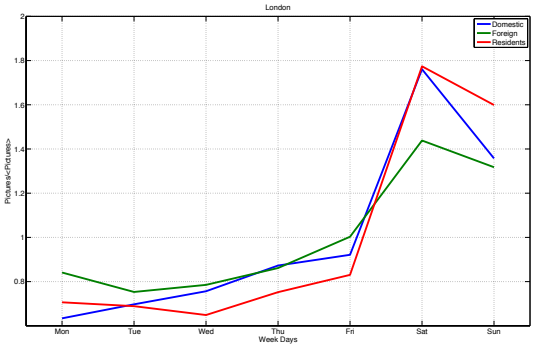

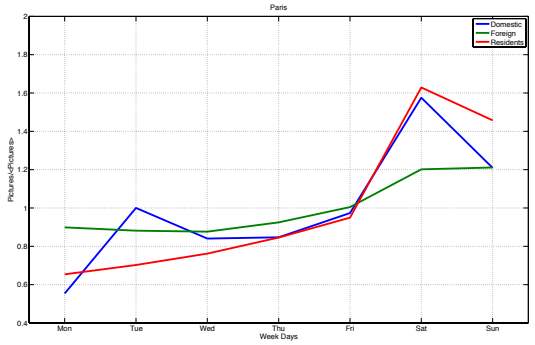

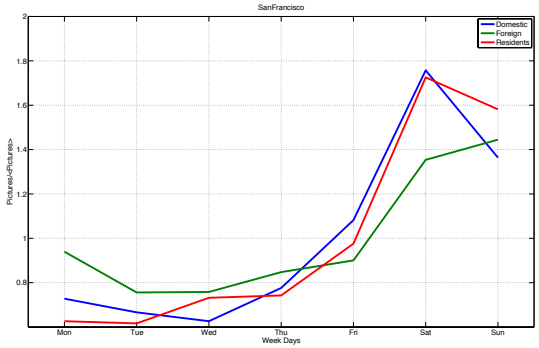

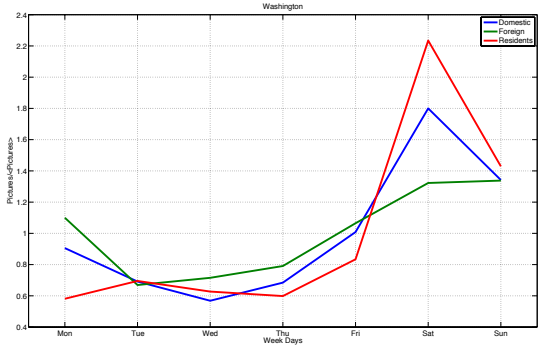

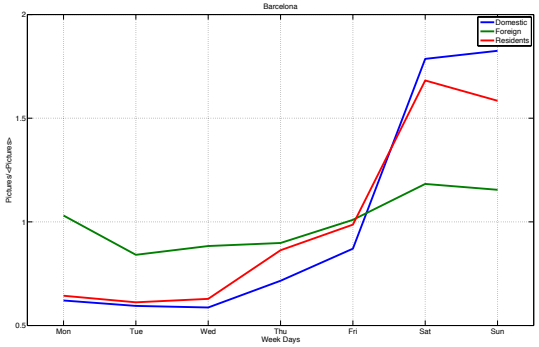

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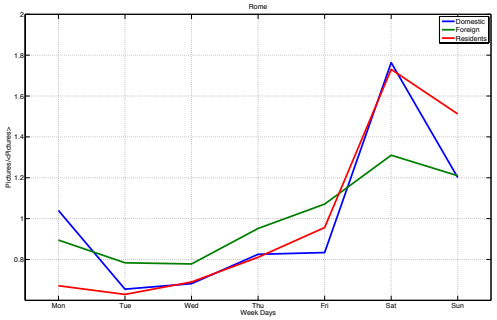

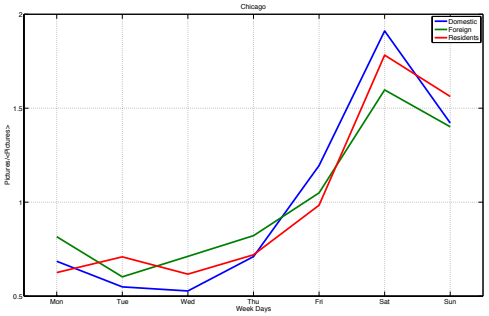

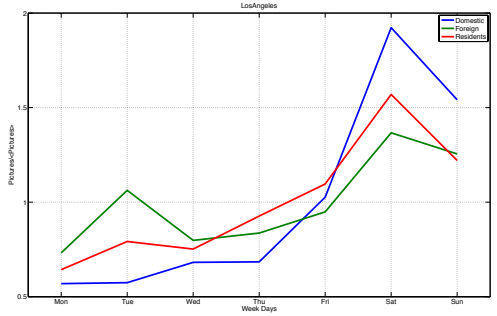

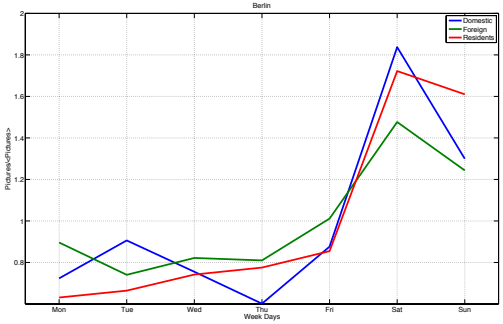

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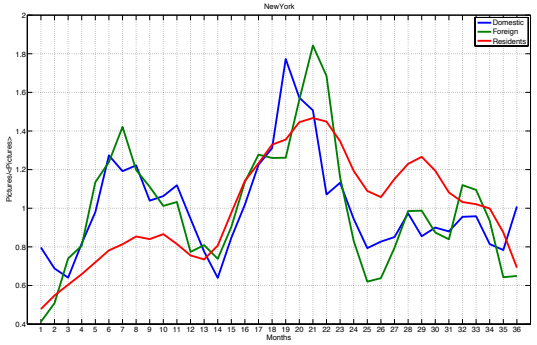

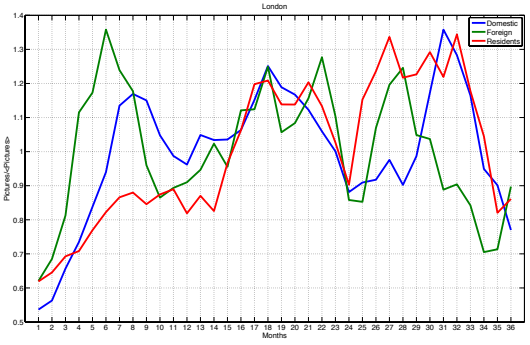

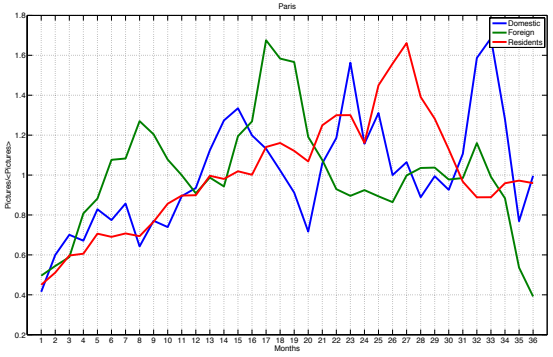

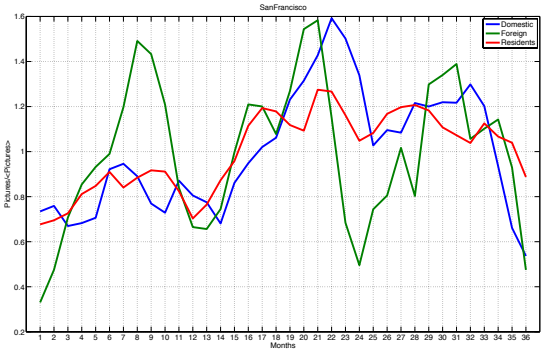

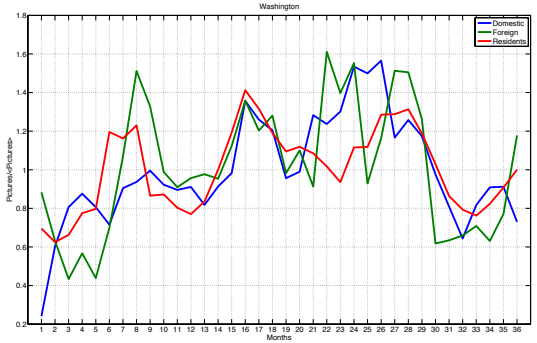

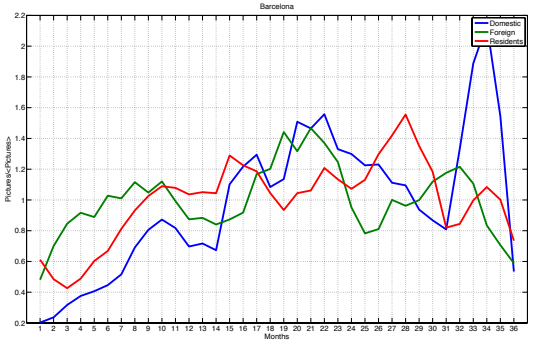

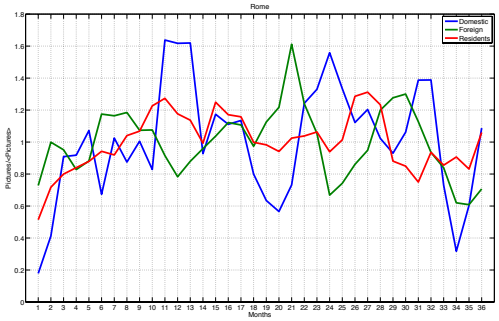

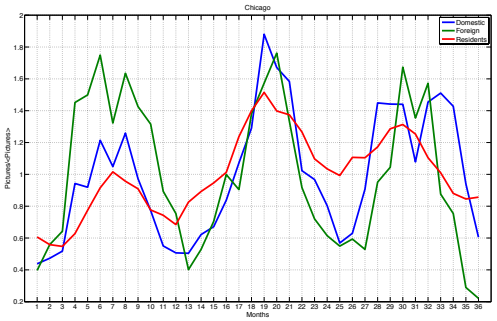

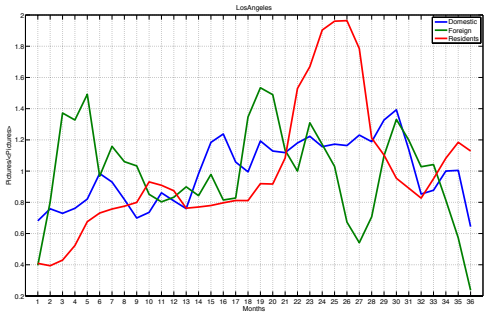

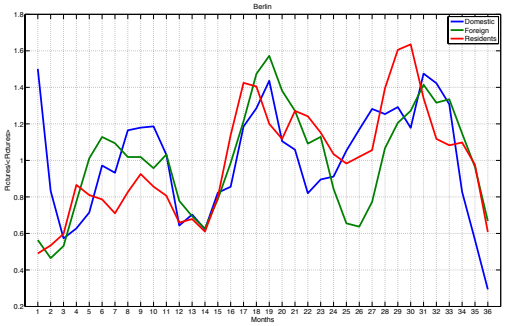

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Chapter 5

Picture by Moyan Brenn - Flickr

Chapter 5

Barcelona Smart City: Application Case Study

Abstract

Barcelona is generally considered one of the smartest city in the world, thanks to the good transportation system, the various different opportunities to enjoy the city, the quality of life, the importance of the innovation and so on. It is also a very active city in the urban changes: in fact, it is always considered a pioneer city in the urbanism evolution, from Cerdà, the great interventions about the Olympic Games of ’92 until the last changes requested from the new concept of smart city. In particular, in this study we are going to check two examples of the last most important urban interventions applied in Barcelona in our days: the district 22@ and the Raval renovation. We

checked these interventions with an unconventional method, i.e. considering big data as geo-tagged photographs shared on social networks. This method can actually have many applications, giving a new different reading of the city. In this paper it is used as a tool of urban evaluation. In this way, we were able to extract informations about the evolution of Barcelona city area by mapping the pictures that visitors and residents had taken in the last 10 years. This gives us a kind of objective measure and evaluation of the city attractiveness in general, but, in particular for the aim of this study, the maps interpretations say us how the urban interventions had or not a real impact on the city life. From our results, the 22@ looks like a positive intervention, having impacts on the whole area, while this is not happened in the Raval, as it just gave impacts in the strictly limited area of the intervention and nothing more.

Keywords:

[Barcelona, smart city, urbanism, big data]

Introduction: The City and the urban interventions

Barcelona Smart City

The city of Barcelona, characterized by a population of about 1,600,000 inhabitants, is located in the north-east of the Iberian Peninsula and it is the center of a beautiful largest metropolitan areas in Europe. Barcelona has quickly become a reference point at international level about the topic of smart city (Fig. 1). The strategy proposed by the Catalan city always attract strong interest and it is recognized as a successful practice from which to take example. For this reason it is useful understand how this initiative was structured and what are the pillars on which it rests not only from the technological point of view but also social and cultural, as the success of the 'Barcelona model' lies in the culture and in the openness of a city that has understood for years the value of knowledge and cooperation as a mean to improve the functioning of an urban environment and its infrastructure. The same concepts that should be the basis of any smart city strategy. In Barcelona, the change began long before the phenomenon of

smart city, through a long period of preparation in which will be observed in detail before submitting the main technical features of the initiative.

This city has come already prepared to the appointment smart city; prepared by years of hard work aimed at the regeneration of its social, economic and cultural heritage. The city has accepted the challenge to change many years ago and what we see today is the result of far-sighted policies started around years ‘90.

Trying to get out the technicalities of this concept both fascinating and complex, in order to allow easy understanding of its meaning, thanks to the words of Richard Florida, we can summarize the principle that the economic growth and the competitiveness of a territory no longer depends only on production of material goods, but also on the ability to produce and maintain a good much more complex as knowledge. In the light of this principle, whereas the processes of production of material things are quite different with respect to the acquisition and production of knowledge, cities around the world, as is happening today with the movement of the smart cities, they have begun to think about how to seize opportunities for growth

offered by this new vision. This condition has opened a scenario of change in which the city of Barcelona has thrown immediately, starting to work and invest in the reorganization of its social and economic system in an effort to develop a city where the continued production of culture and knowledge is facilitated and used to create benefits for all players in the city. Since 1990 the city of Barcelona has placed at the base of its activities this ambitious goal, which is the centerpiece of its Strategic Plan for the development of the metropolitan area; a plan that comes from the work of more than 650 experts from all over the world, belonging to different fields of study, who have worked for more years in an attempt to imagine a future projection of the city and the territory.

Fig. 5.1 - Barcelona Smart City [1]

In this work we want to give an evaluation to two urban interventions of the last years in Barcelona:

1. District 22@;
2. El Raval.

5.1 District 22@

The district 22@ is one of the best example of smart city's strategies in Barcelona [2], as in this district the city has pushed the limits toward an effective and sustainable city by transforming itself from an industrial area into a home of new innovative companies, becoming the digital pulsing heart of the city. The 22@Barcelona has a model of knowledge city that covers Smart City standards with economics, green infrastructure, inclusiveness, science and tech, housing, mobility, quality of life and identity. It also supports a series of projects that will add value to companies and cities like Barcelona Urban Innovation Lab &Dev (BUILD) programme exists as a mixed sphere in the Smart City model development [3, 4]. Based on the Smart City model, this programme aims to foster the

participation of the private sector in the development of innovative products and services related to improvements in the urban space management. This creates two types of relationships between the city council and organisations—urban research and urban lab.

The 22@Barcelona district supports the formation of urban research and facilitates a new working space among the Barcelona City Hall, companies and institutes. This space is intended to foster research activities about the smart management of the urban space and e-Services. To achieve successful outcomes, the city council supports this urban research through providing human resources and tools. Thus, the main objective is to sustain an area for the collaboration with companies and institutes for new product developments while improving the urban management.

As a district, 22@Barcelona also creates a space of personal relationships. It constructs an affiliation sensation to the community of 22@Barcelona and this also encourages feelings such as pride to live and work in 22@Barcelona district. To develop and sustain this space, a number of programmes such as

agora programme, relationship spaces and 22@Barcelona Network have been implemented by the city hall for the professionals. For the residents in that district, other kinds of programmes used such as digital district programmes, support the initiatives of the district and actions of direct communication, like poblenou district [5].

Then, there are many living labs, used as tools and processes for the creation of user innovation cooperatively in real-life environments. The BUILD programme uses 22@ district as a leading living lab for new infrastructures and services, inspiring companies to test and develop innovative solutions as products or services in any field: sensorization, urban planning, mobility, education, etc.

As a promising method, living labs not only provide benefits like product improvements but also foster innovation and give insights for future markets while lowering risks. This is why living lab applications have been accelerated tremendously in the recent years across Europe.

In the case of 22@Urban Lab, the experimentations of new products and services that are at pre-commercial stages ease the

market access for companies, while boosting competitiveness in their sectors. Thus, 22@Urban Lab is used as a tool to bring the latest products and services closer to the city hall services. The district already has a collection of about 14 pilots in various domains such as environment, mobility and telecom. It involves projects aimed at creating sustainable living, working and mobility with advanced infrastructures. Some pilots include the imple- mentation of 12 outdoor public street-lighting points, Eco Digital with LED technol- ogy that includes sensors of vibration, temperature, humidity, sound and pollution as well as GSM aerials, Wi-Fi Mesh access point and webcams for video surveillance functions. Another trial was about the implementation of charging points for electric cars and the management and analysis of the system from a centralised control point in Barcelona City Council. This district embraces clusters of ICT, media, energy, design and biomedical with a triple helix case [3, 4]. Here, new business culture is promoted based on collaboration between companies, universities and the public sector for innovation.

With the 22@Barcelona District, the city hall created new

employment opportunities, moved universities to the area, provided social housing, urbanised green areas and provided more efficient public services. It has created more than 4,000 units of new housing with 25% at minimum rental, 55,000 jobs with over 1,500 new companies and new institutions, mainly in information and communication technologies and media industries. It has ten universities and 12 R&D centres [4].

Similarly, private organisations gained from the use of leading-edge infrastructures, higher density of collaboration and networking. For instance, through the 22@Urban Lab, new products and patents could be generated from commercial products that have been tested and validated at least in one city. This assures the viability of their solutions in a real environment while fostering innovation. Hence, the Smart City model provides a higher rate of innovation, creativity and cohesion for both parties.

Nevertheless as in any other city, Barcelona faced certain challenges such as providing exact and appropriate infrastructure, deployment and management of wireless networks, creation of triple helix, networks, clusters and collaborations. In the case of

22@Barcelona district, the research of Leon [6] highlighted five major challenges that city hall faced:

1. the skilled human capital level was not enough to satisfy the needs of industry clusters,
2. the level of local entrepreneurship was lower compared to any other country in Europe,
3. venture capital funding was not sufficient to attract firms and finance start ups,
4. the number of large firms to lead innovation was low and
5. in the business context, global connectivity of Barcelona was poorer compared to other European cities.

The 22@ project started building the famous Torre Agbar, and it is still work in progress with the great work of Glories.

The area that is now occupied by the Glories Catalanes square has always been a place of passage, rather than a place of stay, as the natural exit from Barcelona to the Vallés and Maresme [3]. The Augusta Roman road passed through this place as the path to Coll de Finestrelles and its layout is still visible if we cross the road Ribes and the street Clot. In those days, the coastline was

very close and the environment, populated by marshes, lakes and ponds, not invited to settle at all.

From the X century, the construction of the county ditch changed the face of this place. Throughout its course, they were water and flour mills and swamps that stretched to Llacuna, the Joncar and the Royal road from Barcelona to Mataró were transformed into pastures and irrigated crops. All this situation contributed to make the corner of Sant Martí de Provençals a large fertile plain, which was almost exactly unchanged until the XVIII century. With the siege of Barcelona in 1713-1714, the trenches and mortar batteries, installed here to bomb the city, left their mark. The construction of the Fort Pienc, one year later, as advanced defense point of Ciutadella, underwent chose this place as "military glacis", necessarily devoid of any permanent building. A premonition, maybe, about the character of urban void that has since marked this place.

In the mid-XIX century, as the city was struggling for breaking down the walls, the Northern Iron Ways Company, in 1852, built the Barcelona-Granollers line, which crossed from north to south the future square. This milestone was really important, since the

passage of the railway mortgaged for many years the urban development environment of Glories. To this first footprint, many others were added, as the line MZA (Madrid-Zaragoza-Alicante), the branch liaison station in France with Sants (up the Diagonal and following Arago Street) or tram line 40, which for decades joined with Urquinaona Square the core of Sant Andreu. When, some years later, the engineer Ildefons Cerdà, author of the Cerdà Plan for the reform and expansion of Barcelona (1859), imagined the future city center at the junction of Gran Via, Diagonal and Meridiana, the orthogonal mesh of his plan collided with the train tracks and forced him to change the plan in this area. Thus, the square was like a big rectangular hole of 9 hectare plot in the Eixample, rotated 30 degrees from the Gran Vía and aligned with the northern railway line. An exception to the regularity of the Cerdà scheme that gives an idea of the difficulties that has always raised this corner in the city.

In the early XX century, the French urbanist Léon Jaussely continued betting on the Glories as the great center of Barcelona, and its 1905-1908 plan proposed to move the town hall and other facilities to this area, giving it a radial road scheme and a marked

monumental character. But this ambitious plan was never carried out. In the same way, the architect Josep Puig i Cadafalch's idea to locate in Glories the pavilions of the future International Exhibition of 1929 did not prosper and was finally dismissed by the difficulties arising from such a complex space, poorly communicated and marked by the presence of the railroad. So, while projects and proposals for the Glories were born and died, the square actually became like a big wasteland in the middle of nowhere, a degraded space in the suburbs, devoid of all management and crossed by the railroad tracks.

In 1909, city officials approved a plan and, six years later, a special commission ruled the convenience of burying the railroad passing through the square, which still take some time to occur. Meanwhile, residents improvised in Glories a neighborhood soccer field -the field Sidral- on a piece of land between the tracks and the county ditch.

On 13 May 1919 the square was officially opened as part of a municipal plan to clean up and develop the outlying suburbs, but the sewers, in fact, did not arrive until ten years later, coinciding with the controversial decision to move the Fira Bellcaire, in

1928. The Encants, the markets, which has since turned into a singularity of the square, they settled in a corner of the mountain side, next to the garden of the estate of Can Caubet. They were, therefore, an element that was integrated into the heterogeneous and desolate landscape of the square, with boundaries approximately defined by fishmeal factories such as the which one of St. James (that today is the "Centro Cultural La Farinera del Clot"), the "Paraigües d'en Pio Rupert" factory and numerous workshops, sheds and facilities related to railway companies. All these aspects together contributed to made Glories as a space with fuzzy and questionable edges, neglected by municipal authorities, that soon became the scene of clandestine activities, focus of crime and gangsterism.

From the 30s, progressive urban densification allowed improving communication with the city and the proliferation of tram lines. In times of the Republic, the Plan of Railway Connections of 1933 foresaw to prolong the Metro Transversal to the Sagrera and in 1935, a plan for the excavation of the routes and the development of the environment was adopted. With the advent of the Civil War only came to run a section of the Meridiana, and

during the war contingent already initiated tunnels were used by the neighborhood as bomb shelters.

During the 40s, the transformation of Glòries stalled: the Franco's authorities prioritized the development of future road Guipúscoa, to the detriment of the Gran Via continuation to the Besos. The only highlight, in that period, was the construction of the modern facilities of the Hispano-Olivetti, who managed to give a small boost to the urbanization of the square on the side of Sant Martí. Besides, the precariousness of the post-war period, together with migratory waves and widespread homelessness, unearthed a vast slums that overwhelmed the mountain side of the square. In the late 40s, the stretch of road that climbs the Meridiana street was buried.

The grinding of the new project and slopes of the “Plaza de las Glories” was approved in 1951. It is the first large formal transformation, introducing a circular shape of 10 hectares. The proposal project about the square, which regulated the incipient predicted traffic flow through a ring high above the railway lines, was approved in 1953.

In March of that year, it began the demolition of the slums. During those same years, the subway line was extended to Fabra i Puig and the county ditch is definitely channeled. In 1961, a first tranche of the ring linking the Gran Via and Meridiana describing a quarter circle was built, but only five years later it was decide to tear it down because it was ineffective for traffic.

In the late 60s, the period in which everyone had a car in the city, the Gran Vía crossed the plaza connecting with the highway of Mataró. Glories thus became the main road junction in the city, as the input in Gran Vía and output in Meridiana. The landscape of this corner of the city, which still had not really gotten into a square, was totally hostile to pedestrians and had been absolutely dominated by vehicles.

In 1973, the square was crossed by two elevated roads and a pedestrian branches tensioned structure, that saved the ring between Encants and the subway exit and in 1975 it won a prestigious European award for metal constructions. The environment had a public park equipped with a children's play area and an artificial stream, trying to sweeten the south side of the square. During the 70s, the traffic volume continued to

increase and the square presented a complex set of roads, ramps, overpasses and underground tunnels. A complex situation inherited the Metropolitan General Plan 1976, which reflects the reality of the square as a nodal point foresaw road infrastructure and land reserves for future development.

In the late 80's, the Plaza de las Glories was included in the catalog of new central areas of the city. The 1992 Olympic project envisioned transforming it into one of the gateways to Barcelona. As part of the works to be carried out with the aim of improving the city for the Olympics, the road mess seventies was replaced by the double ring (which housed a parking) that has survived still today and was inaugurated inside the park road junction of the Glories (1992), a garden of 2.10 hectares, and three years later the project Forest Encants began, at the confluence of Gran Via Meridiana and Castillejos.

The extension of the Diagonal to the sea and back and progressive transformation of the 22 @ district required the definition of a new urban project for Glòries. The first gestures that pointed in this direction and began to define the immediate surroundings of the square were, among others, the opening in

1995 of Glòries Shopping Centre and the Cultural Center Farinera Clot, the construction of the Agbar Tower (1999-2005) and the inauguration in 2000 of the new facilities of IES Salvador Espriu.

In 2003, the City Council urged municipal action program to discuss the future development of the square and a committee to monitor the renovation project of the Glòries was established, with the participation of the municipality and neighborhood associations. The findings of the commission were collected in 2007 in the so-called Commitment to Glòries, a summary document and starting point for the drafting of the Amendment of PGM in the square and its surroundings. Its most essential aspects are, among others, the complete elimination of the high ring road, a model plane park, with no traffic and with maximum green surface, the burial of the Gran Via, an integrated mobility model and building agreed equipment. Since 2008, the gradual demolition of the ring with the dismantling of the drum and the parking was started. And between 2009 and 2010 he started the construction of the Museum of Design-DHUB and the New Encants two metropolitan scale equipment and unique

architecture that would be added to the Auditori and the National Theatre of Catalonia, appeared twenty years earlier in occasion of the extension of the Meridiana avenue.

The agenda for the transformation of the Plaza de las Glories is underway. From March 2014 it carried out the progressive demolition of the beltway; in February 2014 disclosed the architects team winning the competition for the development and construction of the future park of the Glories, which takes place between mid 2015 and late 2017, partly coinciding with the construction of the tunnel Gran Vía. A definite momentum to solve a long claimed space for the city.

Fig. 5.2 – Project of the Plaza de las Glories

5.2 El Raval

El Raval was the suburb or district outside the walls. And his name appears destine it to marginalization, but it is precisely there where the Raval draws its character. In the Middle Ages the Raval were fields, so there monasteries, hospitals, hospices and universities, which had no space inside the walls were installed. The beautiful Romanesque church of Sant Pau del Camp, at the end of the street Sant Pau attests that what was in the middle of the field. In the fourteenth century the new wall that included the Raval in the city was completed.

The Hospital de Sant Pau and Santa Creu Hospital street, is another medieval survival, today Library of Catalonia and art school. It has a cute little garden with orange trees that can be visited, some beautiful Renaissance steps, and facing the street and the beautiful patio Carmen seventeenth Convalescence House, now the Institute of Catalan Studies.

Between the late nineteenth century and the 70s of XX, the Raval became the so-called "Chinatown", ie, the neighborhood hostess, in a port city like Barcelona has always been a very active

neighborhood. Chinatown not only covered the Raval, also included large areas of the Gothic -Escudillers, Avinyó, Plaza Reial. Since the early twentieth century when incursions by Picasso went from brothels in Barcelona - "Demoiselles d'Avinyo" are none other than the young ladies of the street Avinyó- brothel in the area had an intense sexual intercourse. Even today, in the nearest sea Raval, it guesses what the neighborhood was. On the street Sant Pau there was first bar of coffee elegant gentlemen pricipios century and then dissipated epicenter of life. Also in the street Sant Pau there is a hidden treasure: the beautiful modernist decor of the rooms at Hostal Spain, designed by Domenech i Muntaner.

Today the Raval has again changed its skin: in the 80s and 90s it became a bohemian and alternative district, home to many young artists who invented the new Raval: Poor but modern, cosmopolitan, popular and artisan district, without losing their "border" character in the business district and lead families living in Pakistan, Morocco, Philippines, India, China, Bangladesh, Ecuador, Dominican Republic. For the tourist is interesting to

walk through the streets and discover the variety of proposals to eat, shop, and cut Hair, see art or a drink.

The top of the Raval houses today Universities, the Contemporary Culture Centre of Barcelona housed in the old Casa de la Caritat, the FAD (Promotion of Decorative Arts) and the Barcelona Museum of Contemporary Art (MACBA), by the architect Richard Meier, at the Plaça dels Angels, which has become a large public plaza that brings together fans scooter, Pakistani mothers, future artists and children from 5 continents playing football. Also flanking the square is the former convent of the XVI Angels and now FAD headquarters, local institution dedicated to design.

One of the last interventions is the Rambla de Raval. The Rambla del Raval is a new space gained the neighborhood torn down several blocks of flats, in a final lunge to Chinatown and marginalization. Today it is a wide promenade with palm trees, terraces and a large cat Botero in the end, to the delight of children. A playground for the local people, especially appreciated by the Pakistanis to the point that some call the "promenade Pakistan." On the weekends there is an interesting

market of artisans, with a tent where Arabs enjoy tea and cakes. Sometimes the Rambla del Raval seems an oasis in the midst of darkness and disorder of some streets of this neighborhood, like a gap between the effervescence of life of Pakistanis, Catalan and touristy living around and haunting the place. Other days, the feeling of being completely consolidated and belong to the city since the neighborhood was industrialized by the eighteenth century. Ten years after its inauguration, is the need to overrun is sufficient to carry out the destruction of an area of the city consolidated argument? Aware that this project has set a precedent in the history of world urbanization, both in conception and development and cultural position taken neighborhood in the context of the city, the side effects of gentrification and displacement of indigenous population an issue that still needs to solve.

5.3 Materials and methods:
Urban success story told from geo-tagged photography

1. Method

Thirty two photosharing sites exist on the web with billions of photographers and this trend is constantly increasing. This leads to a very large set of data regarding where people have been and when they were there. Analysis of these digital footprints can provide novel insights into how people live and experience the city, revealing aspects of mobility and tourism, and discovering the attractions in the urban landscape. So, we studied Barcelona city area through geo-tagged picture data that could be considered a direct measure of residents and visitors' interests, in order to define city attractiveness. Specifically we consider a dataset of geo-tagging pictures taken by customers worldwide including longitude and latitude coordinates capturing GPS information, at the time the photo is taken or uploaded from the photograph to a map after the picture is taken.

The electronic trails are currently considered to be an efficient and consolidated way of collecting useful big data in urban and

tourism studies. There are in fact various ways to electronically track human behavior and the most diffuse one is collecting data from mobile phones [7,8]. Many previous researches demonstrate that it is an accurate method to understanding crowds and individual mobility patterns [9-11], land use classification [12-15] or regional delineation [16-18]. However, when it comes to studying human mobility, exploring mobile phone data is not the only one possibility – other sources of big data collected from digital maps [19], electronic toll systems [20], credit cards payments [21, 22] twitter [23], circulation of bank notes [24], vehicle GPS traces [25] and also using geotagged photos [26-28] could be successfully applied.

It is clear how much social media can help promote a territory rather than another. In fact, people buy through the social and choose clothes, shoes and accessories for the car through Facebook and Twitter, and of course, they also plan their vacations by using the same media. So, we can say that by studying social network information, it is possible to have a general idea of people perceptions.

The big novelty of this study does not only lie in mapping Big Data in GIS, since there are many examples of that in the literature, but in the particular kind of data considered.

In the large variety of social networks, we have chosen Flickr, the most famous social for picture sharing. We focused on geo-tagged photos because photography is a disciplined way of viewing and investigating landscapes, able to inform about design and planning in a more "qualitative" way. Residents and visitors take photos in particular places they consider important for some reasons. It could be very useful to understand what we like in our cities, in our territories, what we are interested in, or also where residents or tourists want to go. In turn, understanding this could provide important indications for urban innovation. For this reason, photography is already considered a good mean of inquiry in architecture and urban planning, being it quite useful for understanding the landscape [29].

By exploring big data from photoshared websites, it's possible to define a measure of City Attractiveness [30]. In particular, in this study we want to verify if two important urban interventions

applied in Barcelona in the last year had or not a great impact on the area.

2. Materials

As we can see in Fig. 5.3 (already mentioned in Chapter 2), for Globalwebindex, in 2014, Flickr has been the first social network dedicated to sharing photographs.

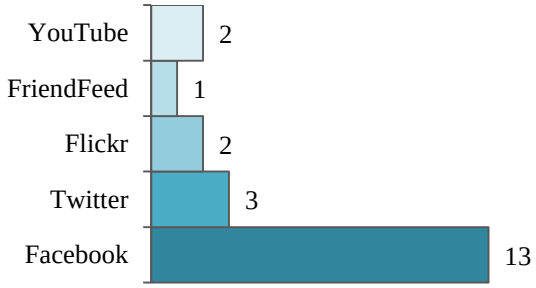


Fig. 5.3 - Main social networks used, source Globalwebindex 2014.

Flickr photos are publicly available, and there are many "Applications Programming Interfaces" (APIs) allowing the download of picture-related data. To carry out this study a tool was prepared, connected with flickr.photos.search API. This tool is the website http://urbanmagnetism.cloudapp.net, creating for this research by the Urban Magnetism Team. Through it, we had the possibility to insert the name of the place (Barcelona) we were

interested in and download the information related to the pictures shared for that place.

We think that this visualization can be considered as representative of the popularity rating of people, who, satisfied after being in a place, want to preserve the memory, and then take a picture and share it on the social.

Through the downloaded Data, the origin of the users can be traced, information for year can be classified, and the geographical coordinates of the place where it was taken can be associated to each photograph; thanks to this approach it was simple to recognize the most popular sites, the months of the year when people flows are greater, and to try to create attractions; but above all, it becomes clear the need to analyze the deficiencies of the territory, which are immediately visible by the mapping of the area, and suggest strategies to overcome the gaps found.

We chose to download for the city of Barcelona a range of 10 years, from 2006 until 2015.

This could give us a real picture of the attractiveness evolution of the city, at least on the website. Cleaning the data, at the end, we collected a whole dataset of more than 40.000 pictures for the ten

years. The data are presented in a form of matrix with as much rows as the number of pictures and 9 rows:

Location	Location Id	Latitude	Longitude	Username	User id	Datetime	Link	Image

3. Application and Results

First of all, from the data we have downloaded, we were able to extract and elaborate the density attractiveness map [28] with the most photographed places in Barcelona in the last 10 years. With an algorithmic method, we found the coordinates of the ranked photographed cells considering the custumer activity and identified the real places on the map, that are the most photographed hotspot of the city (Fig. 5.4).

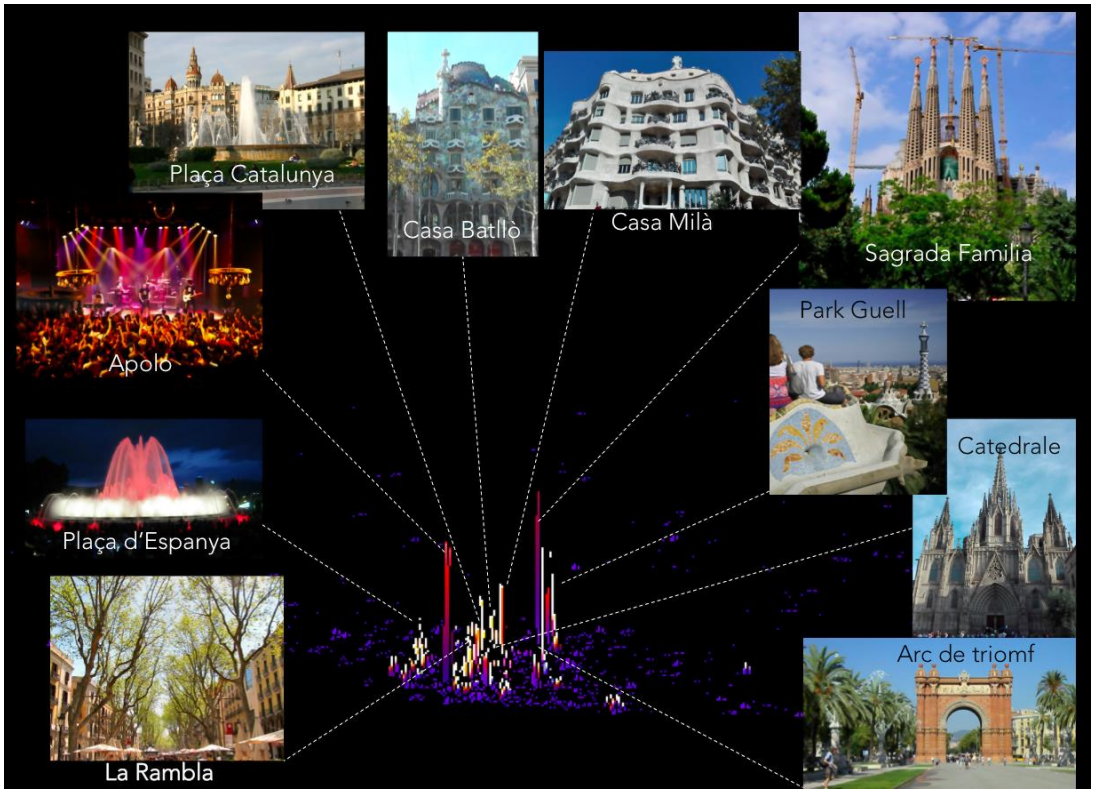


Fig. 5.4 - The density attractiveness map in Barcelona from 2006 until 2015. The most photographed place is Sagrada Familia.

In the Table 5.1, we show the rank of the most photographed hotspot. As expected, the four Gaudi's works, that are all UNESCO World Heritage, are in the first positions. Very interesting is, between them, at the II position, the discomusic Apolo, actually one of the most famous in Barcelona. Then we have others of the most famous touristic destinations of the city.

Table 5.1. Most photographed hotspots in Barcelona.

	Hotspots
1	Sagrada Familia
2	Apolo
3	Casa Milà (La Pedrera)
4	Park Guell
5	Casa Batllò
6	Catedrale
7	La Rambla
8	Plaça Catalunya
9	Arc de triomf
10	Plaça d'Espanya

Furthmore, we elaborated the time series of the city attractiveness in the last ten years.

For a deeper analysis of temporal distribution, we can extract the time series of attractiveness of the city. The temporal attractiveness can be described from:

$$A_t = f(t) + u_t$$

where

A_t= temporal attractiveness

$f(t)$= deterministic sequence

u_t= stochastic sequence

The determistic sequency is constituted from two contributions: the trend and the seasonality.

The stochastic sequency, instead, is representative of the random events.

So, the observed data of each cities is an additive time series (Fig. 5.5), that can be described from:

- trend;
- seasonality;
- random.

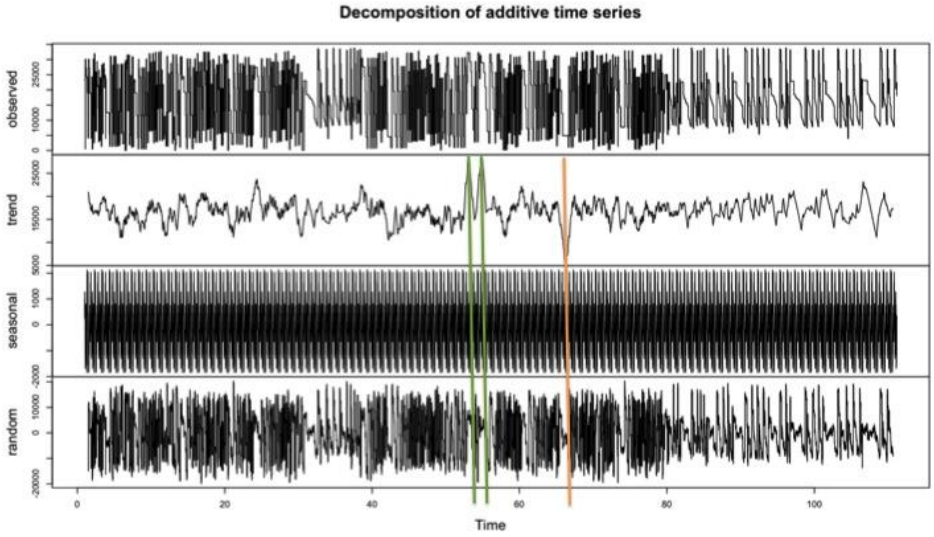


Fig. 5.5 - The decomposition of the time series of attractiveness in Barcelona, considering additive noise. The first row is the observed data, the second is the. trend, the third the seasonal (cyclic) part and the last is the random component. Green lines indicate the 'positive' events, while the orange one indicates the negative one.

Considering the trend, it is very interesting to note that the two ‘positive’ peacks, corresponding to sport events: the World Cup 2010 won by Spain team, and immediately after the European Athletics Championships 2010, both in summer 2010. Also interesting, at reverse, it is the ‘negative’ peack, that corresponds to the Spain election of November 2011.

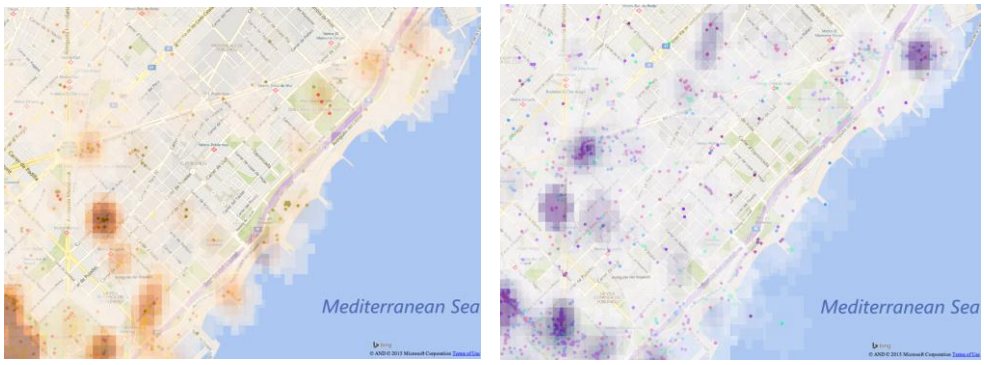
After this general review about what pictures tell us about the city situation in these last 10 years, we were deeper in the two interventions mentioned above.

We prepared a maps comparison between what happened before and after 2010, that means after the interventions. We plotted the geotagged pictures as dots in the maps and from that it was possible to create heatmaps.

The first example is district 22@. It looks like a positive intervention comparing the two maps: in fact, before 2010 (Fig. 5.6 a) the area of 22@ was not an hotspot in the city, all the area was completely empty and without any attractive for people. But, after the interventions, that still are in progress, we can note in Fig. 5.6 b, that now the area is absolutely much interesting in general. In particolar, there were created two new hotspots: one

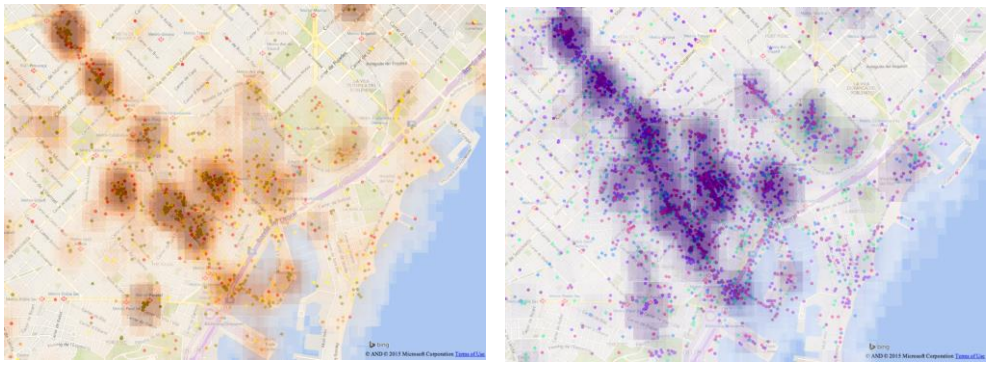
close to Glories and Torre Agbar and the other at Diagonal Mar. It means that the intervention really had impacts on the whole area. Instead, looking at Fig. 5.7, we can see the comparison between what happened in the Raval.

Surely the area is a little bit much interesting than the strictly limited area of the intervention, but, unfortunately, nothing happened around them. It could mean that it still needs some more interventions or maybe a different kind of.



a) **b)**

Fig. 5.6 a-b. 22@ intervention: comparison between the situation before (a) and after (b) 2010.



a) **b)**

Fig. 7 a-b. Rambla de Raval intervention: comparison between the situation before (a) and after (b) 2010.

Paradoxically, 22@ was a bigger but also simpler intervention respect to the others, because it is an industrial area, and it is very easy to move business, it is not affectively linked to a particular place, but just to the most convenient one.

In the Raval, instead, we are talking specifically about people, because are the people who make the neighborhood. In this case it is necessary to do more than a riqualification, it is necessary to use other methods. In the Raval a big sum of fundings it is used to requalify the square, incentivating hotels and restaurants to open there, but, around there, still are poor people, living in very bad conditions, so, actually, none still want to go there, it is still a poor neighborhood, except in the strictly little area of the interventions. So maybe it could be more appropriate to spend something more in it, in improving people conditions, or houses, not just the place itself in this case.

Conclusions

The importance of the city in our society is well-founded and it is evident that cities play a crucial role as more than half of world

population is urban. So rethinking cities is a key component of the world sustainable development paradigm. The first and direct way to rethink cities is rethinking the way we plan them. To reach out a better planning, we need to start considering our needs while people obviously need efficiency, better transportation and green energy, but the sole reasons for us to move and visit a city as tourists investing money to go and experience it, are its beauty, what we like in it and what attracts us about the city. Therefore, in this study we have suggested an unconventional way to analyze city: geotagged pictures from the most important publicly available photosharing web site, like Flickr. Over the last decade big data is being increasingly utilized in urban planning. But the pictures can provide us an additional layer of information useful for the urbanism in general: they say what places in the city seem enough important for people. This reveals interesting and sometimes unexpected patterns in human activity. Further, this is practically useful to understand what places have to be potentiated, where can it be appropriate to increase services or to reduce them, and so on.

We analyzed the smart city strategies of the first smart city in the world, Barcelona and in particular, two of the most important urban interventions in the last years: 22@ and Raval.

Through geotagged picture we were able to tell a nice story about Barcelona: its most photographed and attractive places in the last 10 years and the most attractive events.

In particular, we used this method, that actually can have many different applications, to give an evaluation on urban interventions. From what people say through the dialy activity they do on the web sharing pictures in the last ten years, it looks that 22@ is a positive intervention, having impacts on the whole area, while Raval no, because it just gives impacts in the strictly limited area of the intervention.

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Conclusions

The study was set out to explore the concept of new kind of urbanism, relative to smart cities, and has identified the nature and form of it through big data, the reasons and motivation for innovation, the type, the extent, resources required and the role and impact of it in a city. The study has also sought to know whether big data can result in effective helpful in smarter cities, or, at least, can give to the planner a new reading of them. The general theoretical literature on this subject is huge, but this research study goes on, analyzing new kind of data (geotagged pictures from photosharing websites) and using them to describe and compare people perceptions in different cities and, at the end, in the application case study, to read the territory of Barcelona (one of the smartest city in the world), giving an evaluation to the last urban interventions.

The study basically sought to answer to the questions: What do we like? Where do we like to go? How can we know it?

This is interesting because “Not only do people need efficiency, better transportation and green energy, but also do they need a better experience of living in cities enjoying the things that they have interest in and that they find attractive. In this study we thus conducted an analysis of cities through the city attractiveness and derived patterns.” [Chapter 3].

The firt two chapter are a kind of introduction to the reasons and the methods of this research, exploring the literature on this topics: the first one is about the city evolution until the actual smart city; the other one is about the importance of GIS and Big Data. While the first two chapters are more theoretical, the main empirical findings are exposed in the central and most important chapter of this research study: Urban Magnetism Through The Lens of Geo-tagged Photography, Chapter 3. This section will synthesize the empirical findings to answer the study’s research questions, exploring it mostly through the differences between American and European behaviours.

These findings are again explored in the fourth chapter, from a temporal point of view.

The last chapter is the applicative one. The exposed methodology could actually have many different applications in many different fields, from urbanism to economy, from tourism to marketing. This application is about using the methodology as a tool to evaluate urban interventions in Barcelona. It was possible thanks to the creation of an “ad hoc” website, able to download geotagged pictures from Flickr.

The scale of this debate is therefore extensive and multifaceted at every level. To generate achievable policy strategies and development targets with regards to smart city and big data correlations, there is need for more case studies at the local level to allow further assessment of local dimensions of the subject.

As future research strategies can facilitate the attainment of the research goal and expanding it, it could be interesting first of all to use also other kind of big data and obviuosly to explore many other application case studies with different and new objectives, under the macro-goal of improving our cities and then our life.