Using Ambient Geographic Information (AGI) in order to understand emotion & stress within smart cities

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Abstract

Since one of the main ambitions of a smart city is to improve urban functions and provided services, it is often perceived as a living urban fabric, in which connected urban citizens, acting as active sensors, have the capacity to contribute even more efficiently to the spatial intelligence of cities. This "immaterial" dimension is related with the need that smart cities have to assess their citizen's feelings, perception and well-being, giving rise to an emotion-aware city.

Mapping emotion builds on a tradition of studies in cognitive mapping, evaluative mapping, environmental preference and environmental affect, adding an approach in which people experience, evaluate and describe their environment "in situ" through social media.

This paper aims to present an Ambient Geographic Information (AGI) approach to assemble geo-tagged data from Twitter, Flickr, Instagram and Facebook related with people's perception and feelings regarding Lisbon (Portugal), and therefore characterize its emotional dimension, by comparing these subjective observations with objective measurements (such as socio-demographic statistics, questionnaires and data retrieved from biometric sensors).

With this vision of a smart city, that is capable to interpret and harnessing the emotional states of its citizens, it is essential to find new methods and techniques to sensing affect in an urban context.

Keywords: *Ambient geographic information (AGI); Volunteered geographic information (VGI); emotional mapping; Social media; emotion-aware city; smart city*

1 Introduction

We can sum the relevance of cities in modern societies with just four numbers: cities cover only 2% of the Earth's inhabited land area; 50% of the population on the globe live in cities (80% by 2050 according to the United Nations); cities account for 75% of total consumed energy and 80% of CO2 emissions [27].

The idea and concept of smart city itself tries to address these challenges. A smart city's main goal is to increase the quality of life for its citizens and to make the city more attractive, lively and greener [17]. To achieve this goal, physical sensors are deployed throughout the city to monitor various aspects such as environmental parameters (weather, pollution, etc.), traffic and the consumption of resources [1]. However, this does not directly reflect how humans actually perceive their environment and the city's services [23].

These physical sensors are interconnected into a computing framework to create a big picture of the live state of the city [14]. This live state, however, only includes measurable quantities and disregards how the citizens actually feel. It is likely that there exist correlations between the emotional states of the citizens and relevant statistics like well-being of the city's inhabitants or quality of living [18]. When urban planners use the collected data to optimize parts of the city, the emotional state of the inhabitants can thus serve as valuable implicit feedback. This gives rise to the vision of an emotion-aware city with the ability to understand and utilize the emotional states of its citizens to enable improved planning and decision making [14], in which urban citizens can be called upon to act as active sensors, staging their personal spaces and sharing their spatiality [12].

Besides the literature review, this paper aims to present a conceptual framework in order to assess the human/emotional component within a smart city, through its 5 sections (excluding this introduction): section 2 The "smart" in the city, in which the focus will be given on the definition of a smart city, more specifically its human component; on section 3, AGI: "following the heels of VGI", the concept of volunteered geographic information (VGI) will be revisited with Ambient Geographic Information (AGI); section 4 will address issues and examples of emotion & stress mapping and its relevance through a smart city; on section 5, the conceptual framework for this research will be presented, giving an overview of this AGI-based methodology; finally, the last section will present some of the possible outcomes of the research.

2 The "smart" in the city

A smart city operates primarily in four dimensions: the intelligent city (its social infrastructure), the digital city (informational infrastructure), the open city (open governance) and the live city (a continuously adaptive urban living fabric) [27]. In this context, today's actors are no longer mere

consumers of urbanity, but true producers (or *produsers* [2]) of these intelligent cities, since their level of spatial commitment is essential to the effective functioning of the smart city's four dimensions.

Mainly, the idea of the smart city is truly connected with today's hypermodern society, which can be characterized by at least three major transformations that all have more or less to do with geolocation. 1) There is a dematerialization of a growing segment of society, referred as digital humanism [27], a type of society in which new mediums (books, maps, multimedia, augmented reality) cannot be fixed in space or stabilized over time, changing the way we interact and relate with objects; 2) There is a "global location age", in which personal and private space has turned into potential place for instant capture and sharing of events [27]; 3) Lastly, there is the growing importance of digital socialization. Since social media and networks raise mediation of social relations, Geolocation (and indirectly GIScience) is a key component of these social media and networking sites [27].

To complement this information, the figure 1, identifies and clarifies the main conceptual variants and core factors of a smart city according do Nam and Pardo [23]: Technology (infrastructures of hardware and software); People (creativity, diversity, and education); and Institution (governance and policy).

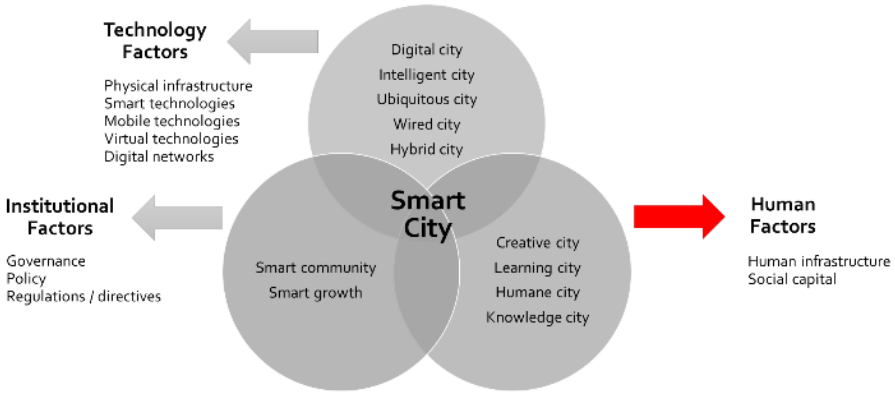
But more important for a smart city is its capability to capture the sense of places. A city is not a machine, but rather made by people local actions and feelings. This could not be captured and represented without active citizens sensors (Volunteered Geographic Information [12], Ambient Geographic Information [30], crowdsourcing [13]) connected to location based-social networks [26].

3 AGI: "following the heels of VGI"

An active and engaged citizen is indeed the main driving force of a "smart city" [26]. Nowadays we give a growing amount of location-based contents generated by connected – anytime and anywhere – *produsers*, mainly equipped with smartphones. The exponential growth of ambient geographic information through social networks (most of them are location-based social networks) became the basic feature of a spatially enabled society [26]. Social networks are vessels which millions of people use to share their current thoughts, observations and opinions, and have been shown to provide more reliable and trustworthy information than traditional methods like questionnaires and other sources [22].

These contributions raised through the ubiquity of mobile

Figure 1: Fundamental components of Smart City.



Source: Adapted from Nam & Pardo, 2011

The above mentioned "immaterial" component of the smart city is connected with the idea that a smart city is also a living urban fabric that is continuously being reshaped as is adaptive to change [27].

In this context, there's a need to consider affect and emotion within a smart city, which are key elements towards rational decision making [24]. Since emotion is a central component of human behavior and, in order for a city to be truly "smart", it is important not only to assess *what* people are doing, but also, *why* they are behaving in a certain way [6]. Considering emotional states is essential for achieving real-time judgment and perceived life satisfaction [14]. With this information, city planners can make use of the gathered affective data to detect positive or negative trends developing in the city, managing to take early countermeasures. Answering subjective questions such as "which part of the city is the best?", requires affect and emotion [14].

technologies, but accessible from different platforms, act as socio-spatial mediators [19]. Mobile technologies are definitely a valuable tool for collecting affective data in the context of an emotion-aware city [20], since they can simultaneously collect both spatial location and the user posts, which should contain emotion or mood content.

Social media generated from many individuals is playing a greater role in our daily lives and provides a unique opportunity to gain valuable insight on information flow and social networking within a society [16]. Through data collection and analysis of its content, it supports a greater mapping and understanding of the evolving human landscape [30].

Such data conveys Ambient Geographic Information (AGI), capturing for example, people's references to locations that represent momentary social hotspots. Harvesting this ambient geospatial information provides a unique opportunity to gain valuable insight on information flow and social networking

within a society, support a greater mapping, understand the human landscape and its evolution over time [30].

This emergence of AGI represents a second step in the evolution of geospatial data availability, following on the heels of Volunteered Geographic Information (VGI) [4]. According to Stefanidis [30], harvesting and analyzing such ambient information represents a substantial challenge needing new skillsets as it resides at the intersection of disciplines like geography, computational social sciences, linguistics and computer science.

There are two major research challenges in the new field of emotion-aware cities, which are the *detection* and *aggregation* of affective data in an urban scenario [14]. These issues are related with the specific and personal effect of appraisal and enthusiasm, which differs from person to person [34].

This research aims to develop a methodology towards emotion and stress mapping, in order to assess people's emotional responses to their environment as they walk through the streets of Lisbon (Portugal). Results could suggest that people's shared feelings about specific places are influenced by the particular physical properties and characteristics of a given place.

In this context, a methodology based on AGI and VGI, could produce alternative representations of space, based on individuals' georeferenced experiences, thoughts and emotions by mapping stress and emotion. The use of geospatial user-generated content, including social media information (*twitter, flickr, facebook, instagram*), could lead to a better urban planning [9,10,25], and how living in a urban area could relate to well-being.

4 Emotion & stress mapping

Smart urban solutions have to be built on the vision of citizens as active sensors on one hand, and on the other hand on spatial enablement of citizens via social network. These kind of solutions have also to be built on the potentials offered both by embedded sensors to crowdsource the process of collecting geo-referenced information about places in the city.

Most people, if questioned, will have an opinion as to whether a particular landscape is aesthetically pleasing or not, and the role of everyday landscapes in the well-being of people is receiving increased focus [7]. Nevertheless, criticism in landscape aesthetics refers to subjectivity, lack of standardization in methodology, non-transparent application of values, and lack of replicability [7].

Personal associations were a primary example of intangible and subjective feelings, related much more to memory than to anything immediately visual. Positive personal associations stemmed from memories about a range of personal experiences with friends and family and attachment to the place or locality [33]. Negative personal associations can be articulated as disappointment regarding the ruined or unrealized potential of a space, often tied to a sentiment that municipal leaders could failed to follow through on promises to complete development, livability, or beautification projects.

A mental map refers to one person's point of view perception of their own world, and is influenced by that person's culture, background, mood and emotional state, instantaneous goals and objectives [15]. If we move along the streets of any city in a rush, trying to find a certain type of shop or building, our experience will be different than the one we would have had if we were searching for something else.

There is a multitude of reasons why a pedestrian may choose to avoid areas with negative affect: Emotions like fear and anger indicate danger and should be avoided by travelers feeling afraid. Stress may be felt in areas of high traffic or crowdedness which are undesirable for pedestrians. The emotion disgust indicates places that are unsuitable for relaxation. Likewise, there are reasons to seek areas with positive affect: A detour through a relaxing area can be acceptable when someone is feeling stressed. The emotion relaxed may also be correlated with higher safety to walk in an area. Furthermore, someone may want to seek locations with increased surprise when they are curious and in the mood to explore. Reasons to seek or avoid areas with a certain affective state are as manifold and personal as affect itself [29]

The basic emotions are anger, disgust, fear, happiness, sadness and surprise. As an alternative, dimensional models of emotion have been proposed, where an emotion is expressed by a number for each dimension. In its most simple form, the two dimensions pleasantness and arousal are being used. Pleasantness corresponds to the common intuition of good and bad emotions. High pleasantness is indicative of a situation that is in agreement with a person's own goals. Arousal denotes the level of physiological change the emotion causes in a person. High levels of arousal are characterized by a faster heartbeat and the readiness for action which is also found in emotions like stress and anger. This is in contrast to low arousal states like contentment [28].

We can find some good practices on emotional mapping:

For example, Christian Nold's fundamental work on Biomapping and Emotional Cartography [3], which is a set of methodologies and tools for visualizing people's reactions to the external world. In the project, a rather large number of people (about 2000) have taken part in community mapping projects in over 25 cities across the globe. In structured workshops, participants re-explore their local area with the use of a device which records the wearer's Galvanic Skin Response (GSR), which is a simple indicator of emotional arousal, in conjunction with their geographical location.

In this way, a map is created which visualizes points of high and low arousal. Nold's work can be considered to be a seminal one in exploring how devices can capture location-based emotional states, and make them accessible through maps and other means [15].

Using a different approach, the City of Vilnius [32] has found a way to track emotions on its territory using a social tool that gauges the average residents' level of happiness. Residents submit their overall level of happiness for each given day using their smartphones, or by scanning a barcode on the post advertising the initiative dubbed the "Happiness Barometer." Votes are later totaled to determine the overall happiness level of the town – displayed on a large urban screen and on the website.

Another relevant project is Mappiness [21], part of a research project at the London School of Economics. This mobile app and online system actively notifies users once a day, asking how they're feeling. The data gets sent back along with users' approximate geographical location and a noise-level measure, as recorded from the phone's microphone. In this way users can

learn interesting information about their emotions – which they see charted inside the application – and the operator can learn more about the ways in which people's happiness is affected by their local environment — air pollution, noise, green spaces, and so on.

5 Methodological Approach

The rise of social media and the ability for analysis raises several concerns with respect to the suitability of traditional mapping and GIS solutions to handle this type of information [11,31]. We no longer map just buildings and infrastructure, but we can now map abstract concepts like the flow of information in a society, contextual information to place and linking both quantitative and qualitative analysis in human geography [30].

In a sense one could consider AGI to be addressing the fact that the human social system is a constantly evolving complex organism where people's roles and activities are adapting to changing conditions, and affect events in space and time. By moving beyond simple mashups of social media feeds to actual analysis of their content we gain valuable insight into this complex system [30].

To implement an AGI-based methodology this research will focus on creating tools and methods that can collect, analyze and share information, based on geospatial user-generated content linked with social networks and media. Any spatial information related with emotion, enthusiasm, memories and stress related with the people's perception about the urban space, will be georeferenced. As a case-study, the city of Lisbon will be analyzed by using a text-mining approach in order to place in a map, any spatial *tag/post* related with emotion, either good or bad.

Error! Reference source not found.2 represents the conceptual approach for this research. The emotional states of Lisbon citizens will be sensed through a variety of social media sources, by extracting features and applying machine learning techniques. Finally, this AGI-based data (*subjective observations*) can be compared with results from *objective measurements*, such as socio-demographic statistics, questionnaires and data retrieved from biometric sensors.

In order to collect geo-tagged data to analyze Lisbon as an emotion-aware city, Twitter, Flickr, Instagram and Facebook public stream API's (Application Programming Interface) should be used, allowing interaction within the social network's ecosystem (users, communities, content, e.g.) [15].

6 Expected Results & Conclusions

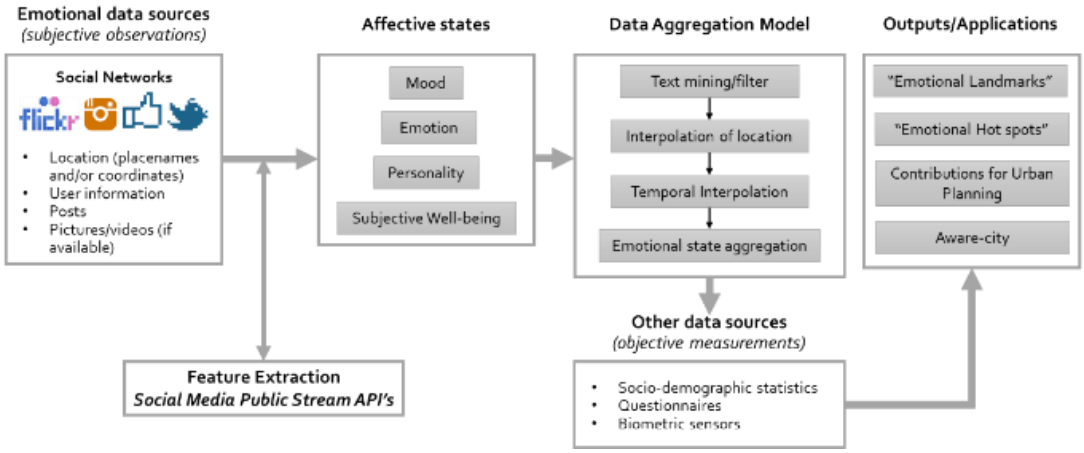
Mapping emotion builds on a tradition of studies in cognitive mapping, evaluative mapping, environmental preference and environmental affect [33], adding an approach in which people experience, evaluate, and describe their environment *in situ* through social media.

With the emotional mapping of Lisbon it'll be possible to visually discern areas of strong feelings, either good or bad. These areas can be called as emotional clusters, which can be defined as the tendency shared by two or more participants in a particular place. The greater the number of people reporting a strong positive or negative feeling in the same location, the more pronounced the emotional cluster. These "hot spots", exhibit aggregations of positive ratings, negative ratings, or in some cases, a mixture of strong positive and negative ratings in the same place.

Other main goal will be to identify "emotional patterns" – those spaces where, at a specific or recurring time, a certain emotion is expressed powerfully and abundantly. If they exist: do emotional landmarks change over time? Do they change according to the observer? To language? To the time of day, week, month or year? Additionally, several groups of *produsers* will be established, based upon social-demographic characteristics, such as: gender; age; education level; motive of trip (leisure, business, e.g.); "level of acquaintance" of the place (*old-timer*, *newcomer*, tourist); origin (country and/or city).

These geospatial practices could highlight how emotions, subjectivities and spaces are mutually constitutive in particular places and at particular times, disclosing the socially encoded meanings of different kinds of bodies in specific spatial,

Figure 2: Conceptual framework



Source: Own source

temporal and cultural contexts. Results could suggest that people's shared feelings about specific places are influenced by the particular physical properties and characteristics of a given place, since this technique could be used to create and maintain spaces that are attractive, inviting and emotionally pleasing to a variety of users.

By engaging an emotion-aware city, new forms of communication can be engaged. Traditionally, the choice of partners for online group communication is either based on pre-existing relationships or based on similar interests or location [8]. In an emotion-aware city, communication groups can be formed spontaneously, based not only on a topic, but also on location and matching emotional state. These type of interactions can start interesting discussions about controversial projects or places within the city, since personal and sensitive issues are best shared with those who fell the same about a specific area of the city, creating participatory movements.

An emotion and stress mapping methodology could lead to understand, assess and evaluate the "immaterial" and emotional dimensions of the city and its spatial expression. GISciences can truly support the development of the *intelligent city* [5], due to crowdsourcing, VGI, AGI, including location-based social networks which stand out as key geospatial data sources indicative of the *pulse of the city.*

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