



Smart City and Images: The Use of Image Hashtags to Get Insights on Citizens

Roberta De Michele¹ and Marco Furini²(✉)

¹ Fondazione Marco Biagi, Università di Modena and Reggio Emilia,
42121 Modena, Italy

roberta.demichele@unimore.it

² Dipartimento di Comunicazione ed Economia,
Università di Modena and Reggio Emilia, 42121 Reggio Emilia, Italy

marco.furini@unimore.it

Abstract. The knowledge of citizens' interests and problems is crucial for the smart management of a city. Up to few years ago, the employment of opinion agencies was mandatory to get this knowledge, but since this process is cost and time consuming, many studies are beginning to exploit social media contents to understand citizens. In particular, the attention is usually focused on textual data, and only few studies consider multimedia contents. In this paper, we investigate whether it is possible to know citizens' interests and problems by using images published in the Instagram platform. In particular, we propose a method that analyzes and measures the importance of hashtags associated to images. The experimental evaluation shows that images could be an important source of information to understand citizens.

Keywords: Smart city · Image analysis · Hashtag classification
Hashtag indexing

1 Introduction

The Internet of Things (IoT) is expected to change the way we live and work. It is a paradigm that envisions a future where people and objects will be interconnected and will be able to communicate each other through suitable protocol stacks [1, 2]. Currently, there are millions of physical objects already connected to the Internet and different research reports estimate that from now on millions of new objects will enter the IoT world every day, reaching the number of 21 billion by 2020 and generating a market of more than \$300 billion by 2020. These objects will contribute to make the Internet even more pervasive than it is today, and they will foster the development of applications able to provide new services to citizens, companies, and public administrations [3–5].

The transformation of a city into a smart city seems to be the solution to the problems emerging from rapid urbanization and urban population growth, as the employment of smart strategies might reduce wastage (e.g., energy, water,

etc.) and might improve services (e.g., public and private transportation, waste management, etc.), resulting in an improvement of the life quality of citizens [6]. Most of the processes, which aim to transform cities, primarily focus on the technological aspect (e.g., sensors, devices, communication protocols, etc.) but, although this is necessary, it is not sufficient to transform the city as a whole. Indeed, to really improve the services offered to citizens and to address challenges of development and sustainability more efficiently, citizens should be involved when designing and implementing strategies to transform a city into its smart version [7–9].

The involvement of citizens necessarily passes through their understanding and usually this task is usually achieved through the employment of opinion agencies that prepare and submit questionnaires to a sample of citizens. In general, these investigations are effective and regard general aspects of daily life (e.g., public transport satisfaction, social safety, etc.); however, they are expensive and time consuming. Therefore, many administrators tend to use these investigations sparingly. Recently, to overcome these problems, researchers are proposing an alternative approach: exploit the large amount of data available in social media platforms to understand citizens [10]. The goal is to use contents published in social media to make decisions that will end in better use of resources, better organization, better citizen lifestyle, better human relations and, eventually, better society.

In literature, one of the most used approach to understand citizens is the analysis of their sentiment in general, or towards specific topics [11–14]. For instance, Nakov et al. [15] exploit tweets and SMS contents to provide insights about the sentiment of citizens; Mitchell et al. [16] used geolocated tweets to measure the social level of happiness in specific locations; Lin [17] used Twitter data to identify the sentiments of people living in the Pittsburgh area; Guo et al. [18] used tweets to understand the influence of socioeconomic and urban geography parameters on happiness. Due to the large usage of multimedia contents [19,20], recently, researchers are considering the analysis of images posted by users on social platforms [21,22].

We are convinced that images can be transformed into an important source of information and, therefore, we propose a method that focuses on the hashtags present within the captions of images and has the goal to identify citizens' problems, topics and places of interests. It is worth recalling that hashtags are community-driven keywords used by people to emphasize contents and to highlight topics; originally introduced in Twitter, hashtags are spreading throughout the entire social scenario. Motivated by the large use of mobile photo sharing applications [23,24], in this paper we propose ICA (Image Caption Analysis), a method that measures and ranks the importance of hashtags within a set of images. By considering the hashtags related to problems, topics and places of interest it is possible to understand what citizens think. To evaluate our proposal, we performed an experimental assessment focused on the Instagram platform. We observed more than 110,000 images related to different Italian big/medium cities (e.g., Milan, Bologna, Florence, Rome and Naples) for a period of 20 days.

The obtained results show the feasibility of our proposal and also show that it is possible to identify citizens' problems and interests through an analysis of the captions of the images. Therefore, the proposed approach might be very useful to city administrators and/or enterprises that want to manage/transform a city into a smart city.

The paper is organized as follows: in Sect. 2 we briefly overview studies that use social media data to understand citizens; in Sect. 3 we present details of our ICA method, which is evaluated in Sect. 4. Conclusions are drawn in Sect. 5.

2 Related Work

Recently, many studies focused on social media data to measure the emotion of people who share data on public platforms. This information is assuming more and more importance in the nowadays scenario, as it might be used to provide better services and/or to manage resources in an urban context. For instance, through this "sentiment analysis", administrators can become aware of unhappy areas, might analyze and identify problems and might implement improvements in services such as public transport, security, recreation, etc. While there are several studies that focused on Twitter, the use of images as a source of information to retrieve insights about citizens is in its early stage and in the following we provide a brief overview of recent studies in this area.

Different proposals focused on images to retrieve information that can be used in the tourist sector. For instance, Xu [25] proposed a method that uses the photos users share in image-sharing websites (e.g., Flickr and Panoramio) to recommend tourist locations. The method does not analyze the contents of the image, but it focuses on the associated metadata: the embedded GPS data are used as the building blocks for the recommendation system. Bojic et al. [26] considered Flickr as a proxy for attractiveness. In particular, they investigated how country attractiveness scales with its population and size using the number of foreign users that take photographs. The proposed method did not analyzed images, but it extracted GPS data to infer the nationality of photographs and to compute the country attractiveness index. Quercia et al. [27] focused on the Flickr platform to design a method that automatically suggests routes that are not only short but also emotionally pleasant. Although based on an image-sharing platform, the proposed method did not consider image contents, but instead they exploited Flickr's metadata. You et al. [28] proposed a methodology to numerically represent the happiness of a city by mining user generated contents in Flickr. In particular, the methodology is based on titles, tags, descriptions, and comments. The obtained results are then compared against real world phenomena including population, crime rate, and climate. Bujari et al. [29,30] proposed to automatically modify the story of a trip by identifying interesting places to visit in the nearby of an itinerary. The developed system combines data associated to Flickr geo-tagged pictures with information provided by WikiLocation. A user study showed that users deeply appreciated the possibility of discovering interesting places located in the nearby of a given itinerary.

Other studies proposed a different focus: the usage of images to retrieve information that can be helpful to city managers. For instance, Abdullah et al. [31] analyzed images available on the Twitter platform, used them as a resource for sensing societal characteristics, and introduced a formalized measure of societal happiness. In particular, they converted to grayscale all the retrieved images and then they applied a smile detection algorithm to detect the happiness of people over a period of time. Liu et al. [32] proposed a method to filter redundant information produced by citizens when using a collaborative system provided by city administrators. They grouped together similar images by analyzing their RGB color histograms and then they extracted all the captions associated to similar images, with the assumption that similar images discuss similar topics. Oliveira and Painho [33] proposed to extract data from Twitter, Flickr, Instagram and Facebook in order to identify the Lisbon citizen's feelings and to help the smart city transformation process by improving urban functions and services. Unfortunately, there are no details regarding the mapping between images and citizens' emotions.

3 Image Caption Analysis

Motivated by the need to understand citizens through social media data and based on the observation that images are more and more used in the social media scenario, in this paper we propose ICA (Image Caption Analysis), a method that focuses on the hashtags associated to images to get insights about citizens.

Our hypothesis is that by collecting a set of images in a specific area (e.g., a city, a district, a street, etc.), the hashtags associated to the images represent an important source of information to identify citizens' problems, topics and places of interests, information that can be very useful in decision making processes. Indeed, as shown in Fig. 1, ICA takes in input a set of images, analyzes all the hashtags available in the set of images and ranks them according to their importance; then it outputs three different lists of information about citizens.

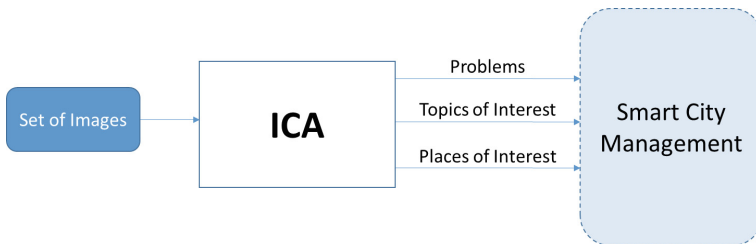


Fig. 1. ICA Scenario: ICA can transform a set of images into useful information for smart city administrators.

The core of the ICA proposal is the measurement of the importance of a hashtag. ICA does not use the number of times a specific hashtag appears within

the dataset to define its importance, as this approach may be misleading. For instance, one may think of a single user who post several images with the same hashtag (e.g., #smog). Although this is the concern of a single user, the analysis would reveal that “smog” is a concern for the whole society. Similarly, suppose the dataset is composed of just two images: one described with the hashtag #food and one described with the hashtag #art. If we consider the number of times the hashtags appear within the dataset, it is impossible to call for the preferred topic.

A possible solution to deepen the understanding of the scenario is to consider the number of likes an image receives. For instance, suppose the #food image received 100 likes and suppose the #art image received no likes, is it still impossible to call for the citizens preferred topic?

In the analysis of hashtags, ICA considers the number of likes a picture receives and defines $Importance(H)$ as a way to measure the significance of a hashtag H within a set of N images:

$$Importance(H) = \sum_{i=1}^N P_i * L_i \quad (1)$$

where $P_i = 1$ if H is a hashtag associated to image i , 0 otherwise; L_i is the number of likes that image i received.

By analyzing and ranking all the hashtags present within the considered dataset, ICA is able to measure the importance of these hashtags. Furthermore, by providing ICA with a set of possible problems (i.e., smog, security, pollution, decay, traffic, etc.), topics (i.e., art, food, architecture, museum, gallery, etc.) and places, ICA can output different lists of information about citizens’ problems, topics and places of interests. Therefore, if a city administrator is interested in the opinions of citizens living in a specific area (e.g., a particular district, a block, a neighborhood, etc.) it is sufficient to collect the images produced in that area and to analyze them through ICA.

4 Experimental Analysis

The first mandatory step to investigate the feasibility of our approach, is data collection. We focused on the images related to big and medium Italian cities (i.e., Milan, Bologna, Florence, Rome and Naples) posted on the Instagram platform. In a period of 20 consecutive days, we observed 110,572 images. Details of the dataset are reported in Table 1, where we also show the number of hashtags used to describe these images.

Looking at the dataset, it is possible to note the large number of hashtags (i.e., on average from 21 to 30 per image) used to describe every image. This confirms that Instagram users make a great use of hashtags to enrich and complete the visual content of images. Therefore, hashtags represent an important source of information to get users’ insights.

ICA extracts all the hashtags used to describe the images of the dataset, and it computes the $Importance$ index defined in Eq. (1). The resulting list of

Table 1. Dataset details.

| City | Number of images | Avg number of hashtags per picture | Number of different hashtags |
|----------|------------------|------------------------------------|------------------------------|
| Milan | 28,761 | 23 | 66,927 |
| Bologna | 13,114 | 21 | 33,376 |
| Florence | 17,718 | 21 | 37,507 |
| Rome | 29,865 | 24 | 68,758 |
| Naples | 21,114 | 24 | 47,918 |

hashtags is then sorted according to the *Importance* index (from the most to the less important one). Then, the hashtags related to problems, topics and places of interests are extracted. It is worth noting that the extraction is currently based on a predefined set of topics and of problems, whereas the extraction of places of interests is based on a separate file that is manually edited using the “Things to Do” list available in TripAdvisor.com. As a future work we plan to automate this process.

Table 2 summarizes the obtained results for the three different categories. Note that the number in parentheses indicates the ranking position, and also note that the ranking position is city-based and not category-based (i.e., ICA produced a list for every analyzed city).

Table 2. Ranking of the identified feelings, problems, topics and places of interests. The number in parentheses indicates the ranking position.

| City | Topic of interest | Place of interest | Problem |
|----------|-------------------|-------------------------------|------------------|
| Milan | fashion (6) | duomo (58) | traffic (4486) |
| | football (26) | galleriavittorioemanuele (97) | trash (8179) |
| | design (29) | navigli (329) | smog (10408) |
| Bologna | architecture (41) | piazzamaggiore (117) | trash (5288) |
| | fashion (45) | sanLuca (526) | traffic (6113) |
| | music (50) | sanPetronio (698) | smog (9608) |
| Florence | architecture (14) | duomo (22) | security (11472) |
| | art (20) | pontevecchio (41) | smog (17785) |
| | fashion (53) | arno (213) | trash (22603) |
| Rome | art (43) | coliseum (94) | traffic (3045) |
| | fashion (44) | vatican (137) | security (10451) |
| | architecture (45) | fontanaditrevis (241) | squalor (17089) |
| Naples | football (10) | teatrosancarlo (501) | fine (89) |
| | fashion (18) | lungomare (525) | traffic (8470) |
| | food (28) | casteldellovo (619) | trash (10112) |

It is to note that we did not perform any tag filtering and therefore the ranking list also has hashtags related to applications used to modify the image (e.g., #instagood, #instagram), hashtags related to brand (e.g., #nikon, #canon, etc.), hashtags associated to specific events or to specific entertainment contents (e.g., #xfactor, #bolognainspired, etc.) and general hashtags (e.g., #Italy, #girl, #city, etc.).

A general look at the results shows that users are not really concerned about problems. In general, problems are very low in the ranking. For instance, in Milan the first problem (traffic) is in position 4.486, in Florence the first problem is security, but it is in position 11.472. The same applies to Bologna (trash in position 5.288) and Rome (traffic in position 3.045). The only exception is about the city of Naples: citizens pay particular attention to fines (position 89).

Results related to the topics of interest show what really matters to citizens. For instance, in Milan “fashion” is high ranked, whereas in Naples people are more interested in “football”. “Architecture” is a popular interest both in Florence (14) and in Bologna (41). Citizens of Naples are also very interested in “food”, whereas Bologna citizens are interested in “music”.

Results related to the places of interest show the most popular places of the city. In addition to the places listed in the ranking, it is interesting to look at their position. For instance, in Naples, the “San Carlo” theater is the most popular venue, but it is ranked at position 501. Conversely, in Florence, the “duomo” (cathedral) is in position 22. It is also interesting to notice the difference within the same city. For example, in Bologna, “Piazza Maggiore” is the highest ranked venue (position 117), but the near “piazza Santo Stefano” (fifth ranked venues, not reported in the Table) is ranked 1029. The two places are 200 meters away, and clearly this indicates a problem in the communication process towards tourists: tourists (and people in general) seem to ignore this place.

In summary, results obtained through the experimental analysis confirmed that a smart analysis of the hashtags provides useful insights about citizens’ problems, topics and places of interest. Although it is difficult to show the importance of the results, as these results are very linked to the knowledge of the city, it is possible to identify two large areas that could benefit from the results produced by the proposed ICA.

- **Smart City.** City Administrators can better manage resources and services as the knowledge of problems, topics and places of interest might be very helpful in decision making processes. For instance, they can monitor the city in a very precise way and they can take effective countermeasures (e.g., more trash-bins where there is a garbage problem, installation of surveillance cameras where citizens perceive a security issue, etc.). To make a particular example, by looking at the places of interest, Bologna administrators can act on public transportation to provide novel services and/or to improve the existing ones (e.g., “San Luca” is a church ranked second among the places of interest, but it is a venue not easy to reach as it is located outside downtown on atop a forested hill). Similarly, Bologna administrators needs to investigate the reasons why two famous venues (i.e., “San Petronio” and the “Towers”) are

not high ranked. In Florence, administrators needs to improve tourist routes (e.g., “Palazzo Vecchio” is ranked to 221 although very close to “Duomo” that is ranked 22).

- **Business.** Companies may take advantage of the knowledge of topics and places of interest to improve or create business opportunities. For instance, local businesses like restaurants and bars may find interesting business prospects around places with the highest ranking; similarly, new business opportunities can be developed around topics in the highest ranking. To make a particular example, in Naples people are interested in “food”, whereas in Bologna there might be business opportunities in the area of music.

5 Conclusions

In this paper, we investigated whether it is possible to use images posted on the Instagram platform to know the interests and problems of citizens. We considered the hashtags present in the captions of the images, and we proposed a methodology to measure the importance of hashtag within a dataset of images. Results revealed the feasibility of the proposed method and confirmed our initial hypothesis that images could be an important source of information for city administrators and/or enterprises.

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