Real Time Rome

Francisca Rojas, Francesco Calabrese, Filippo Dal Fiore,
Sriram Krishnan, Carlo Ratti

MIT SENSEable City Laboratory
10-400, MIT
77 Massachusetts Avenue, Cambridge, MA 02139, USA

phone: + 1 617 253 7926
e-mail: ratti@mit.edu

Abstract

The real-time city is now real! The increasing deployment of sensors and hand-held electronics (such as mobile phones) allows a new approach to the study of cities and the built environment. In the visualizations of Real Time Rome we synthesize data from various real-time communications and transportation networks to understand patterns of daily life in Rome. We interpolate the aggregate mobility of people according to their mobile phone usage and visualize it synchronously with the flow of public transit, pedestrians, and vehicular traffic. This reveals for the first time the relationships between fixed and fluid urban elements: how people use neighbourhoods during the course of the day, how the distribution of buses and taxis correlates with densities of people and how different social groups, such as tourists and residents, inhabit the city - in short, how the formal structure of the city relates with the informal, bottom-up patterns of daily life.

Introduction

"…And then came the grandest idea of all! We actually made a map of the country, on the scale of a mile to the mile!"
"Have you used it much?" I enquired.
"It has never been spread out, yet," said Mein Herr: "the farmers objected: they said it would cover the whole country, and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well…"

Lewis Carroll, *The Complete Sylvie and Bruno*, 1893

Real Time Rome is the MIT SENSEable City Lab's contribution to the 10th International Architecture Exhibition in Venice, Italy, dedicated to Cities, Architecture and Society held in 2006. The project used data from mobile phones, buses and taxis to better understand urban dynamics in real time. By revealing the pulse of Rome, the project shows how visualizations of data generated by everyday digital devices can help us observe the ways people and urban systems use urban space. In the long run, individuals will be able to use tools such as these to make more informed decisions about how they move about their environment and thus reduce the inefficiencies of present day urban systems and open the way to a more sustainable urban future.

Project Statement

In today's world, wireless mobile communication devices are creating new dimensions of interconnectedness between people, places, and urban infrastructure. This ubiquitous connectivity within the urban population can be observed and interpreted in real time through aggregate records collected from communication networks.

The visualizations of Real Time Rome expose the dynamics of the contemporary city as urban systems coalesce: traces of information and communication networks, movement patterns of people and transportation systems, spatial and social usage of streets and neighbourhoods. Observing the real-time city becomes a means to understanding the present and anticipating the evolution of urban environments.

In the visualizations of Real Time Rome we synthesize data from various real-time networks. We interpolate the aggregate mobility of people according to their mobile phone usage and visualize it synchronously with the flow of public transit, pedestrians, and vehicular traffic. By overlaying mobility information onto geographic references of Rome we reveal the relationships between fixed and fluid urban elements. These real-time maps help us understand how neighbourhoods are used in the course of a day, how the distribution of buses and taxis correlates with densities of people and how different social groups, such as tourists and residents, inhabit the city. Using the resulting visualizations, users can react to the shifting urban environment.

Rome's mapping legacy

Real Time Rome fits into a long legacy of depicting the city of Rome through maps. Historical depictions of Rome are superb examples of how maps abstract a single perspective and reveal the dominant ideas about the city at a particular time.

Giambattista Nolli's representation of the city in 1748 is the first iconographic map of Rome (previously, the city had been drawn from a bird's eye view). In detailing the city's streets and the interiors of public buildings as public space, this map illustrates how social and public life was valued in late-Renaissance Rome. From another perspective and another time, Edmund Bacon's (1974) diagrammatic plans of Sixtus V's urban interventions reveal the logic and significance of landmarks for our understanding of the Eternal City.

Today's electronically interactive maps by Google Earth (2006) combine detailed aerial and satellite images, sophisticated zooming-panning abilities and local search functions. These maps are also modifiable by users when combined with geotagged, place-related information. Real Time Rome takes those capabilities further to dynamically reveal the rhythm of the city as it occurs, in real time.

System architecture

For the Real Time Rome project, the MIT SENSEable City Lab obtained mobile phone, bus and taxi data directly from Rome and transformed it into the visualizations displayed at the exhibition hall in Venice by the following means.

From the city of Rome, we collected time-stamped location data simultaneously from the mobile phone subscribers of Telecom Italia, public buses run by the local public transport authority Atac and taxis run by the Samarcanda company. The Telecom Italia network base stations used an innovative location platform called 'Lochness' to collect and process data about mobile phone users throughout the city of Rome in an anonymous and aggregate format using two methods:

1. by measuring Erlang, which describes the amount of telecommunications traffic in a particular area (one Erlang is one person-hour, or the equivalent of one caller speaking for one hour on one phone or two callers speaking for 30 minutes each);
2. by recording and processing with ad-hoc algorithms the signal strength of mobile phones engaged in calls in a particular area of Rome (for this purpose, the city of Rome was divided into a grid of 250 meter by 250 meter squares).

The Atac buses and the Samarcanda taxis carried Global Positioning System (GPS) devices, which calculated each vehicle's location based on GPS satellite transmissions and reported this data to the Atac and Samarcanda servers in real time.

A secure server set up at the MIT SENSEable City Lab in Cambridge, Massachusetts, continuously collected the real-time aggregate mobile phone and GPS data from Telecom Italia, Atac and Samarcanda, and ran custom-designed software to analyze it together with geographic references of Rome – like the satellite maps provided by Google. Computers in the Venice Biennale exhibition, one for each screen, constantly acquired the processed data from the SENSEable City Lab's server at MIT and ran algorithms to visualize the different dynamic maps of the city in real-time. The outcome of this process is shown in figures 2-7.

The Real Time Rome project respects individual privacy and only used aggregate data already collected by communication service providers. At no time could individual users be identified based on the data that was collected and analyzed.

The schematic of the data collection and transfer is presented in Fig. 1.

Screens

Real Time Rome used six different screens or visualizations to present real-time information about the dynamics in Rome. Snapshots of each of these screens are presented in Figures 2-7. Each screen addresses a question about Rome, which in many cases could not have been explored prior to the availability of real-time data produced by the widespread use of digital communication technologies.

Pulse – What are the patterns of use in Rome?

Where in Rome do people converge over the course of a day? This software visualizes the intensity of mobile phone calls in Rome at a given moment and compares it to yesterday's data. Unsurprisingly, this visualization shows how over the course of a day, the intensity of activity moves from the periphery of the city in the early morning towards the central parts of the city as the work day begins. In the late afternoon, that pattern is reversed as people leave work and return to their neighbourhoods.

Connectivity – Is public transportation where the people are?

How do the movement patterns of buses and taxes and pedestrians overlap in the neighbourhoods around the central station (Stazione Centrale)? This software shows the changing positions of Atac buses and Samarcanda taxis indicated by yellow points, and the relative densities of mobile phone users, represented by the red areas. If a tail on a yellow point is long, this means that a bus or a taxi is moving fast. Areas coloured a deeper red have a higher density of pedestrians.

Flow – Where is traffic moving?

This software visualizes the movement of mobile phone callers travelling in vehicles. It focuses on the area around the Stazione Termini and the Grande Raccordo Anulare (Rome's ring road). Red indicates areas where traffic is moving slowly, green shows areas where vehicles are moving quickly, and arrows represent the dominant direction of travel.

Icons – Which landmarks in Rome attract more people?

This software shows the density of people using mobile phones at different landmarks and attractions in Rome such as the Colosseum, and Trevi Fountain. The location in green is the most popular, while the location in red is the least popular. At the bottom of the screen is a week-long data comparison between the most popular site and the least popular site.

Visitors – Where do tourists congregate?

Where are the concentrations of foreigners in Rome? This 3-D software highlights a 24-hour loop of the locations around the Stazione Termini neighbourhood of Rome where tourists are speaking on mobile phones. The software uses SIM card data from the mobile phones in the area to distinguish Italians from foreign visitors.

Gathering – What does Rome look like during special events?

How do people occupy and move through certain areas of the city during special events? This software shows the pre-recorded movements of mobile phone users during two notable events in Rome during the summer of 2006:

- Viewing the World Cup final match between Italy and France on July 9, 2006, and celebrating the arrival in Rome of the winning Italian national team on July 10.
- Madonna's concert in Rome on August 6, 2006.

The software recorded great spikes of mobile phone use during particularly emotional moments during both events. Figure 7 shows people making calls during Madonna's controversial performance in front of a mirrored cross.

Analysis

One of the main contributions of the Real Time Rome project is the development of a visualization tool with the potential to empower individuals and city officials to make decisions using dynamic, location-specific information. Mobile phone data acquired in real time can eventually enable a chain of bottom-up decisions, which can then result in a better use of urban resources.

For example, the screen titled *Connectivity* (Figure 3) indicates how the locations of public transportation and pedestrians evolve simultaneously. For a transit authority, such information could influence the design of more responsive and accurate transit routes to serve riders. For pedestrians, such information could provide a better set of options with which to optimize their mode of transportation and minimize time in transit.

The *Icons* screen (Figure 5) reflects the metamorphosis of spontaneous social gatherings. By showing the concentration of visitors at important landmarks in Rome, we see which destinations are more popular during different times of day or different days of the week. Will standard queuing theory apply so that tourists try to visit less crowded locations? Or, will people attract more people, as Whyte (1988) proposed, with tourists being drawn to the desirability of a venue, thereby increasing the flow of visitors to already crowded locations? If such visualizations were available to residents and visitors in Rome, they could individually decide whether to join or avoid the crowds.

Thus, a database of real-time information can be useful to different audiences at different levels of urban activity – from those city officials charged with logistics like traffic flow or service delivery to individual inhabitants who want to maximize their utility in urban space (by avoiding traffic or by participating in public gatherings). The possibilities of real-time, aggregated, and location-specific information in a city are endless. With Real Time Rome, we hope to both uncover some of these possibilities and set the stage for further work on the use and importance of such information to a city and its population.

Returning real-time information to final users

The Real Time Rome software and visualizations present a novel methodology and tool made possible through the dynamic data that is already being collected by communications and transportation providers. This approach presents both professionals concerned with urban issues and informal networks of urban inhabitants with perspectives on the city that are now made possible due to the proliferation of mobile digital devices. At an academic level, the quality and quantity of data collected through the system provides an unprecedented dataset for testing urban theories of space and mobility. At the level of the urban inhabitant, the availability of this data can spur the development and prototyping of innovative ICT applications for individual users, which can provide people with useful feedback information on the real-time conditions of the city. As Townsend (2006) explains, the availability of context-aware data and computing will allow, "…an interplay between top-down systems for command and control and bottom-up systems for collective action".

From a bottom-up, user's perspective, several questions must be addressed in order to ensure that real-time information feedback services are meaningful and useful to final users:

- Who are the final users? And how does that influence how the data is visualized?

Real time information such as that which is made available through the Real Time Rome project can be useful in different ways to many types of city stakeholders, such as residents, city officials, commercial entities, and research institutes.

- How is real-time information useful to final users?
  Real time, location-based information can be useful for instant decision-making and behavioural change (i.e. changing driving directions after knowing real-time traffic conditions) or for better future decision-making on the basis of aggregate data analysis (as in the case of an assessment of public transportation's level of adequacy to the physical distributions of people on the move, see Section 3.2).

- How and where can users access real-time information?
  In this case it is a matter of exploring available media systems and prototyping new ones such as web-based applications, mobile phone-based applications, urban-sized screens/traffic signal systems, and long-standing media information channels (i.e. radio and TV). Depending on the context, information may be pushed or pulled by final users, with the former being, for example, the case of emergency situations.

- How can real-time information be visually communicated and understood?
  Further research is needed to understand, on a case-by-case basis, which are the most effective media to present location-based information (i.e. texts, visuals, graphs, etc.). Is a map-based format always appropriate?

- How can systems that are already in-place be enhanced with new data and interfaces?
  We need to consider how real-time information can successfully complement or be integrated with existing urban information systems for real-time data collection and diffusion, such as, for traffic monitoring, on-site traffic cameras/webcams and on-site direct reporting.

- How can existing regulations and/or practices hamper the acquisition and diffusion of real time information?
  Privacy policies for data management should be taken into account and new information management routines should be developed and implemented to benefit urban information feedback systems.

Most of these considerations seem to be outside the current debate with the exception of privacy issues. These are being publicly debated and cotrolled due to the fear that digital information and media are both bringing about a 'big brother' society and making people vulnerable to exploitation by cyber criminals.

In the European Union (EU), the privacy issue is regulated by a 2002 Directive by the European Parliament and Council, which allows location data to be processed by Telecom operators if the data is anonymous (or available with the consent of the mobile phone customer) and if the data is collected for the provision of a value-added service (European Union, 2007). If the availability and transformation of location-based data into real-time information about urban processes is considered to add value to urban life, then the Real Time Rome project falls within the guidelines of existing EU privacy regulations.

In order to harness all of the potential social utility of real-time information, we believe that a flexible framework of rights and duties must be tied to private information management, necessarily around the concept of 'informed consent'. The Creative Commons movement provides a positive example wherein the producers of information decide how 'open' their data or 'content' is in terms of what information to release, to whom and for what purposes.

Taking a step forward from the simplistic 'all rights reserved' versus 'no rights reserved' model, users could allow their telecom operator to access their location anonymously for the purpose of gathering data on urban processes to be managed by a not-for-profit research institute, but concurrently deny access to commercial third parties interested in targeting them with location-savvy advertisements. Ultimately, the individual decides how the data they produce over the course of their daily activities is used by the command and control systems of the city. Conversely, individuals could collaboratively contribute to, and access, bottom-up, community-based urban information systems by using open source tools through their mobile phones or other ICT devices. A real time, iterative 'folksonomy' of the city could develop over time where individuals, '…dynamically create context using very informal and open vocabularies, by uploading content and describing it with contextual tags'. (Townsend, 2006).

Conclusion

In summary, the Real Time Rome project makes the following contributions to our understanding of urban processes:

1. An unprecedented, dynamic perspective on the use of urban space over time
2. A real-time visualization of urban flow in various dimensions (intensity of pedestrian use of urban space, density of transportation mobility, etc.)
3. A first step in realizing the potential of creating a real-time, information feedback loop to both top-down and bottom-up systems in the city.

We hope that with the presentation on Real Time Rome, we have brought about another step towards the 'Internet of things.'

Acknowledgements

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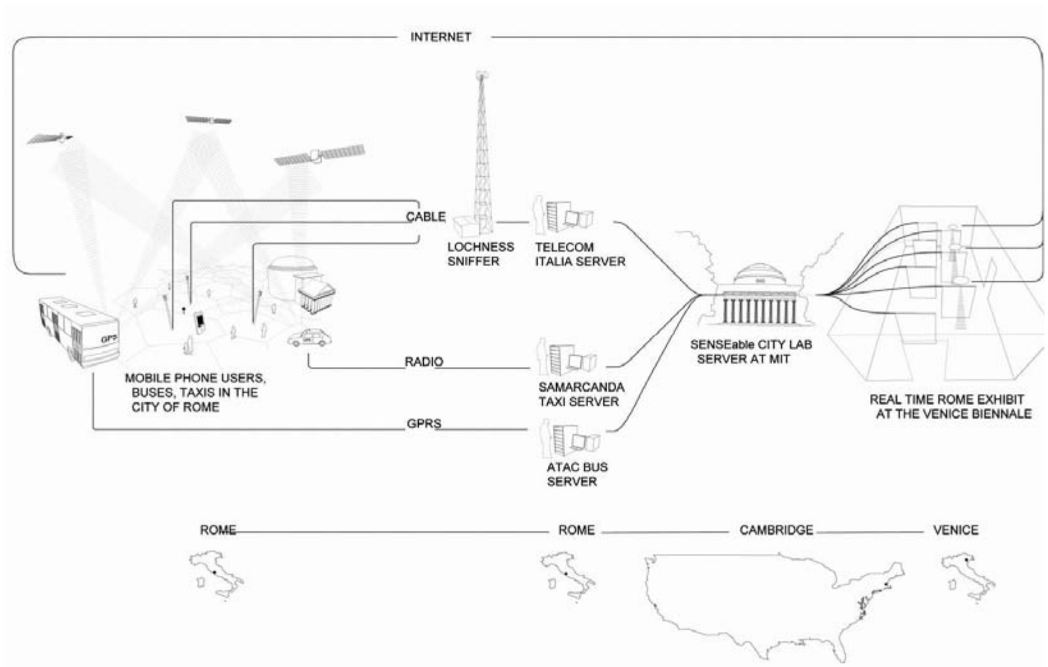

Fig. 1. Schematic of the data collection and transfer

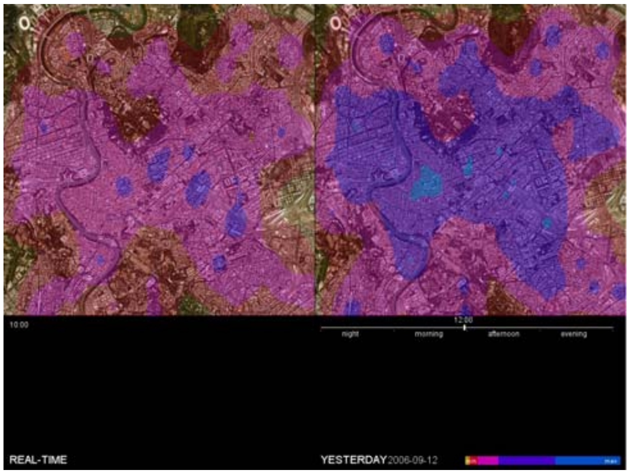

Fig. 2. Pulse

Fig. 3. Connectivity

Fig. 4. Flow

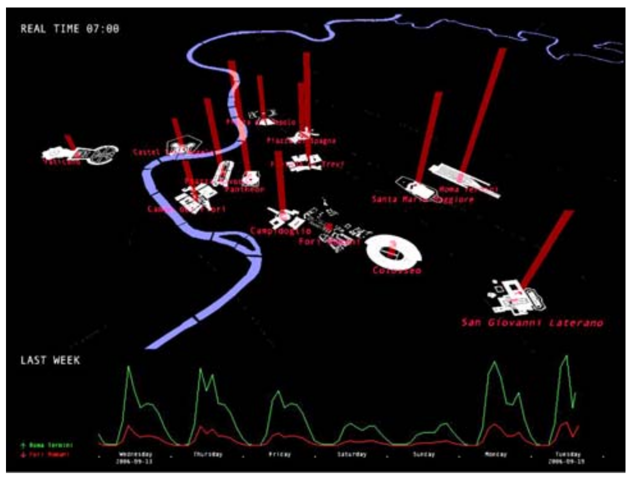

Fig. 5. Icons

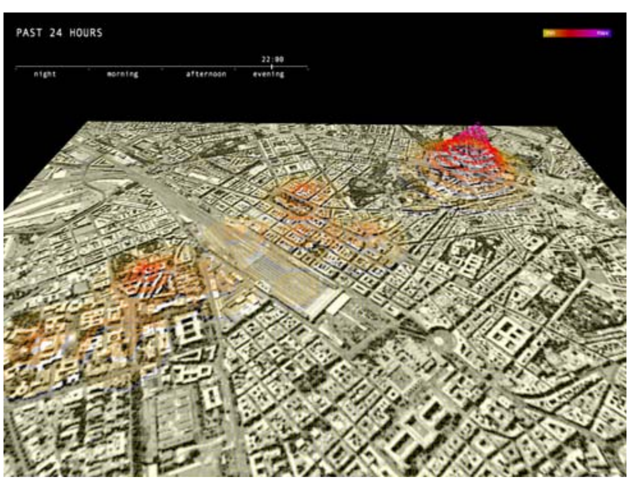

Fig. 6. Visitors

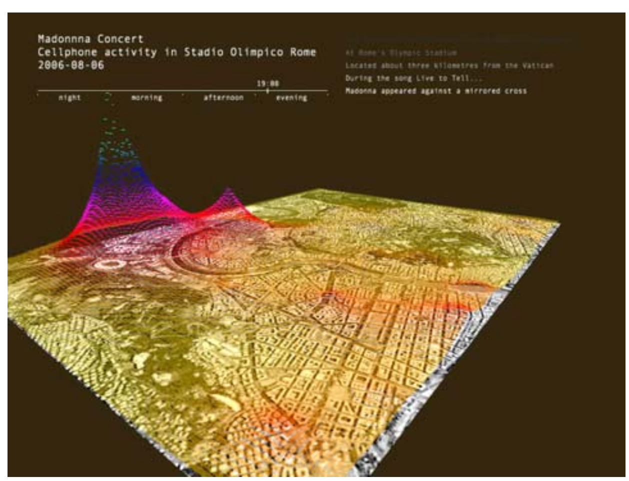

Fig. 7 Gathrings