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A Biologically Inspired Representation of the Intelligence of a University Campus

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Abstract
Intelligence or smartness in an urban environment implies several factors directed to improve quality of life and efficiency. It is important to note that in this context the inclusion of citizens and their devices is a key factor for reaching smartness. Data from mobile devices are increasingly used in everyday activities and have to be considered a useful means for handling and analyzing knowledge and communications. This paper shows how to represent important data when dealing with smartness by creating an analogy between the representation of human brain areas, activated when specific tasks are performed, and groups of students when behaviors or needs arise. The brain traffic concepts have been used for representing data and information exchanged in the University of Palermo campus.

Keywords: Smart cities, Brain representation

1 Introduction

What does it mean to be intelligent, or smart, in an urban context is still an open question. Several different definitions of intelligent city have been proposed in the literature [9][7][13]. The proposed descriptions typically refer to one or more factors of a smart paradigm described by items like economy, mobility, environment, people, living, governance. Smartness thus resides on the capability of problem solving in an urban context by one or more of the cited axes. Nevertheless, an accepted definition of intelligent city is still a debated concept.

A comprehensive definition has been proposed by Komnios [8]: "Intelligent cities (communities, clusters, districts, multi-cluster territories) outline a new planning paradigm pertinent for urban-regional development and innovation management".

Thus, smart cities or communities, aim at optimizing and innovating public services to improve citizens' quality of life and to satisfy needs and demands of citizens, enterprises, and institutions.

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Moreover, Komnios highlights the capability of a smart city to learn and innovate through the digital infrastructures that allow the communication and knowledge management.

However, this is still a long-term vision rather than a reality: a vision of cities, or contexts, where the needs of people are immediately satisfied. It remains an open question how these goals could be reached.

Discussions in this field concern different arguments within the research area of smart cities. For instance, the problems related to the development and implementation of novel technologies are today a mainstream debate. An important feature of smart cities is related to the network infrastructure as a mean to improve the efficiency of the city from the political and economic point of view. Above all, the problem is how to foster the social, urban and cultural development of a city [7].

Networks infrastructures should be analyzed and studied not only from a technological point of view but also from the methodological and theoretical perspective concerning the knowledge and the data management they imply. Latest technological advancements radically changed the way knowledge is produced and managed in a city. Today, a huge number of citizens own and use smart devices. These smart objects make oneself recognizable and moreover, they can communicate data and have access to information from other similar items. Thus, citizens own an active role towards the realization of city smartness.

In the urban development, citizens have an important social role: they may be included in public services managed by innovative apps deployed in smart devices. Then, citizens are vital actors for the co-designing of services and for the changes needed to reach smartness [4].

The realization of a smart city implies a novel way of managing knowledge and innovation in the urban context. It is then vital to understand how cities are changed and may change, how the vast amount of data and information may be managed to figure out in which direction urban creativity and smartness may go together and how to handle them. To figure out how the new paradigm of *Augmented City* may be realized [5]. A city where the enhancement of life goes beyond the pure employment of technology but refers to a connection of spatial, social, cultural and economic forms.

It thus becomes necessary to represent the flow of data and information within a city to plan the urban policies and identify values and potentiality. Urban systems are complex and interactive entities that need to be investigated in an integrated fashion.

There is thus the need for a systematic and methodical approach that starts from data and communication knowledge and management toward the implementation of intelligent activities satisfying people's needs.

In this paper, inspired by the "brain traffic" representation (Taylor et al [11]), we propose a biologically inspired model for analyzing and managing these data. Then, we show a preliminary experiment on representing aggregate data exchanged among students in the University of Palermo campus (UNIPA campus). Along this work the UNIPA campus will be considered as a small city district.

The rest of the paper is organized as follows, in section 2 Taylor et al.'s work is briefly introduced, in section 3 the biologically inspired analogy is explained along with an example of data representation and in section 4 some conclusions are drawn.

2 Representing Functions of the Brain Modules

Taylor et al. [11] combined two different approaches (brain topography and neural modeling) to represent and model the tight interactions among different brain areas during the solution of a task. Their objective is to explain how neural modules interact in the brain and which function they perform while a task is activated.

They primarily discussed the question on what are the roles of the several brain modules involved in cognitive functions. In particular, they analyzed the interactions among brain modules during memory tasks.

The problem was to understand the brain operations by the representation of the network of modules performing suitable functions. After the acquisition of brain imaging data by PET or fMRI, they employed the structural equation modeling (SEM) to analyze the acquired brain images [10][3].

SEM is a mathematical technique that allows to analyze statistical data in situations where multiple random variables are involved. SEM allows inferring the so-called "latent variables" starting from a representative model of some observable and measurable variables: the latent variables depend on the observable variables. As a trivial example, intelligence is not physically measurable; however, in psychology, researchers elaborated techniques, based on specific questions (observable variables), that employ SEM to analyze intelligence.

The representation of the paths among variables that represents the areas activated by tasks, allows to infer suitable values about the interaction between modules, about the convergence of information in the brain and the existence of convergence zones. Taylor et al. employed the notion of "brain traffic" associated with the brain modules to guide SEM analysis.

3 UNIPA Campus as a Brain

Inspired by the previously described work by Taylor at al., we claim that, as in the human brain the flow of data carried by the blood, oxygen and so on, converges into the brain areas related to suitable tasks, the same happens by analogy with data exchanged among citizens or groups of them in an intelligent city. In brief, we propose the analogy of brain traffic with smart city data traffic.

According to this analogy, data spontaneously aggregate, locally and semantically, on arguments, events or themes. This aggregation is the signal of emergent behaviors or needs to pay attention in order to enhance the quality of life of the city area.

Our long-term objective is planning and design of an intelligent campus, and therefore, we consider the UNIPA campus like a brain where brain traffic approach is applied. In doing so, we perform the following steps: *(i)* representing the flow of information among students; *(ii)* representing emergent phenomena and needs; *(iii)* analyzing variables and events generating emergent phenomena and needs; *(iv)* activating all the tasks that allow *UNIPA* to acquire, as a whole, an "intelligent" behavior.

Figure 1 briefly shows the analogy: on the left the Taylor's approach on the human brain is sketched whereas on the right our approach applied to UNIPA campus is depicted.

It is worth noting that functions in the brain trigger suitable tasks, and each task is, in turn, the answer to some urgent or delayed need of the human organism. In the same way, in the proposed analogy, the UNIPA campus needs are satisfied by automatically activating suitable tasks in response to the necessities underlined by the flow of information among groups. Similar to the blood flow in the brain, we take into consideration the flow of messages from the students in the UNIPA campus. In particular, we consider suitable messages and data extracted from Twitter and Facebook groups.

Our reported results have been reached by employing the Gephi software [2] that helped us to understand how graph representations of the flow of messages can be interactively analyzed in our framework. In the literature the adoption of graph representation is well known in the

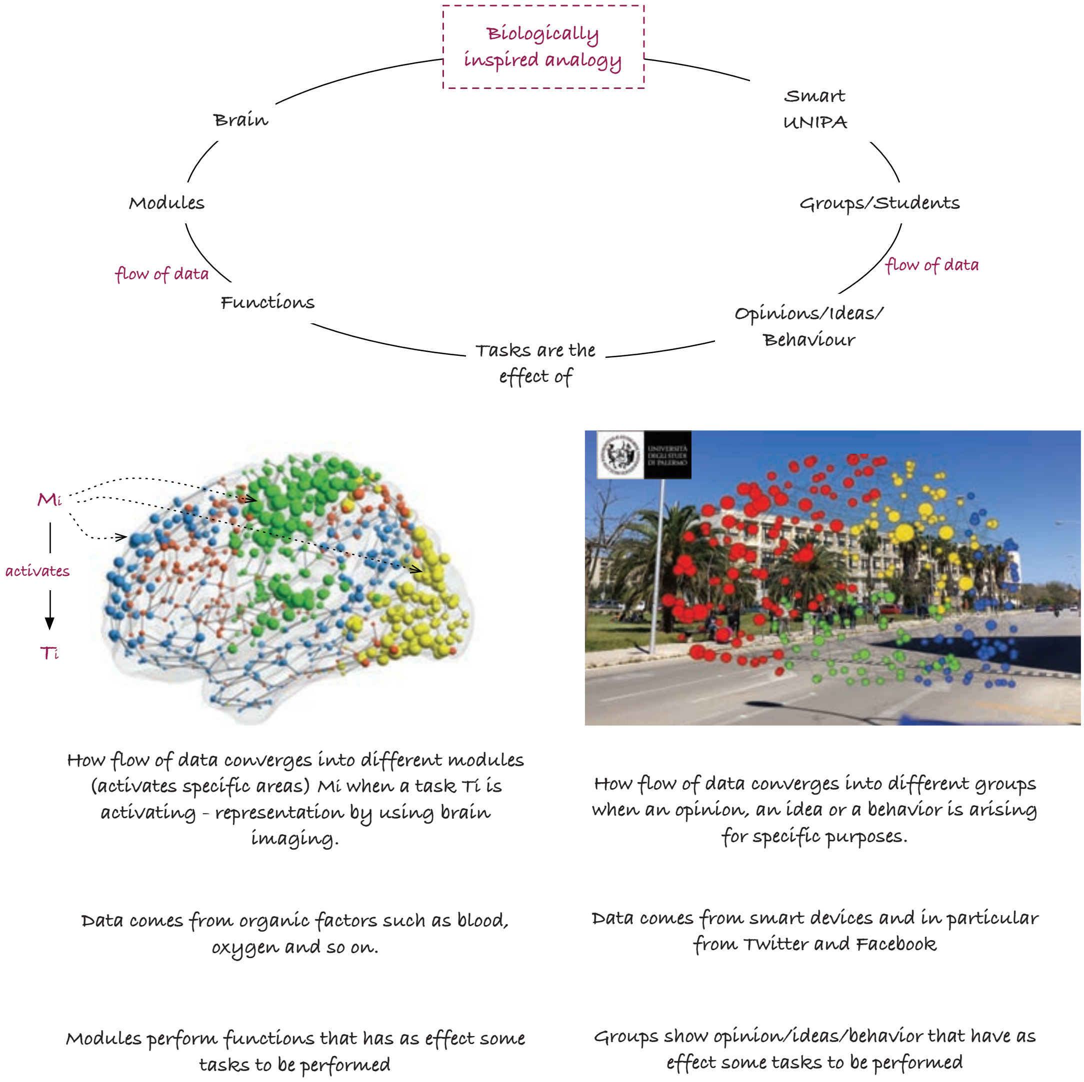

Figure 1: The Biologically Inspired Analogy between Brain and UNIPA

areas of social science and simulation of behavior, see e.g. behavior of crowds. But we go one step further, and we aim to have a tool allowing us to answer to these questions:

- how many connections among different groups for a given argument?
- how are groups localized?
- when and how much do connections among groups suggest the emergence of a social phenomena? Which are the interested parameters?
- can we measure the capability of adaptation on the basis of the emergent phenomena?
- does a complex system adapt in a passive fashion or by evolving itself?

To answer these questions, we firstly need a suitable representation and analysis of data.

3.1 Data Representation

In the context of the UNIPA campus, messages on Facebook and Twitter have been used as a source for identifying observable variables to be used for inferring knowledge on latent variables.

Firstly, we analyzed a great amount of data and used a set of existing tools, such as Netvizz, for retrieving and exporting data to format compatible with software like Gephi. Then, we employed reading techniques [12][1] for data extraction in order to identify possible observable variables to represent in the form of a graph. The graph is then used for carrying out analysis and statistics.

Particularly, data representation with Gephi allows to set several parameters and algorithms for the graph visualization. Moreover, novel plugins may be implemented for performing specific analysis or for applying particular algorithms.

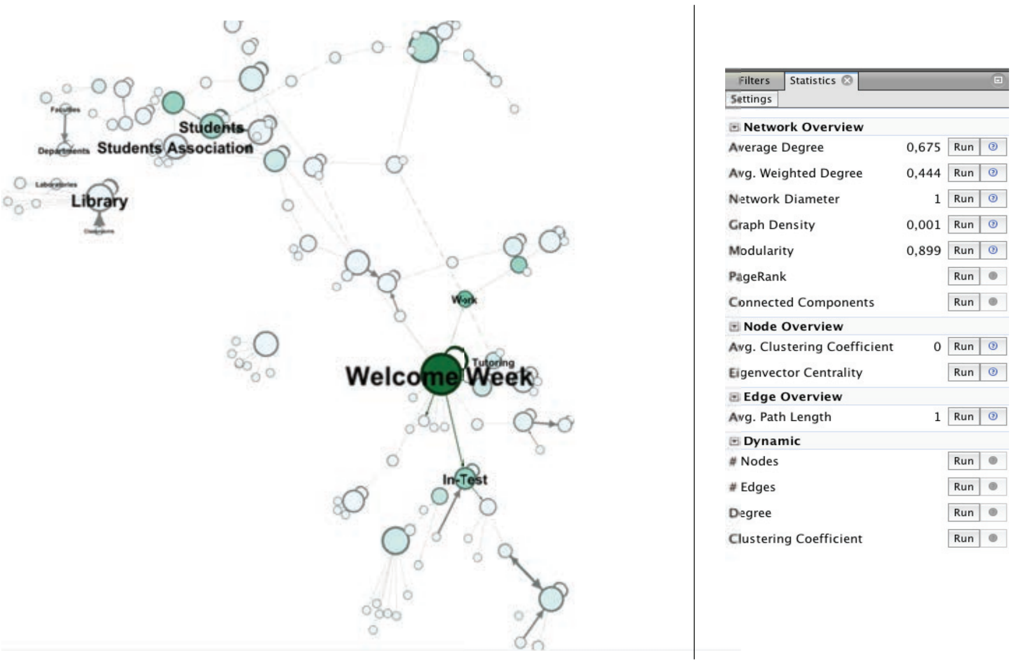

Figure 2: A portion of Gephi Representation on Communication about *Welcome Week* event

The graph reported in Figure 2 shows an excerpt of the data retrieved from Facebook during the *Welcome Week* event in the University Campus and some statistics on the graph. For clarity reasons, we show only few labels and use as main parameter the numbers of *likes* received by each post. Each node represents a post about an argument and its dimension represents the number of likes it received; edges represent relationships among different arguments with a weight (the line width) representing how many times the argument has been discussed. Arguments correspond to observable variables. For instance, the *Welcome Week* event is related to arguments such as *Tutoring*, *In-Test* and *Work*; the dimension of nodes reveals that students attending the *Welcome Week* event are much more interested to the entry tests to the university courses than to the possibility to have a tutor during their study. Moreover, students are more interested in the possibility to study in libraries and to be in some student associations rather than in knowing the structure of the university (departments and so on).

From this very trivial and little example, we may obtain results representing some needs to face and then the indication of some tasks to perform in order to improve efficiency and the quality of life. In our vision tasks may be automatically activated by apps.

4 Conclusions

The work presented in this paper is the first step of a long-term project aimed at designing an intelligent campus. Students with their smart devices provide a great amount of data to be used and elaborated for different purposes, mainly for enhancing quality of life and efficiency. Especially, for a first experiment, we handled the flow of data exchanged through social networks (we mainly used Facebook and Twitter) and employed a biologically inspired analogy with the “brain traffic” concept.

The UNIPA campus is assimilated to a human brain where the flow of blood grows when specific tasks are activated for performing functions. The same happens to data and information among students when a behavior or a need emerge. Data flow within the campus is represented and analyzed using Gephi and the structural equation modeling.

In the future, we plan to refine techniques for data retrieving and for the creation of the Gephi data set and to implement plugins for applying various SEM-based measures.

Moreover, a further improvement in the data analysis may be reached using Agent Based Modeling [6] paradigm which representation and simulation of complex systems ground in.

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