Chapter 1

UNDERSTANDING AND PREDICTING HUMAN BEHAVIOR FOR SOCIAL COMMUNITIES

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1. Introduction

Over the last years, with the rapid advance in technology, it is becoming increasingly feasible for people to take advantage of the devices and services in the surrounding environment to remain "connected" and continuously enjoy the activity they are engaged in, be it sports, entertainment, or work. Such a ubiquitous computing environment will allow everyone permanent access to the Internet anytime, anywhere and anyhow [1]. Nevertheless, despite the evolution of services, social aspects remain in the roots of every human behavior and activities. Great examples of such phenomena are online social networks, which engage users in a way never seen before in the online world. At the same time, being aware and communicating context is a key part of human interaction and is a particularly powerful concept when applied to a community of users where services can be made more personalized and useful. Altogether, harvesting context to reason and learn about user behavior will further enhance the future multimedia vision where services can be composed and customized according to user context. Moreover, it will help us to understand users in a better way.

However, despite all the technological revolutions, for the end user (Humans) it is the perceived Quality of Experience (QoE) that counts, where QoE is a consequence of a user’s internal state (e.g., predispositions, expectations, needs, motivation, mood), the characteristics of the designed system (e.g., usability, functionality, relevance) and the context (or the environment) within which the interaction occurs (e.g., social setting, meaningfulness of the activity) [2].

Dealing with the previously enumerated challenges and trying to achieve the aforementioned goal, we propose an architectural framework and a methodology, which together will pave the way to understand and predict human behavior in future multimedia systems. Furthermore, our work overviews some application scenarios, which could benefit from such innovation, namely advertising, augmented reality and self-awareness systems.
2. User Data Management, Inference and Distribution

Current service creation trends in telecommunications and web worlds are showing the convergence towards a Future Internet of user-centric services. In fact, some works [3] already provide user-oriented creation/execution environments, but these are usually tied to specific scopes and still lack the capability to adapt to the heterogeneity of devices, technologies and the specificity of each individual user. Based on these limitations, the research in [4] identifies flexibility and personalization as the foundation for users’ satisfaction, where the demand for different types of awareness needs to be present across the entire value chain of a service.

Despite most initiatives require or propose some sorts of user profile management systems; these are usually proprietary and include limited information about user preferences and contexts. Therefore, in order to apply user information across a range of services and devices, there is a need for standardization of user related data and the architecture that enables their interoperability. These efforts have been seen at both fixed and mobile worlds and are usually taken under the European Telecommunications Standards Institute (ETSI), the Third Generation Partnership Project (3GPP), Open Mobile Alliance (OMA), among others. Considering data requirements from a wide range of facilities and from different standardization organizations, the concept of Common Profile Storage (CPS) is defined by 3GPP in [5] as a framework for streamlining service-independent user data and storing it under a single logical structure in order to avoid duplications and data inconsistency. Being a logically centralized data storage, it can be mapped to physically distributed configurations and should allow data to be accessed in a standard format. Indeed, several approaches have been proposed to guarantee a certain interoperability degree and can be grouped into three main classes: the syntactic, semantic and modeling approaches. The work in [6] proposes a combination of them to enable interoperability of user profile data management for a Future Internet.

Independently from the technology, all systems should allow user related data to be queried, subscribed or syndicated and ideally through web service interfaces. However, standardization, interoperability, flexibility and management are not the only challenges. To improve the degree of services personalization it is important to generate new information from the existing one. In this sense, social networks, user modeling and reality mining techniques can be empowered to study patterns and predict future behaviors. Consequently, all the adjacent data necessary to perform such operations must be managed within the scope of a user/human profile. Nevertheless, due to the sensitiveness of the information we are referring to, it is important to efficiently control the way this information is stored, accessed and distributed, preserving users privacy, security and trust.
With the aim of inferring users needs, desires or intentions, several research initiatives from different fields (e.g., eHealth, Marketing, Telecoms) are starting to become a reality. Despite the different methodologies and approaches, the user requirements and the technologies involved to address the problems are usually the same. They commonly involve social network analysis, context-awareness the data mining. The basic motivation is the demand to exploit knowledge from various amounts of data collected, pertaining to social behavior of users in online environments. A prime example of this are the research efforts dedicated towards the Enron email dataset [7]. Together, these techniques proved to be useful for analysis of social network data, especially for large datasets that cannot be handled by traditional methods.

Real world situations usually have to be derived from a complex set of features. Thus, context or behavior aware systems have to capture a set of features from heterogeneous and distributed sources and process them to derive the overall situation. Therefore, recent approaches are intended to be comprehensive, i.e. comprise all components and processing steps necessary to capture a complex situation, starting with the access and management of sensing devices, up to the recognition of a complex situation based on multiple reasoning steps and schemes. To handle complex situations, the concept of decomposition is applied to the situation into a hierarchy of sub-situations. These sub-situations can be handled autonomously with respect to sensing and reasoning. In this way, the handling of complex situations can be simplified by decomposition [8]. Another similar perspective is called layered reasoning, where the first stage involves feature extraction and grouping (i.e., resulting in low-level context), the second event, state and activity recognition (i.e., originating mid-level context), while the last stage is dedicated to prediction and inference of new knowledge [9]. In what concerns social networks, research usually focuses on quantifying or qualifying the relationship between peers, where algorithms such as centrality and prestige can be used to calculate the proximity, influence or importance of a node in a network [10], while clustering and classification can be applied to similarity computation, respectively [11], [12]. In addition, when user related data is associated with time and space dimensions, by empowering data mining techniques it is possible to find hidden patterns that can be used in any of the previously identified stages of reasoning.

In this sense, combining all of pre-enunciated concepts with ontologies and semantic technologies, we present a generic framework for managing user related data, which, together with a specific methodology will pave the way to understanding and predicting future human behavior within social communities.
3. Enabling New Human Experiences

After over viewing how the challenges related with the user data management and new knowledge inference are dealt, it is important to understand what are the technologies behind it, how to link them and what can they achieve when combined in synergy. Altogether, dealing with different aspects, they are capable of covering both the emotional and rational aspects inherent to human behavior.

3.1 The Technologies

Social Networks
Humans in all cultures at all times form complex social networks; the term social network here means ongoing relations among people that matter to those engaged in the group, either for specific reasons or for more general expressions of mutual solidarity. Likewise, social networks among individuals who may not be related can be validated and maintained by agreement on objectives, social values, or even by choice of entertainment. They involve reciprocal responsibilities and roles that may be altruistic or self-interest based. Usually, network members tend to trust and rely on each other, and to provide information that other members might find useful and reliable. Social networks are trusted because of shared experiences and the perception of shared values and shared needs [13]. This phenomenon has recently created and converted existing online communities into complex online social networks. Although the behavior of individuals in online networks can be slightly different from the same individuals interacting in a more traditional social network (reality), it gives us invaluable insights on the people we are communicating with, which groups are we engaged, which are our preferences, etc.

Reality Mining
To overcome the discrepancy between online and “offline” networks, reality mining techniques can be empowered to approximate both worlds, proving awareness about people actual behavior. It typically analyzes sensor data (from mobiles, video cameras, satellites, etc) to extract subtle patterns that help to predict and understand future human behavior. These predictive patterns begin with biological “honest signals,” human behaviors that evolved from ancient primate signaling mechanisms, and which are major factors in human decision making [14]. In fact, these systems enable us to have the “big picture” of specific social contexts by aggregating and averaging the collected data (e.g., identify and prevent epidemics). Moreover, it allows data/events correlation and consequently future occurrences extrapolation.

Context-Awareness
In today’s services, the sought to deal with linking changes in the environment with computer systems is becoming increasingly important, allowing computers to both sense and react based on their environment. Additionally, devices may have
information about the circumstances under which they are able to operate and based on rules, or an intelligent stimulus, react accordingly [15]. By assessing and analyzing visions and predictions on computing, devices, infrastructures and human interaction, it becomes apparent that:

a. context is available, meaningful, and carries rich information in such environments,
b. that users’ expectations and user experience is directly related to context,
c. acquiring, representing, providing, and using context becomes a crucial enabling technology for the vision of disappearing computers in everyday environments.

3.2 Architectural Framework and Methodology

In order to enable human behavior understanding and prediction, there are several independent but complementary steps that can be grouped into three different categories: Data Management, New Knowledge Generation and Service Exposure and Control. Figure 1 depicts these relationships as well as the sequence of activities involved.

Figure 1. Human Behavior Understanding and Prediction process.

Data Management

This activity usually starts with data acquisition. This process involves gathering information from different information systems. In our experiments we included user preferences, social networks, devices, policies, profiling algorithms, external contexts, as well as reasoned and predicted knowledge. Figure 2 exemplifies the type of information that can be stored in the Human Data Repository, a set of...
properties build within a generic structure that allow services of the future to use user related information, while respecting their privacy, needs and concerns.

Due to real systems limitations, data is usually not captured without errors, therefore it is necessary to pre-process it in advance (before mining), otherwise it would not be possible to correlate information correctly. Once this is done, data is mined by using two different approaches: the first, uses know statistical algorithms to help pattern recognition and consequent algorithmic modeling, the seconds uses the opposite approach, where specific algorithms are designed to identify patterns in the data (this requires previous modeling). Combining both, allows us to address the specifics of our applications, but at the same time automatically detect new relevant correlations that might occur after a few iterations.

![Figure 2. Example of information to be stored in the Human Data Repository.](image)

**Knowledge Generation**

New information inference is based on user related data, which we call context and can be separated into three different categories: real-time, historical data and reasoned context. Nevertheless, only real-time information is considered as context in the real meaning of this term. As illustrated in Figure 1, there are several layers of abstraction in a context-aware system and any context-aware middleware or architecture must therefore be capable of building representations and models of these abstractions. However, these high-level abstractions can only be made...
from lower level context, which requires some form of context management function (performed by a Context Broker). In our case, this is performed at the Human Data Repository.

The main context management features are context acquisition, context aggregation & fusion, context dissemination, discovery and lookup. In order to manipulate context information, it must be represented in some form that is compatible with the models that will be used in the reasoning and situation recognition processes. These models could be object oriented, ontological, rule based, logic based, based on semantic graphs or fuzzy logic sets. Expressing context using just one representation is almost impossible since the range is from the most specific, for example a temperature reading, to the most abstract, the state of happiness. Furthermore, the representation must lend itself to the reasoning and inference techniques to be used, such as classification, filtering, aggregation, feature extraction, taxonomies, data mining, clustering, pattern recognition and prediction. Reasoning mechanisms allow high-level context to be deduced or situations to be recognized and often, the output of one process can be used as an input to another. Moreover, reasoning is also used to check the consistency of context and context models.

Transposing this ideology to the methodology presented in figure 1, once the data is prepared, it is run through a set of algorithms and ontologies (which also make use of existing semantics systems), which were designed to predict intermediary states (e.g., mood, stress, receptivity, engagement, etc.), used to infer human behavior. Afterwards, the information is passed to the prediction engine, which, de-
pending on its configuration, reasons new possible behaviors. It is very important to stress that the prediction does not necessarily anticipates the user wishes or desires, but a possible future that could be interesting to the user.

Service Exposure and Control

The third layer is divided into two main capabilities. The first is user-centric and relates to the ability of the user to stay in control of the whole scenario, enabling it to specify when, what, why, who, where and how the data is or can be accessed. This opens the doors for opportunistic communications, as user context is disclosed according to contextual privacy policies and settings, enabling systems and devices to sense how, where and why information and content are being accessed and respond accordingly. Furthermore, through the Human Enabler, users are able to influence the way their behavior is predicted, by controlling how there are being profiled (automatic, off, manually personalized). In an extreme situation, they can build their own profiling algorithms. In fact, people will wish to manage their identities in different ways, sometimes opting for full disclosure, at other times disclosing it only in an anonymous way to preserve their privacy. This is essential for establishing and managing trust and for safeguarding privacy, as well as for designing and implementing business security models and policies. The second set of features is associated with the capacity of exposing this information (both raw data and inferred one) to 3rd party service providers (such as advertising agencies), through well-defined web service interfaces. Once again, always considering the users privacy restrictions. Besides exposing user related information, the human enabler allows data to be subscribed, syndicated or updated on request.

3.3 Innovations

The analysis of the first results indicated the following key findings:

- It is possible to infer user behavior based on user preferences, social networks and context-aware systems, with the help of reality/data mining techniques.
- Proximity and Similarity are great weight indicators for inferring influence and can be computed or calculated analytically.
- Both online and offline social networks have influence over a person’s behavior.
- User perceived QoE is improved as the methodology delivers personalization, contextualization, interactivity, adaptation and privacy.
- Users are willing to participate in their own profiling experience and the results are positive.

Applying these techniques into different fields of computer social sciences may have significant applicability in different parts of the value chain. Here are some examples:
• Infer and suggest missing information in users profile according to his/her peers contextual information.
• Understand how a specific user can be influenced by another user or community and vice-versa.
• Understand how similar two users are, even if they don not have friends in common.
• Infer strengths of relationships by analyzing interactions within multimedia content available on social networks.
• Improve visualization of social relationships according to a set of known or inferred parameters.
• Improve users perceived Quality of Experience by focusing on aspects such as personalization, contextualization, interactivity, adaptation and privacy.
• Enable users to participate in their own profiling experience.
• Leverage user behavior predictions to be accessible to 3rd party providers while concerning user privacy, preferences, desires and intentions.
• Improve recommendation systems as ideally predictions usually correspond to what users want, need or desire. In other words, it is a personalized and automated electronic word of mouth that reasons contextualized information for a specific user or set of users.

4. Applications

When applying the previously introduced framework to real-world scenarios, its applications are countless. Nevertheless, in this article we will be focusing on social communities. The first one presents a new way of interacting in a new immersive social experience, while the second shows how it can be used to visualize social self-awareness. The last one introduces a simple use case that illustrates how it can be used to improve existing business models and consequently generate revenue when applied to an advertising scenario. From the applications described, although the information leveraged by them is available and can be reasoned by the proposed framework, it was not yet tested in the presented scenarios.

4.1 The Augmented Social Experience

Merging a set of different social networks and different context providers into a single interface is not new, yet challenging and in vogue. What if there was a way for users to simply point their mobiles at people and automatically know more about them? By combining the proposed solution with facial and object recognition techniques, it is possible to emerge in a new way of interacting with people. Figure 4 provides some examples of what could be possible to achieve. In scenario a), the user wants to know more about the publicly available information regarding the Facebook profile of the person currently being tracked, while b) on the
other hand provides basic profile information that the person in the picture decided to share at that precise moment within that context, improved with the system inferred information. Case c) presents a summary of keywords that better define a someone’s profile within the Digg community (this could give a quick overview of someone’s interests). In this sense, we can see that the services presented can be provided directly by the Human Data Repository (exposed by the Human Enabler) but at the same time can be a combination of previously reasoned information with specific application data itself.

As mentioned earlier, all the information disclosed by the user is dynamically managed by himself and can be updated in real-time. Depending on the time of the day or event the user is attending, he can decide which information can be retrieved by the system. Such application will also help to promote collaboration and enrichment of existing content, as it can provide the interface to interact with it and consequently the user himself. If the user does not have permission to edit the content, he can still tag it by associating an event to it. Such ubiquitous augmented reality scenarios will become possible and we will embrace a new era of context-aware social communications. Furthermore, depending on the type of ontologies deployed on the system, the amount of inferred information can vary. While figure 3 introduces a couple of examples, by combining different contextual information, the possibilities are unlimited.

Figure 4. Example of a Human Social application: a) Facebook option, b) Personal Profile option, c) Digg option.
4.2 Future Self-Awareness

A creative integration of emerging digital technologies and the appropriate methods of futures studies enables the creation of an adaptive and context-sensitive personal future simulation system. Such a system can be used to produce comprehensible and informative future simulations by utilizing the unprecedented amount of continuously cumulating personal digital data. These future simulations should be generated using the standards and principles that have been negotiated and approved by the users of the system.

The emerging future simulation consists of interconnected interactive micro future scenarios that depict an individual’s future, focusing on her daily activities, decisions and choices. Educational simulations provide additional context-sensitive information, alternative future paths and recommendations based on an individual’s personal circumstances and environment. The creation of comprehensible micro future scenarios is based on an effective analysis and processing of the personal data deriving from the versatile networked digital environments and personal digital applications like social networking sites, micro blogging services, community platforms, information management systems, email programs and web browsers.

The creation of a functional digital future simulation system would enable new ways to approach the future from personal and social perspectives. Through an adaptive future simulation system — implemented as an active part of an individual’s life — the “future discourse” could have comprehensible everyday applications and concrete consequences at the level of everyday choices and decisions. The future simulation would become a platform for the emergent personal and social intellectual processes. Informative and interactive micro scenarios could connect and contextualize an individual’s mundane existence to wider social, cultural, political, economical and ecological realities. Simultaneously, the system would enhance an individual’s ability to recognize the variety of alternative paths and worlds possible for them in the future.

Substantially, the creation of an appropriate number of personal future simulations would allow the observation and analysis of wider patterns of potential future development. The futures of communities, societies and even humanity could be studied and extrapolated through the accumulating personal future simulations.

4.3 Advertising

Despite not being exactly a business model, advertising is for sure one of the most successful revenue models in today’s industries. In fact, due to its preponderance, it is one of the services that most evolved in the last years. Today, most products or services are very well described and in the digital words, this information is usually presented in a standardized way in any metadata format. Consequently, if there is a technical way of matching it with users profile information, interests and affiliations, it is possible to improve the targeting accuracy and user satisfaction.
Nevertheless, alone this information is not very useful. A user may like sports but does not mean he is interested in being advertised about it. Therefore, the main change must occur in the way advertising is perceived by the end user. What if we could shape it into a recommendation enhanced with the word of mouth effect?

Indeed, online social networks provide most of the required data to make this vision a reality. Like explained earlier, within social networks there are a couple of algorithms that might be preponderant in reasoning new knowledge. Within this context, similarity between users (by matching profiles, affiliations, friends in common, shared media, etc) can be used as a predictive factor of interest. It is likely that people with similar profiles like the same things. Another good parameter is proximity. With it, it is possible to understand how close two individuals (or group of people) are. Usually, people that are directly connected within social networks have something in common. Applying data mining technologies might help to identify what is or are the common denominators between people and explore this link on future reasoning processes. Lastly, if advertisers can measure the influence users have on each other, they can differentiate and prioritize offers accordingly. Inside social networks this is usually possible to infer based on the amount of interactivity between peers (e.g., number of comments on a wall, photos or groups and participation in similar events) and the number of shared multimedia objects (e.g., photos, videos, links). Furthermore, as the Human Data Repository includes information other than user profile and its social activities, advertisers can explore the amount of context data associated with it. Advertisements (ads) are no longer limited to static demographic information. Instead, it is possible to dynamically target users according to external context information such as weather, location, traffic, influence among his peers, or other reasoned data. In addition, this information can be delivered in a personalized and adapted way (if the multimedia content is available in such format), has it is possible to know at each moment what type of devices the user has enabled.

In what concerns the way the ads are displayed or consumed, it should also be possible to use the social exposure layer to present the recommendation results, benefiting from the viral effect social media offers us. What would happen if a user publishes to his contact list, in a non-intrusive way (e.g., social networks), that he just bought a particular product? In a first instance advantages might only be seen for the advertisers, but what if he got a discount for that? What if he could add a recommendation to it (can be in the form of an event)? After all, Electronic Word of Mouth (eWOM) is one of the most important decision factors in today’s society (e.g., when choosing an Hotel online). Moreover, if this recommendation comes from a known peer, the influence factor is much higher.

Ideally, recommendations should occur only when user predicted needs, intents or desires match a specific advertising offer (I am hungry vs. I offer food). As an example, we have profiled that a specific user usually drinks coffee after lunch, when the weather is sunny. From past behaviors, if this set of situations occur, it is likely that the user will have the same idea. Therefore, if in the system there is an
advertisement to be targeted only within a specific location (where the user is currently) and when the user fits a specific profile group, it should be triggered/delivered accordingly. If this ad is made in a form of special discount, it is likely to be well received by the end user. In the future, if all privacy issues associated with advertising can be efficiently tackled, advertising might even co-exist as a service itself.

5. Conclusions and Future Work

Merging digital and physical worlds will create unprecedented ubiquitous user interfaces enabling a set of seamless rewarding user experiences. In our work, by extending regular user profile data (user preferences) to accommodate social, context, device and policy related information, we open the path to a new era of services where these can become user behavior aware, paving the way to understand user needs, desires and intents. Moreover, by applying a set of methodologies to it, it became possible to reason new knowledge about people actual behaviors. Exposing these data to third party providers in an application friendly way will enable unique ubiquitous and pervasive scenarios. Together with other security considerations (authentication, privacy and trust) this work will have considerable social and economical impact in the services of the future. In a way, it will improve users perceived Quality of Experience by changing the way they see, use, consume and interact with content and services in any futuristic scenario. In the future, we would like to explore further the possibility to integrate our work with the Internet of things, extending the Human Enabler concept to any other object, focusing on how they can be described, characterized, consumed and correlated with people.

References


Index terms (alphabetically):

Context-awareness
Human Behavior
Personalization
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Social Networks
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User-centric.