Reflections on Ambient Intelligence Systems Handling of User Preferences and Needs

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***Abstract*— We start by assuming the hypothesis that Intelligent Environments are essentially user-centred systems and that the effectiveness of such systems is proportional to their knowledge of the user's preferences and needs and to their capacity to deliver services based on that knowledge. We then start with the complex task of examining the intricacies of dealing with preferences and needs in a more systematic and computational way with the hope these concepts will be given more relevance in the future within our community. The aim of this discussion is to encourage future research to produce an effective way for Ambient Intelligence systems to represent and reason with the preferences and needs of the users of such systems.**

Keywords - Ambient Intelligence; User-centred Design, Artificial Intelligence, HCI.

INTRODUCTION

"An Intelligent Environment is one in which the actions of numerous networked controllers (controlling different aspects of an environment) is orchestrated by self-programming pre-emptive processes (e.g., intelligent software agents) in such a way as to create an interactive holistic functionality that enhances occupants experiences". (Vic Callaghan [1])

We focus here on the challenge of achieving the goal that "… it enhances occupants' experiences". We want to analyze the knowledge the system has to have about the user in order to achieve this goal. The section "Balancing Preferences and Needs" in [1] addressed the importance for the Ambient Intelligence module of an Intelligent Environment to be able to know preferences and needs of the users using the environment however, because of the nature of the article, it does not say explicitly how to achieve that. This is a very important discussion to have in our community and one which should produce results which can help different types of application areas. Advances in this topic will benefit most of the nine principles of the Intelligent Environments manifesto [1]:

P1) *to be intelligent to recognize a situation where it can help.*
P2) *to be sensible to recognize when it is allowed to offer help.*
P3) *to deliver help according to the needs and preferences of those which is helping.*
P4) *to achieve its goals without demanding from the user/s technical knowledge to benefit from its help.*
P5) *to preserve privacy of the user/s.*
P6) *to prioritize safety of the user/s at all times.*
P7) *to have autonomous behaviour.*
P8) *to be able to operate without forcing changes on the look and feel of the environment or on the normal routines of the environment inhabitants.*
P9) *to adhere to the principle that the user is in command and the computer obeys, and not viceversa.*

A. *Aims of the Research Programme*

The main purpose of this research is to understand how to gather, represent and utilize the user's preferences and needs (UPN). There are many questions worth investigating which can help us to understand these. For example:

- What are UPNs?
- What is the best way to represent UPNs?
- How to know when UPNs changed?
- How to update a system's perception of UPNs?

B. *Techincal Background*

Research on Preferences and Needs for Intelligent Environments can relate to several fields in computing. Especially there seems to be a relation with notions like obligation and permission which have been dealt with by Deontic Logic and Normative Systems for several decades, first in philosophy, then in logic and artificial intelligence (see for example: [2, 3]).

As a consequence there are suggestive titles which one hope will throw some light on these issues, for example "the Modal logic for preference based on reasons" [4] however all these approaches, interesting as they are, focus on the mechanics of logical systems which can derive truths which should be preferred for specific reasons. Although a logical and computational study of 'what is needed' and 'what is preferred' can benefit from logical systems created for the study of "obligation" and 'permission' there seems to be differences which merit a study on its own.

Although Deontic Logics should not be discarded as a tools for our study there are interesting features of human behavior in dealing with preferences and needs which make them difficult to grasp, sometimes these are conflictive, they can change with contexts (for example with time), and they are influenced by mechanisms which are outside a self-contained system of preferences and need, for example we may have a need not to drink more wine, not to smoke or not to take sugar in high amounts but an addictive part of our personality may be stronger and override that need.

II. CONCEPT AND IMPLEMENTATION CHALLENGES

Before tackling the problem at a practical level aiming for an implementation which can be deployed in real applications we need to understand the problem in more detail and plan where it is worth to put our effort.

A. *Conceptualization*

Figure 1 shows a first attempt at the conceptualization of this problem, highlighting main components and main interactions affecting the process.

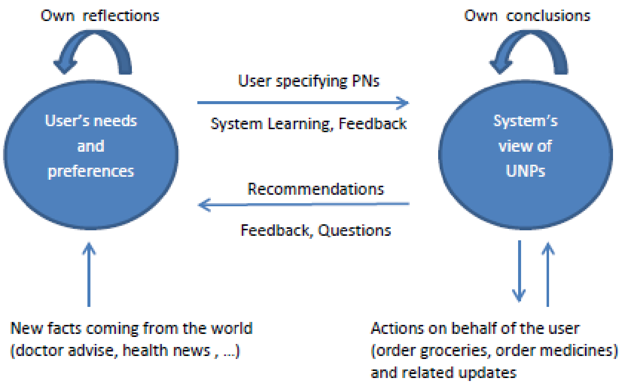

Fig. 1. Main interactions between user, system and real world affecting the dynamics of preferences and needs.

A user has needs and preferences which we assume given. The user can also self-reflect on her/his needs and preferences and this can lead to changes. The external world can influence these too. Some preferences may be modified by experience, for example, tasting new dishes, seeing movies, listening to music or our latest trip may make us change our mind on an opinion we have before about a product and we may decide to consume more or less of it. Influential news media can modify our opinion in subtle ways about products or activities which we consume or practice daily. Some of these PNs can even be imposed to some extent, for example, lifestyle adjustments requested by doctors and insurance companies, or the need to take medicines.

A system can acquire PNs from the user through one of the various interfaces (see "User specifying PNs" in the top arrow) or it may be the system learns these by observing behavior. The system may also have the capability to infer new facts based on the available data. The main input for the system are the preferences and needs coming from the user her/himself however for the system to detect opportunities to help and to make recommendations most possibly will need some real-time mechanism which keeps it updated on the availability of a range of products which may be communicated through an 'internet of things' infrastructure (e.g., food, television programs, medicine, train timetables, etc.).

The last and most important interaction happens when the system communicates with the user to provide feedback, reminders, or interesting information related to the preferences and needs of the user. This is an extremely important part of the system because if it is not effective, it may significantly deteriorate the utility perception of the user on the system. Hence some PNs will be about the way the user expects this interaction take place (e.g., in which contexts the system is allowed to interrupt, in which way the system is expected to make suggestions, etc.).

B. *Considerations on Implementation*

Clearly the focus of implementation is on the centre and right side of the figure. There may be a case on discussing implementing the left side of Figure 1 if we were considering implementing a simulator which can somehow behave as a user for system testing purposes. We will postpone such discussion and in this paper we will focus purely on the implementation of the system as such. Hence it is relevant to consider the core PNs system (right-hand side bubble in Fig. 1) as well as the interactions of the system with the user and the rest of the external world.

If the system is connected to the external world, this should be through a secure connection and interact with services approved by the user. More adventurous set ups may allow the system to crawl the web for potentially interested products and services.

Interaction with the user can take several forms depending on the interfaces available (e.g. visual, sound, haptic). We are not focusing on that element within this discussion and we will assume information travels between system and user somehow. We are more interested in what type of information is required to realize this type of service.

The focus is then on the core decision-making module, the right-hand side bubble of Fig. 1, which has the responsibility of being serve the user in the best possible way. In doing so, the two most prominent behaviours which will be expected are: proactively detecting situations where to help and sensitively handling interaction with the user related to those situations.

What information will be required to support this proactive and sensitive behaviour? An initial estimation suggests:

U, a structure which contains information about the user, for example:

- N: a list of needs
- P: a list of preferences
- $N_{\geq}$: a partial order relation over elements of N
- $P_{\geq}$: a partial order relation over elements of P
- M: a maintenance module which can keep up to date P, N, $N_{\geq}$ and $N_{\geq}$ based on the input from the user and the world. It has processes to compare preferences and needs with existing ones and decide when they are genuinely new, when they are conflicting with existing ones, when they are updates of existing ones.
- I: an inference system which can make inferences based on P, N, $N_{\geq}$ and $N_{\geq}$. It is a mechanism capable to link preferences and needs but also general knowledge which may be relevant to support decision-making.

W, a finite list of inputs from the outside world as services which the system is aware of and can enquire when needed to update P, N, $N_{\geq}$ and $N_{\geq}$:

- S_1 : service 1 (e.g. train schedules)
- …
- S_n : service n (e.g. healthcare contact details)

C, a finite list of contexts the system is aware of and influences the decision on when help can be offered and how it has to be offered:

- C_1 : context 1 (e.g. office)
- …
- C_m : context m (e.g., home)

To clarify a bit further how such system may work with the architecture described above, we can consider a practical example where we use informal language to instantiate the elements listed above. For example, let us assume U=< P, N, $N_{\geq}$, $N_{\geq}$, M, I> such that:

P={p1: “always have chocolate available in the house”, p2: “be healthy”, p3: “save time”, p4: “visual reminders”}

$P_{\geq}$={p2=p3>p1, p4} meaning both p2 and p3 are more important than p1.

N={ n1:”be at office by 9AM”, n2: “reduce BMI 20%”}

$N_{\geq}$={n1=n2} meaning they are equally important.

M: { n1 entered at 07/01/2014-17:40:45,
p1 entered at 07/01/2014-17:40:56,
p2 entered at 07/01/2014-17:41:10,
p3entered at 07/01/2014-17:41:22,
n2 entered at 23/01/2014-12:10:03,
p4 entered at 25/01/2014-10:20:45 }

The element I may have information stating that the intake of fatty and sugary food can increase BMI, which types of chocolate have more sugar and/or fat, that exercise can reduce BMI, that walking is a type of exercise, that walking to the office takes time, and putting these together realize that although walking takes time it satisfies the needs and the preferences in P and N and that p3 can also be satisfied if the system advices to leave early. This example seems to indicate that at least constraint based reasoning (e.g. spatio-temporal), and perhaps planning, may be useful to realize such modules.
The dimension of priorities itself is a source of interesting problems where some priorities may be incomparable, for example health aims may not be comparable to when the user is allowed to be interrupted by the system.

W={train_timetable(…,…), google_maps(…,…),… }

C={time, location, …}

III. Future Work

The discussion above has many unanswered questions. There is another dimension which makes the problem even more interesting and that is when we consider that systems of this nature will usually have to deal with multiple users (for example, at home and at office). How a system can manage UPN from several users, especially when they are conflictive (see [5]).
Each user and each system will have a generic logical framework which is instantiated and personalized to each individual, in the case of a multi-user environment this will imply the same central system dealing with several individual UPNs systems and also dealing with the interactions between these (see Fig. 2). There will be new modules which are entirely dependent of the multi-user setting, for example to state if there is a hierarchy of users (e.g. carers in AAL systems).

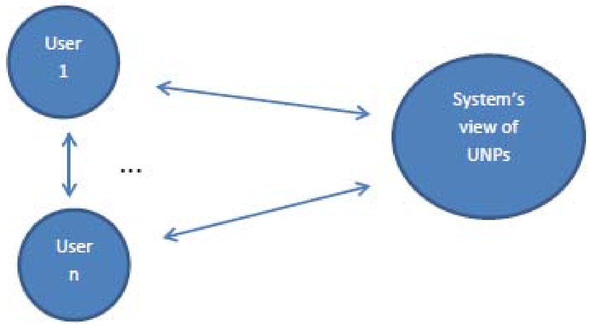

Fig. 2. In a multiuser environment the system has to understand each individual as well as the social relationships amongst different members.

IV. Conclusions

We have discussed the possibility of starting an organized study of how ambient intelligence systems can approach in a more systematic way the development of modules handling preferences and needs. There seems to be consensus in the technical literature of its importance and often mentioned as an aspiration but its consideration from an engineering point of view is almost non-existent.
This is clearly only a first and superficial assessment of what developing such type of systems may entail. There are several questions unanswered which will be considered in future explorations.

References

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