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An experiment of subconscious intelligent social computing on household appliances

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ABSTRACT

Subconscious Social Intelligence refers to the design of social services oriented towards user problem solving, providing an underlying innovation layer is able to generate new solutions to yet unknown problems. The innovation layer is achieved by Computational Intelligence techniques, encompassing machine learning to build models of user satisfaction over solution quality, and stochastic search as the means for innovation generation. The SandS project provides an instance of such paradigm, where household appliances are the subject of the social service. This paper proposes a specific architecture, reporting results on a synthetic database build according to SandS project current designs. Database synthesis for system tuning and validation is a critical issue, hence the paper details the considerations guiding its design and generation, as well as the validation procedure ensuring the ecological validity of the innovation process simulation. The architecture is composed of a Support Vector Regression (SVR) module for user satisfaction modeling, and an Evolution Strategy (ES) achieving recipe innovation. The paper reports some computational experiments that may guide the real life implementation. The reported results are methodologically sound as far as they are independent of the generation process.

1. Introduction

There is an emerging view of social networks as information and knowledge repository at the service of the social agents to solve specific problems or to learn procedures relative to a shared domain of problems. Besides popular web service implementations, social networks have shown to be useful to spread educational innovations in health care [25], manage product development programs [26], foster farmers engagement in agricultural innovations [35].

Social computing [40] may be defined as the result of social interaction when it is oriented towards information processing or decision making. Preliminary elaborations towards a taxonomy of social computing systems [22] include the term *subconscious intelligent social computing* [20–23] characterized by some hidden layer of intelligent processes that helps to produce innovative solutions to the problems posed by the social players. The social player asks for the solution of a problem, i.e. how to wash my laundry composed of items with some specific dirtiness and according to my preferences? The social framework provides solutions either from previous reported experiences of other social players or as innovation generated by the hidden intelligent layer.

Intuitive description of the system: Fig. 1 gives an intuitive representation of a Social Network architecture mediating the interactions among users, each owning a set of household appliances. In the framework of the Social and Smart (SandS) project[1] users are called eahoukers [3]. There are two repositories of knowledge in the SandS Social Network containing tasks to be carried on the appliances and the recipes solving them. When a user requires a task to be performed (blue dashed arrows) there are two possible situations, either the recipe solving the task is known or not. In the second case, the so-called Networked Intelligence incorporating the hidden intelligent layer is in charge to produce a new recipe to solve the unknown task. In other words, it is in charge of achieving innovation (green arrow). The recipe found either way is returned to the appliance (black arrows).

This simplified description introduces the fundamental questions that we are tackling in this paper by a prototype system and its validation. The first question is: how to decide that we have a "known" recipe solving a task? We cannot expect exact equality in the task specifications, therefore we must formulate some way to manage ambiguity and noise. The answer given in this paper follows an indirect approach: we model the satisfaction of the user by machine

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[1] http://www.sands-project.eu/

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0925-2312/

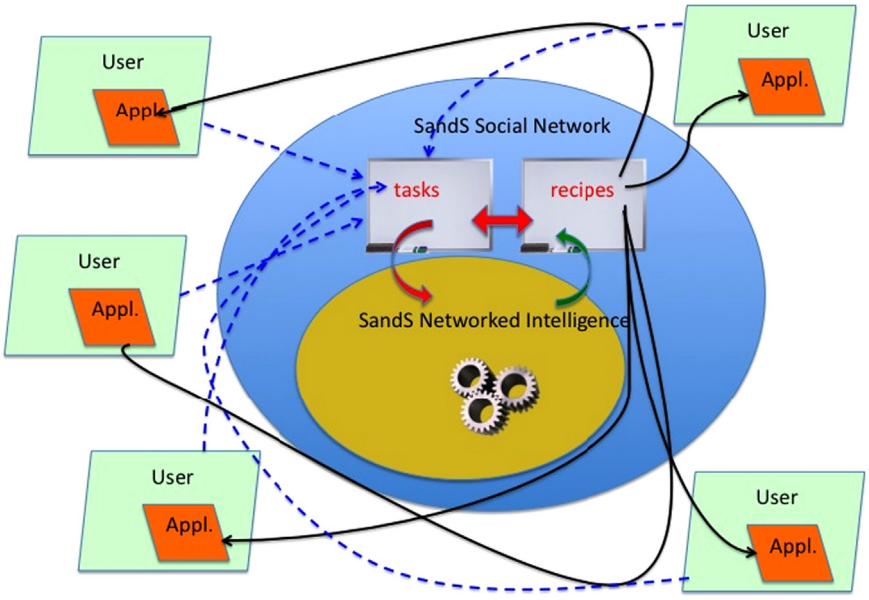

Fig. 1. A prototypical subconscious intelligent social computing architecture in the framework of the social network of household appliance users of the SandS project.

learning, then we look for the recipe with highest expected satisfaction solving the proposed task. The second question is: how to perform innovation? We need to build some generative process that achieves to create new recipes optimizing expected satisfaction. The answer is a stochastic search process guided by the learned user satisfaction model, specifically an Evolutionary Strategy approach [7–10,19].

A critical issue is the lack of real life data supporting the design and validation of this architecture. The SandS project is currently building the framework that would allow users to experience this social interaction, but no actual data is being generated yet. So we have to resort to synthetic data, generated assuming a latent variable "user type" which conditions the kind of tasks and recipes of the user. This latent variable is only used in the data synthesis phase, it is ignored in the training and validation processes. Furthermore, we have restricted the scope of the data to washing machine related tasks, and we have provided a parameterization of tasks and recipes in order to be able to build a working system.

Contributions of this paper: We provide an architecture for the underlying intelligent layer of a SandS type social network composed of a Support Vector Regression (SVR) modeling the user satisfaction and an Evolutionary Strategy (ES). The SVR predicted user satisfaction allows us to decide if innovation is required or not. Innovation is achieved by the ES guided by the SVR. To demonstrate the approach, we have defined specific parameterizations of the data objects, i.e. users, tasks, recipes, satisfaction. Based on a latent user categorization, we have built a synthetic database for training and validation to overcome the lack of real life data.

The contents of the paper are as follows. Section 2 reviews relevant ideas about social computing and social intelligence. Section 3 recalls the general setting of the washing machine tasks and recipes. Section 4 describes the design and construction of the synthetic database. Section 5 formalizes the computational architecture implementing the subconscious computing scheme. The conducted experiments results are reported in Section 6. Finally, we draw some conclusions in Section 7.

2. Social computing and social intelligence

Computational Social Science [27] aims to understand the dynamics of social systems analyzing data extracted from all existing sources of information on human behavior: surveillance cameras, mobile identification tags, social web services, electronic commerce, and any other source. From the point of view of computational social science, the social players (i.e. users in social networks) are the experimentation objects, searching for answers to questions about the overall system behavior and properties, regardless of individual conditions. Most research questions relate to diffusion processes inside the system, or the emergence of uniform states, like the ones found in particle physics. To this end, social computational science must resort to intelligent and efficient hardware/software systems able to process the huge amounts of data within real time constraints.

Social Computing [31,43] concerns the development of software for the enhanced interaction between social players and the creation of simulation scenarios allowing to forecast the effects of policies, such as technological innovation, on societies. Examples of these systems are entertainment/therapeutic social games involving autonomous intelligent agents, negotiation, recommender and reputation systems, security applications for the detection of criminal social activities, and artificial societies of agents designed to provide adaptation to changing environments (i.e. traffic) through competition, platforms for scientific collaboration offering information about the current state of the research community and research effort planning. Social Computing is developing into a productive model where rewarding mechanisms play a critical role to control the desired output of the system [37]. A relevant definition of *social computing* has been proposed by Vannoy and Palvia [40] in the study of social models for technology adoption: "intra-group social and business actions practiced through group consensus, group cooperation, and group authority, where such actions are made possible through the mediation of information technologies, and where group interaction causes members to conform and influences others to join the group".

The paradigm of Social Intelligence is concerned with the emergence of problem solving behaviors in social systems from the point of view of the social player. In other words, the social player expects to obtain solutions to his/her problems from the intelligence pool available from a social network and the computational resources that may be at work behind it. Let us draw a distinction between *conscious* and *subconscious* computing. The former happens triggered by the decisions and actions performed by the social players on the basis of the information provided by the social service. The latter happens automatically and autonomously on the basis of previous information gathered from their interactions with the social media. We may find that subconscious computation may be carried out in