Seeking Prevention of Cognitive Decline in Elders via Activity Suggestion by A Virtual Caregiver

Demonstration

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ABSTRACT

Addressing the lack of social, cognitive, and physical stimuli among elders is a key factor to contrast Mild Cognitive Impairment (MCI) that can arise during the third age. Against such background, agent-based technology has been applied to different application domains related to the assistance of elders. In this demo, we introduce an application of this kind: an activity center featuring social, cognitive, and physical activities targeted for elders. This activity center interacts with an autonomous agent, called Virtual Caregiver, residing in the cloud and generating interventions based on users' data. We show how the user experience can be enriched with an adaptive configuration encouraging socialization and cognitive training.

KEYWORDS

Human-robot/agent interaction; Reasoning in agent-based systems

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1 INTRODUCTION

As population ageing remarkably impacts on the costs of health care [6], technologies targeted at maintaining cognitive health can play an important role. Cognitive changes induced by normal ageing have been observed to develop into dementia by crossing an intermediate phase called Mild Cognitive Impairment (MCI). The lack of social and cognitive stimuli in everyday life is a fertile ground for MCI [7] and digital platforms that evaluate cognitive impairment and provide stimuli are considered as effective intervention tools [9, 10]. Multi-agent technologies can be profitably employed in the development of such platforms, thanks to their robustness, heterogeneity, adaptability, and autonomy. This is demonstrated by the many health-oriented applications where agents are deployed [4], with monitoring, pervasive care, and teleassistance being typical examples of domains where their effectiveness has been assessed [3].

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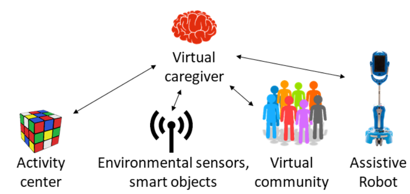

Figure 1: The Movecare multi-actor platform

In this demonstration, [1] we show an application of agent-based technology focused on promoting social and cognitive activities to elders, which exploits Machine Learning (ML) and Artificial Intelligence (AI) techniques. The system we demonstrate is composed by two main actors. The first one is an application accessible through a tablet interface called Community-Based Activity Center (CBAC). Through this application, the elder can access a virtual community of peers, caregivers, and interested participants. By means of a simple interface, the elder can invite partners to join activities like board games or virtual training rooms. Such activities aim at entertaining the elders and stimulating their cognitive abilities while, at the same time, allow transparently maintaining access stats and gathering performance data. The second and most important component is an autonomous agent called Virtual Caregiver (VC). The VC can be thought of as a personal assistant living in the cloud and with access to the data collected by the CBAC. It promotes socialization and cognitive training by means of *decisions of interventions* computed from the data and delivered through the CBAC interface.

The CBAC and the VC concur in providing a demonstration of two main functionalities. The first one is related to the user experience provided by the CBAC and constitutes the most interactive part of the demo. By running the tablet application, a user can invite partners, and undertake activities with them. The second functionality will show how the CBAC can be adapted by the VC agent to boost socialization and cognitive training.

These two functionalities are building blocks of the multi-actor platform developed in the Movecare project [1], which pursues the development of a multi-actor system to provide assistance, activities, and monitoring to the elder at home. Figure 1 depicts Movecare's enlarged view where the CBAC, an assistive robot, environmental sensors, smart objects, and a virtual community

[1] An exemplifying video is available at https://youtu.be/3DuTCmpJYpE

populate are orchestrated by the VC agent. In the paper, we briefly discuss also how our demo is framed within this general scope.

2 SYSTEM FEATURES

Upon first access to the CBAC, the user carries out a registration procedure where preferences on activities are acquired. Collected preferences constitute the user's initial profile. In our demonstration, the CBAC will showcase:

- *Social Activities*: users can easily create virtual rooms for chatting or setting up video calls with multiple partners as well as exchanging media such as images and links;
- *Multi-Player Cognitive Games*: games fostering cognitive abilities and socialization with video calls among players; in our demo we will show a cards game and the game "Pictionary";
- *Physical Activities*: virtual rooms for group gentle exercising sessions where a video instructor guides the participants.

During activities, the CBAC transparently gathers access times, session durations, and, for cognitive games, score indicators reflecting the performance of players. The data are at the disposal of the VC that, on a proactive basis, generates personalized interventions. In this demo, interventions take the form of *activity and partner recommendations*. With activity recommendations, the VC promotes activities for a specific user based on data collected about him/her. (*Example: the room temperature is not very high, the user spent a lot of time in the previous days playing board games, and his profile indicates a preference for physical activities; the VC recommends gentle exercising*.) With partner recommendations, the VC recommends partners for an activity based on data about him/her and others. (*Example: users A and B have similar score profiles for cards games and some time has passed since they played together; the VC suggests A to invite B for a cards match.*)

3 SYSTEM ARCHITECTURE

The components that we demonstrate, as well as the other ones available in the Movecare project are designed according to a modular architecture composed by autonomous agents (like the VC and the robot) and applications (like the CBAC). This architecture is robust (modularization allows to easily handle faults: standalone execution modes are employed in each component in case others stop functioning) and flexible (agents and applications can be easily reconfigured or added with limited costs). The components' are developed by means of web technologies and deployed in the cloud.

3.1 Activity Center

The Community-Based Activity Center is a web application with a simple and adaptive interface tailored for tablet devices, but that can also be displayed on different devices (like PCs or TVs). It provides digital interactive activities as well as physical ones, some of which are inspired from exergames for rehabilitation [8]. It leverages REST technologies, WebRTC, and WebSockets to provide real-time game-playing and communication. The data collected during the execution of activities are temporarily stored in a local cache and then transmitted to a data center in the cloud where they become available to the Virtual Caregiver. (All collected data are anonymized and only accessible to explicitly allowed agents).

3.2 Virtual Caregiver

The Virtual Caregiver is the central agent in the Movecare ecosystem, as shown in Figure 1. It exploits information collected by the different components and performs various tasks in a proactive way. In particular, it analyzes the heterogeneous data provided by the monitoring system (environmental sensors), the CBAC, and the community by combining the Machine Learning (ML) and Artificial Intelligence (AI) techniques described below, and generates interventions with the goal of improving the users' quality of life. Interventions in Movecare are suggestions given by the VC to the users about, e.g., activities to perform, measurements to take, games to play. These suggestions are given to the users when the VC considers they need it without the users asking for them and can be adapted based on their past and current activities as well as their overall state of mind. Interventions can be notified through the CBAC (as messages or with graphical features) or delivered by an autonomous assistive robot interacting with the user.

In this demo, which revolves around the interaction between the CBAC and the VC, the latter takes into account the users' physical and cognitive scores, their preferences (from the initial profile), as well as context information (e.g., the current weather) to provide recommendations regarding the activities they should engage in and the users they should play or interact with.

At its core, the VC performs advanced cognitive reasoning by combining different techniques, which include:

(1) *Spatio-Temporal Reasoning*: this functionality is essential for dynamically propagating spatio-temporal constraints as they become available, handling inconsistencies, revising the knowledge base, and performing on-line recognition of spatio-temporal patterns [5]. (For example, detecting anomalies in everyday activities.)
(2) *Ontology Reasoning*: this task is interrelated with the previous one and it aims to assist with the identification of spatio-temporal patterns, whilst also add an extra semantic dimension to the spatio-temporal pattern at hand (e.g., possible fire in the apartment) [2].
(3) *Time Series Analysis*: this technique is useful for analyzing time series data in order to extract statistics and other meaningful characteristics, and forecast future situations (e.g., unexplained weight loss, severe cognitive decline).
(4) *Scheduling*: this element is needed to handle incoming and outgoing requests from the different actors within the VC itself, but also within the Movecare ecosystem.

In complement to the aforementioned key functionalities, the VC performs other operations such as computing rankings of the users' performance and polling weather data through a web service. These modular functionalities are then composed and exposed through a RESTful API. As an example, when the VC suggests an activity, it takes into account the temperature and weather conditions , as well as the historical data of the user, in order to include or exclude specific activities, such as a walk.

4 ACKNOWLEDGEMENTS

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