Towards the NESTORE e-Coach: a Tangible and Embodied Conversational Agent for Older Adults

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Abstract
The ability to engage the user in a conversation and the credibility of the system are two fundamental characteristics of virtual coaches. In this paper, we present the architecture of a conversational e-coach for promoting healthy lifestyles in older age, developed in the context of the NESTORE H2020 EU project. The proposed system allows multiple access points to a conversational agent via different interaction modalities: a tangible companion that embodies the virtual coach will leverage voice and other non-verbal cues in the domestic environment, while a mobile app will integrate a text-based chat for a ubiquitous intervention. In both cases, the conversational agent will deliver personalized interventions based on behavior change models and will promote trust by means of emotionally rich conversations.

Author Keywords
Embodied Conversational Agent; e-Coach; Wellbeing; Older adults; Tangible Interface.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI).

Introduction

In the next years, the population aged 65 and over will dramatically increase, from 17.4% in 2014 to 25.6% in 2030 [1]. Technological solutions might have a great impact in supporting healthy ageing, providing knowledge and tools for enabling longer and more engaging independent life at home. However, designing digital tools that can promote healthy lifestyles is particularly challenging, because they should meet the variegated needs and desires of older adults, avoiding stigmatization, yet providing intuitive and easy to use interfaces. NESTORE, an EU-funded H2020 project, aims at designing and developing an e-coach for improving the well-being in four different domains: physical activity, nutrition, social activity and cognitive. An intelligent system, based on cloud data analysis and leveraging Decision Support logics will deliver "advice and coaching" which will be offered to the user via a conversational agent, virtually embodied in a smartphone chatting app and physically embodied in a tangible object. Indeed, the system should be able to dialogue with the user either through a chat in the smartphone or through vocal interaction in the tangible object, switching between the two interfaces according to user preferences and context information (e.g., proximity of the user to the tangible object). In order to better meet users' needs and expectations, the Nestore platform is conceived and developed following a co-design process, in collaboration with partners from 4 different countries: UK, Spain, The Netherlands and Italy. In this paper, we focus on the system architecture and the different interaction modalities that can access the conversational agent. First, we will present the state of the art of the virtual coach, then explain the virtual coach in Nestore that provide personalized interventions based on behavior change models and finally, we present the architecture of the e-coach showing the different modalities of interaction. We conclude the article discussing future work needed in the NESTORE project.

Systematic Review and Previous work

The technological progress in device for user monitoring and in data analysis has paved the way to e-coaches, digital equivalent of human coaches. In particular, e-coaches for behaviour change are particularly promising since they can provide large-scale interventions without the need of expensive human resources. According to Banos and Nugent [2] coaching a user means to "frequently, but not continuously, observe, listen to, question, understand, reason with, teach, and/or advise the users in order to change their behaviour and to improve their health". Kanphorst [3] highlighted several features that an e-coach should boast. In particular, it should be able to engage in conversations with the user, learning from the user preferences and providing the user with credible advises in a proactive manner. Conversational agents fit particularly well these requirements. To better understand how previous work designed the interaction of e-coaches for older adults, we are conducting a systematic review. In a first phase, we individuated 27 articles from Pubmed, Scopus and Ebsco proposing e-coaching for older adults in wellbeing. The keywords used in the queries were aimed at individuating e-coaches for promoting healthy lifestyles for older adults. In particular, the queries were aimed at individuating different intervention modalities and interfaces, including "conversational agents", "robots", and "chatbot" since this text-based conversational agents are growing in popularity and are used in most messaging applications. Thus, wellbeing keywords and seniors keywords were also added to the

queries. First of all, e-coach definition was observed in each paper. In all the papers analysed in this systematic review, none reports a definition of e-Coach. However, 17 out of 28 articles mention some of the characteristics that an e-coach should present. One characteristic reported in these articles (7 out of 28) concerns companionship and the social role that the e-coach should play. Other focused on a system that seeks the user to reach his/her goal (8 papers), motivates the user (5 papers). Another important feature that the e-coach should provide is the personalization. We analysed then the interface modalities used for the delivery of the intervention across the reviewed papers. In particular, [4, 5, 6, 7, 8] described an embodied conversational agent, where an animated computer character simulates face-to-face conversations using a synthesised voice which is synchronized with other non-verbal behaviors, [9] a conversational agent integrated in the smartphone, and [10, 11, 12] a robot. Screen-based interventions can be found as well: a touch-based digital photo [13, 14], a PC-based virtual board game [15], a display that were tackled by 3D camera [16, 17].Other traditional intervention media found in the reviewed papers were emails [15], phone calls [15, 18] and printed material such as booklets [16] and manuals [15]. It is worth noting that despite of the diffusion of chatbots in the past years, conversational agents were always embodied with virtual avatars or robots in previous work. From the analysis of previous work we highlighted the need of a physical embodiment to increase the empathy for the e-coach, which could lead also to long-term interactions with the coach and increased adherence to the well-being intervention. On the other end, chatbots have been proved to be a powerful ubiquitous intervention tool, always available in the user's pocket. Examples of chatbot for improving well-being are Woebot for mental well-being [20], Nombot and Forksy for nutrition [21, 22] and Xtra for general well-being [23]. There is limited knowledge in the literature on the older adults' appreciation of chatbots. Moreover, to the best of our knowledge, no previous system implemented a multimodal distributed conversational agent. Conversely, Nestore will be able to interact with the user through different modalities, text through a chat interface and voice, through a tangible companion with a physical embodiment.

E-Coach in Nestore

The Nestore e-coach is a "virtual coach" that provides personalized advice on the 4 aforementioned domain of well-being based on physiological and behavioral data collected through wearable and environmental sensors and through the different conversations with the user. Nestore is a ubiquitous conversational agent acting as a caring coach that will interact with the user assuming many forms, will use different modalities (voice, text, apps, tangible interfaces), and will be adapted to the user's preferences and to the contextual information. The vision of the Nestore e-coach is to be a friend, a companion and a coach. As a friend, Nestore knows some information about the user and is willing to learn more about him/her with time. As a coach, Nestore wants the user to improve and maintain a healthy life.

NESTORE Conversational Agent Architecture

E-coaching intervention delivery and architecture

In order to adapt to the different needs and desires of the Nestore users, different interfaces will be provided. In particular, the e-coaching intervention can be delivered through:

- Tangible coach (voice and tangible interaction)
- Chatbot (text and images)
- Mobile apps and games

Users will be able to choose among the different interfaces, according to their preferences. Each interface has different advantages and disadvantages, providing a different user experience but the same e-coaching content. Indeed, the coaching plans suggested by the Decision Support System (DSS) which is a computer program that makes decision for personalizing coaching plans, recommendations of activities, matching users and generating notifications to one or more interfaces, according to user preferences and context information (e.g., if the user is outdoor, the e- coaching intervention will be delivered to the chatbot or the mobile app; if she is indoor, close to the tangible coach, this latter interface will be used). Moreover, a consistent experience will be ensured for the e-coaching: through a co-design process, a virtual coach embodiment will be identified and coherently distributed in the different interfaces. An embodiment is an interactive physical-digital artefact developed in wearable, tangible and ubiquitous computing.The purpose of such embodiment is to make the user identify the embodied virtual coach sender of any e-coach message as this embodied virtual coach. Such embodiment (e.g., a pet plant) can be physically implemented for the tangible coach, and linked visually in the chatbot (e.g., in the chatbot avatar) as well as in the tips and messages provided by the apps and games. Such embodiment for the virtual coach is intended to increase the user's empathy and the user's trust in the system. Emotional attachment and trust is when the user will bond, connect with the system and will trust the system will do what is expected. The mobile apps and games are integrated in the personal device of the user, therefore available ubiquitously, provided that an internet connection is available when using the personal mobile device. Also in these latter interfaces, the virtually embodied coach will be able to speak to the user providing contextual tips and recommendations as if they were sent by the same e-coach entity, which will be likely identified with the tangible coach with physical embodiment.

The tangible coach

The tangible coach is a physical device that will be installed in the user's environment and possibly displaced from one room to another. Besides providing coaching and feedback on user's progress through an ambient tangible interface, the main goal of the tangible coach is building empathy with the user. To this purpose, the physical embodiment of the tangible coach has to be carefully designed, in order to maximize the emotional attachment with the coach, and consequently, the trust in the system. The tangible embodiment will be designed through a co-design process, in a dedicated workshop where the participants will paper prototype the tangible coach form and will imagine their daily interaction with the coach. As the tangible interface, the tangible coach may not only embody the e-coach conversational agent but also the user's progress through the goal through data physicalisation [19] in order to stimulate self-reflection. The tangible coach interface will also support voice conversation with the users through the same conversational agent infrastructure available in the chatbot, using text-to-speech and speech-to-text APIs. This infrastructure is described later in the system architecture section. The conversation style supported by the tangible coach is also discussed in the next

section. In figure 1, the flower is used only as a symbol of the tangible coach in figures 1 and 2.

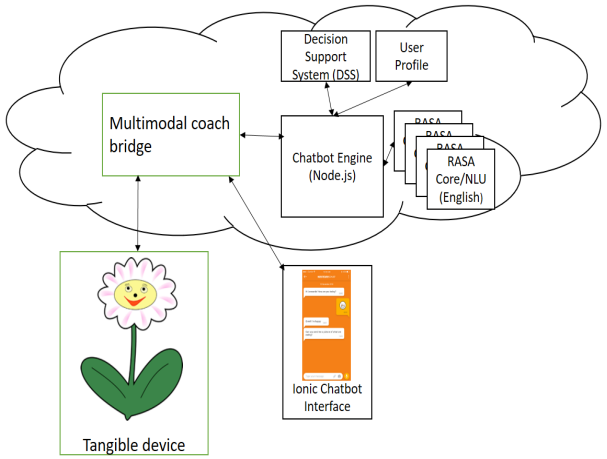

Figure 1: System architecture of Nestore

The chatbot

The chatbot is a text-based conversational agent. The user can chat through text or media content (e.g., images, emoticons, etc.). The personality of the e-coach conversation has also to be fine-tuned according to the users' needs and preferences. The personality is linked to what the elderly may tolerate (caring, loving, supportive etc). Tone and register (formal, informal) is also taken into consideration. Co-design workshops are conducted in the 4 different countries in order to understand the personality of the user. The e-coach conversation is designed in English and then manually translated in Spanish, Dutch and Italian, adapting them to local traditions and common saying. The coach personality is also investigated through co-design workshops in the different countries. Preliminary results suggest that older adults prefer a friendly and encouraging coach that can motivate their well-being actions rather than a colder directive coach. Praise messages are also expected from the coach. Figure 2 shows a simple scenario of multimodal interfaces.

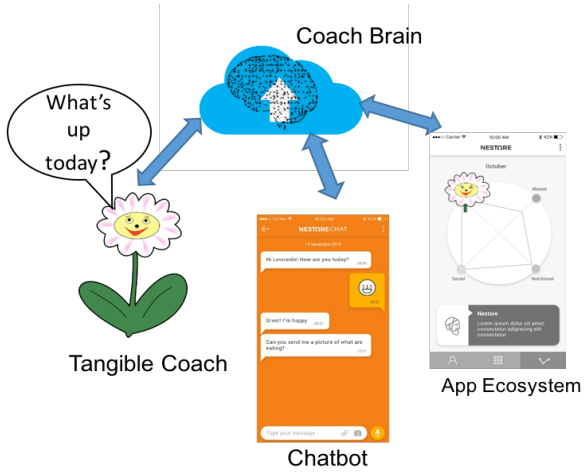

Figure 2: Multimodal interfaces

System Architecture

The logic of the Nestore conversational agent is composed by three main components, RASA Core and NLU for intent recognition and Natural Language Understanding (NLU), a Node.js server for managing the logic of the conversation and an additional server for dispatching the messages to the different interfaces according to the context information and user preferences. As discussed before, two main interfaces will be available for enabling ubiquitous conversations with the coach. The chatbot interface is integrated in the Nestore mobile app, available for both iOS and

Android. Indeed, in order to maximize the accessibility to the chatbot, we preferred integrating the interface in a standalone app developed with the Ionic cross-platform development framework rather than using existing messaging applications (e.g., Facebook Messenger) which often require also joining external social networks. The tangible coach will rely on a similar infrastructure and its physical embodiment will be built around a tablet with Arduino add-ons for sensing and actuation or will be built from scratch using a Raspberry Pi. The choice of the speech API for using the Rasa Core/NLU as a voice conversational agent will be driven by the availability of the different languages and their performances for granting to the user the best user experience. All the coaching interventions will be provided and orchestrated by the Decision Support System, which will tailor the intervention based on the personal data collected by the system or filled in by the user.

Conclusion and Future work

The ageing population is increasing and e-coaching technology offer a major opportunity to promote healthy lifestyles in older age. The NESTORE project focus on designing a multi-domain virtual coach based able to interact with the user through a multimodal distributed conversational agent. Indeed the same tailored intervention can be delivered as a text-based conversation in a chatbot, always available in the user smartphone, or as vocal conversation in a tangible and embodied personal coach, which will provide an emotionally richer in the user's domestic environment. As shown from the analysis of previous work, this approach has never been tested before with older adults. The conversations and the tangible embodiment of the virtual coach will be designed in order to shape the Nestore coach as a friendly supportive companion able to motivate the user to increase their wellbeing in 4 different domains. Through the proposed architecture, we showed how the different interface modalities can be used to access the same coaching intervention. Mobile apps, chatbot and tangible devices are the three different access points considered in the Nestore project as a virtual coach. Each interface has different advantages and the user will be able to switch among the interfaces according to their preferences and the context of use. A first prototype of the chatbot that initiate the user to the Nestore system and provide coaching in the nutrition domain has already been developed for the English and Dutch languages and will be tested soon with older adults in the Netherlands. Other workshops are planned in 4 countries (Spain, Italy, England and The Netherlands) to further assess the design choice of the Nestore coach and to iteratively test the system.

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