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EHealthPortal: A social support hub for the active living of the elderly

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eHealthPortal: A Social Support Hub for the Active Living of the Elderly

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***Abstract*—The absolute and relative increases in the number of elderly are evident worldwide, from the most developed countries to the lowest-income regions. The fast demographic transition poses great challenges to the healthcare system and introduces a significant burden to the elderly and their family. To meet the unprecedented challenges of global aging, various aging-in-place (AIP) solutions have been proposed to enable the elderly to live in their own home and community safely, independently and comfortably. Elderly need support in various aspects, such as physical, cognitive, emotional, and social, in their daily life. However, most existing AIP solutions provide support in one or two aspects only and many focus on anomaly detection rather than deliver care or companionship. To better facilitate eldercare at home, we propose eHealthPortal, which is a social support hub for the active living of the elderly. By crowdsourcing help and support from the users' family and friends, caregivers, and doctors, eHealthPortal cares for the wellness of the elderly in all the four aforementioned key aspects. As a novel feature of the system, eHealthPortal is supported by a group of virtual and robotic agents for providing reliable sensing in unobtrusive ways seamlessly, tender caring in a holistic manner proactively, and actual companionship in natural forms constantly.**

I. Introduction

Populations around the world are rapidly aging and this trend is evident from the most developed countries to the lowest income regions [1]. The fast demographic transition poses great challenges to the healthcare system and introduces a significant burden to the elderly and their family [2]. A survey [3] shows that nearly 90% of persons aged 65 or above indicate that they want to stay in their home as long as possible, among which four of five believe their current home is where they will always live. Thus, aging-in-place (AIP) or "the ability to live in one's own home and community safely, independently, and comfortably, regardless of age, income, or ability level" [4] has received a significant amount of attention within the last decade.

In the AIP scenario, elderly face challenges in many aspects, including the physical, cognitive, emotional, and social challenges [5]. Generally speaking, the physical and cognitive abilities of the elderly deteriorate as they age, and they require constant social support (companionship) to keep them emotionally healthy (away from loneliness, depression, and anxiety). Ideally, a home-based healthcare system should support all-round care to the elderly. However, most existing systems only focus on one or two challenges (e.g., fitness tracking using wearable devices [6]) and many only focus on anomaly detections (e.g., fall down [7]) rather than all-day general care and companionship. An ideal system is still not available as research prototype or commercial system.

To better facilitate eldercare at home, we propose eHealthPortal, which is a social support hub for the active living of the elderly. By crowdsourcing help and support from the users' family and friends, caregivers, and doctors, eHealthPortal cares for the wellness of the elderly in all the four aforementioned key aspects. As a novel feature of the system, eHealthPortal is supported by a group of virtual and robotic agents for (i) providing reliable sensing in unobtrusive ways seamlessly, (ii) tender caring in a holistic manner proactively, and (iii) actual companionship in natural forms constantly.

The rest of this paper is organizes as follows. We introduce related work on eldercare at home in Section II. We present the overall system architecture design in Section III. We delineate our approach of using a web portal to seamlessly connect humans and agents in Section IV. We articulate various benefits of the eHealthPortal system in Section V. Finally, we conclude this paper in Section VI.

II. Current Situation on Eldercare at Home

Although both smart home environments designed for the elderly [8] and activity recognition of the elderly from commercial devices [6] may have been extensively investigated, their combination is still rare. Moreover, some activation recognition algorithms and approaches are not robust. For example, when using the accelerometer embedded in smartphones for motion detection, the phone model, the location and orientation of placement, and the user difference should not make the system under-achieving or obsolete [6]. For all sensors and gadgets running on limited power source, the balance among energy consumption, transmission latency, and sensing accuracy has to be leveraged [9]. Our research center has already built an in-room sensory network and a smartphone data collection framework. By integrating the home- and mobile-based sensory networks (see Figure 1), the overall activity recognition is expected to be more accurate, efficient, and robust.

Although numerous wellbeing promotion applications (e.g., [10]) have been implemented, few are built on cross-platform. More importantly, to the best of my knowledge, none is

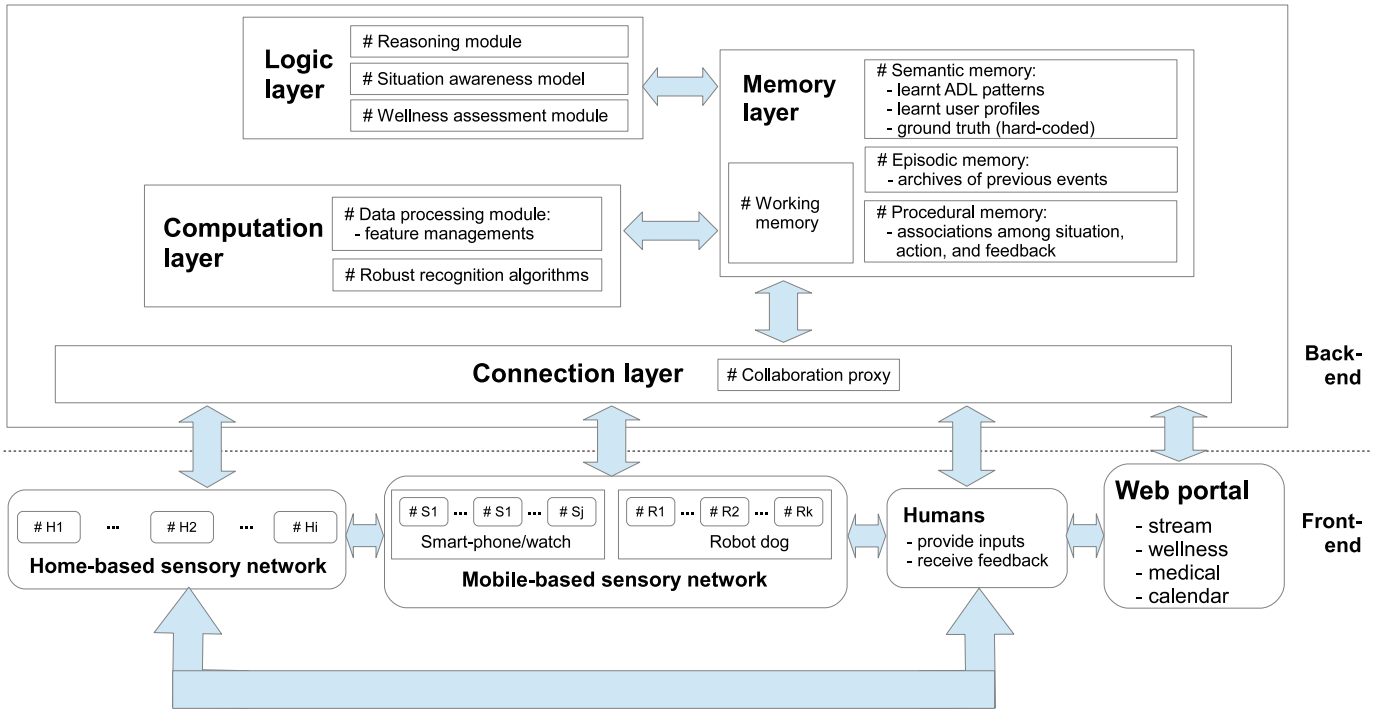


Fig. 1: Overall system design architecture of eHealthPortal.

designed specifically for the elderly and helps them in all four health-related aspects. The front-end of eHealthPortal (see Section IV) can be accessed using most web browsers installed in different devices and its wellness assessment module is specially designed for the elderly [11]. Moreover, we have developed virtual agents [12], [13] to provide all-round tender care to the elderly (see Section III-C).

User profiling is one of the most important requirements in human-machine interactions to customize personal services [14]. Moreover, human-like virtual characters perform better when interacting with human users through natural conversations [15]. In eHealthPortal, the situation awareness model (see Fig. 1) captures user profiles. Moreover, our agents initiate natural conversations with human users while collaborating with each other [12] (see Section III-C).

In summary, no existing system is designed to provide all-round care to the elderly, covering the physical, cognitive, emotional and social aspects. Moreover, home-based eldercare systems seldom incorporate human efforts into a multiagent coordination framework (mainly to create more opportunities for interactions with the elderly and to maximize the ubiquitous access) and vice versa [16].

III. Overall System Design of eHealthPortal

eHealthPortal is designed as a social support hub for the elderly, their family and friends, caregivers, doctors and caring agents to connect with each other and care for the wellness of the elderly in the physical, cognitive, emotional, and social aspects. The sensing is unobtrusive, the caring is all-round, and the companionship is natural. Moreover, it is cost-effective and works 24/7 for both anomaly detections (e.g., detects depression [17]) and provision of general care and companionship (e.g., proactive recommendations [11]).

Fig. 1 shows the overall system design architecture of eHealthPortal. As delineated in Fig. 1, eHealthPortal consists of two building blocks: (i) the front-end, which comprises the web portal (see Section IV) to connect everyone and the home- and mobile-based sensory networks to interact with the users while non-intrusively collecting their data, and (ii) the back-end, which comprises the connection layer for facilitation of information communication, the memory layer for various types of information storage, the computation layer for information processing, and the logic layer for reasoning and decision making.

eHealthPortal has mainly two key novelties over the existing models: (i) comprehensiveness that the wellness of the elderly is evaluated in all four health-related aspects and the agents provide appropriate tender care accordingly in a holistic manner and (ii) seamless involvement that humans and agents work closely to take care of the elderly under the same framework.

A. Justification on Using Modern Devices to Assist Elderly

According to Human Factors studies on age-friendliness [18], [19], although less confident than younger people, elderly who have experiences of using the modern gadgets generally hold more positive attitudes and greater confidence. Furthermore, if computers (extensible to smart devices) are modified according to the specific needs of the elderly with simpler interfaces that follow the natural mental concepts, the elderly can benefit much from them [18]. In addition, the usage

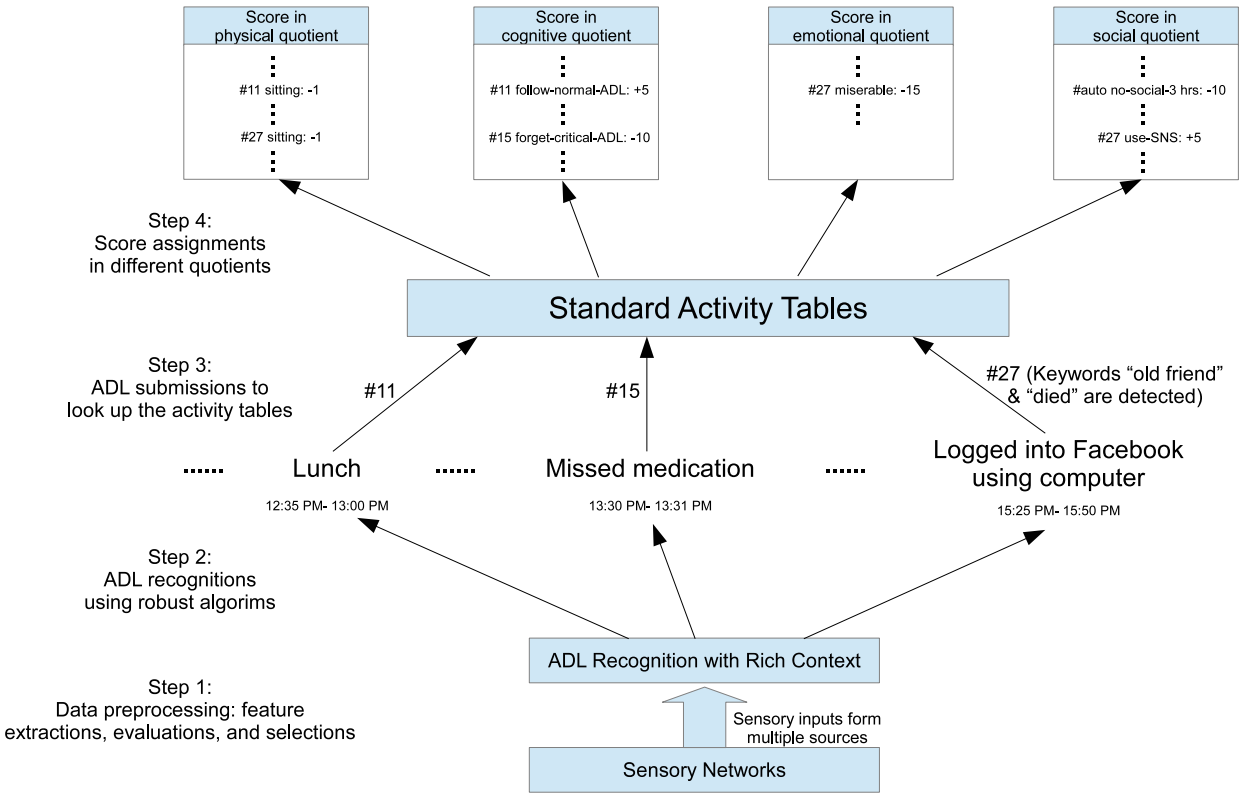


Fig. 2: Step by step illustrations of how eHealthPortal assigns wellness scores in all the four different quotients.

of Internet, computers, and social network service platforms among the elderly keeps increasing over the past decade [20]. Therefore, using smartphone and computer to deliver better healthcare to the elderly is a feasible and practical way.

B. Key Groundwork of eHealthPortal

The key groundwork of eHealthPortal consists of the home- and mobile-based sensory networks and the robust algorithms for activity recognition with context awareness (see Fig. 1). Based on the identified Activities of Daily Living (ADLs) of the elderly [21], wellness scores are assigned using standard activity tables in the physical, cognitive, emotional, and social quotients, respectively [11]. How to assign the wellness scores according to the recognized ADL is illustrated in Fig. 2. Although the wellness scores are assigned based on the relationship between the autonomously recognized activities and their corresponding effects in the respective quotient, eHealthPortal also allows the elderly to self-report their activities.

C. Multiagents for Better Sensing, Caring and Companionship

Multiple agents are required in the AIP scenario [5] for the following purposes: (1) to perform unobtrusive sensing from multiple sources, (ii) to guarantee ubiquitous access of information and assistance for all-round tender care, (iii) to better serve the elderly with different specialties, and (iv) to create more opportunities for interactions with the elderly. Fig. 3 shows an example demonstration of the collaboration framework consisting of one robotic and two virtual agents.

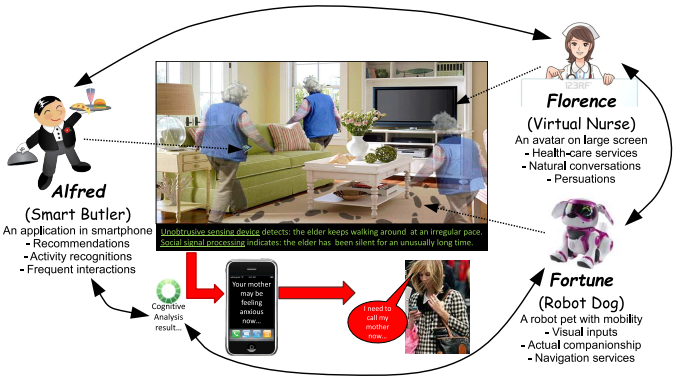
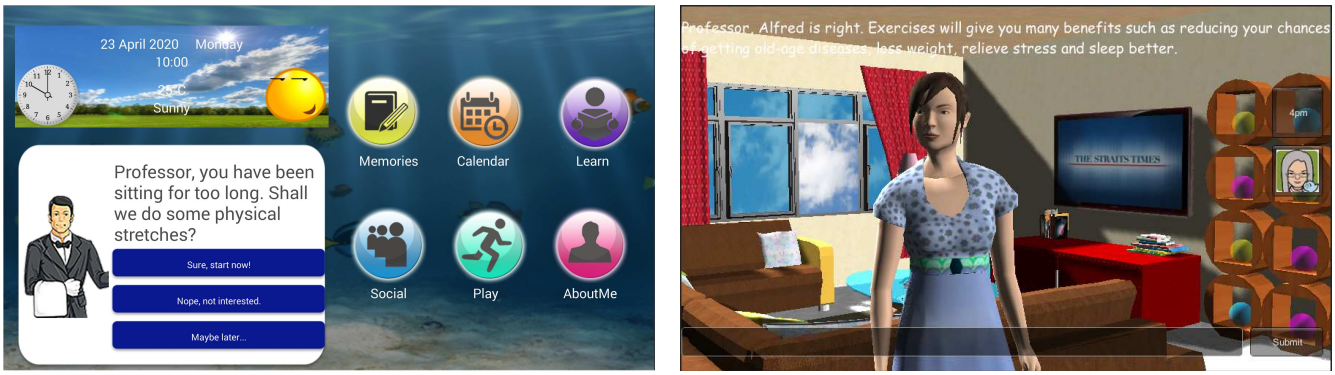


Fig. 3: An example demonstration on how the agents collaboratively sense the status of the elder occupant and notify her daughter for the recognized emotional abnormality.

The functionalities of the agents can be categorized according to the four types of supports that the elderly generally require: (i) physical assistance such as notifying the family for any detected abnormality (fall down or get lost outside home) and encouraging the elderly for more physical exercises (normal stretch or rehabilitation), (ii) cognitive assistance such as warning for mistakes (forget to turn off the stove or lock the door) and reminding the scheduled events (medication or appointments), (iii) emotional assistance such as offering appropriate suggestions (cheer up by telling a joke or calm down by playing a peaceful music) and notifying emotional



(a) Smart Butler Alfred

(b) Virtual Nurse Florence

Fig. 4: User interfaces of the virtual agents. (a) Smart Butler Alfred is recommending physical exercise to the elderly occupant. (b) Virtual Nurse Florence agrees with Alfred and is trying to persuade the occupant who did not wish to follow the advice.

abnormality (depress or over excitement) to the family, and (iv) social assistance such as providing actual companionship (touch and small talks) and promoting more interactions with others (personal conversations or upcoming social events).

The smart butler Alfred (see Fig. 4(a)) resides in the mobile platform and provides all-round tender care through frequent interactions (i.e., speech and tap). Its context panel (upper left portion) displays peripheral information. It provides various functions via their respective buttons in the function panel (right portion). The interaction panel (lower left portion) delivers all types of messages, such as reminders, recommendations, small talks, etc., and receives the user responses through button presses. More details about Alfred can be found in [5], [17], [12]. The virtual nurse Florence (see Fig. 4(b)) resides in a home computer and specializes in promoting healthy lifestyles and providing health-related recommendations to the elderly. It interacts with the elderly through speech and mouse click. Its most unique features is the use of a computational model for adaptive persuasion. More details about Florence can be found in [5], [12], [14]. It is illustrated in Fig. 4 that Alfred and Florence can work together seamlessly.

IV. A Web Portal for Seamless Communications

The front-end of eHealthPortal consists of four different tabs, namely Stream, Wellness, Medical and Calendar, which can be accessed using any web browser installed in computers and mobile devices. Fig. 5 shows where eHealthPortal gets its contents (see Fig. 1 for cross-reference) and each type of the registered user can access which tabs of eHealthPortal. For example, the caregiver and doctor cannot access Stream and Calendar tabs due to privacy concerns.

Fig. 6 shows the layout of the Stream tab, where the elderly and their family and friends connect with each other for streams of past events. This Stream tab may seem similar to other timeline-based applications. However, as a novel feature of eHealthPortal, the agents can join the hub as the friends of the elder user and they can post on the stream autonomously. Typical posts of the agents include the current status of the

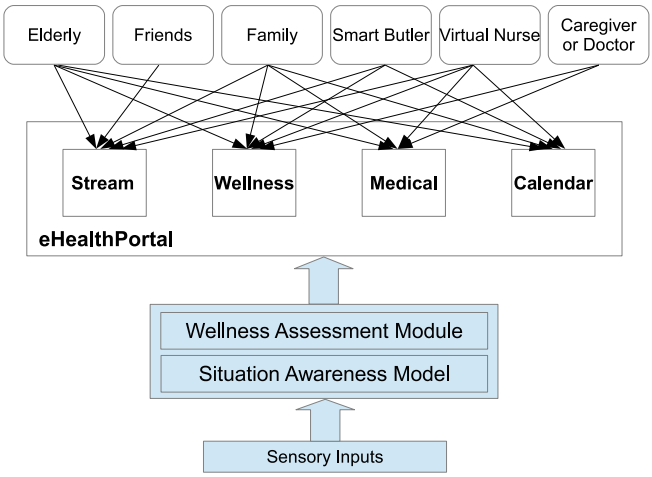


Fig. 5: The simplified illustration of information flow from the back-end to the front-end in eHealthPortal.

elder user (users can define the level of disclosure), graphical diary [22] of the elder user, and interactions (invitations and acceptance of an upcoming event) on other's stream on behalf of the elder user. Moreover, in the Stream tab, different user icons indicate different identities of the message poster. For example, in Fig. 6, the elder user herself posted the 10:00 and 14:00 messages, the Virtual Nurse posted the 13:30 message, and a friend's Smart Butler posted the 15:30 message. By enabling both humans and agents post messages, eHealthPortal encourages and enriches the social interactions of the elderly. Furthermore, eHealthPortal does not work alone, but autonomously migrates posts from popular social network service platforms, such as Facebook.

eHealthPortal also provides the real-time wellness scores to the elder user and others with granted access. Although traditional wellness evaluation questionnaires are designed to assess the elderly weekly [23], for real-time appraisal, in eHealthPortal, users can view and analyze the wellness scores at any time in different time scales (hourly, daily, weekly, and

Fig. 6: The Stream tab of eHealthPortal.

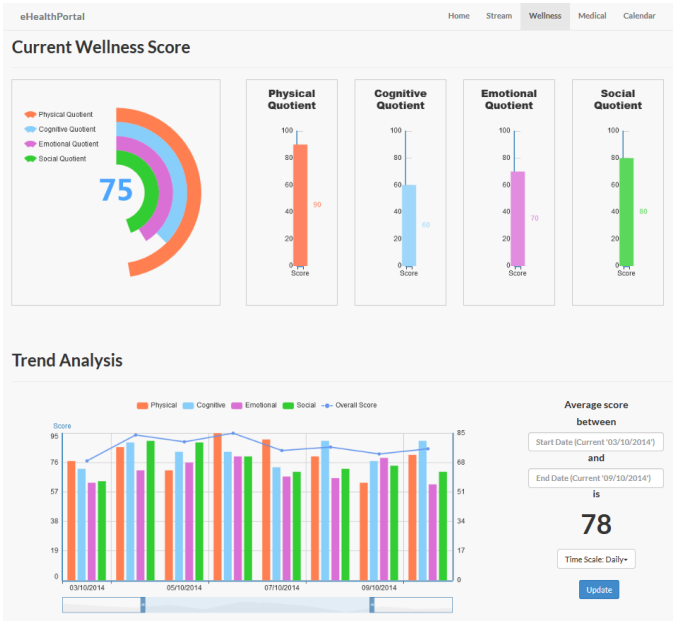
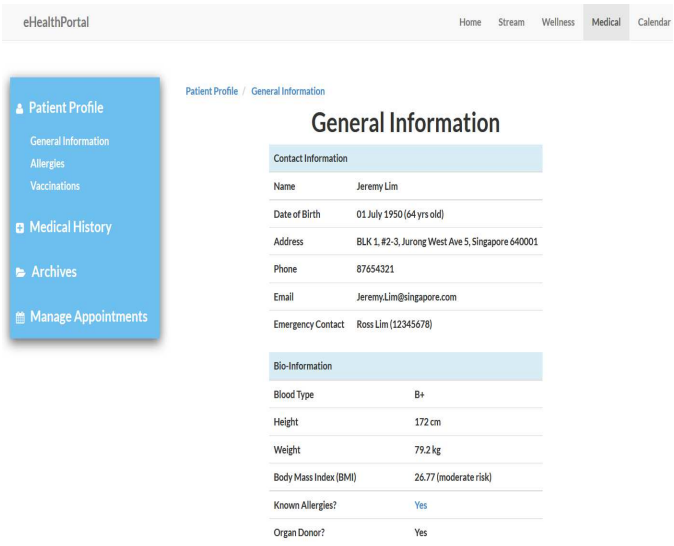
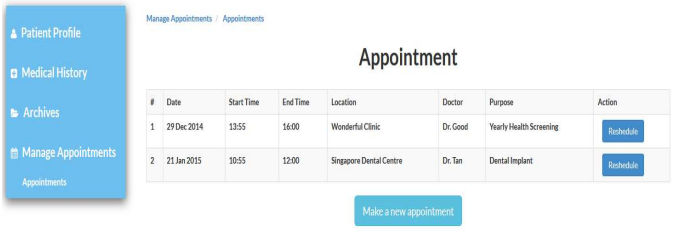


Fig. 7: The Wellness tab of eHealthPortal.



(a) General information of the elder user



(b) Making appointments with the user via the Virtual Nurse agent

Fig. 8: The Medical tab of eHealthPortal.

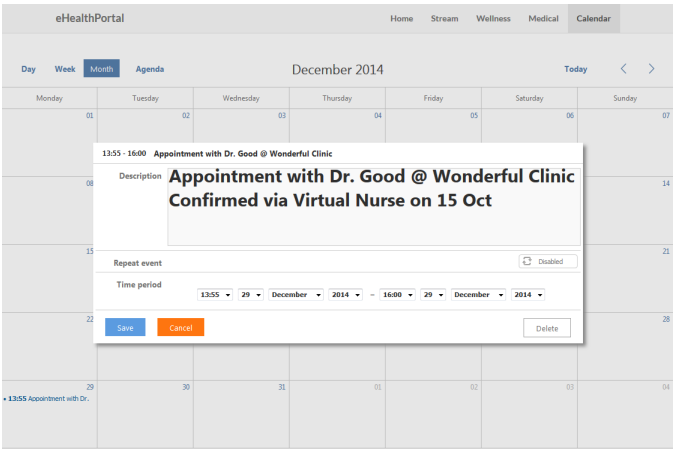


Fig. 9: The Calendar tab of eHealthPortal.

monthly). Therefore, these scores (see Fig. 7) provide instant and relatively subjective performance indications of the elderly in different aspects.

The Medical tab (see Fig. 8) enables doctors (including physicians or therapists) and caregivers to update the health-related information of the elder user and manage medical appointments (see Fig. 8(b)). Among all the agents, only Virtual Nurse, who is equipped with health-related knowledge, can access this tab. The innovation here is that all appointments are confirmed via Virtual Nurse that the doctor or caregiver only knows whether their proposed time slot is available to the elder user (if not, Virtual Nurse will suggest alternative time slots) for privacy protections.

The Calendar tab (see Fig 9) organizes the past and upcoming events of the elder user. The uniqueness here is that Smart Butler can use the scheduled events (managed by either human or agent) as prospective memory [24] to

dynamically deliver reminders to the elder user. Currently, the calendar used in eHealthPortal has been synchronized with Google Calendar. Moreover, eHealthPortal assigns hidden attributes to be associated with each event. For example, for the appointment shown in Fig 9, eHealthPortal defines three reminders to be delivered by the Smart Butler: (i) three days prior, (ii) on the day, in the morning after wake up, and (iii) two hour prior (relatively earlier due to the reason that last appointment at this address was late). As such, eHealthPortal can provide better tender care to the elder user.

V. Benefits of eHealthPortal

Elderly in general belong to the lower-income class. Therefore, cost is an important issue for every eldercare system. eHealthPortal does not impose much additional financial cost because it can leverage on existing equipment. The highest cost component or the most troublesome deployment of the eHealthPortal infrastructure is probably the built-in sensory network. However, more and more smart-home projects have been or will be launched on a large scale in the near future. For example, Singapore will install home-based sensors in new residential buildings [25], which can be directly linked to eHealthPortal. Another high-cost component is the smartphone (or pad), However, nowadays, the penetration rate of smartphones is quite high, even among the elderly. For example, a survey [26] shows that 83% of Singaporeans aged 55 and above already own at least one smartphone. Actually, eHealthPortal is flexible enough that only the sensory network and the smartphone can realize most of its functionalities (in case the elder user does not have a computer, the Virtual Nurse's functionalities can be merged into the Smart Butler). Furthermore, to upkeep the system, a small amount of maintenance fees will apply. However, some might be already paid without using eHealthPortal (e.g., Internet connection) and some governments (e.g., Singapore) subsidy the utility bills for selected households.

The key novelties of eHealthPortal have been highlighted in Sections III and IV. In addition, anonymous user information can be collected and analyzed on the national scale for further analytics. Normally, national well-being indices are obtained by sending out numerous surveys and questionnaires, which may contain biases and definitely require much human effort in data collection. Alternatively, eHealthPortal provides relatively subjective wellness analyses because most data are collected directly from the sensory network and processed autonomously. Furthermore, eHealthPortal can work or share the knowledge with other systems, applications, and people through an open mHealth architecture [27]. Therefore, the research impact of eHealthPortal would be promising.

eHealthPortal would bring tremendous societal impact as well: (i) the elderly could extend their enjoyable lives in the familiar environment but still live comfortably, safety and independently with the help of the intelligent agents all day long, (ii) the family would have less financial and short of manpower problems but still can check the elderly's status frequently and in real-time through cyber and actual communications, (iii) instead of building more nursing homes and care centers, the government could spend the money to support or subsidy other caring expenditures, and (iv) some personnel attached to eldercare would contribute elsewhere to compensate the shrinking workforce in the future.

VI. Conclusion

The eHealthPortal system is a well-designed social support hub for the active living of the elderly. By crowdsourcing help and support from the users' family and friends, caregivers, and doctors, eHealthPortal cares for the wellness of the elderly in the physical, cognitive, emotional and social aspects. As a novel feature of the system, eHealthPortal is supported by a group of virtual and robotic agents for providing reliable sensing in unobtrusive ways seamlessly, tender caring in a holistic manner proactively, and actual companionship in natural forms constantly. Some components of eHealthPortal have already been developed as prototypes, such as the sensory networks, virtual agents, front-end web portal and various embedded algorithms and communication protocols. Some components are being developed and tested, such as the robotic agent. We will soon finish the overall system and conduct pilot studies in the near future. We do believe eHealthPortal will be a successful crowdsourcing platform where everyone jointly contributes to provide better eldercare to our seniors.

Acknowledgment

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