SilverWisdom: Towards a Knowledge Base for Elderly People

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***Abstract*—Active aging has become a hot research topic for both academia and industry. A lot of initiatives have been set up and delivered fruitful results and applications towards this emerging research area. As the society and population develops, many elderly people have high education background and knowledge, which enable various opportunities in knowledge sharing and learning, and even creating new knowledge. Relatively little attention has been paid to knowledge management for elderly people. In this position paper, we present a system named *SilverWisdom* towards a comprehensive knowledge base for elderly people. SilverWisdom manages the entire life cycle of knowledge, and fosters an infrastructure for multi-disciplinary research. Particularly, we present the system architecture of SilverWisdom and outline the open research problems. We believe that the success of SilverWisdom empowers active aging with knowledge and makes elderly people feel more fulfilled and socialized.**

I. Introduction

Today, population aging is a trend spreading across the world. It is estimated that one third of the population in developed countries and one fifth of that in developing countries will be elderly people by the year of 2050 [1]. In Singapore, the proportion of residents age 65 years or above rose from 9.3% in 2011 to 9.9% in 2012 [2]. On the one hand, a large aging population imposes significant pressure to the medical and healthcare systems. Government and business have set up initiatives to address various issues risen from global aging. On the other hand, there are vast opportunities in enabling elderly citizens to continue making important contributions to society, which will derive enormous benefits. They posses invaluable knowledge, wisdom and skills accumulated over many years. With the economic and social development, more and more elderly people have high education background, according to statistic up to 2010 [3], there are 3.7 percent of Singapore residents age 65 years or above have received university education. In this paper, we investigate whether and how we can leverage knowledge, wisdom and skills from elderly people to impact the development of the entire society.

While there have been already many initiatives conducting some research works for elderly people, they mainly focus on physical health care, social integration and business value. Little attention has been paid to knowledge management for elderly people. The elderly population as a pool of great wisdom, experience and skills have been traditionally overlooked. Indeed, some studies have quantified the potential economic benefits of tapping into the elderly talent pool (e.g., it is estimated to be $10.8 billion per annum in Australia [4]). In view of this fact, we plan to use emerging computing technologies to build a knowledge base for collecting, mining and sharing the knowledge and skills of elderly people.

Building knowledge base for elderly people, especially for those high education background people, will reap huge economic and social benefits. Firstly, knowledge and experience from elderly people is highly dependable and precious for next generation people, and young people can learn more which may not be always available from books. Secondly, even though aging people cannot finish high-demand labor works, they still can continue making important contributions to society taking advantage of computing technologies. There are many opportunities to leverage their knowledge and experience in different sectors [5]. Thirdly, in modern societies, continuing their contributions to the society attract more and more elderly people. They can find their personal fulfillment by continuously contributing their knowledge to the society. Moreover, the knowledge base itself forms a social network among generations and will mitigate the feeling of loneliness.

There are many technical challenges for building a knowledge base, especially for elderly people. The challenges comes from many technical domains, from underlying data representations for knowledge to elderly friendly HCI. Essentially, we envision that building a knowledge base is a big data problem, where we need to address the 4V challenges.

- **Variety:** varied data model and file formant, new insights will be found when analyzing these data types together.
- **Velocity:** data and events come in at high speed, they must be stored and analyzed efficiently to maximize social and business value.
- **Volume:** ever-growing data of all types, easily amassing terabytes even petabytes of information
- **Value:** mining the insights and value from the massive data sets.

Specific to knowledge base, we identify the following challenges associated with 4V. Firstly, the data collected from elderly people should support different formats. Knowledge is hard to express using an unified format, which can be any type of data - structure, semi-structured and unstructured data such as texts, pictures, audios, videos, sensor data, and so on. Secondly, data are often relevant and correlated. It is a complete system constituted different information sources. Each information source can't form a whole knowledge sepa-

rately, they must be organized together. Moreover, most elderly people have some physical drawback or degration, and there are many noise existed in the knowledge data collected from elderly people. We need to design better interactive interface for elderly people to reduce noise and mining in case of interference is still a huge challenge. Finally, as a knowledge base, we care about the scale. Only the scale is sufficient, we can achieve the real knowledge, as a general principle of crowdsourcing [6].

In this paper, we propose a system named *SilverWisdom* towards building a comprehensive knowledge base for elderly people. It collects information from elderly people, advocates advanced pre-processing to guarantee data quality, organizes and stores them together for further mining, and finally shares these knowledge to people. *SilverWisdom* is built upon various emerging technologies: HCI, cloud Computing and crowdsourcing. Even though the related technologies are existed, it is a challenging task to integrate them together into SilverWisdom. In this position paper, we outline the architectural design of SilverWisdom and discuss the open problems for further research. We hope that this paper will bring awareness to the research community about the important opportunities of building a knowledge base for elderly people.

Organization. The rest of the paper is organized as follows. Section II introduces an background and related works of ageless computing and related emerging technologies. Section III presents the architecture of *SilverWisdom* and open problems of each component. We summarize this paper in Section IV.

II. Background and Related Work

This section introduces the background on ageless computing and reviews the related work on emerging technologies.

A. Ageless Computing

The impact of global aging is unprecedented, pervasive, enduring and has profound implications for many aspects of human life. As the education people experienced is better generation by generation, we believe that this elder population will be more well-educated and have more financial power. Elderly people want to be physically fit, active, socially connected and self-reliant [7]. To that end, participating in normal social activities which will help them to achieve self-fulfilment is crucial. The current situation is far from ideal. The participation rates of both male and female elder workers are no more than 21% in developed countries [1]. In this case, it is of great importance that the elder people can enjoy proper ways to reintegrate themselves into the society which can benefit not only the elder but also everyone.

In 1993, Graafmans and Bouma defined the concept of *Gerotechnology* [8]. Then the International Society of Gerontechnology was founded. And more recently, computer scientists started to explore the possibilities of helping the elderly people taking advantage of computing technologies and the research community has marched into a new area called Ageless Computing.

Major research challenges of ageless computing including emotional challenges, physio-congitive challenges, social challenges and others are sumarized and discussed in a recent position paper [9]. A broad range of technologies such as virtual reality, cloud computing, AI and ubiquitous computing have already been applied or being applied to face these challenges in areas like smart homes [10], robotics [11], and telemedicine [12], [13], etc. Specifically, computing techniques like virtual assistant and gaming have been proposed for ageless computing.

Multi-functional virtual assistant has been a hot research topic in ageless computing. In [14], [15], researchers designed virtual agents to assist disabled elderly people with their daily life at home. Supported by AI techniques, virtual agents can contribute in more aspects such as agent assisted e-commerce [16], remote health care at home [17] and life companions [18]. Using robotics technologies, elderly people are able to enjoy rehabilitation and social services provided by real assistants [19], [20]. Dedicated robots emulating real animals like a car or a seal can improve elderly people's feeling with positive impacts [21].

Gaming also plays an significant role in ageless computing. Many physical rehabilitation games have been developed for rehabilitation of elderly people [22], [23]. And, cognitive training games can make cognitive training enjoyable for elderly people [24], [25].

The VR(Virtual Reality) technology plays an important role in both virtual assistant and gaming. This paper also leverages VR to build a more innovative and interactive knowledge sharing system.

B. Related Emerging Technologies

Many recent emerging technologies are relevant to the proposed ageless computing systems, ranging from HCI, big data, crowdsourcing to knowledge base. Each field has its own surveys and reviews (e.g., for crowdsourcing [26], [6]). We refer readers to them for more details on each emerging technology. Instead, for each emerging technology, we mainly focus on its relevance to ageless computing.

HCI: Although some efforts have been made to promote age friendly HCI [27], most researches still focus on young users. Due to age related physical disabilities, conventional HCI experience cannot meet the need of the elderly people. This has made age friendly HCI a challenging topic. However, some current techniques can be adjusted and optimized for old users. For example, motion sensing devices like Microsoft's Kinect can help to promote old users' rehabilitation experience as well as monitoring their health statues.

Big Data: Prior to offer assistance to elderly people, large monitoring data regarding of living habits, movements, health status are collected and analyzed. This is a form of big data problem [28]. Hardware and software approaches are emerging to address those challenges [29]. Additionally, special attention needs to be paid on the privacy and security of the data.

Crowdsourcing: Crowdsourcing has the potential to boost the knowledge market based upon the elderly and highly

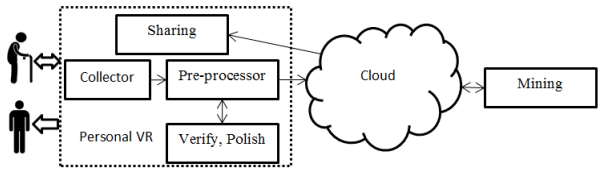

Fig. 1. The proposed architecture of SilverWisdom

educated people. Notable examples of crowdsourcing include Threadless, iStockphoto, InnoCentive, the Goldcorp Challenge and so on [30].

Knowledge Base: Knowledge can be categorized as tacit knowledge and explicit knowledge. While the explicit knowledge refers to knowledge that cab be easily stored and communicated to others, tacit knowledge is much more internalized knowledge that an individual may not even be consciously aware of. For explicit knowledge, there are already some online sharing systems in different forms such as Wikipedia, Quora and Stackoverflow. For tacit knowledge which the elderly people are especially rich in, it is still challenging to share it effectively.

III. Proposed System Architectures

In this section, we will present the architecture of SilverWisdom and discuss the research problems.

A. Overview

SilverWisdom is designed as an aging friendly cloud based virtual environment system. It is capable of information gathering and mining for sharing knowledge and experience among users. Prospective users of SilverWisdom not only include elderly people but also other people who want to learn from or contribute to the knowledge base. Figure III-A shows the proposed architecture. It consists of four key parts: Collector, Pre-processor, Storage and Sharing. The collector collects information from the elderly people. The pre-processor removes the noise from inputs and guarantees the quality of the information. A cloud infrastructure serves as the online infrastructure for knowledge mining and storage. The Sharing component facilitates people to communicate with other in a real-time and/or interactive manner. With VR techniques, this system should be capable of setting up a virtual meeting rooms for both the knowledge contributors or the learners.

B. Research Problems

There are many interesting and challenging research problems ahead for building the SilverWisdom system. Some are general to the entire computing community and others are specific to ageless computing. We list the open problems for each component and call for actions to address them in the research roadmap of building the SilverWisdom system.

1) Collector: As the front-end of the system, the collector gathers information from users in multiple forms. Traditionally, people express their idea, thoughts, experience and other forms of knowledge in words, audio or video. Since the elderly people who may have issues in using normal computers, new forms of HCI tools are of great need. We envision that different user-specified age-friendly HCI tools will be developed to compensate the declining physical abilities of elderly people. One potential approach is to enhance HCI with aging friendly VR. It allows most straightforward and easy-to-use tools for people to interact with the virtual world. Currently, although VR has a broad range of different applications and implementations, it is more about a fancy and fashionable device for the young. We hope that, with proper tuned age friendly VR, the elderly people get their youth back in the virtual world. All their declined capabilities will never keep them away from enjoyable communication with others again through the VR-based adjusted and improved HCI.

To this end, we propose personal customized age friendly VR experience. Firstly, the experience should be personalized so that the cost of relevant devices are reasonable and affordable. This is of unique importance since the elderly people may not be willing to carry awkward digital devices. For people suffering from hearing difficulties, we can provide augmented audio or improve the visual parts to replace the audio part. For people suffering from body inconvenience, we may provide audio controlled virtual body to assist. We hope that VR can bring us huge amount of possibilities to make the impossible possible.

2) Pre-Processor: It is a unique need for the elder people that their time-proved knowledge need to polished since they may suffer from declined abilities to express themselves which may make the collected data "noisy". In SilverWisdom, the pre-processor embraces advanced data cleaning technologies to guarantee the value and quality of the knowledge contributed by the elder people.

At the first place, the pre-processor recognizes speeches, body movements, facial expressions and other types of information. Then the information will be processed for errors and weakness. Errors may be caused by unclear voices, lost words, etc. They should be recognized and corrected prior to further processing. Weakness may be caused by age related issues of the elder people including inaccuracy of body movements, low voice and so on.

While the errors may be relatively easy to correct, compensating the weakness is challenging. We need not only technical support but also the understanding of the elder's intensions. This is especially difficult when the elder people themselves do not know what they want to express for sure, because they may suffer from memory loss. Thus, new challenges have risen from human understanding oriented artificial intelligence. When one elder person is contributing his knowledge in one specific filed, we can train our domain knowledge as well as context awareness to guess the intention and compensate the weakness from the elderly people.

3) Data Storage: Knowledge can be understood and expressed easily for humans. However, it is very hard for computers because all information are presented in binary format. We must design an intelligent, robust and elastic storage system for the knowledge base making the knowledge

data be stored, mined and retrieved efficiently. The following issues are data-centric challenges in SilverWisdom.

Heterogenous knowledge data formats: Heterogeneous data results in varied data formats within storage system and newly data in different formats from external sources continue to be added to the knowledge base. Our initial work has addressed the scalability of large-scale graphs (like social network) [31]. The storage system for knowledge base should be highly scalable so that we can add any knowledge expressed by a new format easily. Moreover, in the view of features of different categories of knowledge data, designing efficient data and index structure specific for different data formats is also very significant.

Mining knowledge data: Knowledge base is a system consist of huge information. Even though we can collect these information individually, knowledge is only meaningful if we connect and mine different data sources. How to organize, mine and express the relationships of partial knowledge information upon heterogenous and huge datasets is another challenge.

Knowledge explosion: The size of knowledge exceeds the storage and processing capacity of conventional database system. We need to a new generation storage system designed to extract knowledge from very large volumes of a wide variety of data, by enabling high-velocity capture, discovery and analysis.

Cycle management. Knowledge has its life cycle. For example, knowledge may be out-dated. It requires a lot of information and context to judge whether a piece of knowledge has been outdated or not. One may leverage crowdsourcing techniques to address this problem.

4) Sharing: Together with the collector, the sharing component provides immersive or semi-immersive experience for users. Ordinary knowledge sharing mechanism often has no strict requirement for users. But the SilverWisdom's potential users may include people suffering different forms of disabilities since the elder people may be much more likely to devote their energy and enthusiasm to help the weak in the society. Thus, it is of great importance that we can make the sharing subsystem very natural and easy to use. This rises challenges to the design of relevant devices which should be not only embedded and mobile but also natural to people' life.

The sharing infrastructure should be configurable depend on different situations. For sharing of explicit information, normal LED or LCD display is enough. For sharing of multimedia information, semi-immersive or immersive VR or Augmented Reality(AR) is the most efficient solution especially for the elder people.

Software applications should be developed to enable users to customize the AR environment as well as the collector mentioned before. According to a classic survey [32], AR can be applied in various filed including medical, military, entertainment. For application in ageless computing, optimization and customization for the elder's use is in need.

In summary, ageless computing is relatively a new field waiting for further exploring. In addition to the above-mentioned challenges, we have identified other challenges in general. First of all, the success and value of ageless computing depends on whether the elderly people are willing to involve technologies in their late life. The experience should be enjoyable and pleasant for them, and provide solid and practical help rather than beautiful amusement. Secondly, there are many issues in relevant areas including the study of age friendly UI design, the study of smart technologies' psychological impact on the elder people, the economical study of the elder market, etc. The SilverWisdom system we proposed is a part of the ecosystem for elderly people. Its own success depends on the development of the entire ageless computing ecosystem.

IV. Conclusion

Aging has brought unique challenges and opportunities in our society and economy. In addition to striving to improve the medical and health care services for elderly people, this paper argues the importance of enabling them to continue to contribute their knowledge, skills and experience to the society. We present the architectural design and open problems for building SilverWisdom, a system for creating, mining and sharing knowledge from elderly people. We hope this paper will bring the awareness to scientists and engineers from multiple disciplines as well as government and business, and eventually develop an aging-friendly knowledge world.

Acknowledgement

Xuntao Cheng and Zhaojie Niu are supported by the Ph.D. scholarship from joint NTU-UBC Research Center of Excellence in Active Living for the Elderly (LILY).

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