Transcultural Health-Aware Guides for the Elderly

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Abstract

In this brief position paper, we present our vision for using software agents and related technologies to address the growing need of transcultural health-aware "Guides" for the elderly, an increasingly important topic given the clear trend of population ageing. Such autonomous intelligent guides are employed in smart living/city infrastructures to give emotional and healthcare support for the elderly wherever they are, whether at home, outdoors, or in hospital. The main purpose is to help ageing people to avoid progressive loss of physical, cognitive, and emotional activity, and most importantly to avoid social exclusion.

Keywords

Population ageing, smart environment, argumentation, ontology

1. Introduction

Most continents, in particular those where the authors live, are exposed to the tangible effects of the ageing of the population, with all the challenges for the society and for the individuals (the ageing people, but also their relatives, caregivers, doctors) that this demographic change raises.

In this paper, we present our vision on how to address some of these challenges; in particular, we investigate how intelligent software agents could mitigate the risk of progressive loss of physical, intellectual, and emotional activity of ageing people, and of their social exclusion,

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in particular when a transition from different situations (moving from home to a protected structure, or from a protected structure to an hospital) takes place.

We believe that one way to cope with the needs of old people, especially during these delicate transitions where they are much more fragile than in stable situations, is to provide them with highly-interactive culturally adaptive "Guides" that not only care for their health but also serve as entertaining companions that interact through spoken dialogues and that stimulate their cognitive abilities. Such Guides, designed and implemented as software agents compliant with the strong notion of agency [1] and also characterised by emotional features à la Bates [2], besides mentalistic ones à la Shoham [3], are meant to become a familiar and trustable point of reference for their users. The Beliefs-Desires-Intentions (BDI) agent model, extended with emotional features as suggested for example by Pereira et al. [4], Alfonso et al. [5], Su et al. [6], would hence represent a suitable architecture for our Guides, and has been recently adopted in healthcare applications [7]. Given the BDI-oriented nature of the Guides[1], we will exploit languages like DALI [8], SR-APL [9], IndiGolog [10], or Jason [11], meant as a standalone infrastructure or, better, integrated in the environment- and organization-oriented JaCaMo framework [12], for their implementation.

We use the word "Guide" to emphasise that such interactive assistants are always available to their users when they need advice or company, wherever they are, be it the comfort of their home, outdoors, but also at difficult times for example when moving to protected structures or hospital is needed. The Guides may provide guidance — following a protocol pre-agreed with doctors, psychologists and caregivers — to the elderly on all those situations which do not require a doctor evaluation and assessment (entertainment, social activity, physical activity, diet, medication to take according to the agreed protocol). By watching over the elderly, Guides can collect precious information on their behaviour and can serve as a source of reliable information for the doctors who care for the elderly. Hence, guidance is bidirectional: caregivers choices and focus of attention can indeed be driven by the Guide, based on what it senses, observes, hears, and deduces.

We expect that Guides should quickly learn the cultural profile of their users and flexibly adapt to cross-cultural interaction. This means adapting the style of conversation to the conversation party: old users may require the adoption of a limited, simple vocabulary, which includes words familiar to them, while doctors may take advantage of a rich technical vocabulary.

By boosting cross-cultural interaction, our Guides will also facilitate people to get in touch and to interact, hence achieving one of the main risks of ageing: social exclusion.

The targets of our investigation are indeed natural language processing, ontologies and argumentation techniques to ensure cross-cultural interaction [13, 14]; agent-oriented approaches to make such cross-cultural interaction intelligent and emotionally realistic and believable, which requires explicit representations of the user's state of mind [15]; and smart-* approaches to make agent-oriented approaches efficient and well integrated with the existing environment and infrastructures.

[1] By "BDI-oriented" here we mean, in a very broad sense, the conceptualization and implementation of the Guides based on explicit knowledge/ beliefs, declarative and rule based reasoning/planning, explicit goals to achieve.

2. The "Guides" and Their Smart Environment

The architectural framework we have devised relies upon a "sensing layer" which is necessary for creating smart environments where people are cared for. Improving the state of the art on the sensing layer falls outside our research investigation: we plan to exploit as many out-of-the-box techniques and tools as possible, among the many available ones [16], to allow the Guides to sense what people are doing in an unobtrusive (or "acceptably obtrusive") way. Among these tools, we will consider cameras tracking people and their actions for detecting falls [17], wearable and IoT devices [18], sleep sensors [19].

We are much more interested in exploring the potential of software agents as the building blocks for analysing, designing, and developing the Guides. In particular, we are interested in argumentation schemes that are specific for the elderly and for each culture, and in their translation into properly formalised argumentation frameworks [20] where the Guides, implemented as agents, can play a role; in the integration of ontologies and ontological reasoning [21] inside such argumentation schemes; in the identification of a way to interact with the user naturally also via voice interaction [22]; in the exploitation of NLP profiling techniques to detect depression and anomalies in the emotional and cognitive status of the user [23].

The adoption of methods grounded on formal techniques throughout all the stages of the Guide engineering will ensure that the actions of the Guide are trustworthy, explainable, and – up to the extent ethics can be formalised and implemented – also ethical [24, 25].

A summary of the main research challenges are:

- developing an intelligent agent approach that supports natural language dialogues with elder users that is suitable for elderly of a particular culture; the evaluation therefore requires human subjects of different cultures to ensure that cultural adaptation works well for different cultures as well as ensuring that the dialogues are suitable specifically for elder users;
- connecting the agent technology with existing smart living environments and smart city infrastructures, so that dialogues are appropriately situated;
- adding features for the intelligent agents to give emotional support for the users as well as care for their overall health (which includes doing physical exercises, taking medication, etc.);
- ensure that access to medical data used in dialogues with the users are ethical and that data about living routines of the users provided to doctors are respectful of privacy.
- verifying formally that dialogues will never lead to unethical or culturally inappropriate interactions.

To address these challenges, our vision builds on a number of technologies:

- **Smart-environment and smart-city infrastructures**. Since the Guides accompany the elderly wherever they are, we need to access data from smart environment sensors as well as inter-operate in "systems of systems" in the context for smart cities, and in particular with hospital systems; we will rely on available standards for this, and connect them to our multi-agent systems infrastructure to allow interconnection of Guides of

different people as well as between Guides and existing systems. To this aim we will exploit the lessons we learned while engineering systems that integrate ambient intelligence/IoT on the one hand, and agents/MAS on the other [26, 27, 28]. Besides existing work emerged from the autonomous agents community, in order to immerse the Guides in a smart environment we will also consider the potential offered by open and configurable frameworks like FIWARE[2]. Albeit not being an agent-oriented infrastructure, FIWARE presents many features worth exploring: it has demonstrated its industrial strength in many smart* application domains including healthcare, it implements distributed smart components that interact asynchronously via message passing, and may be in principle integrated with (or "under") JaCaMo, to provide access to the surrounding smart environment via a standard API.

- **NLP profiling techniques and voice-based interaction**. All the interactions between Guides and humans will be through spoken dialogue in natural languages; although existing tools will be used, in our vision we call for a seemless integration between out-of-the-box voice-based human-computer interaction tools and the sophisticated culturally adaptive AI techniques described below, which address the communication level in a broad sense.
- **Big data and computer vision**. We need to have summary information from the relevant data for the various activities the Guides will accompany the user, for supporting medical staff about the ongoing health state of the user, as well as symbolic representation of the surroundings of the user; again we plan to use out-of-the-box techniques for this but connected to our approach on representing environments for autonomous agents.
- **Planning and reasoning**. To provide useful information and support, and to engage in complex dialogues, we rely on various formal techniques such as non-monotonic reasoning, logic programming, and automated planning, adapted to the context of transcultural smart-environment elder care. The literature on adoption of formal techniques for modelling and implementing agent planning and reasoning mechanisms is vast and many recent proposals may be taken under consideration for being integrated into the Guides. They include, for example, extensions of goal-based plans used in BDI programming languages to encapsulate both proactive and reactive behaviour, which supports agent reasoning at runtime [29], contextual planning for multiple agents in ambient intelligence environments, useful for making the plans developed by the Guides aware of the surrounding smart environment [30, 31, 32], dynamic goal decomposition and planning in scenarios characterized by a strong inter-dependency between action and context, needed to cope with unexpected, or even catastrophic, events [33], automated synthesis of a library of template-based process models that achieve goals in dynamic and partially specified environments, which are exactly the kind of environments where the Guides will operate [34].
- **Ontologies**. Ontologies will provide the necessary vocabulary (in various languages and also in accordance with different cultures) to be used in the multi-agent dialogues that the Guides will be able to engage. Normally the Guides only dialogue with their user, but for example in medical consultations the Guides may need to participate in multi-agent

[2] https://www.fiware.org/, accessed on July 2020.

dialogues with the doctor and the user. The interplay between ontologies – and semantic web in general – and BDI-style agents – and declarative agent approaches in general – has been studied for a long time [35]. Our experience ranges from design and development of ontologies in the health domain [36, 37, 38] to their integration into AgentSpeak [13, 39], into MAS via CArtAgO artifacts [40], and into data-aware commitment-based MAS [41]. We will exploit this experience to provide the Guides with the semantic layer required to boost their interaction with users. One further advantage of using ontologies is that they could suitably cope with the dynamism that characterizes the application domain, due not only to the dynamism of the environment, but also to the cultural specificity of the elderly people. Many works on ontology evolution have been proposed in the literature [42], including those connecting ontology evolution and belief revision that seem extremely relevant for our research [43].
Finally, to make ontologies suitable to different cultures, profiles, ages, and genders, but still interoperable, we plan to exploit our background on upper ontologies [44, 45] and design ontologies in such a way that they have some upper layer shared among them, and specialized sub-ontologies for different users and tasks.

- **Argumentation**. The core of the transcultural component of our vision are argumentation protocols based on argumentation schemes (i.e., patterns of reasoning and dialogue exchange); these are used to decide the utterances of the Guides when engaged in dialogues. This is possible in practice given long-term work on the integration of Argumentation Theory techniques into Jason and JaCaMo for both reasoning and communication [14, 46, 47]. Also, the development of an argumentation-based inference mechanism for BDI agents based on Toulmin's model of argumentation [48] recently put forward [49] can be used as an alternative basis for this part of our investigation.
- **Theory of mind**. *"An individual has a theory of mind if he imputes mental states to himself and others. A system of inferences of this kind is properly viewed as a theory because such states are not directly observable, and the system can be used to make predictions about the behavior of others"* [50]. The theory of mind is the ability to attribute mental states – beliefs, intents, desires, emotions, knowledge, etc. – to oneself and to others. Its philosophical roots include the work by Dennet [51] that is very well known to researchers working on BDI-oriented agent theories, languages and architectures. With aging, cognitive abilities including theory of mind seem to decline [52, 53], and cultural factors impact its development as well [54]. Based on these observations, another fundamental aspect of our vision is that we are able to model the minds of users through formal representation of their beliefs and intentions. Current dialogue systems have no such representation and the literature in the area makes it clear that without such a representation, intelligent systems cannot fully address the needs of their users. Our existing framework for theory of mind relies on standard rationality assumptions. Based on our previous, recent investigations [55, 56, 15] we aim at doing pioneering multi-disciplinary work on modelling the minds of elderly and their culture, in particular what are the most appropriate ways to infer beliefs and intentions of users given what they communicate. This is clearly specific to the elderly public and different cultures, specially as the elder might have debilitating diseases that compromise their cognitive processes or even for cultural reasons may want to conceal certain states of mind.

- **Organisations**. Our approach also provides the ability to represent the various organisations that the users are part of (for example elderly clubs, hospitals, former employees, etc.) and this too needs to be adapted to support the different cultural systems where the organisations are situated. By integrating MOISE [57], JaCaMo already supports the specification and implementation of organizations [58], and the research on the exploitation of organizations in MAS is still very active [59, 60].
- **Runtime verification**. Because the basis of our work is formal, this also allows us to employ Runtime Verification (RV) techniques to ensure that Guides never make dialogue utterances that are unethical or inappropriate for the elderly or for a particular culture. RV can also be used at a lower, IoT, level, to check that what sensors transmit is in line with some known pattern recognised as "normal behaviour", to raise an alarm if sensory inputs deviates from that pattern. Runtime verification engines based on computational logic, like RML[3] [61] and the trace expressions formalism it builds on [62, 63, 64, 65] are a promising direction to address this challenge, and are integrated with Jason [66].

Clearly, to evaluate the results of this research, we will need a multidisciplinary team to interact with elderly users, including geriatricians, as well as psychologists, sociologists interested in population aging and philosophers interested in ethical AI systems.

3. Conclusions

This short paper presents the preliminary results of a feasibility study that the authors carried out looking for an answer to the question: "How can we address the growing need of transcultural health-aware tools and technologies for aging people?". We believe that the integration of existing IoT and smart-* approaches can help providing a very effective, pervasive and reliable "sensing layer", on top of which intelligent software agents can be designed and implemented, and can provide the "intelligence layer" needed to implement a cross-cultural Guide. The MAS infrastructure adds a further "intelligent coordination layer" to the architecture. The proper management of emotional aspects is part of this intelligence layer, as the theory of multiple intelligence suggests [67], and a natural interaction interface is the means to reduce the barriers between the users and the Guide.

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