Persuasive and Polite Sentences to Drive Human-Robot Interaction in Smart Homes for Elderly Care

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Abstract

This paper addresses a scenario where a smart environment drives a proactive robot to motivate the elderly in maintaining a healthy lifestyle. The robot is in charge to trigger a vocal interaction with the person by proposing a suggestion that is polite and persuasive. We focus on the representation of sentences based on some attributes and, through spatial and temporal reasoning, we classify them over time. In an ontology, attributes are used to classify sentences and decide if the robot should start an interaction, and with which sentence. We present a preliminary implementation of the system, and we show that it is suitable for undertaking an iterative development process guided by domain experts toward a polite and persuasive virtual coaching.

Keywords

Human-Robot Vocal Interaction, Smart Home, Elderly Care, Pragmatics, Ontology

1. Introduction

The paper presents a framework to exploit politeness and persuasiveness sentences for human-robot interaction in an assistive scenario. We argue that recommendations would be more persuasive if they are provided by a robot that is polite. To design a human-robot interaction with this features, we need to investigate semantic and pragmatic formulation of sentences. Also, a robot would require proactive and coaching attitudes for starting an interaction with the intent to motivate a person in carrying out a specific activity. The paper introduces those aspects, and it presents a data representation that can be used for triggering persuasive and polite interaction based on spatial and temporal contextualisation.

Robots with different polite strategies have been considered for healthcare and recommendation and their attributes (*e.g.*, appearance and friendliness), as well as appropriate social behaviour affect acceptability [1]. Although several studies have confirmed that robots would be more persuasive if nonverbal cues are also used, *e.g.*, [2], the problem of starting a persuasive

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interaction remains a challenging open issue. The problem is especially challenging in elder care, as the elderly might have different needs, and a strategy that is persuasive for someone might not be persuasive for others. Therefore, we argue for an intelligible system that can be developed in collaboration with caregivers and that might be configured for different users.

The system we prototyped triggers a human-robot verbal interaction by controlling a robot for telling sentences that are polite and persuasive in a specific context. The context is evaluated by a higher-level reasoner (called Kibi) which process data from sensors distributed in the environment and wearable devices. Such a reasoner is in charge to track the well being of a person based on his/her routine while performing the Activities of Daily Living (ADL) [3]. In this paper, we present an extension of Kibi such to proactively motivate the person to maintain a healthy life style. With this purpose, we develop a phrasebook of persuasive sentences in Italian, and we design a context to classify data over time and start the interaction.

2. Persuading with Polite Sentences

Considering human interaction from a *transactional* perspective (*i.e.*, the communication is considered as a a mutual exchange [4, 5]), there are implicit, pragmatic rules underlying the communication between two persons that makes a transaction more acceptable for both sides. Robin Lakoff elaborated a theory within pragmatics about the *logic of politeness* [6] and she fixed three basic principles: do not impose, give options and make a feel good.

The study [7] recalls the elaboration of Gricean cooperative principle [8], further adapted by G. N. Leech [9]. The latter presents conversational maxims for being polite, and it presents a theory when persuasive sentences are obtained by minimizing or maximizing different aspects. Such aspects involve: *tact*, *generosity*, *approbation*, *modesty*, *agreement*, and *sympathy*. The Generosity Maxim concerns minimizing the expressions that provide benefits for self and maximizing the cost for self. Similarly, the Agreement Maxim concerns minimizing the expressions of disagreement, and maximizing the expressions of agreement, between the speakers.

We consider a phrasebook enriched with personal and temporal pronouns, with the usage of associative plural, and with conditionals in declarative sentences. Also, we prefer sentences involving infinite modal verb over imperative one, and we consider opening greetings to improve familiarity with *phatic* communication mechanisms [10], whose function has been well deepened by Roman Jakobson (1960). For instance, *backchannels* are expressions that provide feedback to the interlocutor to assure that the communication is correctly taking place. They are phatic expressions [11] used to verify the cleanliness of the communication channel. The ability to start and finish and interaction as been considered through explicit backchannels in [12], while those are considered as an implicit mutual agreement in [10].

Italian *deictic* expressions, *i.e.*, expressions of time or places (*e.g.*, this, that, now, then, *etc.*), are also polite, and [13] lists some techniques for supportive politeness, *e.g.*, involving reinforcing adverbs and repetitions. *Sociative* plural (*e.g.*, *us* instead of *I*) and second singular person's usage usually generates a strong involvement between speakers. Another strategy consists in preferring infinite mode over imperative's one, and conditional verbal modes in declarative sentences, *e.g.*, using past continuous; in Italian, *imperfetto*. Furthermore, attenuating expressions (*e.g.*, *maybe*) and passive, impersonal verbal constructions improve politeness.

Other persuasive strategies have been proposed, *e.g.*, in [14] a context-aware system based on ontologies is used to implement a persuasive interaction with a potential user for a healthier lifestyle. Also, [15] illustrates a model based on goals, beliefs, actions and rules. In that model,

one of the possible outcome is to induce an action or a decision toward an action in the user by projecting negative or positive consequences of this certain action that has or has not to be taken, and both lead to a sequence of decision rules the person is induced to elaborate.

In this paper, we took as inspiration this particular outcome of the model, where, for the elaboration of some sentences, we thought it appropriate to show any positive or negative consequences to induce our ideal user to perform the desired action. Among other techniques, we consider *foresighted* (powered by negative consequences) and *inspirational* (powered by positive ones) sentences.

3. Sentences Representation

We consider a robot that speaks with a person for suggesting to perform ADLs, which are activities that can be monitored to assess the independence of an elderly. We focus on ADL with the purpose to motivate a person in maintaining a healthy lifestyle and assess him/her status to be reported to caregivers. Since Kibi cannot track all ADLs (*e.g.*, managing money), and since we want a robot not to be invasive, we can reduce the scope of the interaction from a free dialogue to a set of recommendation related to *basic* ADLs, *i.e.*, drinking, eating, sleeping, personal hygiene and walking.

We contextualise ADLs through the concepts of needs and *urgency*. The former represents the need for a person to perform a given action and maintain a healthy lifestyle. The latter represents how urgent a given activity is for maintaining the well being of a person, and it is used to rank needs over time. We formalise those concepts using the Ontology Web Language (OWL) [16], and we represent them in terms of *triggers* for specific needs, and urgency. We preliminary consider two levels of urgency based on time intervals, *i.e.*, *soft* when an activity has not been carried out yet, and *high* when the person forgot to perform the activity. We also consider a representation of locations where sentences are supposed to be more persuasive for triggering the person doing an activity and, consequentially, satisfy a need.

In the ontology, we define `S` as an instance associated to a sentence with some *attributes* `p`. Each attribute relates `S` with another instance `X`, *i.e.*, `(S,X):p`, that is classified in the ontology through contextualised *concepts*, which are indicated with capitalised names. We preliminary consider three attributes, *i.e.*, `hasLocation`, `hasUrgency` and `hasTrigger`, associated with instances `X` of the concepts `LOCATION`, `URGENCY` and `TRIGGER` respectively. In particular, we refer to a room `X` as a location where a sentence is supposed to be persuasive, and we relate `X` with a sentence `S` through the property `(S,K):hasLocation`; where `K:KITCHEN`$\sqsubseteq$`LOCATION` is associated to the current position of the assisted person. Furthermore, we classify the `X:URGENCY` attribute in the ontology with a `X:SOFT` or `X:HIGH` degrees, while `X:TRIGGER` involves the needs of the assisted person, *e.g.*, `X:DRINK`, `X:EAT` or `X:WALK`.

In our ontology, the OWL reasoner can deduce the hierarchy of concepts shown in Figure 1. Since each sentence `S` is an instance of the `SENTENCE` concept and it has some attributes, we can query to the reasoner possible sentences given a combination of attributes, *i.e.*, the context. For instance, given that the person is in the kitchen, we can query a set of sentences that are ranked by urgency and associated with a need to trigger. Some sentences, differently formulated, can share the same attributes, as you can see from the examples of sentences shown in Table 1. In this case, we rely on a strategy based on the urgency for choose a sentence among a set of polite and persuasive sentences for a given context.

4. System Integration

Kibi is a system (depicted in Figure 2) relying on Bluetooth beacons and a smartwatch to localise persons in an apartment. The smartwatch is also used to count steps, measure the heart rate, and processes acceleration data to detect gestures and postures, *e.g.*, such as pouring or falling. Kibi aggregates sensory information based on data-driven models that generate semantic data encoded in some ontologies. The models are used to detect patterns related to ADL, (*e.g.*, visiting the bathroom or closing a door), and they generate *events* representing actions. We provide Kibi with a higher reasoning level which evaluates sequences of events to recognise ADLs and track the routine of a person. Kibi can describe how an activity has been performed to caregivers because we contextualise events in an intelligible formalism, *i.e.*, ontologies. Moreover, Kibi provides support to the caregiver also through a graphical user interface, *e.g.*, motility or feeding indicators. On the other hand, Kibi drives the robot that speaks with the person with the purpose to provide recommendations.

The robot's suggestions are based on the current location of a person and on the need to trigger an action with a given urgency. Kibi provides a representation of the activities that the robot might address during the interaction, *i.e.*, `TRIGGER`, and the time in which activities are usually performed, *e.g.*, lunchtime. Based on the expertise of caregivers, we classify the urgency of an activity as either high or low, and we perform such a classification based the time provided by Kibi for each activity.

We reason on the ontology that represents sentences with a certain strategy, *e.g.*, when the person's enters in the kitchen or where he or she approaches the robot. In this situations, we query to the reasoner a set of sentences from our phrasebook that are known to be persuasive and polite based on the deduction provide by Kibi, *i.e.*, knowing previous locations, as well as which activities should be performed and when. Moreover, we can exploit the reasoner to rank sentences based on urgency and, eventually, retrieve a sentence that the robot should tell.

In our implementation, a person can decide to respond and, if he/she does it, the collected data could be used to update the beliefs of Kibi, and the robot should notify its understanding to the person before then the interaction ends. Nevertheless, there are other suitable approaches for specific activities. For instance, to reduce false-positive when Kibi detects a fall, the robot would ask the person if he/she needs help and, if the person does not respond with the intent to deny the support, an alarm to caregivers would be forwarded.

5. Conclusion

We introduce possible definitions of polite and persuasive sentences to motivate an elderly in maintaining a healthy lifestyle through an evaluation of ADL. Based on a smart environment, we exploit spatial-temporal contextualisation of the routine of the assisted person to classify sentences in an ontology and trigger a human-robot interaction. We developed an ontology representing sentences on the basis of attributes used to retrieve and rank suggestions that are persuasive for a given context. We preliminary consider three types of attributes, but we argue for an iterative development process guided by domain experts to validate, through questionnaires, the persuasiveness of the system, which might involve different robot embodiments. In the next development iteration, we aim to represent urgency on a fuzzy ontology [17] to assure a continuous ranking of sentences. Also, we want to consider user's feedbacks to adapt to different preferences, and this is facilitated since the ontology is intelligible for the user.

Sentence (S)	TRIGGER	LOCATION
Mi sembra tu stia andando molte volte in bagno, ti senti bene? Are you feeling good? You are visiting the bathroom often.	Hygiene	Bathroom
Visto che sei in cucina, potresti mangiare qualcosa! Non hai mangiato per tutto il giorno, hai qualche difficolt da segnalarmi? Since you're in the kitchen, you could eat something! You haven't eaten all day, do you have any difficulties to report me?	Eat	Kitchen
Ehi, che ne dici di farci quattro passi? Hey, what about going out for a walk?	Walk	Kitchen
Ricordati di non aspettare di avere sete per bere un po' d'acqua durante la giornata. Remember, don't wait to be thirsty for drinking something during the day.	Drink	Not Kitchen
Ciao! Come va oggi? Stai bevendo abbastanza? Hello! How are you today? Are you drinking enough?	Drink	Not Kitchen

Table 1
Sentences in our phrasebook in Italian (and traduced in English) contextualised by location and activities.

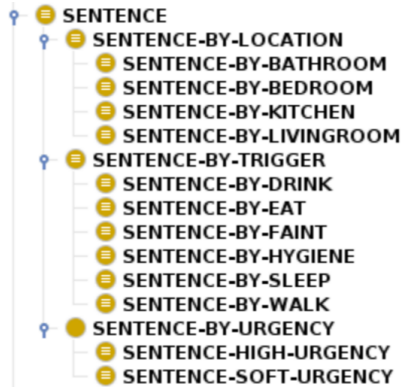

Figure 1:
The contextualisation of sentence based on three attributes, *i.e.*, space, trigger and urgency.

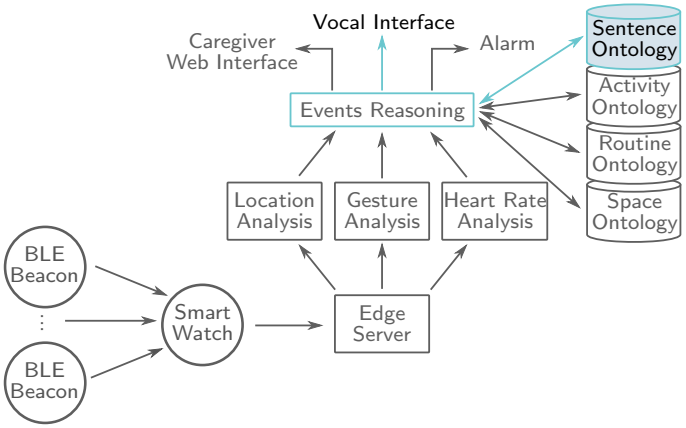

Figure 2:
The Kibi's architecture and our extension (highlighted in blue).

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