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Assistive Robotics: Adaptive Multimodal Interaction Improving People with Communication Disorders

Edward Simon John, Sandro José Rigo, Jorge Barbosa

Interdisciplinary Graduate Studies Program in Applied Computing (PIPCA), Universidade do Vale do Rio dos Sinos
(email: eddsjohn@gmail.com; rigo@unisinos.br; jbarbosa@unisinos.br)

Abstract: A significant portion of the Brazilian population consists of people with hearing or visual impairment. Multimodal interaction systems do not suit the needs of a mixed audience, since they are designed for a specific user profile. We propose a model for a Multimodal Human Computer Interaction System (MMHCI) based on services, embedded on an assistive robot, which is able to adapt the communication according to the type and degree of the user's disabilities. The proposed approach emphasizes adaption of interaction channels according to the user's needs. The experiments elicit positive user attitudes towards usability aspects of the system.

Keywords: Assistive robotics, multimodal interaction, assisted living.

1. INTRODUCTION

According to Lebec et al. (2013), Assistive Robotics (AR) is an area of research that has received increasing attention since the beginning of the 1970's. AR aims to maintain independence and to improve quality of life of people with disabilities, using robots that help in simple activities of daily living. There are several known projects of assistive robots for people with some kind of impairment (Pollack et al. 2002; Goetze et al. 2012); some are already available on the market, such as Hobbit (Fischinger and Einramhof 2013) and Care-O-bot® (Hans et al. 2002; Graf et al. 2009). Socially assistive robots are able to perceive and to understand human needs and behavior, to communicate with users in a human-centered manner and to respond safely and efficiently to controls (Ranasinghe et al. 2014). Assistive robots use concepts of multimodal human-computer interaction for communication between robot and user. Multimodal interaction provides more flexibility to users, enhancing communication experience between user and system. According to Gupta (2012), a Multimodal Interaction Human Computer System (MIHCS) is a combination of multiple modalities or usage of more than one independent channel signals for the interaction between a user and a machine.

However, despite the fact that many assistive robots have the elderly as target public, its development did not take into account a wide range of difficulties that this audience usually faces. In most cases, it ignores the visual and hearing difficulties arising from the ageing factor or restrictions imposed by speech disorders, common after strokes, which has an increasing incidence among the elderly. In the examined literature, multimodal interaction in assistive robots is restricted to its traditional objective: man-machine communication. According to Akiki, Bandara, and Yu (2014), development techniques of user interface that try to generate universal interfaces result in rigid interfaces and despise the variability of usage context. Adaptive user interfaces are considered a solution to the variability of the context, because of its ability to adapt automatically to the context of use and to the users' possibilities. Identification of system contexts would be a way to bring interaction, offering the most appropriate communication channel to reality and users' needs, optimizing the contact (Goetze et al. 2012) Knowing that more than 20% of the Brazilian population suffers from some sort of disability (either physical, hearing, visual and/or intellectual) and considering that Assistive Robotics is still focused on specific or exclusive audiences, this paper proposes a model for Multimodal Interaction Human Computer System, embedded on an assistive robot, able to adapt the communication according to the type of the user's impairment and to provide relevant information from a set of services.

The main contribution of this paper is a model for Adaptive multimodal interaction in an assistive robot, in order to adapt the interaction channels selection according to the needs of users with hearing and visual impairment. For such task, adaptive multimodal interaction systems were investigated, allowing the definition of a model. Then a prototype of embedded MIHCS in an assistive robot was implemented, enabling interaction with the user according to its needs, based on information regarding their hearing or visual limitations. The usability of this prototype was evaluated by a group of 14 users, collecting information that collaborates for its improvement as future work. The main differential of this work is the use of information relating to disability, contained in user profile, to establish input and output channels for multimodal interaction. This perspective is not included in any of the works studied.

This paper is organized as follows: the next section presents the review of related work. As the third section is dedicated to the presentation of the proposed model, the fourth section contains the description of the prototype. Section 5 presents

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evaluation conclusions, and the last section points out final remarks.

2. RELATED WORK

In this section, some aspects of the state of the art and research opportunities regarding Assistive Robotic and Adaptive Multimodal Interaction systems are presented. Some papers describe Assistive Multimodal Robots (Fischinger; Einramhof 2013; Mayer; Beck; Panek 2012; Reiser et al. 2009, Papoutsakis et al. 2013) for home assistant living and elderly care.

Adaptation can take place in interface level (Maat; Pantic, 2006; Stefeen, 2011), in input and output channels (Uluer et al. 2015), in dialog management (Gnjatović et al. 2012; Steffen 2011) or in the selection of available services (Djaid et al. 2012).

As adaptation motivation, we can list user preferences (Maat; Pantic 2006; Muller; Sprenger; Gross 2014; Stefeen 2011), user necessities (Uluer; Akalin; Kose 2015) or yet the user context (Djaiad; Saadia; Ramdane-Cherif 2012; Reithinger et al. 2003; Stiefelhagen et al. 2007).

A summary of these aspects, relating both module and criteria of adaptation, was produced based on six of the Multimodal adaptive systems studied. Although some systems do not present any aspect of adaptation, context and user preference are the main criteria for multimodal adaptation. Therefore, we highlight as a relevant contribution of our work the focus in adaption of multimodal interaction based on specific user characteristics, such as disabilities. These user characteristics are treated by the model as basic information that drives the choice of interaction through different interface elements, according to the user's possibilities.

3. PROPOSED MODEL

The presented model aims the general management of the human-computer interaction, considering a context in which a user with disability needs some adjustment of input and output channels according to their capacity of dealing with these channels. This was a gap identified in the studied models devoted to attend explicitly a group of disability people or to adapt interface components based on user preferences. The model provides a use of this set of resources to enable access to several services previously registered. During the development of the model, the references considered were necessities of users with hearing and visual impairment, as a way to have consistent elements to plan and also to evaluate. Despite that, the model can incrementally accommodate new contexts, as it will be described.

The model architecture is shown in Figure 1 and is represented in TAM notation - Technical Architecture Modeling (FMC 2015). The model architecture is divided into 4 main modules. These modules follow a logical sequence of relationship, which starts on User Management module and proceeds to Input processing and management module, Interaction control module and Data interpreter, until reaching the output module.

User Management module has as its main functions to maintain the user registration and to perform user identification at the start of an interaction session. A previous register of users is a necessary step to collect a profile data of each single user, in order to make this information available in activities involving interaction.

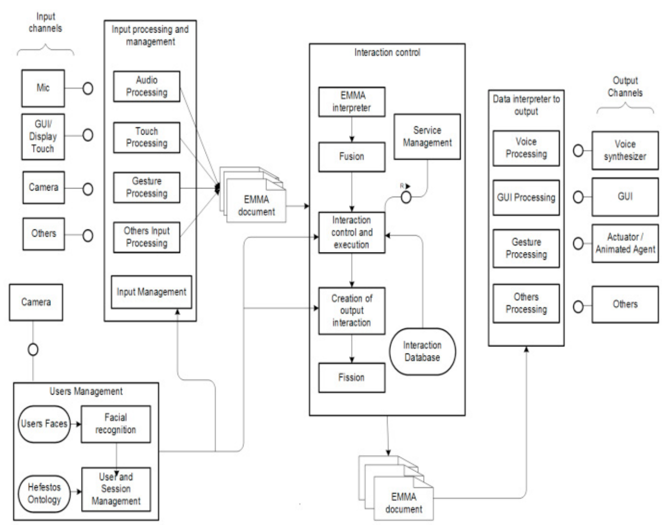

Fig. 1. Proposed model

Input processing and management module manages the usage of each input channel and is designed to be expandable. New data entry devices may be included into the model and added to sets of equipment in use. One of the resources adopted to facilitate this flexibility was the utilization of Extensible MultiModal Annotation markup language – EMMA (W3C 2009) format to represent the data in each data entry point, thereby maintaining a flexible mechanism for data transfer in the system components.

The Control module is responsible for receiving and integrating interactions information, which is received in EMMA format documents and used to generate an output for the user. Thus, the Control module performs the treatment required for the joint use of several possible data entries and then manages the interaction with the user, in order to run and consume requested services. Finally, this module performs the creation of documents, also in EMMA format, containing the output interaction information, which are processed by the next module.

The Data interpreter to output module performs analysis of the received EMMA documents, extract the output target to the interaction and assigns to each correspondent submodule of output the data available. This module adopts the same concepts of data input module, providing the possibility of inclusion for new devices without changing the operation of the model.

The proposed model is based on services, where user consumes the service information or performs a specific action (e.g. check the forecast). Another element to highlight