Affect- and Behaviour-Related Assistance for Families in the Home Environment

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ABSTRACT

The ABRA System for affect- and behaviour- related assistance for families in the home environment is a modular system, comprising components for assessing a person’s state, for communicating and displaying relevant information, and for social togetherness. The technology platform is being developed to study novel approaches to social inclusion, particularly for elderly, and new, senior-friendly interaction and display techniques. This paper describes a first implementation of a bi-modal sensing module for assessing a person’s wellbeing, combined with an assistance and communication module for enhanced social inclusion and sense of safety.

Categories and Subject Descriptors

D H.4 [Information Systems Applications]: Miscellaneous, H.5.2 [Information Interfaces and Presentation]: User Interfaces, H.5.3 [Group and Organization Interfaces]

General Terms

Measurement, Experimentation, Security, Human Factors, Verification.

Keywords

Social Network, Social Inclusion, Activity Monitoring, User State Detection, Affect, Cognition, Pervasive Assistance, Sensor Fusion, Wellness Technologies, AAL.

1. INTRODUCTION

Families in modern societies are often separated by space and time. Often, the senior members of a family live in their own home while their adult children live with their children in a different part of the town or even farer away. Due to their busy days filled with job, housework and family life, the contact between seniors and their children is often restricted to occasional phone calls and visits on demand. The consequences of this minimalistic social inclusion of the elder members of our societies cannot be overseen anymore. Insufficient social inclusion often leads to depression, which exaggerates isolation even more. Affected persons tend to be less active and inattentive concerning their own health, with considerable consequences for their wellbeing and physical and mental health [17].

On the other hand, the younger family members live in a world in which mobile phones, social software, and digital gadgets are an essential part of daily life. They are connected with colleagues, friends and each other not just by phone but use Email, text messages, Internet platforms, chat programs and mobile applications to keep in touch, schedule appointments, and getting and giving advice on actual issues.

Conversely, seniors only rarely use modern technologies and are excluded from electronic communication networks due to inappropriate services and user interfaces.

This obvious discrepancy of use of modern technologies for staying in touch on the one side and an increasing degree of isolation on the other side should not be accepted by our societies. We propose a solution using state-of-the-art technology to bridge the digital gap between the generations, helping to stay in touch and giving a stronger sense of presence to each other. Our solution not only provides easy to use communication between generations, but also includes new technology to unobtrusively detect and react on relevant states of the seniors.

We introduce an exemplary implementation of the ABRA System (ABRA – Affect- and Behaviour-Related Assistance), a modular system comprising components for assessing a person’s mental and physical state, for reasoning about a suitable response to this state, and for communicating and displaying relevant information and interactions (Fig 1). For assessing a person’s mental and physical state physiological sensors and off-the-shelf motion sensors are used. Both information sources are analyzed and used to generate real-time information on the cared-for person, which is continuously available through the Internet to selected persons as the senior family member desires. Reversely, family members can post pictures, and trigger text messages like reminders to the senior, which can be displayed on e.g. a digital picture frame.

The paper depicts the principle function of the ABRA system. In section 2 we illustrate the principle system architecture, while section 3 describes exemplary implementations of two sensing modules for collecting information on the elder person, an approach to data fusion and reasoning, and an implementation of

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a simple assistance and communication module. A short evaluation is given in section 4, followed by a summary and outlook.

2. SYSTEM CONCEPT AND ARCHITECTURE

The ABRA system follows a strongly modular approach with an arbitrary number of input and output modules being connected through a central control module. Fig.1 shows the architecture from a data perspective.

Sensing modules such as cameras, microphones, wearable devices or ambient sensors collect data on a person. Further sensors can provide contextual information such as lighting, ambient noise or temperature, or the radio or TV program currently playing. Each sensor provides its pre-processed data to the central **Reasoning** module, which merges the incoming data in a sensible way. After the data have been analyzed and the current state of the person been appraised, the result is forwarded to connected **Assistance** modules through a central control unit. The assistance modules make their own assumptions as to if and what action is required to assist the person. Their suggestions will be evaluated by the control unit, which finally decides which action(s) should be taken and in which degree and timely order. While in most of the situations the person might be fine without any intervention, assistive actions could be information on appointments, reminders on daily activities and necessary actions such as medication intake. For the sake of improved social inclusion, information on relatives or friends can be displayed and information on own activities and wellbeing can be relayed to caring persons. The following sections describe an exemplary setup.

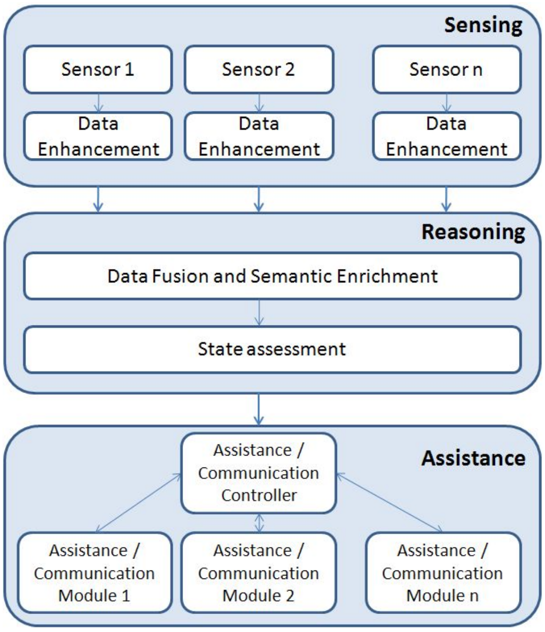

Fig. 1 The ABRA system - schematic overview.

3. EXEMPLARY IMPLEMENTATION

3.1 Sensing Components

3.1.1 Physiological Sensor

Sensing and recognizing emotional and other mental states is a challenging, yet promising undertaking, requiring the integration of sensors, algorithms for data enhancement and filtering, pattern recognition and classification.

While the human body permanently sends out information on ongoing emotional or cognitive processes through many modalities (e.g. face, voice, gestures) which can be observed with remote sensors such as cameras or microphones (cf. [1-3]), physiological sensors provide a deeper view though direct access to the underlying physiological processes. Measures like heart rate, heart rate variability, skin temperature and electro-dermal activity are directly linked with processes in the autonomous nervous system and correlate with emotional and cognitive processes [4-6]. Other than e.g. video data on gestures or facial features, physiological data are permanently available. They can't be masked and are independent from actual social influences. The scientific foundations of affective and cognitive physiology are well established and continuously expanded (cf. [4-6]), and sensing technologies improve over time.

In the described setup of the ABRA system we use the Fraunhofer EREC system [7], which measures heart rate, skin temperature and electrodermal activity. Those three parameters are understood to be key indicators for emotional as well as cognitive processes. The EREC system consists of a sensor glove and a small wrist pocket which carries the sensor electronics (Fig.2). The data are pre-processed on the device and provided per Bluetooth to subscribed components for analysis and reasoning.

Fig. 2 The EREC physiological sensor system.

3.1.2 Activity Sensor

Physical activity is one important characteristic of daily routines. Assessing activity patterns allows to analyze a person's behavior for irregularities. Atypical activity patterns might be indicators for inappropriate lifestyle, insufficient social inclusion, or generally disadvantageous life conditions. Generally, people tend to have distinct activity patterns over the day and the week, the knowledge of which allows to detect irregularities [18] and to suggest appropriate interventions.

Detecting bodily activity can be done by visual means with cameras observing the person in the home environment, by wearable sensors including accelerometers, or, indirectly, by installation of e.g. passive infrared sensors in doorways.

In the described setup, we utilize acceleration sensors integrated in smart phones and apply Fraunhofer DiaTrace technology [19] to infer activity information. DiaTrace is a software program running on standard mobile phones, which collects the movement data from the acceleration sensor, pre-processes them, and runs analyses on them to detect characteristic movements. The version we used is able to distinguish movements like walking, running, cycling, jumping, and car-driving. Using the phone's standard communication possibilities, the analysis results can be relayed to a server immediately for further processing. Fig. 3 shows an exemplary activity diagram as collected with DiaTrace on a smartphone.

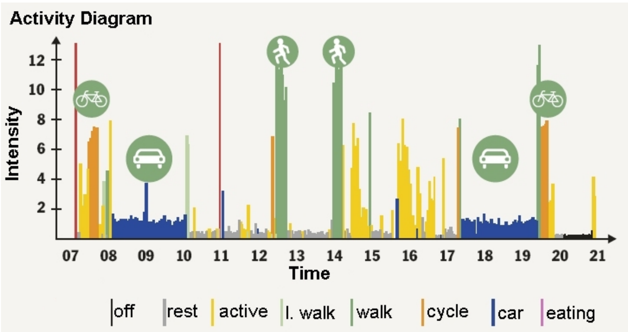

Fig. 3 An Activity diagram taken with DiaTrace.

3.2 Data Fusion, Semantic Enrichment, and State Detection

Detecting mental states and activities of a person can be done through various modalities, cf. [1-3, 8]. Accuracy and robustness vary over the different channels used and depend on the context and application in which they are used.

Using multiple modalities can significantly improve the results of classifiers. Their information can be used complementary either equally or with some of them "just" providing semantic information to be considered in the classification of user states. Sensor fusion techniques used commonly vary mainly in the phase at which the fusion of modalities is performed. Early fusion approaches combine features of multiple modalities at the feature level which then are fed into a global classifier. Late fusion approaches apply modality specific classifiers to the respective features and then fuse the different classfiers' results. Combinations of both can also be found [9-15].

In the described prototype we merge activity information (derived from accelerometer) with knowledge on the emotional state of the person (derived from physiological sensor) to make assumptions on the actual wellbeing of the person. Fig. 4 shows an example for how adding emotional information can make a difference in interpreting activity data. If a person is less active over a period of time than usual it might be a reason for concern. But, if physiological sensors and subsequent emotion analysis indicate that the person is in a positive mood (i.e. valence is high), the reasoning component can conclude that the person is still alright and no intervention is required.

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IF activity <= low AND valence >= neutral
   THEN state = ok
IF activity <= low AND valence < neutral
   THEN state = nok
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Fig. 4 Example for fusing activity and emotional information

In the current implementation, fairly simple relationships as shown in Fig. 4 are applied. However, more sophisticated algorithms will be developed in the course of ongoing projects.

3.3 Assistance and Communication Modules

Social inclusion is based on communication of various important but also seemingly unimportant events. Persons that have been met, virtual or real places that have been seen, or thoughts that came into mind are usual things that are shared within a network. Older people who live in their homes often drop out of this information chain due to their increasingly limited physical mobility, which avoids them more and more getting actively out meeting people, and due to their family members leading their own lives in a seemingly unbridgeable distance.

The ABRA system's philosophy is to use simple, off-the-shelf technology to relay information from family members or friends right to the living rooms of the senior, but also from the senior to the caring persons. For this, we connect common and simple devices used also by seniors nowadays with services for electronic communication. Mobile phones, digital picture frames, or more dedicated devices like the Nabaztag ambient device [16] are examples here.

By connecting common equipment of the senior (like mobile phones and digital picture frames on our first prototype ABRA implementation) to the Internet via specific services and amending them with nonobtrusive simple new devices (like the EREC glove in our first prototype ABRA implementation) we create a digital communication space connecting the senior with his family.

The described setup supports both ways. For the elderly, a digital picture frame serves as the visual interface to the social net of the person. Associated family members and friends can send pictures to the ABRA server, which then are immediately relayed to the digital picture frame. In a future step, family members will be able to send text messages or use a web portal to send further information to the cared-for person such as timely reminders, stories or short videos to be shown on the picture frame.

For the family members, information on the senior is provided on a web page (Fig. 5). The current affective state is displayed along with activity information over the day and the estimated state of wellbeing. The manikin bottom left is animated and depicts the actual activity (walking, resting …) while the smiley indicates the actual affective state. The summarized state is given top left in a traffic light metaphor and short sentence (I feel great, I'm fine, I feel bad). In the central column the day schedule of the elderly is displayed. This could be generated from the elderly's calendar which is also used to display timely reminders on the digital picture frame. An activity diagram is shown below this, allowing caring persons to check if the daily schedule is adhered to (for instance, if she got up as usual and had her daily walk). The right column is a list of pictures shown on the picture frame.

As the server also functions as communication platform for the caring persons, text messages can be exchanged and notes left for others to coordinate possible care activities. Via RSS, people can also subscribe to a newsfeed on their loved one's state or any other events on the portal.

Fig. 5 A screenshot of the ABRA server information page.

4. EVALUATION

A test system has been deployed at a family with very positive feedback. The elderly person especially loved the immediate foto updates from children and grandchildren. Talks with both user groups, elderly and adult children, exposed the need for easy access to information on the others' wellbeing and activity, as well the possibility to easily share special moments and thoughts. More extensive evaluations will be performed in the near future.

5. SUMMARY AND OUTLOOK

We have developed a reference architecture for a sensor based communication environment for seniors and implemented a prototype system for this – the ABRA system for affect- and behavior-related assistance – in order to connect seniors with their family by state-of-the-art electronic communication. The ABRA system provides state-of-the-art Internet based communication via easy to use interfaces which are, due to their easy usage well accepted by elder citizens. It is amended by non obtrusive devices for affective state detection – the Fraunhofer EREC glove, and non-obtrusive activity recognition – the Fraunhofer DiaTrace technology. The system is scalabele by sensors, assistance, and functionality. The ABRA prototype supports the communication between seniors and their social network (children, grand children, and friends) through on the fly providing of actual pictures and text messages on the digital picture frame at one side and affective and behavioral information of the senior at the other side. This creates a basis for not only integration of seniors into modern communication structures but also for specific interventions of family members if needed.

Further developments will include a notice board for the caring persons, a storytelling gadget, and further sensor modules. Different ambient displays and interaction devices will be investigated as well.

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