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Gesture Driven Systems in Mobile Environments for Telecare Applications

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Abstract: In this work, we address a challenging area of research. Gesture driven systems have had a vast interest from researchers. In particular, telecare applications are a promising field for deploying gesture driven systems. Adapting gesture driven systems onto mobile platform imposes more challenges. In this work, we explore these challenges and discuss the requirements of developing such systems.

Keywords: Gesture, Telecare, Mobile Environments, Sensor fusion, Signal and image processing, Elderly, Disabled.

1 Introduction

The field of telecare is gaining more and more interest from both the research community as well as the medical society [1]. The total value of the care home market for elderly and physically disabled people in the UK at April 2003 was estimated at £10.2 billion, of which private sector operators accounted for £6.9 billion [2]. The need of more advanced Telecare systems is becoming more evident with the increasing number of elderly people due to rising life expectancies resulting from medical advances. The number of carers and elderly homes cannot meet the increasing demand for them. There is now more need than ever for systems and technologies to support the independence of elderly and disabled people.

The caring systems should be more transparent, intelligent, independent and cost effective [3]. The deployment of behavior analysis in these systems is crucial to achieve this. The subject of behavior analysis is not a new topic [4]. It has been a subject of interest to many psychologist and computer scientists for decades. But it is only recently, that it started to gain special attention due to the major advances in computer hardware in terms of resources, such as processor and memory.

The deployment of human behavior analysis in telecare systems is gaining more and more attention recently [1],[3]. In this work we investigate the design challenges of telecare systems in mobile environments, see Fig.1. The main advantage of mobile telecare systems will be the possibility of having systems that accompany the user in every task of his daily life indoors and outdoors. This in turn will ensure more independence inside and outside their homes.

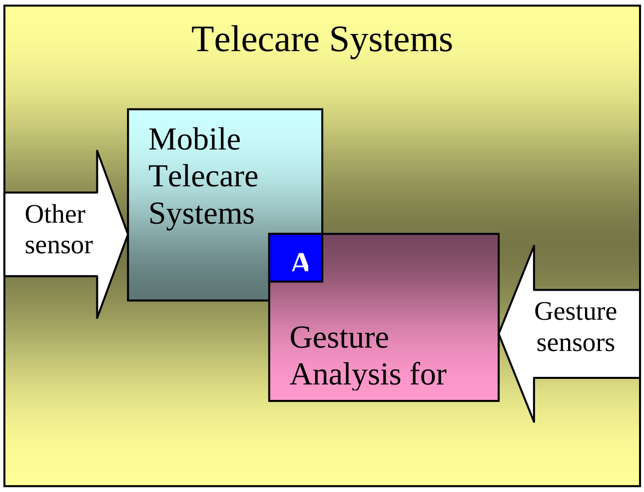

Figure 1: *The components of a telecare system, A is the area under investigation.*

In the next few sections we explore briefly telecare systems, gesture driven systems and mobility issues in that order. In section five we discuss the implications and advantages of combining the three issues. Finally, in section six we conclude this paper.

2 Telecare Systems

Telecare systems in general could be classified into two main categories with respect to their functionality:

a. Caring and assistance:
Which involves assisting users in their daily life and ensuring good quality of life.

b. Emergency handling and alert:
A telecare system also could be responsible for detecting any deviation in the normal daily life or behavior, and act accordingly by alerting the proper authorities.

Both of the above categories are being investigated by researchers. A vast amount of work is being done in the second category, whereas the first category in terms of gestures and mobility is still a young field in research. In this work we concentrate on the caring issue.

The field of telecare systems for elderly and disabled people is a potential field for deploying behavior (specifically gestures) in well-being and lifestyle monitoring. Elderly people could benefit the most from these systems to support their independence [3]. For example, reminding a user when to take his pills, and which pills to take [5]. It could also involve the use of robotics for physically demanding tasks [6]. These systems could also be incorporated with alert and safety systems that are responsible for alerting the appropriate persons or authorities in case a dangerous or irregular behavior is detected [7] (See Fig.2).

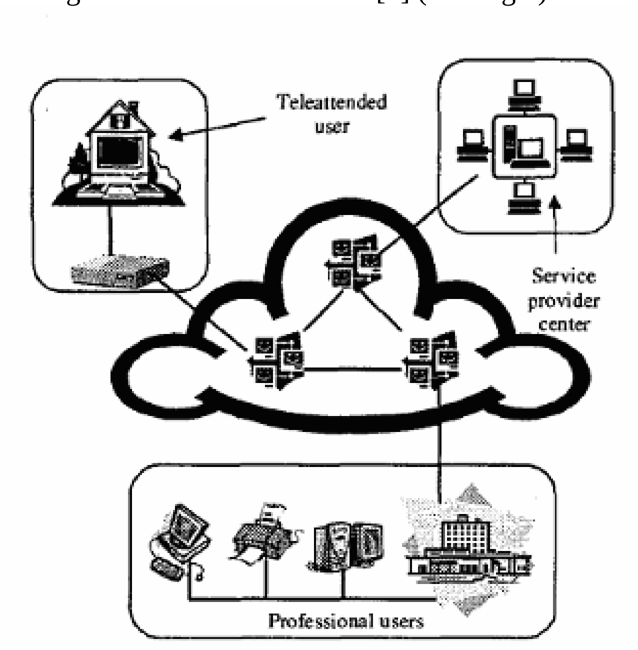

***Figure 2**: A home telecare system (Reina,01)*

The main advantage of telecare systems is that they provide more independence for elderly people, without the need of constant human monitoring. This in turn can save potential amounts of resources and money allocated for elderly houses.

Telecare systems could be used indoor and outdoor. Most of the research in this area concentrates however on the indoor environments, see Fig.3. This is due to the fact that it is simpler and more constrained. The location of sensors and patterns of movement can be fairly easily deducted, whereas outdoors, more variety of surfaces, situations and backgrounds could be encountered, which will pose more challenges on the system. Mobility outside the house has been –up till now- very limited due to the need for relatively large equipment (PC's, cameras,..etc) to process the data, and the resource demanding algorithms.

The tasks that can be involved in behavior are numerous, and include all daily life tasks. For example, the people's habits and daily routine, e.g. going out, bathing, using the toilet, sleeping times, etc. All the information about these tasks could be gathered and patterns could be induced in the long run. Changes to these patterns could then be used to indicate alerts or problems [8].

There are numerous challenges in the process of designing and implementing telecare systems for elderly and disabled people [9].

The main challenges include:

a. Transparency.
b. Interfacing.
c. Cost.

First, the proposed systems should be transparent, in the sense that elderly people should not feel that the system is a burden on them, obstructing their daily life, instead of making it easier. This in turn imposes several constraints on the design of these systems. For example, a system for sleep monitoring should not make sleeping for people uncomfortable by using sensors that should be worn or planted in an uncomfortable form in the bed, causing the change in bed layout [10]. The users should also not be asked to do additional tasks to help telecare systems. The house environment should not be changed or affected by the introduction of a telecare system [11].

The second major challenge is interfacing. Most elderly people are not quite familiar or comfortable with using advanced devices, with lots of buttons. This creates a psychological barrier. The telecare system should introduce friendly and if possible natural interfaces (e.g., speech, gesture, …etc) [12].

The last but not least challenge is cost. The systems should be cost efficient and flexible to be installed within the existing infra structure of the house [8]. In case of outdoor systems, the used hardware could become very expensive in order to have it in small sizes.

3 Gesture Driven Systems

Using gestures for supporting the well-being and independence of elderly people is in many cases important. This is due to the fact that these people require easy, natural interfaces to deal with their environments. Simple gestures may significantly facilitate their lives and provide more information for the carers.

The challenging area of gesture analysis constitutes a major part of the process of behavior analysis. More complex semantic behavior induction based on, e.g. gestures, is still very premature [4].

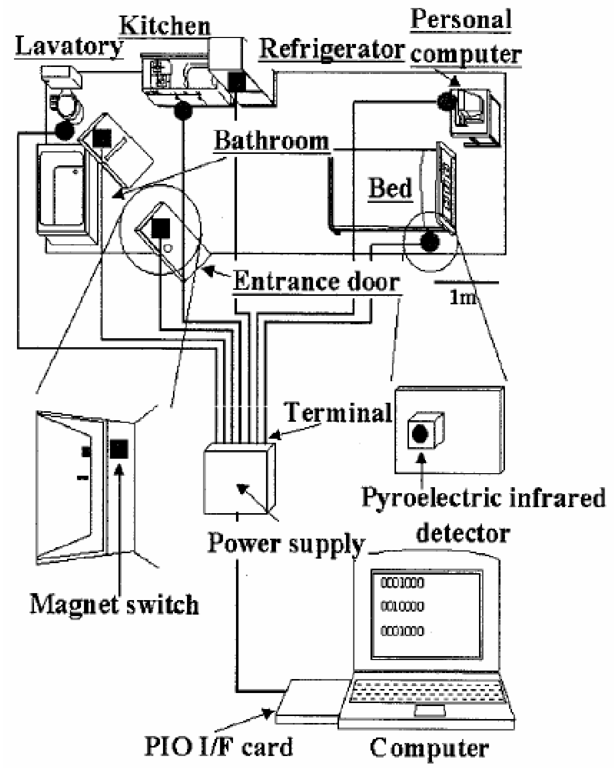

Figure 3*: In-home sensors (Yamagichi,98).*

The process of gesture analysis may employ several types of sensors to identify human gestures. These gestures can then be analyzed to construct behavior models. These gestures can also be deployed as a part of the interfacing and control and interaction between the elderly people and their environment, e.g. at home [1]. For example controlling a wheel chair or the air conditioning unit using gestures or answering the phone are all useful applications for elderly and disabled people.

Body gestures can be classified into several classes, see Fig.4, each of which can be used in the behavior analysis and telecare processes. The main classes of gestures are:

a. *Body pose analysis*: may help in detecting falls or back problems [13].
b. *Hand and finger gesture*: e.g. for the sign language interfaces [14] to control the environment.
c. *Facial expressions*: are a very important part for recognizing human behavior, and are widely employed. The facial expressions can also be used to control other devices, e.g. computer interfaces. Head orientation and movement is a basis of several control interfaces.
d. *Eye control and eye movement analysis*: There are several approaches and techniques that use pupils and winks to control the computer for severely disabled people. Commercial products are now available such as the EyeTrack from *EyeTracking Digital Systems* [EDS].

4 Mobility

Introducing mobility to telecare systems will, as mentioned earlier, give the elderly more independence outside their homes as well as inside. At the same time, it will provide up to date information for the carers about the elderly people through the system.

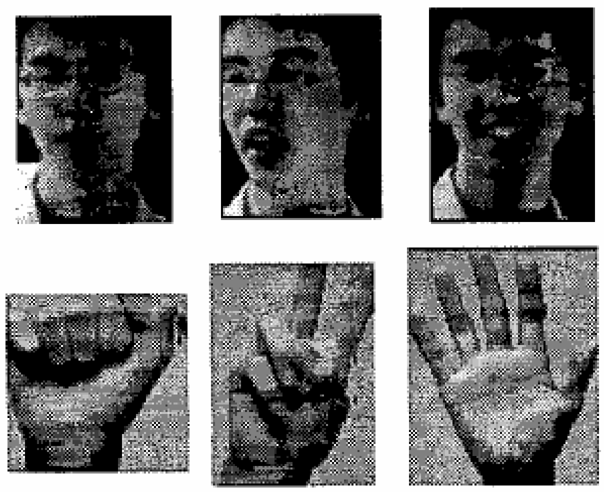

Figure 4*: Face and hand gestures (kong,2003)*

The research in telecare systems in mobile environments is faced with several challenges, such as:

a. <u>*Very limited resources*</u>: to use simple mobile devices (e.g. PDA), the system will have to work with very limited resources in terms of hardware. Memory and processor speed will be limited. Power sources will be limited and operate –usually- on very low power. They will also limit the use of peripherals, to save power. The developments and advances of hardware over the next few years will allow more resources in mobile devices, and thus enabling us to deploy further complex algorithms.
b. <u>*More open environment*</u>: The system will not be fixed somewhere in a room –though it could interact with objects in it- with known layout and backgrounds. The environment will be changing dynamically. This poses many sensor calibration and preprocessing issues.
c. <u>*Invariance:*</u> due to mobility, the position of sensors and objects in the environment will be highly inaccurate. The system should be invariant

with respect to the relative positions of objects and light conditions.

d. Transparency: the system should be light enough and not imposing a burden by having the user to wear many uncomfortable sensors, motors,..etc. The simplicity adds to the above challenges.

5 Analysis

Employing gesture analysis in mobile environments for telecare systems is a young research area. Most of the research activity in gesture analysis was concentrated on solving existing problems of gesture analysis. These problems are not yet solved on conventional platforms with very large resources. Researchers are trying to propose new robust techniques to solve the existing problems regardless of the resources. For example, analyzing video signals has had a big share of research. Though the latter provide huge amounts of information, more than any other sensors, it also requires huge amounts of resources to process this information. This limits the possibility of applying this work in mobile environments. Most of the research in telecare – especially in the mobility part- has been targeted towards telemedicine applications. This involves reading patients data (e.g. blood pressure, heart, diabetes..etc.) and monitoring the patient remotely, which uses very simple sensors. The data is then sent to the physicians to be analyzed.

As mentioned earlier, mobility imposes several challenges:

1. Very limited resources.
2. Sensor calibration.
3. Transparency.

The calibration of sensors, e.g. cameras, in different environments is a huge challenge. Due to mobility, the user could be exposed to different lighting conditions, different backgrounds. The location of the camera and the point of view will not be fixed. Having a stable shot in case of using mobile devices will be extremely difficult, especially when elderly and disabled people are involved. Techniques will have to be used to overcome this problem, such as using stabilizers and frame calibration.

Another major challenge in most telecare systems, but which will be more apparent with mobility, is the need for real time processing. Actions should be processed in real time. Some telecare systems even used parallel processors to process the video sequences to analyze gestures. In our case, this is not available with the very limited resources of mobile devices. Other ways of tackling the problem have to be investigated, e.g. using a low resolution if a camera is used.

Several considerations dictate the type of gesture that is suitable for the mobile telecare system. For example, it should be possible to locate the sensors within the reach of the user. For example, a camera attached to the user to capture the face, would be feasible but it would be difficult to capture the pose.

The system could also interact with the environment. Other sensors could be used (e.g. other cameras in a room) if they are within the range of the user. The sensor fusion approach, see Fig.5, or the deployment of several simpler sensors to analyze the data and identify the gesture is an approach we will deploy. Tackling the problem from this different new perspective (as opposed to the conventional approach of deploying a single complex sensor, e.g. camera, as described above) would significantly reduce the processing requirements of the existing algorithms.

This in turn would make it more feasible to work in mobile environments, and eventually presenting novel perspective for the existing algorithms.

The potential of the existing techniques in mobile environments, and the possibility of extending the use of multiple sensors (sensor fusion) are yet to be investigated and can lead to promising results.

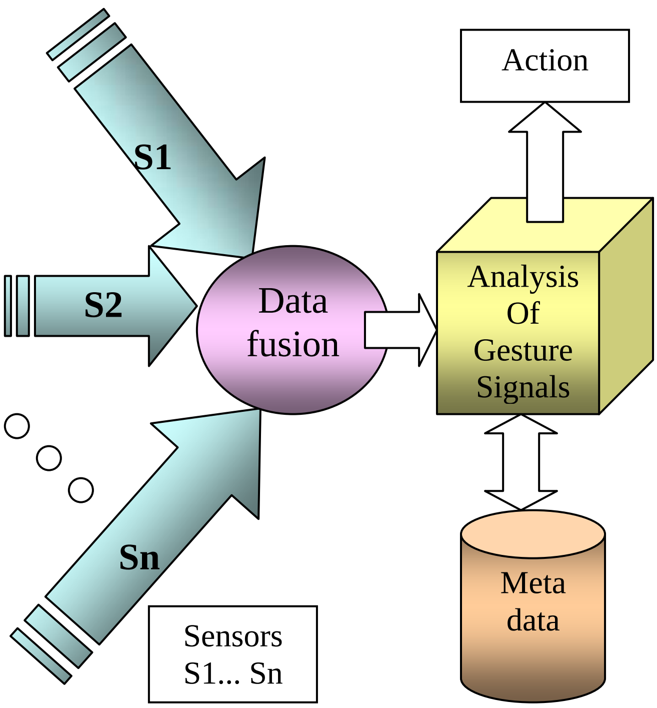

***Figure 5**: The sensor fusion approach provides more information for gesture recognition*

The use of gesture interfaces with mobility may force us to look at the problem from different perspectives.

The techniques deployed in the virtual and augmented reality fields could be of use in our case. The versatile types of interfaces that virtual reality offers could be very well suitable in this case. Other developments in video surveillance systems as well as telematics could be deployed in our system to analyze the data.

6 Summary

Most of the work carried out in the field of employing behavior analysis in caring for elderly people has been targeted towards telemedicine and telemonitoring which is mainly targeted towards monitoring these people in their homes and transmitting the data (e.g., blood pressure, insulin levels, temperature) to their physicians or hospitals remotely.

Telecare is an equally important area, which supports the independence of elderly and disabled people in their home environments. It has more tangible effects on the well-being of the elderly people. It also saves huge amounts of resources for the caring process.

The use of gesture as a means for behavior analysis in the context of telecare could facilitate the interfacing between the elderly and their environments and provide the carers with more useful, higher level information about the elderly.

The application of gesture driven systems in mobile environments with limited resources for the purpose of telecare will open the doors for extending the caring services outside the elderly homes. This area involves several challenges, but promises a vast range of applications. Overcoming these challenges may involve tackling the problem from a different perspective and employing different techniques, such as sensor fusion and virtual reality techniques.

Several research projects are currently involved in these areas, such as the *Georgia Tech Aware Home, MIT's House_n and the University of Washington's Assisted Cognition*. We are currently working on using gestures from multiple sensors in mobile environments for telecare systems.

Future work may involve higher level, semantic analysis of the gestures, and more flexible and transparent systems. The information obtained from these systems may advise the carers of emotional changes of the elderly and well as physiological symptoms.

References

[1] Majeed, B.; Nauck, D.; Lee, B.-S.; Martin, T.; "Intelligent systems for wellbeing monitoring," *2nd International IEEE Conference Intelligent Systems*, Volume: 1 , 22-24 June 2004, Pages:164 - 168

[2] *Laing & Buisson's 2003 full survey on care homes in the UK*, http://www.laingbuisson.co.uk

[3] Barnes, N.M.; Edwards, N.H.; Rose, D.A.D.; Garner, P.; "Lifestyle monitoring-technology for supported independence," *Computing & Control Engineering Journal* , Volume: 9 , Issue: 4 , Aug. 1998, Pages:169 – 174

[4] Bainbridge, L.; "The change in concepts needed to account for human behavior in complex dynamic tasks," *IEEE Transactions on Systems, Man and Cybernetics*, Part A, Volume: 27 , Issue: 3 , May 1997, Pages:351 – 359

[5] Doughty, K.; Williams, G.; Holloway, L.; "TEMPEST-an intelligent pill reminder and delivery system for telecare applications," *Proceedings of the 20th IEEE Annual International Conference Engineering in Medicine and Biology Society,* Volume: 3 , 29 Oct.-1 Nov. 1998 Pages:1206 - 1209

[6] Songmin Jia; Hada, Y.; Takase, K.; "Telecare robotic system for support of elderly and disabled people ," *2003 IEEE/ASME International Conference on Advanced Intelligent Mechatronics*, AIM 2003, Volume: 2 , 20-24 July 2003, Pages:1123 - 1128

[7] Wilson, L.S.; Ho, P.; Bengston, K.J.; Dadd, M.J.; Chen, C.F.; Huynh, C.; Gill, R.W. ; "The CSIRO hospital without walls home telecare system," *The Seventh Australian and New Zealand Intelligent Information Systems Conference*, 18-21 Nov. 2001, Pages:43 – 46

[8] Ogawa, M.; Suzuki, R.; Otake, S.; Izutsu, T.; Iwaya, T.; Togawa, T.; "Long term remote behavioral monitoring of elderly by using sensors installed in ordinary houses," *2nd Annual International IEEE-EMB Special Topic Conference on Microtechnologies in Medicine & Biology,* 2-4 May 2002, Pages:322 – 325

[9] Magrabi, F.; Lovell, N.H.; Celler, B.G.; "Methodology for designing telecare systems: a case study in cystic fibrosis monitoring," *IEEE EMBS International Conference on Information Technology Applications in Biomedicine*, Proceedings, 9-10 Nov. 2000, Pages:60 – 64

[10] Adami, A.M.; Hayes, T.L.; Pavel, M.; "Unobtrusive monitoring of sleep patterns," *Proceedings of the 25th IEEE Annual International Conference Engineering in Medicine and Biology*

Society, Volume: 2 , 17-21 Sept. 2003, Pages:1360 - 1363

[11] Reina-Tosina, J.; Roa, L.M.; Prado, M.; Vera, J.; "Home health telecare and the elderly in Spain: technologies involved and methodological issues," *Proceedings of the 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society*, Volume: 4 , 25-28 Oct. 2001, Pages:3563 - 3566

[12] Hoshi, Y.; Saito, M.; "Psychophysiological aspects of elderly-assist systems," *Proceedings of the IEEE Region 10 Conference, TENCON 99*, Volume: 2 , 15-17 Sept. 1999, Pages:1154 - 1157

[13] Cucchiara, R.; Grana, C.; Prati, A.; Vezzani, R.; "Probabilistic posture classification for Human-behavior analysis," *IEEE Transactions on Systems, Man and Cybernetics*, Part A, Volume: 35 , Issue: 1 , Jan. 2005, Pages:42 – 54

[14] Kong, W.W.; Ranganath, S.; "3-D hand trajectory recognition for signing exact English," *Proceedings of the Sixth IEEE International Conference on Automatic Face and Gesture Recognition*. 17-19 May 2004, Pages:535 – 540.