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AAL for Supporting Elderly

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Abstract: In this paper we analyse demographic problems and propose a solution for taking care of elderly in Europe. We present the nearly completed system for posture and movement recognition in the European FP7 project CONFIDENCE – Ubiquitous Care System to Support Independent Living. CONFIDENCE aims at providing care for the elderly using radio tags attached to the body providing positions and acceleration. The central part of the system deals with the reconstruction and interpretation of the user's behaviour in order to raise an alarm or issue a warning if a fall or an unusual mid- or long-term behaviour is detected. In this paper, the two systems are presented from the user. The first results and demonstrations show supreme performance; however, the costs of the research prototype surpass acceptability for a normal end-user. Cheaper commercial versions will be developed to help elderly live better.

Keywords: Ambient assisted living, elderly care, position meters, e-inclusion, information society.

1. Demographic Issues

The basic motivation for the Confidence system is related to demographic trends. More precisely, while some of the countries must deal with fast population growth, others face a demographic winter with fertility rates below 1.7. Fertility rate (FR) corresponds to the number of children per average woman in her active years. There is an essential difference between the developed and the developing countries. Figure 1 presents basic relations between demographic trends in the developed and developing countries. The consequences of such trends in longer periods of time are presented in Table 1. Comparing the data of the years 1900 and 2050, one can see that Africa will have problems with overpopulation while Europe will have problems with shortage of young and an overload of elderly. The balance of powers will be also shifted. For example, there will be 4 Americans and 20 Indians per 1 Russian in 2050.

Several research groups have studied demographic trends and found several interesting relations. In our studies, for example, the tree in Figure 2 was obtained with DM techniques where the input was all world countries. The properties of the tree are: accuracy 74.5%, F-measure 0.75, AUS 0.48 and kappa statistics 0.6167. The class was 1 for fertility rate below 1, 2 for FR between 1 and 2, and 3 for FR above 2. The numbers in the leaf denote the FR class, the number of countries that are correctly classified at that leaf, and the number of countries that are not correctly classified at that leaf. The discovered tree strongly indicates that one of the most important and cheapest mechanisms for controlling overpopulation is availability of contraception.

Table 1: Population per Continent [1]

Continent	Population in mio	
	year 1900	year 2050
Africa	133	1.900
Asia	946	5.200
Europe	408	664
N. America	82	455

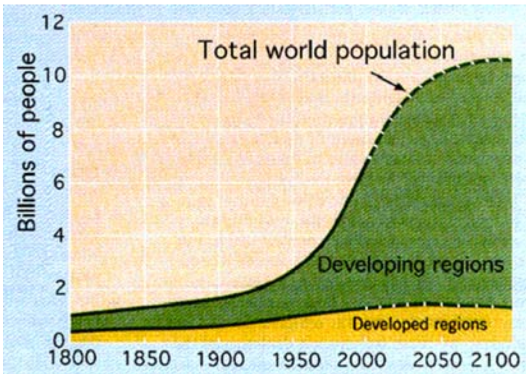

Figure 1: Demographic Trends [1]

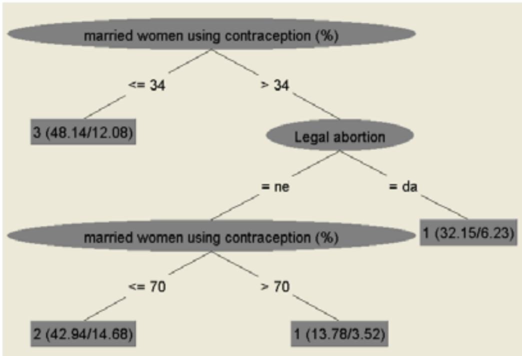

Figure 2: Mechanisms for Controlling Demographic Growth

However, no simple single mechanism was discovered fighting with lack of children. For example, Europe is fast aging due to the increase in life expectancy and decrease in birth rate. The number of the elderly is already exceeding the society's capacity for taking care of the older population, demanding longer working periods and consequently causing social unrests in several countries [2].

One solution to ease the burden of elderly is based on information society tools, services and systems. The technical solutions could ensure that the elderly can live better and longer independently with minimal support of the working-age population. AAL or Ambient Assisted Living aims at making daily life easier and safer by placing unobtrusive smart devices and services into the environment [3]. This is also the goal of the European FP7 project CONFIDENCE – Ubiquitous Care System to Support Independent Living [4].

2. Related Work

Nowadays, there are systems in the market that claim that they prolong the personal autonomy of elderly people by means of AAL applications. There are solutions that help the user remember tasks [5], detect early risks (such as falling) [6], manage specific chronic diseases [7] or maintain social contact [8][9]. However, most of the care systems in the market are limited to short-term analysis or are too intrusive. These systems either use accelerometers or are based on video systems.

Most of the works such as ECAALYX project [10] propose to use accelerometers for detecting the current activity, such as falls. Most of these systems lack of reliability in real life. For example, in case of a loss of consciousness resulting in a slow fall, the accelerometers will not detect it; while the person might not be able to move anymore to reach any communication device, even though they might be only few inches away.

The systems using the video surveillance technology are in general regarded as too intrusive for practical use. The AAL-169 project called ROSETTA [11] tries to combine 3 subsystems: an advanced awareness and prevention service based on video surveillance, an early detection system with ambient sensors in the home environment, and a portable device to provide support for daily activities. The three subsystems are integrated into one common solution detecting abnormal behaviour and critical situations of persons with dementia and Parkinson diseases [11]. However, their reliance on video for one of the subsystems makes the system too intrusive for wide end-user acceptance.

There are some commercial systems such as CODAMOTION [12] that use infra-red technology for posture and activity analysis and can efficiently visualize and measure the current physical state or activity of the person. However, they lack advanced functionality like context-awareness, interpretation ability and mobility. These infra-red systems are expensive and, thus, are most often used in specific laboratory environments.

The EMERGE project [13], is a monitoring system that assesses potential emergency situations of daily living of elderly people in apartments to prevent emergencies, such as a fall, as well as to provide the corresponding treatment options. Its main focus was on the detection of acute emergency situations and the detection of deviations of ADLs to prevent emergency situations. Situations out of home as well as physical behaviour deviations with posture recognition were not addressed.

3. CONFIDENCE

The CONFIDENCE FP7 project is in its last year, in the testing phase with a working prototype. The system already unobtrusively monitors the users in order to detect health problems, such as falls, any abnormal mid- or long-term behavior and some specific diseases. To do this, the system learns from observing normal behavior and adapts to each specific user.

Literature suggests that the elderly face several problems and consequently fears. E.g., the fear of falling or being left unattended in case of trouble can elderly to refusal of mobility, isolation, decline in the ability to perform daily activities and eventually admission to institution care [14]. The target group of the CONFIDENCE project are elderly aged over 65 who live on their own at home and are mobile. With the CONFIDENCE system already developed, the target people are being intensively tested to verify if they will indeed gain confidence, security, better quality of life and longer active participation in the society. The beneficiaries should be not only the elderly, but also their families and caregivers, since the burden on them will be reduced, too. In practical economic terms, the goal of the project is to extend the independent life of the elderly by several years.

The basic task of the CONFIDENCE system is to reconstruct the user's posture and movement and raise an alarm if a critical situation such as a fall is detected. It also detects mid- and long-term changes in the user's behavior that may indicate a health problem in which case it issues a warning. For instance, if the system notices changes in the user's gait that may indicate a lack of stability, it will warn the user about short-term increased risk of falling, and prevent an accident. The system will also detect changes in behavior over longer periods of time, e.g., if a user limps or stays in bed or in the toilet unusually long. In this case it will warn the user, the caregivers or relatives as specified by the user during initialization of the system.

The care systems should not violate privacy and should not bring new demands to the user, in particular to the elderly ones. The system must be therefore as simple as possible from user's point of view. A complex system would cause reluctance among the users, who would regard it as a problem rather than as a solution. Following these guidelines, the CONFIDENCE system is easy to setup and to use, and it does not limit the user's daily activity in any way. All the users have to do is attach tags to the body and from time to time change the batteries. The laboratory tags are similar to a wrist watch, but already there are smaller ones on the market in the form of bracelets, necklaces etc. and some can be sewn into the clothes. These tags are easy to wear and easy to hide. The most common tag placement includes one or both ankles, and a belt or a neck.

The whole system consists of a central base station, which could be designed to look like a decorative item, a small portable device, which looks like a mobile phone, and several tags. The base station is able to determine the 3D location of each tag in the home using radio technology. The portable device will serve the same role outdoors, but does not constitute the current prototype.

A lot of research has been done on fall detection and there are also some commercial systems available (e.g., iLife™ [15]). Most research used accelerometers [16] and gyroscopes [17] combined with threshold algorithms that simply raise an alarm if a certain acceleration or velocity threshold is reached. Some approaches replaced threshold algorithms with machine learning [18]. There were also attempts to recognize activities using cameras and visual markers [19][20]. However, we are aware of no system detecting health problems from locations of body tags, therefore we believe the CONFIDENCE system is breaking new ground.

The described system has already been developed using Ubisense, a real-time localization system [21], and an acceleration system based on Nanotron [22]. Here, we will describe two additional stand-alone versions – a technical version for technically oriented users and technicians, and a simple version for end-users. The two versions primarily differ in the user communication. Both versions do not require additional hardware but only the PC that is already part of the basic Confidence system.

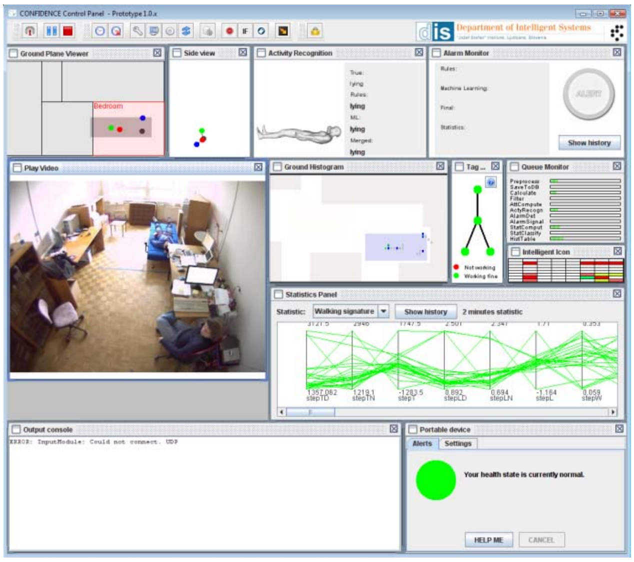

Figure 3: The Confidence Technical Screen

4. Algorithms / Modules for Advanced Users

The common part included in all versions has been developed as a set of independent modules/threads. They are organized as a pipeline where a module gathers the data from the previous module(s), processes them and sends them to the next module(s) in the pipeline. The main modules are the reconstruction modules (consisting of posture modules) and interpretation modules (consisting of interpretation and prevention modules). In addition, the communication modules were also implemented that communicate with a localization system and portable device, and that show the system status in details on the computer screen. The system status is shown on the computer screen only in the technical version of the system. The screen is presented in Figure 3. It consists of the top menu bar and of several windows. In the middle left is the video view of the room where the HW is installed. In the top right is the alarm window. It starts blinking in red and is accompanied by sound alarm if the system observes an alarm as shown in Figure 4. In addition, the bottom down window also reports an alarm since this is a simulation of the portable device. An alarm can be refuted by clicking it or pressing any button.

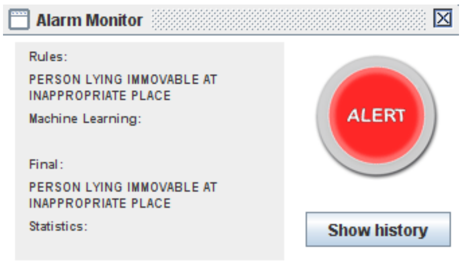

Figure 4: Alarm Monitor Showing an Alarm

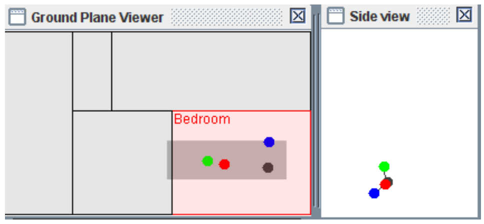

Figure 5: Ground Plane Viewer and Side View

While video is installed for laboratory tests, for all non-laboratory versions of the system there is no other on-line information about the user than the positions from tags. It has been shown that elderly object video surveillance, but not the tags providing body positions even to the point that the users wear them in a toilet. In case of four tags, the top and side view looks like shown in Figure 5. It should be noticed that the system has knowledge / awareness of the department subareas such as bed, kitchen, toilet etc. Figure 5 shows a person lying in the bed – the gray area from top, and from side. Head is denoted by green cycle and is in this particular case a bit higher than the rest of the body. Red cycle marks the belt tag and blue and gray the two ankles.

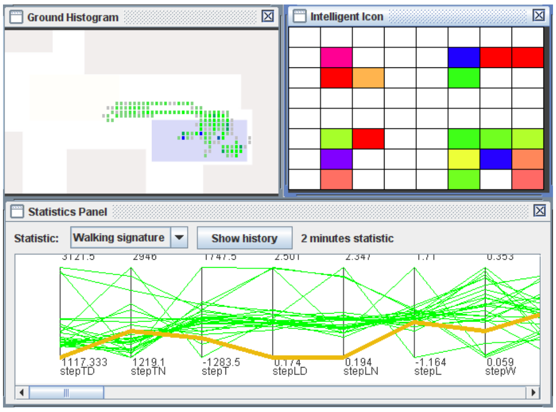

Figure 6: A Warning Showed in Control Panel with the Yellow Line

The system is aware that the user is in this particular case lying in the bed and therefore in this context there is no alarm by default. This represents a simple, but relevant example of system's context-awareness of the user. This is unlike other systems which report falls based on accelerometer peaks regardless of position, resulting in significantly lower performance as shown in Table 2. The falls and other alarms are recognized by a set of agents, each of them proposing an opinion about the current situation. These opinions and therefore agents are summarized into two groups: expert-system agents and machine-learning agents [22][24]. Finally, these two opinions are presented in the top window in Figure 2 between the side view window and the alarm window. Graphical representation of the final opinion is presented in the same window.

The next important window is presented in Figure 7, d). It shows the status of the four tags. If a tag is not attach or not functioning, e.g. it has fallen off or the battery is empty, the system reports such situation and asks for user action as described in user manual [25]. Among possibilities is also having only three, two or even on tag, but the one at the neck or belt is obligatory. In addition to the tag status, the queue status of the system processes is also reported.

The observation of mid-term behavior in terms of hours is demonstrated in Figure 6. The window shows an example of a warning issued due to user unusual behavior. This screen consists of green lines denoting normal behaviour. An orange line shows unusual behavior. Each vertical line corresponds to a particular attribute, e.g., speed of walk or step length. When averaged over several minutes these attributes resemble normal behaviour or not. If the behavior is unusual, an orange line is displayed.

The top two windows in Figure 6 show macro-level behavior. The left top screen shows density of user positions in the room. The top right screen shows the graphical presentation of the posture and position of the user. Both top screens on themselves enable visualization of user behavior showing deviances in behavior thus enabling the care personnel to propose appropriate care actions.

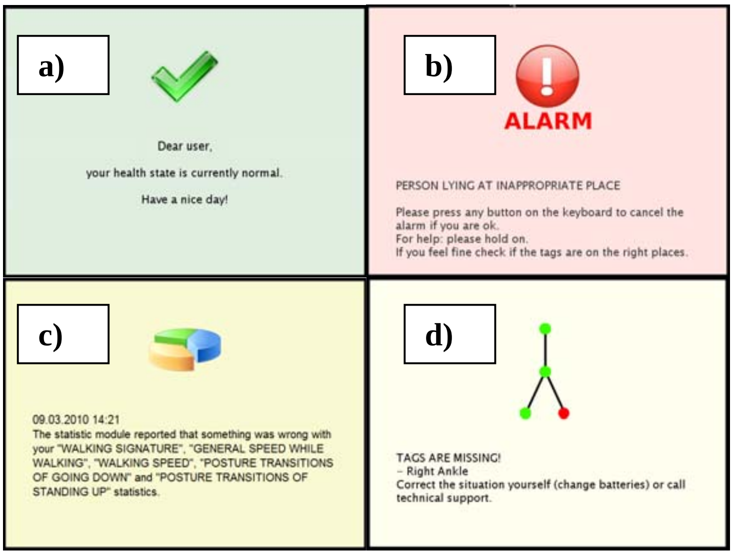

Figure 7: Simplified version for the elderly. Screen a) normal state, b) alarm was raised by the system or the user, c) the unusual behaviour was detected and d) tag is missing.

5. Simple Version for Elderly

There are six simplified screens for elderly or non-technical users, four of them are presented in Figure 7. They report: normal status (Figure 7, a)), an alarm (Figure 7, b)), an unusual behavior (Figure 7, c)) and a missing tag (Figure 7, d)). An alarm can be also raised by pressing the A key and dropped by pressing any key. Other screens that are not represented as a figure are: system pause e.g., the user wants to freeze the system due to any reason, like going to a toilet and a help screen. The help screen is shown if any key but A, F1 or space bar is pressed. These screens are simple and understandable therefore do not demand technical knowledge and are appropriate for any elderly.

Several manuals have been produced describing the presented system and its functionalities. The first one it the System manual that describes the whole system and all of its modules in detail. In addition, it describes the installation of the system and the tag placement.

The second manual is the Recording instructions. It presents how a user can record the data for testing purposes step-by-step. In addition, the preferred scenarios for testing are also described.

The third and forth manual are the User manuals that describe different versions of the system, e.g. the portable device and the possible interaction with it. They show all the possible screens, messages and keys for interaction with the portable device.

The last manual is the Init wizard. It describes the required initialization of the system when it is used for the first time. It also describes which actions have to be recorded, possible errors during the initialization, and which data must be inserted by the user.

6. Verification

The system has been intensively tested in the laboratory with young volunteers simulating walking, sitting, falling etc. The tests presented in [24] are shown in comparison with accelerometers only and accelerometers with body orientation. The results in Table 2 show a significant difference, but one should have in mind that the cases were chosen to deal with the situations that are hard to classify. More precisely, in a typical test, only simple laboratory cases are presented and publications typically report about 100% accuracy. However, in real life, 100% accuracy is not achieved. This is the case also with Confidence since it was not able to detect with high accuracy if a person is sitting on a chair or on a floor in a time limit of 10 seconds. This is due to inaccurate position data that have standard deviation around 20 cm. However, tripping, i.e., falling from walking and fainting from standing, i.e., slowly lying down when fainting were captured with 100% accuracy. Accelerometers with or without orientation are successful when dealing with fast falls, however, fail to recognize lying down slowly due to fainting and sliding from the chair.

The last three rows in Table 2 denote cases when no alarm should be reported. In these cases, accelerometers with orientation perform better than accelerometers without orientation while Confidence performs close to 100%.

Table 2: Performance Evaluation of the Confidence System and Systems Using Accelerometers

Case / Accuracy [%]	End position	Confidence system	Accelerometers and orientation	Only accelerometers
A: Tripping		100.00	100.00	100.00
A: Fainting standing		100.00	0.00	0.00
A: Sliding from the chair		52.00	0.00	50.00
FA: Jumping in bed		100.00	0.00	0.00
FA: Sitting down quickly		100.00	100.00	0.00
FA: Searching for something under table/bed		96.00	100.00	100.00
Overall		**91.33**	**50.00**	**41.67**

7. Conclusion and Discussion

This paper presented some basic demographic trends and a potential solution to the European problem of increasing number of elderly in the form of an AAL system CONFIDENCE taking care for elderly. Two stand-alone versions of the Confidence system were presented as a result of the EU FP7 project Confidence. When compared to the accelerometers, the system achieved over 40% better recall / accuracy. Additional explanation of the sensors and the experiments including a couple of video recordings is provided in [26].

In summary, the demographic problems can be substantially decreased by using proper demographic policies, as the analysis strongly indicates. While Africa and Europe face quite opposite demographic problems, the burden of too fast demographic growth can be decreased by for example contraception and in countries with too low fertility rate demographic growth can be encouraged by increasing the status of family and employment status of mothers. For Europe, AAL systems are a necessity to cope with bright future.

Acknowledgments

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References

[1] United Nations, World Population Prospects: The 2004 Revision. New York, USA.
[2] S. Toyne, Ageing: Europe's growing problem. http://news.bbc.co.uk/2/hi/business/2248531.stm, BBC News.
[3] The Ambient Assisted Living (AAL) Joint Programme. http://www.aal-europe.eu/.
[4] CONFIDENCE. http://www.confidence-eu.org.
[5] Personal Robotic Assistants for the Elderly project. www.qolt.org/Research/Project.jsp?projectID=3.
[6] Zenio, Vitaltronics. www.vitaltronics.be/products/zenio.html.
[7] CHRONIUS project. http://www.chronious.eu.
[8] Assistive Robot for Elderly People Living Alone project. www.fatronik.com/en/proyecto.php?id=44.
[9] COGKNOW project. http://www.cogknow.eu.
[10] ECAALYX project, http://ecaalyx.org.
[11] ROSETTA (Guidance and Awareness Services for Independent Living), AAL-169 project. http://www.aal-rosetta.eu.
[12] CODAMOTION. http://www.codamotion.com.
[13] EMERGE: Emergency Monitoring and Prevention. http://www.emerge-project.eu.
[14] K. Delbaere, G. Crombez, and , G. Vanderstraeten, Fear related avoidance of activities, falls, and physical frailty. A prospective community-based cohort study. In: Age and Ageing 33, ISSN 0002 0729. Oxford University Press, Oxford, 2004, pp. 368-373
[15] AlertOne Services, Inc. iLife™ Fall Detection Sensor. http://www.falldetection.com.
[16] A. K. Bourke, C. N. Scanaill, K. M. Culhane, J. V. O'Brien, and G. M. Lyons, An optimum accelerometer configuration and simple algorithm for accurately detecting falls. In: Proceedings of the 24th IASTED international Conference on Biomedical Engineering, ISBN 0 88986 578 7. ACTA Press, Anaheim, 2006, pp. 156–160.
[17] A. K. Bourke and G. M. Lyons, A threshold-based fall-detection algorithm using a bi-axial gyroscope sensor. In: Medical Engineering & Physics, ISSN 1350 4533. Elsevier Press, 2006, pp. 84-90.
[18] M. Lustrek, and B. Kaluza, Fall detection and activity recognition with machine learning. In: Informatica, ISSN 0350 5596. Informatica Press, Ljubljana, 2009, pp. 197-204.
[19] G. Qian, F. Guo, T. Ingalls, L. Olson, J. James, and T. Rikakis, A Gesture-Driven Multimodal Interactive Dance System. In Proceedings of the International Conference on Multimedia and Expo, ISBN 0 7803 8603 5. IEEE Press, Taipei, 2004, pp. 1579-1582.
[20] G. Sukthankar, and K.Sycara, A Cost Minimization Approach to Human Behavior Recognition. In: Proceedings of the Fourth international Joint Conference on Autonomous Agents and Multiagent Systems, ISBN 1 59593 093 0. ACM Press, New York, 2005, pp. 1067-1074.
[21] Ubisense. http://www.ubisense.net/.
[22] Nanotron. http://www.nanotron.com/.
[23] V. Mirchevska, M. Luštrek, and M. Gams, Combining machine learning and expert knowledge for classifying human posture. In: Proceedings of the Eighteenth International Electrotechnical and Computer Science Conference, ISSN 1581 4572. ERK Press, Portorož, 2009, pp. 183-186.
[24] B. Kaluža, V. Mirchevska, E. Dovgan, M. Luštrek, and M. Gams, An agent-based approach to care in independent living. In: Proc. of International Joint Conference on Ambient Intelligence, ISBN 3 642 16916 3. Springer-Verlag Press, Heidelberg, 2010, pp. 177-186.
[25] B. Cvetković, V. Mirčevska, E. Dovgan, B. Kaluža, M. Luštrek and M. Gams. User manual – User screen. Technical Report IJS-DP 10559. Ljubljana, 2010.
[26] Confidence Experiments. http://dis.ijs.si/confidence/demo.html.