Algorithm Assisted Control of Home Visits in Home Care based on wireless Telecare Sensors

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Abstract: - Telecare is seen in the UK as an important tool to make the Home Care of elderly more efficient and at the same time raise the service quality. Our University develops process enhancements for a Region that is evenly and sparsely populated and is expected to have unusually many old citizens in 2020. We applied Telecare to the Home Care Processes and the first operational implementations have been set up in 2011. There is however a lot of additional development potential in the interpretation tasks associated with the Telecare home sensors. We designed a research project that addresses this untapped potential. The Control of Home Visits can be based on a semi-automatic computer analysis of the sensor events.

Key-Words: - Telecare, Home care, Wireless sensors, Status analysis, Ambient assisted living, Elderly living alone

1 Introduction

The paper describes research challenges derived from observations and conclusions from a 2009 field test involving wireless sensors at homes of elderly living alone and an associated service concept of generating recommendations of action semi-automatically to the home care service from sensor data.

Mikkeli University of Applied Sciences (MUAS) is situated in the South-Eastern district of Finland that has one of the most challenging predicted demographic structures for the 2020’s in Europe. The eastern part of the district is expected to have 44700 inhabitants in 2020, 2130 of which need daily care, 1580 because of memory disorders. The age structure of the population can be characterised by calculating what proportion of the population is children and of over 65 years old, divided by the number of people that are in the working age. The fresh population forecast gives a figure 75,3% for Eastern Finland for 2020 [9].

The Telecare Generation 2 is described as involving in addition to older Alarm Phones also sensors situated in the apartment of an elderly living alone. There are several studies that show that the opportunity to enhance the efficiency and lower the cost of Home Care is strongly related to renewing the work processes of Home Care via the introduction of Telecare [2],[3],[4],[5],[6],[7],[8].

Data communication from homes has become feasible in Finland due to the GSM/3G and Flash OFDM (fast switching Orthogonal Frequency Division Multiplex, at 450 MHz) WWAN networks. Wireless communication has also become feasible at homes due to low cost short range radios such as ZigBee®. The MiUAS generated an initiative to send to the hospital district home care visit recommendations generated at a call centre and based on real time event messages sent wirelessly from the homes of the elderly [1]. The project was financed by the ERDF instrument of the European Structural Fund (ESF) and governed locally.

The project actually built 37 test homes in 3 towns and 3 municipalities. We are aiming at a 40% reduction in hospital days for a selected group due to increased home care, with corresponding cost savings. The main result is the new work process.

The first technical challenges faced by the project were how to maximize the time between replacing batteries to the sensor that detects motion in the living room and providing countermeasures to the
effects of RF (Radio Frequency) shadowing and fading.

The project developed a new wireless sensor (Figure 1). It can detect the alternating current from the inside of an electrical wire without any physical contact with the copper wire. The sensor is battery operated and was successfully used e.g. in detecting the usage of microwave ovens.

Figure 1. The contactless current detector for electrical appliances.

The author thinks applying Telecare to the Home Care processes in the South Savo Region is a key factor to meet the challenges from the rapidly increasing number of citizens of over 75 years of age. The average distance between the Home Care homes is unusually long in this region.

The paper studies the further research challenges from the ERDF (EU) funded project Mobile Care in Eastern Finland realised between November 2008 and April 2010. The configuration of the field test is presented on Picture 1.

The necessary steps to further increase the efficiency of the 24/7 Call Centre are presented.

2 Problem Formulation

According to the Mobile Care principles, the Call Centre is receiving an update of the states of the home sensors every three minutes. The operation of the 24/7 Call Centre is relatively expensive and involves professional nurses. Until now the process to derive Recommendations of Home Visits has been manual. During the Mobile Care Field Test [1] we found out that a team of nurses was capable of detecting anomalies of the daily routines of elderly living alone and having the Mobile Care Home System once every 2 hours when the number of sensor equipped homes was 37. The field test system is described on Figure 2. The goal is to raise the efficiency of the nurse team by developing a software tool that analyses the sensor events in real time and launches Recommendations of Home Visits to the nurse team. We also wanted to ensure the high quality of the Recommendations given by the Analysis Software.

2.1 Decision algorithms created by professional nurses to detect anomalies in the daily routine

The team of nurses began to design Decision Rules at the beginning of the 7 week field test. The work was iterative. We also had nursing students at these teams as a part of their Bachelor studies. The experienced nurses acted as Mentors.

2.2 Implementation of the Decision rules

We designed a Research and Development Project to implement a software that utilizes the Decision Rules from the Nurse Teams.

2.3 Statistical Testing of the Analysis Software by comparing Recommendations from the Analysis Software to a parallel independent Nurse Team receiving the same sensor reports

We designed a statistical test that uses some 6.5 million sensor events from the Field Test. The field test data is available as a database. The Recommendations of Home Visits should be the same when received from the old manual process and from the new semi-automated Process.

2.3 Economic comparison of the Manual Decision Process and a new semi-automated Process utilising the Analysis Software

Cost indicators of performing the Sensor Event Analysis manually is available from the Field Test. We also have parameters from the direct and
indirect Effects of the Mobile Care Service. The economic Results from the manual Field Tests are compared with the similar indicators from the semi-automated Field Test.

2.4 Predictive Analysis of matters that threaten to decrease the Ability of the Algorithms by interviewing Home Care customers and their family members

The Home Care customers and their family members have a very practical point of view about the real circumstances at homes. These conditions not foreseen by the nurses are taken into account in the second version of the Decision Rules. Only the second version of the Decision Rules is used in the actual specification of the Analysis Software.

2.5 Recommendations to the current methods that predict the Ability of customers to be able to live alone

The current methods to predict the ability to live alone (RAI and the short analysis RAVA) do not take into account the new data that becomes available through the sensors. The methods must be updated to include the effects of the Mobile Care System.

2.6 Field test of the new semi-automated process in real homes

The City of Mikkeli partnered with the team of the writer to enable a new field test in the suburb of Haukivuori.

2.7 Research on the willingness of retired nurses to work part time at a semi-automated Call Centre

The availability of nurses is a problem in sparsely populated parts of the country. The retirement rate of nurses is especially high in Finland. Many nurses retire mainly because of the high physical demands of the work. An interview study will reveal what proportion of the already retired nurses would be willing to work part time at a Mobile Care Call Centre.

![Figure 2. The Mobile Care Field Test system.](image)

3 Problem Solution

The Main Decision Rules from the nurse teams are presented below.

The Main Rules follow the concept of examining of the status change curve for each sensor type. The Status Change Curves have the time parameter as the horizontal axis. The curves were available as computer graphics to the nurses during the field test.

(1) Main OK process

Check the Main Activity Indicator that shows green if the status of the door_open OR the status of the bed_occupancy has changed during the last activity_hours period, dependent of the customer.

If not green, then proceed to (2)

(2) Bed occupancy sensor

If customer_present = 1 AND sensor_on = 1 AND bed_unoccupied_for_over_10_hours = 1, then A

If customer_present = 1 AND sensor_on = 1 AND bed_occupancy_varies = 1, then B
A  Check both Movement Sensors. If no movement for Activity_period hours, create an alarm.

B  Check daily_routine , health_status and ability. If occupancy is abnormal, create an alarm.

If customer=present AND bed_occupancy_varies=0, then check sensor_on . Call maintenance or create an alarm.

(3) Corridor movement sensor process

If corridor_movement_in_10_hours=0, then

If corridor_movement_continuously_on=1, then C

If corridor_movement_varies=1 AND corridor_movement_recently=0, then D

C  Analyse the history of corridor_movement. Call maintenance, if equipment failure

D  Check customer_present. Check bed_occupancy. Check living_room_movement. Check health status and ability. If falling incident possible, create an alarm.

(4) Occupancy Analysis

If time_corridor_sensor_1 > time_door_sensor_1 AND ABS(time_corridor_sensor-time_door_sensor)<60, then customer_present=1

If time_corridor_sensor_1 < time_door_sensor_1 AND ABS(time_corridor_sensor-time_door_sensor)<60, then customer_present=0

(5) Living Room movement sensor process

The process is the same as with the Corridor sensor.

(6) Door open and customer_present

If door_open=1 , then E

If door_status_varies_rapidly=1, then E

E  Check the health_status and ability. Check corridor_movement, bed_occupancy and living_room_movement. If abnormal absence from home evident, create an alarm. If door_open and customer_present, create an alarm.

(7) Microwave, stove , oven usage activity

If mw_active_in_10_hours=0 AND stove_active_in_10_hours=0 AND oven_active_in_10_hours=0 AND customer_present=1, then F

F  Check daily_routine. If abnormally inactive, create an alarm.

(8) Stove , oven overheating risk

If stove_active_for_4_hours OR oven_active_for_4_hours, then G

G  Check if customer supposed to use these appliances. If an overheating risk, create an alarm.

(9) Microwave usage activity

If mw_active_in_mw-activity_hours=0, then H

H  Check daily routine. If customer_present AND abnormal_inactivity=1, then create an alarm.

(10) TV / Coffee cooker usage activity

The process is the same as with the mw sensor.
4 Conclusion

The field test prevented one serious danger situation by detecting that a customer left the apartment after midnight and wandered out during winter without warm clothing.

During the 7 week period there were 43 door related alarms, 32 falling related alarms, 37 inactive movement alarms, 21 abnormal bed occupancy alarms and 20 electrical appliance alarms, from the 37 test homes.

The sensors were clearly useful for analysing the status and activity of the customers.

During the field test the nurse teams created the Main Conclusion Rules. They were complemented by more detailed Rules that were written case by case to the test log. The essence of developing the Analysis Software is to convert the detailed conclusion rules from the decision log into software specifications.

The University planned a Research Project that answer the Research Topics 2.1 – 2.7 in one project. The project plan has 63 works and it needs 88 person months of research personnel work. The funding proposal was sent to the Ministry of the Employment and the Economy in November 2010. This ministry funds Technology Research Projects.

The consortium included 4 companies, one city, two local Universities, one Austrian University and a Research Centre from Japan. The requested funding from the state was 631 000 Euros. The evaluation results were received in May 2011. The result was “The effect to the development of new knowledge is smaller compared to the requested funding than in competing investments”.

References:


