RESEARCH PAPERS
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

2013 Special Number

SMART HOME AND ERDERLY PEOPLE

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ABSTRACT

In this article we purport how advances from the device and technological side have not necessarily been matched with a similar level of development in processing of the information recorded within the living environment from an algorithmic or 'intelligent' perspective.

KEY WORDS

Smart House, self-control, home automation, inteligent control

INTRODUCTION

Smart Homes have become firmly established as an active research area with potential for huge social and economic benefits..The use of Smart Homes to support independent living refers here to the possibility of designing an intelligent monitoring system that can detect when an undesirable situation may be developing (e.g., hazard, security threat, etc). Although all people can be involved in such undesirable situations, elderly people and people with health problems require more exhaustive monitoring when they are not accompanied by a healthcare professional. It is possible for someone exhibiting early stages of cognitive impairments to, for example, begin to cook a meal, forgot they have started this activity and subsequently proceed to leave the house or take a bath/shower.. We have focused on improving the level of support offered by devices which are readily available from a commercial perspective and can be deployed with a simple user interface. 'Sensor' is a keyword in this area. Smart Homes can be much more intelligent than they currently are.

SMART HOME SCENARIO

We consider a model for a Smart Home based on a residential care institution for erderly people. The environment is one of shared community care where approximately several individual one-person apartments are contained within the same building each offering high technology solutions to promote independent living for the elderly. At the core of the environment is a central monitoring facility which has the ability to detect all sensor and alarm events concurrently from each apartment. We will focus on just one apartment. Figure 1 depicts the llayout of a person's apartment.

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SENZORS

In this Section we provide a brief description of the sensors in the aforementioned scenario. Not all of them have to be present in a Smart Home and on the other hand new sensors can be incorporated.We focus here on a subset of sensors which are commercially available, affordable and combined can offer an autonomous living environment while maintaining the privacy of the inhabitant.

The environment has motion sensors in the following locations which have the ability to identify the whereabouts of the person (kitchen, livingroom, toilet, reception, bedroom, outside (right below front door)).

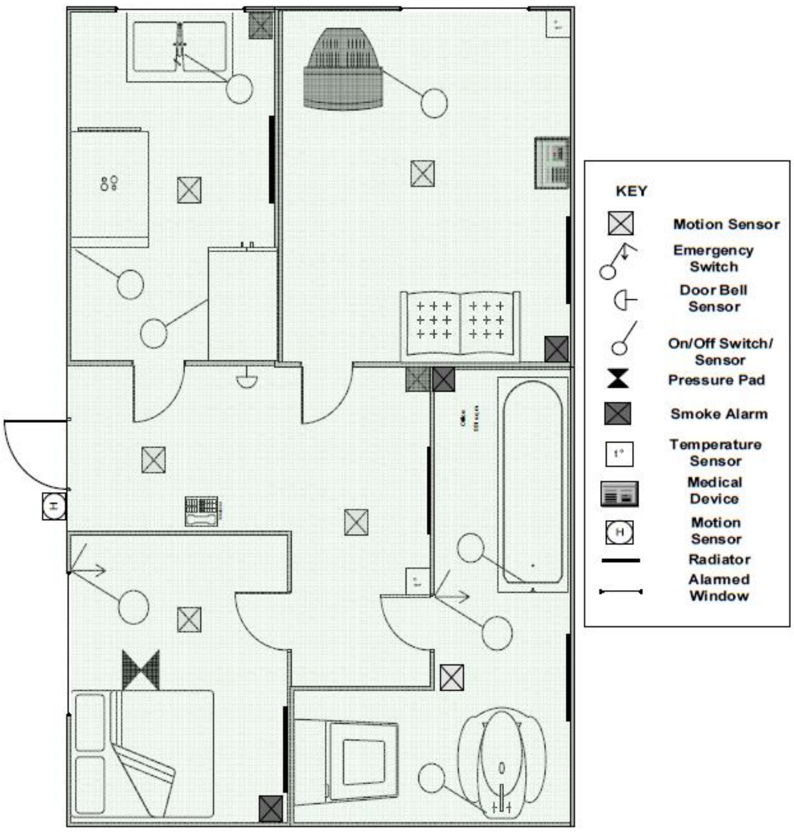

Fig. 1 *Layout of apartment*

In addition, it is assumed the person wears an electronic tag. Such a tag communicates with sensors on the doors to each room and has the ability to complement the aforementioned location sensors. The environment will have smoke alarms in all rooms.

The Smart Home will have control or monitoring abilities over the following common domestic appliances:

1. cooker
2. tv
3. fridge
4. kitchen tap
5. bathroom sink tap
6. bath tap
7. air conditioning
8. doorbell
9. phone
10. emergency pull cord switch
11. temperature sensor
12. radiators
13. bed

All the above will operate in a toggle fashion i.e. can only be active/non active. There is also a difference between items 1-7 and 8-13. The first group are also equipped with switches so that they can be remotely deactivated if needed.

SENZORS AT WORK

An example of a possible sequence of primitive events for our case study would be: *at_kitchen_on, cooker_on, cooker_off, alarm_kitchen_on, alarm_kitchen_off, at_living_on, tv_on, tv_off, doorbell_on, inbed_on, at_outside_on.*

From the initial state, a possible sequence of primitive events (preceded by their instant of occurrence) arriving at the system would be:

0 at kitchen on	*1 cooker on*
2 at reception on	*3 no event*
4 at toilet on	*5 tapSinkBathroom on*
6 no event	*7 tapSinkBathroom off*
8 no event	*9 at reception on*
11 at bedroom on	*11 inbed on*
12 no event	*13 no event*
...	...

Events with suffixes ‘ on’ and ‘ off’ represent sensors changing values from ‘off’ to ‘on’ and viceversa. One special event we considered is the absence of an event at a given point in time, we denote this as no event. These represent that at a particular time no sensor changed its value. The fact that no sensor changed its value does not mean nothing happened inside the house but instead nothing that can be captured by the sensors. In order to develop the necessary approaches to process all of the information from these sensor elements and provide a means of support it is necessary to consider the possible activities that a person may undertake during normal and abnormal conditions. The key parameter is primarily to assess the current location of the person in the living environment. Once this has been realized, it is then possible to determine if the sequence of actions the person becomes involved in are ‘normal’ or ‘abnormal’. The diversity of the types of information generated by the sensors provides a number of dimensions to the information which can be generated for a person. These can be considered to be (a) their whereabouts (b) their interaction with appliances and (c) the duration of these events. Hence, with such information, rules may be modeled and used to discriminate between normal conditions and potentially hazardous situations when an alarm condition should be raised.

SMART HOMES AS DYNAMIC SYSTEMS

We can make an abstraction of a Smart Home and look at it as a system that starting in an initial state can then evolve through different states as events occur inside. Each state is defined by the place the person is in, which devices and alarms are activated, e.g. the temperature of the room. Each of these parameters are discrete values, either boolean ‘on’-‘off’ or within ranges like those used for temperatures. It is important to mention here from a computational point of view that all the constituent parts of the theory (houses, sensors, possible events, possible states and time spanning since the initial state until the current time of use) can be defined as finite sets. The sequence of events can potentially develop ad infinitum but from a practical perspective it would not make much sense to take the complete history and the possible ‘sequence to be’. In reality what happens is that we look at a specific window in time to assess the history and another limited window to assess the possible future sequence in order to infer what may be the case in the next minutes. We do not consider if the cooker was left on by mistake one year ago and we do not try to infer if it will be left on by mistake in one year’s time. Once the initial state has been defined on the basis of the layout of the house, the sensors available and their initial values, subsequent states will be produced as events are triggered and their effects are recorded. Lets suppose a tenant is allocated one such house. The event of the door being opened triggers the anti-burglar sensor attached to the door. This will update the system to the next state where the front door is open. The movement sensor in the reception area will also detect movement and that event will trigger an update to a new state where movement in that room is explicitly included. While the tenant is walking through the front door the movement sensor in the reception area will stay on. Eventually, if for example the patient enters the living room area then the movement sensor in the reception area will go off and the sensor in the living room will go on detecting movement of the person entering the room. Movement sensors have to be strategically located; this posses the first practical challenge relating to the interaction between sensors and the reasoning system. Lets imagine two contiguous rooms like the living room and the reception area. Each one will have a movement sensor, have an overlapping area of detection then when a person is moving in that particular area the system will believe they are in both areas simultaneously and automated analysis may become very difficult or at least it may decrease substantially the options the system can consider. On the contrary if there is a transition area such that it does not belong to any of the two regions then there may be important events/states that can pass unnoticed to the system, like the person staying in that area for a long time, e.g., alzheimer patients can stay in the same place for a prolonged duration during a time of crisis. Occasionally the system can enter into loops. This is neither good nor bad and can be more or less frequent depending on how many moving objects there are inside the house, how many sensors there are and how sensitive they are. For example, imagine a state where the patient is sitting quietly in the living room on one side of the sofa watching TV, the movement sensor in the living room is off. Lets call this state S1. Then the patient/tenant moves to the other side of the sofa activating the movement sensor. After a short period where the patient remains reasonably inactive in the new location the sensor will go off again. Lets call this state S2. If no other sensors are triggered then the state of the house from the system's perspective, i.e., from outside and based on sensor values, will be exactly the same as in S1. Based on these notions further analysis of possible evolutions of the environment under consideration can be made. These analysis can be made before the system is built as an initial approximation during the modelling stage. Alternatively they can also be used once the system is in operation to reason about the way the system itself is evolving, or may evolve, during real-time monitoring of activities in order to undeunderstand the context and decide how to react appropriately.

A POSSIBLE SCENARIO

Imagine the following sequences of events developing one after the other in sequence:
at_living_ on,
at_reception_on,
at_kitchen_on,
cooker_on,
at_reception_on,
at_bedroom _on,
inbed_on,
...

These roughly depict a person moving from the living room to the kitchen to turn the cooker on and then going to bed. It is a common and normal sequence of activities. There are, however, potentially interesting issues in this sequence which depends on other aspects of the activities considered. For example, staying in bed for 'too long'. To address those issues we need to consider explicitly the time when the events occurred, lets suppose we have:

0 at_living_on,
3 at_reception_on,
5 at_kitchen_on,
8 cooker_on,
10 at reception_on,
13 at bedroom_on,
15 inbed_on,
...

The reader can assume that at times when no meaningful event has been detected, for example at time 2, a default event no event is recorded by the system to keep track of the activities developed in the house. Also we omitted repetitions of events in the list above but a more realistic depiction of the scenario will have more information as movement sensors will be stimulated several times in sequence when a person is walking and also multiple sensors can be activated simultaneously. Hence a closer depiction of the information recorded in our scenario will be as follows:

0 at_living_on,		
1 at_living_on,		
2 at_door_reception-living_on,		
3 at_reception_on,		
4 at_door_reception-kitchen_on,		
5 at_kitchen_on,		
6 at_kitchen_on,		
7 at_kitchen_on,	cooker_on,	
8 at_kitchen_on,	cooker_on,	
9 at_door reception-kitchen_on,	cooker_on,	
10 at_reception_on,	cooker_on,	
11 at_reception_on,	cooker_on,	
12 at_door_reception-bedroom_on,	cooker_on,	
13 at_bedroom_on,	cooker_on,	
14 at_bedroom_on,	cooker_on,	
15 at_bedroom_on,	cooker_on,	inbed_on,
...		

Notice that in the list above at door reception-kitchen on and at reception on correspond to what we generically described as MDR and TDRK, respectively, in figure 2. Some sensors can be assumed to persist in an ‘on’ status once they have been activated, e.g. the cooker being on unless it is turned off, whilst other sensors tend to persist in an ‘off’ status, e.g. a movement sensor will be ‘on’ only while movement is detected. Also it is worth mentioning that although we considered a way to attach temporal references to events in this section and to states in figure 2 which resemble instants we do not intend to suggest that this is a mandatory way to associate time with events and states.

CONCLUSION

We present our view in this article which relates to the fact that much more needs and can be performed in terms of equipping Smart Home systems with advanced reasoning capabilities. Increasing the functionality of the available hardware with computational intelligence techniques will have the resultant effect of increasing the complexity of contexts to be understood, increasing the capabilities of the system to identify interesting situations, for example hazards, and to offer the ability of the system to react in a more appropriate way in terms of the quality of judgment.

ACKNOWLEDGMENT

This publication is the result of implementation of the project: “Increase of Power Safety of the Slovak Republic”(ITMS: 26220220077) supported by the Research & Development Operational Programme funded by the ERDF.

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