SMART HOME RESEARCH

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Abstract:
This paper is a survey for smart home research, from definition to current research status. First we give a definition to smart home, and then describe the smart home elements, typical research projects, smart home networks research status, smart home appliances and challenges at last.

Keywords:
Smart home; pervasive computing; home network; home appliances

1. Introduction

The concept of Smart Homes plays an important role in the planning of future housing-based models of care. More and more research groups are working on this domain, such as MIT, Siemens, Cisco, IBM, Xerox, Microsoft and etc. In these groups, nearly 20 home labs have been set. In these home labs, more than 30 appliances are used, over 5 network protocols are produced, and more than 3 AI techniques have been used. In this paper, attention will mainly be paid on smart home networks, gateways, smart home appliances, typical research projects, and research challenges. AI techniques such as multi-agent systems, Neural networks, fuzzy logic and etc will not be mentioned here.

In September 2003, Housing Learning & Improvement Network published a smart home definition offered by Intertek, which has carried out the project named DTI Smart Homes Project. In Intertek view, a smart home is "a dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be remotely controlled, monitored or accessed", remotely here means both within the dwelling and from outside the dwelling. Accordingly, a home, which is smart, must contain three elements, which are internal network, intelligent control and home automation. Internal network is the basis of a smart home, and it can be wire, cable and wireless. Intelligent control means gateways to manage the systems. Home automation means products

within the homes and links to services and systems outside the home. In the following section, we will discuss all these three elements in detail.

2. Smart home networks

Smart home networks technology is available in three main areas: Powerline (X10, EIB Powerline etc); Busline: EIB, Cebus, Lonwork, Batibus EHS etc) and Radio Frequency (RF) (e.g. Bluetooth, and most major smart home manufacturers).

Powerline systems are made of devices that can be connected directly into the main power supply. These devices use the normal wiring to send data to the devices to activate or deactivate them. Powerline technology is enthusiastically used by amateur smart home enthusiast as the devices are simple to configure and a system can be up and running quickly and cheaply. Should the system fail then the installer should be able to repair it on the spot or by locally sourced devices. Often, Powerline systems require a computer to be attached to the system to monitor the devices, change their status, although many newer systems use the X10 coding in proprietary systems, and have bypassed the need for computers by placing the chipsets into the system itself. Many Powerline systems are in use today and some are used to support older and disabled people. Often the major problem with this system is related to interference and power cuts, which can throw the system into chaos, as default reset values can be unsuitable for the client group.

Busline smart homes use a separate 12-volt cable (twisted pair) to transmit data to devices, which runs in parallel to the traditional mains cable. The use of this cable means that devices are independent of conventional mains borne power supplies. The Busline devices can be configured to adhere to stricter operational parameters and therefore systems that are more complex can be envisaged. Busline has, to date been proven to be the most effect and reliable form of smart home, as it can be configured to

prevent devices malfunctioning during power cuts. The two-way protocols also allow the systems themselves to monitor devices without recourse to external computerized systems.

Radio frequency (RF) and Infrared (IR) systems are becoming increasingly more popular. Most manufacturers of smart home technology have a RF product range. These products have tended to be perceived as less reliable due to problems with interference and short-range identification issues, although recently there has been a shift towards more robust whole systems. Many social care alarm systems are using RF components as standard although they may configure these into a Busline or Powerline system. RF systems have been criticized as they could be broken into by an intruder with the correct IR code who could possibly gain access to the home or modifying the settings of devices.

3. Intelligent control – gateways to manage the systems

Gateways have actually two purposes in the connected home – bridging different technologies within the home and providing access from the home to external services as well as vice versa. A number of gateways have been developed by various research projects funded by the European Commission and other Research Programmes. Such as: HAVi/Powerline Gateway, HAVi/UPnP Gateway and UPnP/Powerline.

4. Appliances

Appliances are intelligent artifacts that can make a user's life more comfortable and even more interesting. There are many kinds of appliances, here are some of them.

Smart pen

Smart pen offers a way of finding a definition for any unknown vocabulary when people have problems reading books or documents, and can even save important phrases.

Gate reminder

Forgetting an important item at home that you need for your day is something that happens to the best of us. But now, Gate reminder will remind you what you need before you leave the house, so you will never need to forget anything again.

GIA

GIA is a new professional picture management device that controls every function in your photo album through interaction methods using simple hand gesture.

Smart wardrobe

The smart wardrobe digitally looks up the weather forecast for the user so that they can comfortably and adequately coordinate what they wear with the outside environment before they leave the house. Once the user returns home, the clothes that they have worn can be easily deposited to go through the simple laundry function.

Smart dressing table

The smart dressing table is the perfect accessory for women who are fed up with having to put their make-up on in the morning in a bad and dark environment. This dressing table has several innovative functions that work with the user to create a perfect and convenient atmosphere for putting up make-up on quickly and effectively.

Smart bed

Smart bed system can be programmed to remember your preferred sound, smell, light and temperature settings to gently wake up all your senses and give you a good start to every morning.

Smart pillow

Smart pillow can read any books of your choice to you at bedtime and can play your favourite music to drift off to when you start to get sleepy. Once your body goes into deep sleep, it will automatically check the condition and quality of your sleep, gradually reducing the volume of the music accordingly and, eventually, turning it off completely. As well as being ready for you when you wake up in the morning, it also checks the user's basic body information (such as respiration, pulse and body temperature) and in the case of any emergency or illness it will immediately report via the network through to the emergency system.

Smart mat

Simply by sensing the body weight and footprint of the user, smart mat immediately recognizes which user is stepping on the mat. It is easy to record who is at home and who is not-and even who is visiting-by using this device. Additionally, the display can give a message of choice to each user, whether it is 'hello' or an important message. The mat's analogue function can be programmed to automatically remove dust and bad odours, and it is just the right material and consistency for constant use-not too soft or slippery.

Smart table

By incorporating an interactive touch screen to its surface, smart table allows user to access all parts of the smart network at the touch of a finger and can be used in any situation to communicate messages and create tasks-even in an emergency.

Smart picture frame

Smart picture frame is an interactive device that can simultaneously provide instant information and be aesthetically pleasing. It provides the user with real-time information updates through easily recognized images, and by touching the designated image, additional in-depth information can be accessed easily.

Smart refrigerator

Along with its obvious basic food storing function, the smart refrigerator is equipped with a shopping and storage application that allows the user to keep track of the individual food items expiry dates as well as manage shopping lists.

Smart greenhouse

The Smart Greenhouse is a natural air purifying system that utilizes plants that have naturally powerful air purifying qualities in a mini greenhouse in the house, which provides fresh air and a pleasant natural scent. The greenhouse automatically controls the climate to adjust the plants' purifying abilities in order to provide adequate freshness according to the contamination level of the air in the house.

Smart sofa

The smart sofa has many special functions that enhance your experience when watching the television, films or playing video games. Also, by reading signals from the user's body, it automatically adjusts to create the most comfortable and physically beneficial shape for the user's posture.

DigiFlower

The DigiFlower is a cordless communication system that indicates whether or not any member of the family is approaching the home. It indicates by bursting into bloom when a family member approaches the house. This innovation can act as a new communication interface for the people both inside and outside the house.

Electronic paper

'E-paper' is basically a computer monitor that is so thin that you could roll it up and stick it in your pocket. The goal is to create an electronic paper that has the look, feel and flexibility of paper, but unlike paper, can be erased, updated and used over and over again.

Smart projector

It formulates a new inflectional plan to existing projectors and is a wireless movable projector and home network system that can operate anywhere for ease of use. The main part of the lens can be detached and used to monitor any part of the house desired by using it in conjunction with the input camera.

Smart window

This is an idea that was developed from human behavior patterns of drawing on a frosted window in order to look outside and draw images. This system is developed on top of the normal function of the window, with connections both indoors and outdoors that have allowed the elements of entertainment and sensitivity to be added to the window system.

Smart bathroom

The bathroom is one place where every family member must spend a portion of their time every day of their lives. The smart bathroom provides the user with a more pleasurable sanctuary that really makes use of the space and offers a wide range of multi-media options, including the control of atmospheric sounds, the temperature both inside and outside the bath and a variety of information relating to health and beauty issues.

5. Smart home projects

Several smart home-related projects have been initiated by research labs.

Cisco : Internet Home

The Internet Home is a showcase building situated in Watford, north west of London, and has been constructed in partnership with a well known UK building firm. The technologies that exist within the house are nearly all off-the-shelf components and are used to control domestic appliances or features within the home. A web-based interface has also been created allowing the remote monitoring and control of the home.

Colorado, Boulder : Adaptive House

Also known as the Neural network House, the Colorado project made extensive use of neural network programming in domestic utilities controllers. Water temperature, heating, and room illumination controllers were deployed in an actual house with the idea that no post-programming or control should need to be performed by the inhabitants. Over a period of time a controller could learn the patterns of use of the home and therefore economize the running of the house.

KTH : comHOME

Using a series of rooms within a lab environment to simulate a smart home, this project placed various video communication devices in the space, but mindful of the social structure and constraints of a domestic setting.

Microsoft Research : EasyLiving

Microsoft's Vision research group conducts the EasyLiving project. Using a geometric model of a room and taking reading from sensors embedded within, the EasyLiving project aims to provide context aware computing using video tracking and recognition and sensor readings.

MIT : House of the Future

The House_n project is a multidisciplinary team drawn from architecture, computing and human factors, engineering and materials science. Several key issues are to be investigated for this home of the future, in terms of the building itself and the services that can be offered within.

Orange At Home

The Orange At Home project is a live in lab used by the company to explore near future home technologies.

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Most of the products used in the house are commercially available from manufactures around the world.

Philips : Home of the Near Future, Smart Connections

Home of the Near Future: A project by Philips to design 'products, interfaces and lifestyles' of tomorrow. Like the Siemens home, the design and research has been focused on making familiar physical domestic objects, from the kitchen through to the bedroom, intelligent in some way, particularly looking at personalisation and patterns of use.

Smart Connections: Philips Design have been augmenting everyday artefacts with an ambient intelligence in addition to creating new products that fit the paradigm. Wearable devices, augmented toys and a 'living memory' table have been produced as part of the research.

Portsmouth : Smart Homes in Portsmouth

In this project the Faculty of the Environment and partners wanted to design and build a series of smart houses that supported independent living for disabled users and were power efficient.

SEARCH : CUSTODIAN

One of the primary motivators behind the custodian project is the desire to create barrier-free homes for homeowners with disabilities.

Siemens : Smart Home

A concept home in Milan, using new and forthcoming Siemens products together with some non-commercial prototypes. Rather than create an environment with complete integration, Siemens appear to be concentrating on making everyday devices intelligent, but not interconnecting them.

Sussex,Science and Technology Policy Research Unit

The Application of Home Automation and Assistive Technologies Within Social Housing': a project that evaluated 'smart home' technologies conducted in association with Edinvar and the Joseph Rowntree Housing Trust, each on whom provided a house or flat to host the technology.

University of Massachusetts : Intelligent Home

The Multi- Agent Systems Lab at the University of Massachusetts created a simulation of an agent-based intelligent home and investigated the management of agents, including robots and the resources that they must share in a domestic context.

Intel : Intel Architecture Labs

The interdisciplinary team at the IAL develop a range of technologies for the home and office. They have brought to market several wireless devices, such as MP3 players, cable modems and wireless PC network cards. Intel has also released several open source implementations of home networking protocols, such as UPnP.

Bath : Gloucester Smart House

The Bath Institute of Medical Engineering has created a smart home that can help dementia sufferers to continue to live in their own home for longer. Sensors attached to common domestic items help remind and inform a person that something needs to be done. Spoken warnings and alerts help the homeowner conduct their life, in some cases these spoken messages are recordings made by friends or family. In addition there is a location service, mounted by a door and similar to a light switch in appearance, which allows a resident to be guided to the location of their keys, glasses, or purse.

X10

X10 is a protocol that operates over existing domestic electrical wiring, without the need to modify the wiring infrastructure.

6. Challenges

Challenge One: The "Accidentally" Smart Home

The "accidentally" smart home means a home that contains an accretion of technological components embedded in an environment that has not benefited from a holistic, ground-up approach to design and integration.

Challenge Two: Impromptu Interoperability

Without a priori agreement on both syntax and semantics, interoperability is difficult if not impossible. And yet the smart home posits the existence of a rich fabric of devices and software, somehow all seamlessly interconnecting with one another.

Challenge three: Reliability

We can expect that a paramount concern of occupants (if not developers) of smart home technologies is reliability. Achieving expected levels of reliability, especially when coupled with the ad hoc accretion of devices that may be expected in smart homes, is a great challenge.

7. Conclusions

In this paper we give a survey for smart home research, from definition to current research status of this domain.

Acknowledgements

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