SMART MIRROR FOR AMBIENT HOME ENVIRONMENT

GUIDE BY - Pandiaraj

Anish Kumar Mandal
Computer Science and Engineering
SRM Institute of Science and Technology
Ramapuram, Chennai
600089

Amrit Yadav
Computer Science and Engineering
SRM Institute of Science and Technology
Ramapuram, Chennai
600089

Kunal Satoor
Computer Science and Engineering
SRM Institute of Science and Technology
Ramapuram, Chennai
600089

***Abstract*—This paper describes the design and development of a futuristic smart mirror that represents an unobtrusive interface for the ambient home environment. The mirror provides a natural means of interaction through which the residents can control the household smart appliances and access personalized services. Emphasis is also given to ensure convenience in accessing these services with a minimum amount of user intervention. For example, face recognition-based authentication is used to automatically identify the user facing the mirr or and provide widget-based interface to access data feeds and other services. A service-oriented architecture has been adopted to develop and deploy the various services, where the mirror interface, the appliances, and the news and data feeds all use web service communication mechanisms. The smart mirror functionalities have been demonstrated by developing an easily extendable home automation system that facilitates the integration of household appliances and various customized information services.**

Keywords— -Smart mirror, ambient intelligence, ambient home environment, home automation, service oriented architecture.

INTRODUCTION

The vision of Ambient Intelligence has brought a new twist to the decade old research and industry initiatives in realizing Smart Environments. The AmI vision, as proposed by the European Consortium, promotes a paradigm where humans are surrounded by intelligent and natural interfaces offered by the interconnected heterogeneous computing devices embedded into everyday objects. The environment thus created is capable of recognizing and responding to the actions and presence of individuals . Therefore, Aml can be seen as the driving force toward a more user-friendly and user-empowered smart environment for providing effective support to human interactions.

The AmI aware smart environments and surrounding, whether it is the home environment or the distributed environment, uses a variety of smart technologies. These technologies integrate sensing, processing, reasoning, and networking capabilities in addition to heterogeneous applications, services and digital contents . With all of these rich technologies involved, AmI faces challenges on how to integrate them with the everyday objects. often unobtrusively, in order to provide computing intelligence in the surrounding environment.

The advancement of the key technologies and a variety of smart artifacts will play a major role in providing ambient intelligence in the home environment. Research in this direction has addressed the development of smart pen, gate reminder, GIA (picture management device), smart wardrobe, smart dressing table, smart bed, smart pillow, smart mat, smart picture frame, and so on. The development of smart appliances may be considered as the realization of the vision "the real world is the interface". Our work is geared towards this direction and is focused on the design and development of a smart mirror interface for the ambient home environment.

The application of AmI in the home environment may provide quality, convenience, efficiency, security, and safety to its residents . Aral for asisted living, especially for the elderly and the people with disabilities has already received much attention. Besides, the areas of home automation, communication and socialization, rest, refreshment, entertainment and sports, working, and learning at home will be influenced by the innovations of Aml. Therefore, the design of smart artefacts for the ambient homes should not be only technology-driven, it should also consider other aspects of home environment with a view to providing comfort and convenience to people living in the environment.

In this paper we make the following contribution. First. we proposed and developed a futuristic smart mirror using off-the-shelf technologies that provide personalized data feeds, camera feeds, and other services in addition to controlling the smart appliances in the household. The mirror can be used as a traditional mirror that essentially provides a sense of natural interaction with the surrounding environment. Second, we provide an easily extendable framework for integrating smart appliances and services with the mirror interface in order to automate the home environment.

The remainder of this paper is organized as follows. Section briefly comments on some related works. This is followed by the description of the smart mirror including the design and architecture of the underlying home. automation framework . The implementatio detail, test cases and screen snapshots of the propose system are provided . Conclusion and som thoughts on future work are presented .

RELATED WORK

The proposed smart mirror represents a natural interface that facilitates access to personalized services and control of household smart appliances in the ambient home(environment. This is an attempt to contribute to this design of a smart mirror-like interface as well as the smart environment in which the interface is used for interaction In the following, we briefly comment on some relate research in this direction. Philips Home Lab is a test bed for creating perspective and context-aware home environments. Among several projects, their work on creating an intelligent personal care environment uses an Interactive Mirror in the bathroom to provide personalized services according to the user's preferences. For example, children can watch their favorite cartoon while brushing their teeth. The mirror can provide live TV feeds, monitor the latest weather, check the traffic information, and so on. Personnel recognition has been proposed by using weight, height, etc. The weight scale can be displayed in the mirror and can be connected via several other sensors for providing health information to the user. The mirror is a combination of one or more LCD flat screen displays specifically combined with a mirrored surface and connected with a central processor to provide the intended services. The Interactive Mirror serves as a motivation to provide ambient feelings in the home environment.

The Aware Mirror is an augmented display that is placed in the bathroom for presenting personalized information to the user. It detects the position of a person in the bathroom using a proximity sensor and identifies her/him from the usage of a toothbrush. It provides useful information such as closest schedule, transportation information, and the weather forecast. The mirror is constructed by attaching an acrylic board in front of a monitor. A slider sensor on the mirror is used to navigate the information presented on the mirror. Although it attempts to provide an intuitive interface, it has some limitations that may restrict it from wider usage. For example, the state-of-use of a toothbrush for identifying a person might not provide accurate states to personalize information. Also, the use of magic mirror restricts dark colors from going through it; and hence, requires special attention to the color of the contents to be displayed. In our case there is no such issues as we use a touch screen to mimic a mirror-like interface through the use of touchscreen and video technology.

The Memory Mirror from the Everyday Computing Lab acts as an assistant to elderly people by graphically showing the status of drug usage over a 24-hour period of time. It keeps track of all the drugs removed from the medicine cabinet and records it in a history log in d order to display the details of previous usage and to warn c about possible lost and/or misplaced items. The Memory Mirror heavily depends on RFID technology and requires attaching RFID tags to the household items and RFID reader to know the status of these items. It may not be used as a traditional mirror and it is not suitable as an interface to access personalized services and to control household Iappliances, which are the two main goals we intend to achieve.

The work in proposes a Magical Mirror as an in.terface to provide basic services and enable control of Ihousehold appliances. The intended services to offer are interactive TV, weather data, news, music, reminders, and searches. Unlike our work, it promotes the use of ontology to personalize the services. However, conceptually, our work has similar objectivity to what the Magical Mirror intends to perform, except that we present a working prototype, whereas some of the functionalities in the Magical Mirror have been presented only by simulation such as the control of appliances. In addition, we use open standards like web services to communicate with the devices and customize various personalized services for the user, which is not present in the design of the Magical Mirror.

An earlier work presents i-mirror that attempts to include information services within the mirror interface as a natural way of providing interactive experiences to people. The mirror uses dedicated optical system including a video camera, magic mirrors, and a video projector to imitate a mirror. Its use of magic mirror to superimpose an image to the mirror is similar to the one in Aware Mirror. Three potential uses of the i-mirror have been explored such as the one with ability to show images in the dark one with the capability of providing younger,older looks; and the one with memory.

In comparison to i-mirror and other works described above, our work is different in that we aim to develop a working system for providing services in the ambient home environment based on open standards and off-the-shelf technology, where the smart mirror is the interface to access/control various data feeds, information services, and appliances in the environment.

PROPOSED SMART MIRRO

A schematic view of the proposed smart mirror. The mirror is eventually a technologically augmented interaction device, which allows facial based authentication. The objective of designing the mirror is to provide a natural interface in the ambient home environment for accessing various information services news feeds, multimedia etc. as well as controlling household smart appliances (light, medicine cabinet etc.) when required.

MODULE-DISCRIPTION

Smart mirrors are a new addition to the smart product family that has been getting a lot of attention in recent years by both commercial manufacturers and hobbyists. This thesis explores enhancing such mirrors with intelligence. The goal is to develop a user recognition system that is able to differentiate between the users of the system by using a camera hidden behind a two-way mirror. The recent resurgence of deep neural networks have pushed the fields of computer vision and face recognition to create powerful neural networks that by far outperforms the methods that was before. The Raspberry Pi will be used as the embedded computational device for the intelligent mirror. The question is if it is able to utilize the power of the new face recognition methods or if it is too slow. This thesis will compare a various of face detection and face recognition methods to explore if it is possible to build a satisfactory user recognition system on the RPI. Therefore I propose two different architectures for the intelligent mirror. Either a local architecture that only uses the RPI, or a remote architecture where the RPI simply forwards the camera stream to a remote device that computes the results. The results obtained makes it clear that a user recognition system employing deep learning is today way too computationally complex for the RPI to be a suitable device. Using older methods resulted in a barely acceptable user recognition system that can be used, but will often predict wrong user. When keeping in mind that user recognition is just the first step in developing the intelligent mirror the conclusion is that the system should either use a remote architecture or look for more powerful embedded devices with hardware capable of feed-forwarding deep neural network.

FUNCTIONAL REVIEW

The proposed mirror is designed to perform several functionalities that can be summarized as follows:

Mimic a natural mirror interface: A touch based flat monitor is used for the mirror display. A web camera is used to provide real-time feeds of what is located in front of the virtual mirror, thereby mimicking the function of a regular mirror. The live feeds are not stored for privacy reasons. Distinction among different individuals: One of the core values of the system is to provide customized services based on user credentials. Recognizing the user is the first step towards providing such services. A face recognition based mechanism is used to identify users and unlock their personalized profiles to provide access to otherwise restricted options, applications, and appliances. If encountered with an unknown user, the mirror will deny access to personalized services and will only provide standard mirror functions. Customized management of profiles: Users can create their own profiles and store them in the system. According to this profile, customized services are provided to the user. Remote control access to appliances: After the appliances such as lights, medicine cabinet etc. have been added to a user's profile, their functions become accessible from any terminal, in this case the mirror. All appliances will have standard features such as on and off, as well as customized ones when applicable, such as dimming the lights in different rooms of the house. Personalized information services: Users will have the ability to tap into various XML-based data such as Real Simple Syndication (RSS) feeds. This will allow them to obtain up-to-the-minute updates and converge on topics of interest, such as public news headlines, weather bulletins, stock reports, consumer news updates on products of interest, etc. " Home surveillance: The system provides access to the live feeds from the home security camera

DESIGN AND ARCHITECTURE

The design of the smart mirror can be seen from two perspectives. One is the mirror interface and the other is its underlying infrastructure based on which services are provided. the high-level view of the mirror's user interface (UI). There are several aspects in this design. First live camera feeds are streamed on a touch-based flat monitor to mimic the functionality of a traditional mirror. This is done whenever anybody stands in front of the mirror irrespective of his/her identity. However, the remaining services are offered only to the authorized user after being authenticated via a facial recognition mechanism. Second, the feeds from the home surveillance. camera are streamed on a corner of the mirror interface to produce a picture-in-picture outlook. Third, the mirror interface is decorated with several widgets. A wide is a simple window frame that contains an embedded browser. Unlike a window, widgets do not overlap no' do they contain complex interface elements. The mirror; interface contains two types of widgets, one that enable remote device control (e.g. light on/off, medicine cabinet open/close etc.), and the other enables access to various information services (e.g. news feeds, weather update.

PROTOTYPE IMPLEMENTATION

The system prototype is implemented using some key enabling technologies. These are the web services, the X 10 device drivers, the flash based widgets, face authentication mechanism and the .net software framework. Besides, the system uses a touch screen flat monitor as the mirror surface and a web camera VC, to capture the live video streams in front of the mirror and another web camera VC for home surveillance purpose.

Using the aforementioned technologies we developed our proposed system., the system component diagram consists of five high-level components. These components are the User Interface, Hardware Abstraction, Communication, Directory Service, and Authentication.

The mirror User Interface is the application that runs on the mirror node, and is what the user comes directly in contact with. It consists of a collection of desktop widgets created in flash that allows for another way of easily and quickly extending the system. Flash widgets can be developed quickly, and are lightweight. They are also based on an easily extendable XMI based description. They are meant to provide the user easy access to all the necessary information at one glance. The responsibility of the User Interface component is to provide a framework engine for the widgets.

The Hardware Abstraction component is responsible for wrapping the various devices with device drivers that can be invoked from within a web service. This is where new devices should be added. Third party devices can be easily recognized and exposed to the message bus during runtime to control them remotely from the client. The remote device control is done through the use of XIO drivers which is a standard used for home automation to control remote devices. In our system this is used wirelessly for control between the client computer and the device that the client is trying to control. Typically the client computer is physically near the devices and uses either a COM port or USB transceiver to send wireless signals to the different devices in the area. Each command is text based and is sent to all the devices that are receiving. These commands contain information for identifying which device to control, and the command to be performed. There is dimming as well as the standard on/off commands for each of the devices. Each receiver is identified by a letter and number, A through P and 1 through 16, giving a potential 256 devices for a given home automation system.

The Communication component is responsible for taking care of messaging between various components. To ensure maximum interoperability, web services are used to facilitate communication in our system, by allowing devices to expose services over the Internet in order to be accessed or called upon by other devices. Consumed by desktop widgets mentioned earlier, web services help separate functionalities from the user interface and provide a flexible way for smart devices to communicate. A single web service is inherently using the Server-Client pattern, but when combining the web services from several devices using TCP multicasting, it forms a Peer-to-Peer mesh. The proxy pattern has been used extensively throughout the system because it is the recommended method to access web services. The Communication component will work on any home network that supports TCP/IP. Overall, the use of web services allows us to create a system, which is based on an open standard. Systems developed with web services for ambient intelligence have been practiced by other researchers .

The Directory Service is a small component that stores the user's information in a database system as a persistent storage. The database maintains all the user profiles and preferences to store and retrieve information.

The Authentication component enables authentication of the person in front of the mirror. The primary authentication is performed through the facial recognition mechanism. However, manual authentication with a user name and password is also provided in case the facial recognition based authentication fails. The information about users is stored into persistent storage, which is accessed through the persistence layer.

PROBLEMS AND ISSUES

A number of problems were encountered during the implementation. One of them was related to XlO devices. Unfortunately, the protocol is not as reliable as expected, and sometimes commands get lost in the transfer, especially if there are multiple commands sent to the same device at the same time. Also, the COM port in the .Net framework (that we used as development platform) can at times become locked by the previous command sender. In order to fix these issues, a delay of one second is created after a command is sent to a device. Once the delay is done, the object through which the COM connection is created, is disposed, so that the COM port will be free.

Another issue with the X1O controllers are that in an environment with lots of interference, like a lab environment, the device controllers have to be kept quite close to the computer that runs the device drivers. This would not be an issue in a normal home. Although we could other home automation infrastructure such as Lon Works and BAC net, we avoided them due to their price and proprietary setup.

TEST CASES

The experiment with the prototype has been performed in a lab setting. We attempted to keep the same lighting conditions in the lab, as it is helpful for the face recognition software component to work reasonably. We provide the experimental results in three steps. First, we evaluate the system functionality against some test cases and report the corresponding system behavior. Second. we summarize the performance evaluation of two basic tasks including face.

CONCLUSION

We have designed a futuristic smart mirror that provides natural interaction between users and the ambient home services. The mirror display is provided by a flat LED display monitor which displays all the necessary information which are useful for the user. The mirror also provides a picture-in-picture sub-display to facilitate the display of services such as maps, videos via YouTube. We have developed a functional prototype to demonstrate our work. Overall, the prototype provides an easily extendable framework that can be utilized to provide even more functionality to the user. In our future work we will investigate how the surrounding context of the user and the environment can be utilized in order to provide optimal service experiences in the home environment.The system can be made much more useful to the users by adding more functionality like integrating light settings, speech processing, etc.

REFRENCES

[1] G. Eason, B. Noble, and I. N. Sneddon, “On certain integrals of Lipschitz-Hankel type involving products of Bessel functions,” Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955. *(references)*

[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[3] I. S. Jacobs and C. P. Bean, “Fine particles, thin films and exchange anisotropy,” in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.

[4] K. Elissa, “Title of paper if known,” unpublished.

[5] R. Nicole, “Title of paper with only first word capitalized,” J. Name Stand. Abbrev., in press.

[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, “Electron spectroscopy studies on magneto-optical media and plastic substrate interface,” IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987