Multi-advantage and security based home automation system

Citation for published version (APA):

DOI:
10.1109/EMS.2010.15

Document status and date:
Published: 01/01/2010

Document Version:
Publisher’s PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:
• A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
• The final author version and the galley proof are versions of the publication after peer review.
• The final published version features the final layout of the paper including the volume, issue and page numbers.

Link to publication

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain.
• You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license above, please follow below link for the End User Agreement:
www.tue.nl/taverne

Take down policy
If you believe that this document breaches copyright please contact us at:
openaccess@tue.nl
providing details and we will investigate your claim.
Multi-advantage and security based Home Automation system

Uzair Saeed, Sana Syed, Sheheryar Zahoor Qazi,
Nida Khan, Aneeba Khan
Electronics Department
NED University of Engineering and Technology
Karachi, Pakistan
uzairsaeed702@hotmail.com sanasyed24@hotmail.com

Abstract— We are living in the era of minute by minute developments and new technologies; the demand of easy way of life is the talk of the day. Engineering industries are focusing on the projects which advance and facilitate their customers with comfortable and secure living. This paper discusses the most advanced idea of Domotics, in which the comprehensive controlling and monitoring of all home appliances are done by simple instant message service. However, one of the most successful applications of image analysis and understanding, face recognition has recently received significant attention especially in the field of security. Moreover, globally available GSM is the cheapest wireless medium for any time communication with your deployed device. Above all, embedded designing on FPGA emerged a new way of technology which allows coupling of multi-dimensional features of system in to a single chip package.

Keywords- Keypad locking, mobile application, FPGA, Controlling devices, Machine Vision, GSM

I. INTRODUCTION

The strong need of user friendly systems that can secure our assets and protect our privacy without losing our identity in a sea of numbers is obvious. On our ASIC design, the device controlling option, 24/7 mobile application and image processing services has taken a tremendous leap in molding the vision of domotics in a brand new way.

The security system is worth mentioning as it provides service the resident to observe the arrival of any person around their abode. This could be achieving through image processing via security cameras. If the captured individual is present in the trusted personal list, system unlocks the gate and allows person come into the house. On Contrary, the doors are fool proof locked and checked thoroughly. Live streaming through security cameras can be viewed as well [1].

If the user is present outside the residential boundaries, the controlling of appliances can be done via instant messaging through mobile phones. This service allows the user to select any appliance present in any room of any floor and change its status via GSM based devices. It proves to be a major advantage to the user to keep a check on the status at its will. The mobile application developed in JAVA ME Platform provides further friendly and more feasible environment of controlling. An individual code is assigned to each home appliance and it is send along with the required instruction(s) to the system through instant messaging via GSM media where it is decoded and sent to FPGA for simulation and more secure add-ons are included.

All the above mentioned services have been implemented on the ASIC design. This ASIC design is well-made that it provides countless features to its user in aspect of security and remote monitoring and controlling. The simulation through FPGA facilitate in creating a multi-advantage domotics system.

The inbuilt keypad locking system enables the user to lock or unlock any door or accessory which has increased the security situation tenfold. By providing necessary and self-selected codes, the residential area can be made secure within a matter of seconds. All data will be enabled after 24 hours to the subscribed user.

Another rather prominent aspect of controlling devices has also been made possible. Controlling devices is done through relay cards which have been installed at various locations in the home. Intensity controlling is done through this mechanism. See (Fig: 1)

II. INTELLIGENT FACIAL RECOGNITION SYSTEM & MONITORING

The purpose is to build an application that will automate our entry on recognizing the face of the personnel entering the home. The rationale behind the idea is to simplify life and allow fool-proof gate-security to our homes and keep us updated on people who arrive at our doorstep when we are out of from our homes and allow them entry if we permit. OpenCV libraries are utilized for image handling and machine learning in real time. The whole task can be separated into two modules:

- Face detecting and extracting from live video.
- Face recognition for opening the entry gateway accordingly.

(Figure: 1) Main Block Diagram of System
For face detection, we have made use of Viola-Jones Haar Classifier [2]. This is a very rapid visual object detection algorithm and is most commonly used nowadays not only for face detection but any object detection and machine learning. See (Fig: 3)

The three principal components of this method are:
1. Integral Image: An integral image here is a sum of pixel above and left to it. For this purpose, haar like wavelets are used, which are determined by subtracting the dark pixel from the light pixel and then comparing it with a threshold. The integral image at point \((x, y)\) in a frame (like in fig 1) contains the sum of the pixels above and to the left of \((x, y)\) inclusive: See (Fig: 2)

\[
I_i(x, y) = \sum_{x' \leq x, y' \leq y} i(x', y')
\]

(Figure: 2) The cascaded classifier of Viola Jones - A chain of single classifiers

2. Ada Machine Boost learning: this learning method combines many weak classifiers to make a strong classifier. The weak classifier alone is next to random guessing but when all the weak classifiers are combined; they boost the result and give accurate detection rate.

3. Cascading the classifiers: Different features classifiers are combined two as to subtract the region of no-interest quickly, leaving just the detecting features for processing. This allows rapid processing and real time detection.

After the face id detected, extracted and properly equalized, face recognition begins. Face recognition is simply matching the frame to the closest face in the database if above a threshold. The Eigen faces method is applied as described by Turk and Pentland [3].

The distance measured by Eigen face is Euclidean distance, which between two points \(a(x_1, y_1)\) and \(b(x_2, y_2)\) is:

\[
\text{Euclidean Dist.} = \sqrt{\Delta x^2 + \Delta y^2} \quad \text{for 2D plot}
\]

But before Eigen face can be applied, dimensionality reduction is required, because there isn’t simply enough time to compute each pixel over the entire image in real time. Many methods are available for dimensionality reduction but we have utilized Principal Component Analysis (PCA), project the Eigen face to the subspace and then assign the value which it finds closest to the sample. PCA gives us Eigen faces which are ghostly, but processed enough to be used for recognition.

(Eigenfaces of samples used for recognition)

The susceptible factors which must be taken under consideration for recognizing from Eigen faces are the intensity and direction of lightening, gaze angle and assurance of frontal faces. Variations in these factors greatly affect the output.

Upon the recognition of the face, instructions back to the hardware via the serial port. The serial port is accessed by using some system application program interface (API) functions through Microsoft Visual Studio.

The following actions are taken:

- Open the gate if the face is recognized.
- Send an SMS to the user for further instructions if it’s a known person.
- Deny entry and keep the door closed if it is an unknown face.

(Figure: 3) Flow Chart of the algorithm Used in Image processing
III. GSM

A. GSM Modem

The Global System for Mobile Communications (GSM) is the most popular standard for mobile phones in the world. Therefore it has been used for the purpose of communication between the user and home. A powerful GSM/GPRS Terminal with compact and self-contained unit can be used for the messages providing automation. The system utilizes the basic features is data transfer i.e. message is sent from mobile phone to the GSM modem. GSM modem uses AT commands for the controlling.

B. AT Commands

The AT command set is the fundamental interface with the GSM modem for configuration and its controlling. An AT command is simply a string of characters preceded by the AT prefix that is sent to the modem. The commands typically instruct the modem to perform some action or set some characteristic within the modem. The modem has two states: command state and on-line state. In command state, the modem will accept and respond to AT commands. In the on-line state, the modem will transmit data, but ignore AT commands. Typically the modem is in the on-line state after dialing. These commands are used for request information about the current configuration or operational status of the mobile phone/modem and test availability and request the range of valid parameters, when applicable, for an AT command.

C. PDU SMS Format

There are two ways of sending and receiving SMS messages: by text mode and by PDU (protocol description unit) mode. If AT+CMGF = 0 then PDU mode is selected and if the mode is 1 then text mode is selected. The text mode is just an encoding of the bit stream represented by the PDU mode. If the message is read on the phone, the phone will choose a proper encoding. An application capable of reading incoming SMS messages can thus use text mode or PDU mode. If text mode is used, the application is bound to the set of preset encoding options. In some cases, that's just not good enough. If PDU mode is used, any encoding can be implemented. The PDU string contains not only the message, but also a lot of meta information about the sender, its SMS service center, the time stamp etc. But as of now for this application the phone number of the caller for authentication, the length of the message and the text message which contains the binary message are required.

The octets of the PDU message contain lots of information. All the octets are hex-decimal 8-bit octets, except the Service center number, the sender number and the timestamp; they are decimal semi-octets. The message part in the end of the PDU string consists of hex-decimal 8-bit octets, but these octets represent 7-bit data. This is helpful when one try to communicate with the PDU mode but if one uses the CMGF command then text mode is activated to get the converted text message. So to get the message in the Text message send the following commands.

- AT+CMGF=1 to activate the text mode
- AT+CMGS=1 to check whether the modem supports the SMS message or not.
- AT+CMGR=XX to read the message at the location XX in the SIM card.

IV. MOBILE (GSM BASED) APPLICATION

In order to create an automated connection through mobiles using SMS and Internet services, a graphical user interface is a necessity. It enables the user to get instant access and control every Home-appliance in a most efficient and effective fashion. It comprises an interface that enables the user to control the ON/OFF mechanism in every room of the house. For this purpose J2ME platform is used for developpment of mobile environment.

A. Format

The most efficient and user friendly way to perform this task is to create a program through JAVA ME (Mobile Environment) using net beans software. Every appliance within the houses e.g. light, fans and bulbs are programmed in such a way that the user is able to turn it on and off at will. In order to achieve that purpose, we have acknowledged every floor, room and appliance with its separate and individual code. The reason for doing that is to differentiate the appliances with the help of names so that when the message is sent, it is easily recognized by its code which appliance is to be turned off or on. The command that selects the on and off operation is with a ‘+’ or ‘-’ sign respectively. In order to turn an appliance OFF, negative sign is written at the end of the message after the appliance’s code and in contrary to turn it ON, a positive sign is written.

The format for writing the message is as below:

1. F1 R1 L1 –
2. F2 R2 L2 +

In Code 1; F1 is floor number 1, R1 is room number 1 and L1 is light number 1 and ‘-‘ shows that the light is to be turned off.

In Code 2; F2 is floor number 2, R2 is room number 2 and L2 is light number 2 and ‘+’ shows that the light is to be turned on.

B. Execution

In Net beans software, a Java enabled device manager is present that selects different templates from mobile phones and displays it e.g. in touch panel of Nokia, Blackberry and Motorola sets. At the execution of the program a software based template is emulated on Net beans to check the proper working of the program through the computer.

The first task was to create a front page which would appear when the program is executed. The next page to appear is that of the login. In this page the users are provided with a username and password in order to keep their accounts secure and private. After entering the correct password another page would appear to state that the code has been accepted. The next screen displays the list of floors.
of the respective house: E.g. First floor, Second floor, Ground floor etc. After selecting the required floor, a list of rooms on the floor appears from which the desired room is selected: e.g. Bedroom, Living Room etc. In a Result, another screen displays nested list of all appliances in the selected room like light, fans, power sockets etc. After choosing the required appliance, an ON/OFF screen appears with the options of ON and OFF. Afterwards the selection of either of the option popup a MESSAGE PAGE. It will consist of the code and the number to which the message is to be sent. At the backend the messaging service is turned on in order to perform the selected task. This option allows user to edit the number as well in the phone number panel. By selecting the SEND button, the message will be sent and the operation will take place.

V. SECURITY: INTELLIGENT KEYPAD LOCKING SYSTEM

An embedded system has been designed to provide security and automation. The controlling of lock is being done by AT-MEGA 162 microcontroller. UPS is connected to provide power supply if main supply fails.

A. Operation
The operation of keypad lock system starts by pressing ‘#’ button on the keypad. Universal codes are entered for the opening of lock example, 123 etc. Different codes can be set for each family member. The keypad lock system will remain open for 2 seconds till code is entered. Once the door is opened, a signal will be received by Lab VIEW in order to maintain the Excel Entry-database file and will email the Entry after 24 hours. In case of power failure system does not fail since it is provided with UPS.

VI. CHIP ARCHITECTURE

Before proceeding to the Chip Architecture, we should have general knowledge of system functionality. All possible Signals from different components like GSM Modem, website database decoding via Lab VIEW signal etc. are converge at FPGA communicates all the devices with all the main modules via UART RS-232 protocol. IC processes the data item so as to perform desire controlling. User will send the SMS either by simple messaging or JAVA ME APPLICATION to operate the devices remotely. The system also provide a specialty of real-time monitoring, that the system will receive signals from sensing devices like fire sensing alarm and mirror

Broken sensor and sends SMS to user’s Mobile Phone.

Designed IC is the central hub of the system. The application specific IC has many modules, the most important of them are:

- UART Transceiver
- Buffers
- Compare And Code Generator
- Central Unit
- Output Monitoring And Controlling Module

A. UART Operation
The UART receives and transmits the data. Here, serial data is converted in to the parallel data. RS-232 protocol is used without flow control having no parity bit, 1 stop bit and 8 bit data.

B. Buffers
Special buffer is implemented which provide data reading from serial buffer. The quality of the buffer is that it can be accessed in both LIFO and FIFO Style. Single pointer/counters are used to perform this function.

C. Comparator and Code Generator
The Comparator Module is most important module of system on chip, which tests the data obtained from GSM Modem. This module reads starting bytes stored in the buffer and analyze it.

If the received data is text massage then module further reads the data otherwise it rejects. At the same time it is also being checked, is the massage sent by the authorized person or not? If it is sent by the authorized person, then directed controlling is executed. Or else the message is neglected.

The authorized person is identified by the Sender Phone Number. Moreover, the module also provide with functionality of changing of sender phone number in EPROM via Special message. A message contains password which is tested by the module and then old number is replaced by new number in EPROM.

Code Generator Module takes input from comparator block which generates respective output code. According to the output codes, the conditions are defined to produce the required output. And hence the desired operation is performed.

D. Central Module
This Module could be known as the brain of system on Chip. The module is controlling the Control signals to and from the modules. Followed is the Finite State Machine (FSM) of the Central Module. See (Fig: 5)
The Module has 10 States along with their input transitions. That is:

- **State 0** RESET
- **State 1** IDLE – controller keeps in this state when there is nothing to operate
- **State 2** CODE COMPARATOR – compares the code received from code comparator module and send controller to the respective state
- **State 3** DELETING – Sets up the deleting block of ROM so as to delete the message from Modem memory
- **State 4** SENDNG SMS – Sets up the block of ROM that is use to send the text.
- **State 5** INITIALIZING MODEM – Sets up the ROM’s Block that is use to send those commands to Modem which initializes it.
- **State 6** OPEN SMS – Sets up the ROM’s Block that sends the command to Modem in order to open the received text.
- **State 7** READ SMS - Hit Code Generator Module so as to read the text from Buffer and generate output accordingly.
- **State 8** WAIT1 - Keep waiting until indication for Writing is received
- **State 9** WAIT2 - Keep waiting until Signal of Processing sets up
- **State 10** WRITING SMS - Sets up the respective block of ROM whose data is to write in MODEM

### E. Output Module

The 12 bits code generated by the code generator is given to the output module. Code generator also gives a bit of on/off which shows that whether the output should be at either high or low. The output from the DE2 board is taken from its expansion header. 72 Cyclone II I/O pins, as well as 8 power and ground lines, are brought out to two 40-pin expansion connectors. These expansion headers connect the hardware with the board.

Field-programmable gate arrays (FPGAs) deliver an order of magnitude higher performance. Another reason is the FPGA’s lower power consumption. The main focus is on ASIC design including FPGA and its controlling.

### VII. RELAY CARDS

Relay Cards are used for automation of lights and fans. Relay card is a hardware interface card which provides indirect-coupling of high power with low power. Each switch board is equipped with a relay card, is composed of **NTE R10-5D10-12 10A 12VDC SPDT Ice Cube relays**.

Voltage protection is provided in the board by free-wheeling diodes. Controlling the inductive currents and voltages of a load when the current through the load is suddenly switched off has been taken care of and free-wheeling diodes are connected for protection from back EMF. A simple NPN transistor is placed in forward biasing at the junction between the load and the electronic relay switch so as to control the 12V relay by very small voltage if 3.3V (high logic from FPGA). Further, fuse is connected for protection of relays and back transistors. Short Circuit protection has also been provided.

### VIII. CONCLUSION AND FUTURE WORK

The complete system offering remote controlling of home automation through mobile and website provides the user an easy and cost effective solution.

Concerning future work, an added advantage of wiricity i.e. wireless technology could be provided with the system that can charge a device without even connecting it to the socket. For example, a cell or a laptop placed on a table could be charged without connecting its plug.

### ACKNOWLEDGMENT

We would like to acknowledge many fruitful and interesting discussions on this topic with several colleagues. Special mention goes to Dr. Shoaib Zaidi, Chairman of Electronics Department, and NEDUET. The research reported in this paper is supported under NED University of Engineering and Technology.

### REFERENCES

