ISSN 2229-5518

Smart Home Security System using Fuzzy Logic

Muhammad Anwaar Saeed, Muhammad Saleem Khan, Khalil Ahmed, Umer Farooq

Abstract—Secure home provide a sense of security to its owner. Home security has two aspects, inside and outside. Inside security covers the concept of securing home from threats like fire etc. whereas, outside security is meant to secure home against any burglar/intruder etc. This work is aimed to provide a solution for home security that takes decision dynamically using the pervasive devices. Also this solution has the feature to intimate security analysis results anywhere in the world using internet.

Index Terms —Home Security, Fuzzy logic, Smart Home, Pervasive devices, Dynamic Decision, Sensors, Threats.

1. INTRODUCTION

IT is supposed that in future people will have an invisible and ubiquitous computing infrastructure to perform different activities both at work and home. Modern home requires easy to use and synergistic devices [1]. Spinellis [1] has proposed the idea of Information Furnace to integrate different available devices in home for different services. Currently, a variety of devices is available in modern home with different access modes and interfaces which results in complexity for end user. The Information Furnace model proposes the synergies among these devices [1].

A smart homecare system using smart phones, wireless sensors, web servers and IP webcams is proposed by Leijdekkers et al [2]. Proposed smart homecare system provides facility to elderly people to check their health and status and provides an easy way to contact to hospital in an emergency [2].

Ghorbel et al [3] have proposed the integration of networking and communication technologies in the smart homes concept dedicated to people with disabilities. Proposed concept is based on the UPnP protocol to discover and control devices indoor and uses wireless technologies to enhance mobility [3].

Popescu et al [4] have proposed a security architecture allowing digital rights management in home networks consisting of consumer electronic devices. In the proposed model, devices are allowed to establish dynamic groups in an environment where legally acquired copyrighted content are seamlessly transmitted between devices. Popescu et al [4] have claimed that connectivity between devices has a minimal reliance on public key cryptographic operations.

Gao et al [5] have suggested the concept of a self-programming thermostat that without any human intervention creates a best possible setback schedule by sensing the possession statistics of a home. The system monitors possession using simple sensors in the home and the user defines the desired balance between energy and comfort using a single knob. It is observed that this approach has an advantage over EnergyStar setback schedule approach by reducing the heating and cooling demand by up to 15% [5].

Use of wireless sensor networks is a low cost, easy way to monitor physical environments. By integrating the context-aware capability of wireless sensor networks into surveillance systems is an attractive trend. Tseng et al [6] have proposed iMouse system, which combines wireless sensor networks, and surveillance technology, to support intelligent mobile surveillance services. Proposed (iMouse) system consists of mostly inexpensive static sensors to monitor environment and few expensive mobile sensors to perform some advanced actions [6].

Kim et al [7] have proposed a Home Security system based on Sensor Network (HSSN) configured by sensor nodes including radio frequency (RF), ultrasonic, temperature, light and sound sensors. Proposed system has the capability to acknowledge security alarm events that are acquired by sensor nodes [7].

Initially fuzzy logic control was introduced to model free control design approach but was criticized due lack of systematic stability analysis and controller design. G. Feng [8] has shown the current improvement in the analysis and design of model based fuzzy control systems.

2. SYSTEM ARCHITECTURE:

From the literature, it is observed that previous home security models have considered some limited security concerns. Therefore one security model may be good in one situation but cannot provide the required results in other situations. To provide optimal home security solution, a new model is proposed. In this proposed model, sensors are used to detect abnormalities within the house or outside the house. There is a dedicated server for the sensors used to collect data inside the house. This server is responsible to collect information transmitted by the sensors and then analyze to detect any abnormality. Similarly, a separate server is used to process the information transmitted by sensors located

- *Muhammad Anwaar Saeed is with Computer Science department as research fellow at NCBA&E Lahore, Pakistan. He is currently working as faculty member in VU, Lahore, Pakistan (e-mail: m_a_saeed@yahoo.com)*
- *M. Saleem Khan is with the Computer Science Department as Director in GC University Lahore, Pakistan (e-mail: mskgcu@yahoo.com).*
- *Khalil Ahmed is with the School of Computer Science at NCBA&E Lahore, Pakistan; He is an expert academician and passionately engaged in research. (E-mail: drk@ncbae.edu.pk).*
- *Umer Farooq is with Computer Science department as a faculty member and a research fellow at NCBA&E Lahore, Pakistan (e-mail: umer@ncbae.edu.pk).*

outside the house. Both these servers are connected to a main server which process the information provided by these servers. Fuzzy logic is used to detect any abnormality. In case a threat is detected then main server report about the threat to concern people using internet besides setting the alarms on. Following is the graphical representation of basic logic of the proposed system:

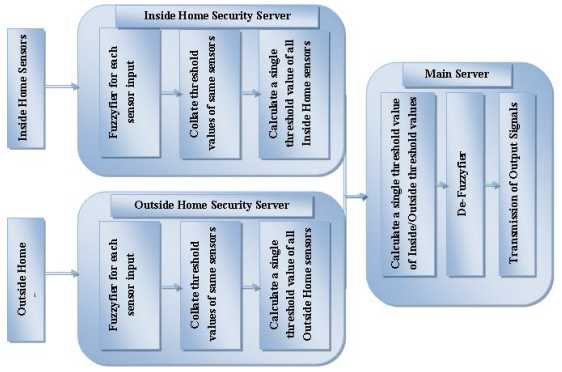

Fig. 1. System Modules

Following diagram depicts the flow of information between different major modules

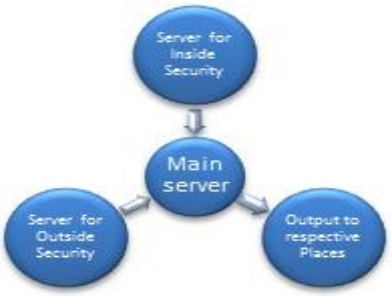

Fig. 2. Information Flow in Proposed System

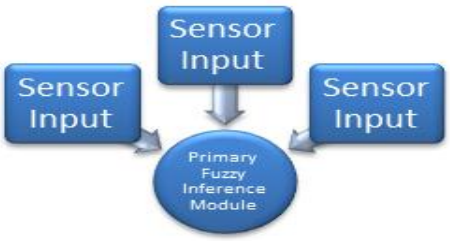

Fig. 3. Calculation of threshold value in Primary Fuzzy Module

Six type of input is provided to the system. Multiple sensors of each type are used to collect data. All inputs of same sensor type are provided to an initial fuzzy inference module, which is responsible to calculate the threshold value. These calculated threshold value of each input type is then provided to respective server responsible for inside or outside security. An overall threshold value of these six initial threshold values is separately calculated using fuzzy logic module on inside/outside security servers respectively. Both inside/outside security threshold values are provide to main server for analysis. Final decision is made based on these values. If any of the value is above the critical value then alarm signal is generated to respective person/department. Using this method, it is possible to generate different output alarms considering the intensity and relevance of threshold value to that specific person/department. Different processes in decision making are described in the following figures. Figure 4 and figure 5 represent the concept of fuzzy inference module at Inside/Outside Home Security Server respectively.

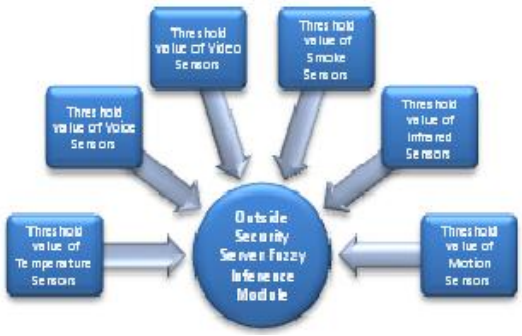

Fig. 5. Calculation of threshold value on Outside Security Server

Threshold values calculated at Inside/Outside Home Security Servers are collated at main server for decision making process. This concept is represented in figure 6. After collation process, threshold value is calculated and alarm signal type for each desired destination is calculated as shown in figure 7.

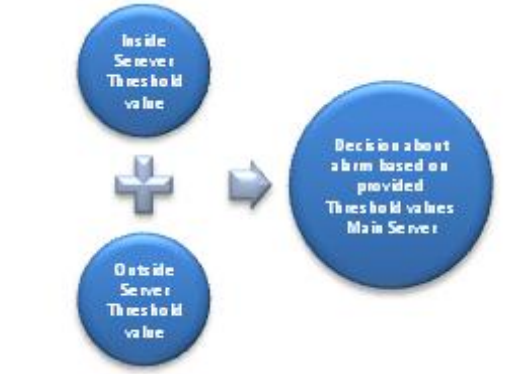

Fig. 6. Process of Decision Making on Main Server

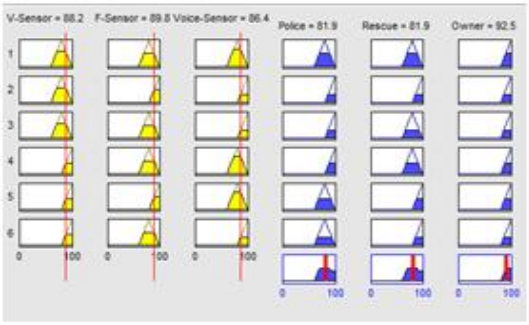

Fig. 10. Input threshold values and respective fuzzy logic based output

Fig. 7. Alarm generating Process

3. FUZZY PARAMETERS FOR DECISION MAKING

Configuration of fuzzy parameters for the proposed system is discussed in this section. Home security system is configured by sensor nodes connected to server. These sensor nodes include radio frequency, ultrasonic, temperature, light, sound and video sensors. Threshold value for each input is above 90% and for a video sensor, used in outside security, distance threshold is taken as 1 feet. If value is increased from any threshold value then alarm is on, and notified to specified location through internet. Inputs to the system and respective outputs from fuzzy inference system are shown in figure 8. Respective member functions are shown in figure 9 for the sample scenario.

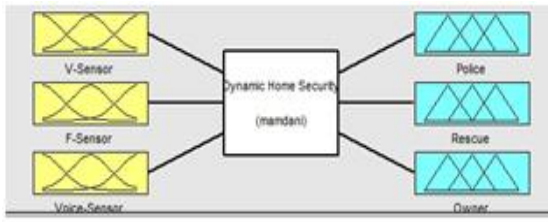

Fig. 8. Fuzzy Inference System for Dynamic Home Security

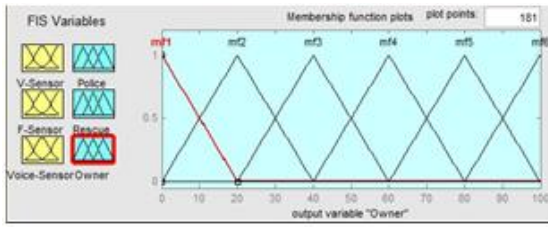

Fig. 9. Member Functions of sample senario

For a sample scenario, where only three types of sensors are used namely video, fire and voice. Effect of threshold values of these sensors and respective fuzzy logic based output using MATLAB is shown in figure 10.

In figure 11, 3D graph show the relationship between voice sensors, fire sensors and output threshold for rescue.

In figure 12, 3D graph show the relationship between voice sensors, fire sensors and output threshold for police.

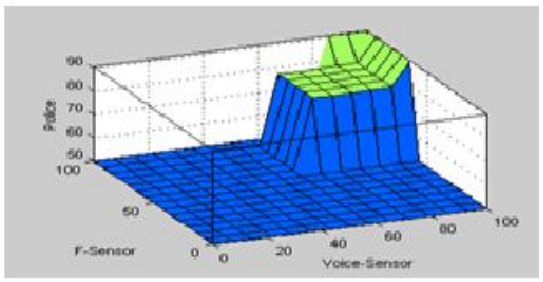

Fig. 12.

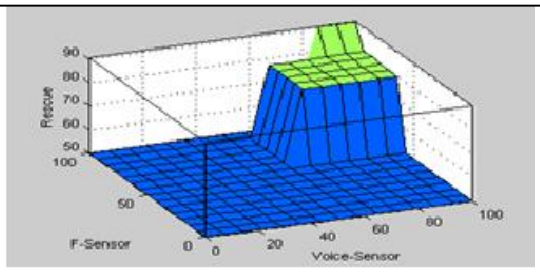

Fig. 11.

In figure 13, 3D graph show the relationship between voice sensors, fire sensors and output threshold for owner.

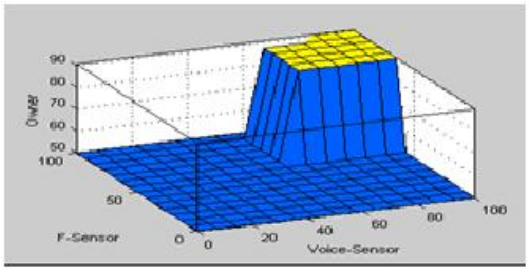

Fig. 13.

In figure 14, 3D graph show the relationship between voice sensors, video sensors and output threshold for police

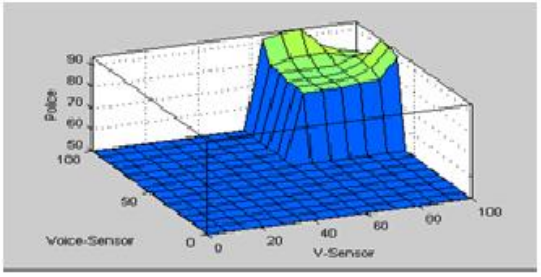

Fig. 14.

In figure 15, 3D graph show the relationship between voice sensors, video sensors and output threshold for Owner.

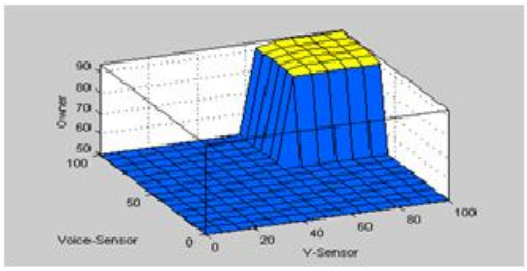

Fig. 15.

In figure 16, 3D graph show the relationship between voice sensors, video sensors and output threshold for Rescue.

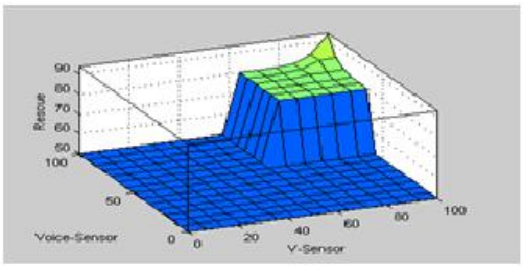

Fig. 16.

From the sample scenario, it is observed that fuzzy logic based home security system provides flexibility to detect different nature of threats and respective outputs. Like in the above scenario, it can be seen that for the same input different output thresholds are provide for owner, police and rescue.

4. CONCLUSION

A fuzzy logic based home security system is proposed. It is observed that using this proposed concept, a better and flexible home security is provided. Proposed system inherits the properties of fuzzy logic and thus provides intermediary values as compare to Boolean logic bi-value outputs.

REFERENCES

[1] D. D. Spinellis, "The information furnace: consolidated home control," PersUbiquitComput, vol. (7), pp. 53–69, 2003.

[2] P. Leijdekkers, V. Gay, and E. Lawrence, "Smart Homecare System for Health Tele-monitoring," Proceedings of the First International Conference on the Digital Society (ICDS'07), IEEE Computer Society 2007.

[3] M. Ghorbel, M. Segarra, J. Kerdreux, R. Keryell, A. Thepaut, and M. Mokhtari, "Networking and Communication in Smart Home for People with Disabilities," Computers Helping People with Special Needs, Springer Berlin / Heidelberg, pp.624, 2004. http://dx.doi.org/10.1007/978-3-540-27817-7_138

[4] B. C. Popescu, B. Crispo, A. S. Tanenbaum, and F. L. A. J. Kamperman, "A DRM Security Architecture for Home Networks," DRM'04, Proceedings of the 4th ACM workshop on Digital rights management, October 25, 2004, Washington, DC, USA.

[5] G. Gao, and K. Whitehouse, "The Self-Programming Thermostat: Optimizing Setback Schedules based on Home Occupancy Patterns," Proceedings of BuildSys'09, November 3, 2009, Berkeley, CA, USA.

[6] Y. Tseng, Y. Wang, and K. Cheng, "An Integrated Mobile Surveillance and Wireless Sensor (iMouse) System and Its Detection Delay Analysis," MSWiM'05, October 10–13, 2005, Montreal, Quebec, Canada.

[7] Y. Kim, H. Kim, S. Lee, and K. Lee, "Ubiquitous Home Security Robot based on Sensor Network," Proceedings of the IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT'06), 2006

[8] G. Feng, "A Survey on Analysis and Design of Model-Based Fuzzy Control Systems," IEEE Transactions on Fuzzy Systems, vol. 14(5), pp. 676-697, October 2006.

Muhammad Anwaar Saeed is a Ph.D. scholar at school of computer science, NCBA&E, Lahore, Pakistan (phone: 092-333-4400473; e-mail: m_a_saeed@ yahoo.com).

M. Saleem Khan is with the GC University Lahore Pakistan, working as Director Department of Computer Science and currently availing a research fellowship at The School of Electronics &Engineering in Edinburgh University UK (e-mail mskgcu@yahoo.com).

Khalil Ahmed is heading the School of Computer Science at NCBA&E, Lahore, Pakistan. He is an expert academician and passionately engaged in research. His area of research is machine consciousness, A.I. and knowledge management. (e-mail drk@ncbae.edu.pk)

UmerFarooq, is M.Phil scholar at School of Computer Science National College of Business administration & Economics(NCBA&E)Lahore, Pakistan and his area of research is Artificial Intelligence, Machine Reflexes and Fuzzy Modeling. (e-mail: umer@ncbae.edu.pk).