

Smart Home Automation for Geriatric using Tactile and Wireless Sensor Networks

Cite as: Patel, H. K., & Sharma, D. (2023). Smart Home Automation for Geriatric using Tactile and Wireless Sensor Networks. International Journal of Microsystems and IoT, 1(5), 326-334. <https://doi.org/10.5281/zenodo.10224708>

Himanshu K. Patel, Dipti Sharma




© 2023 The Author(s). Published by Indian Society for VLSI Education, Ranchi, India



Published online: 23 October 2023.




Submit your article to this journal: 




Article views: 



View related articles: 



View Crossmark data: 

DOI: <https://doi.org/10.5281/zenodo.10224708>

Full Terms & Conditions of access and use can be found at <https://ijmit.org/mission.php>



Smart Home Automation for Geriatric using Tactile and Wireless Sensor Networks

Himanshu K. Patel , Dipti Sharma

Electronics and Instrumentation Engineering Department, Institute of Technology, Nirma University

ABSTRACT

Elderly people who must stay alone in their houses, many a times require some assistance as they might get sick or may forget things which may result into safety and security hazards or even life hazards in some situations. In this paper, a solution is proposed to prevent such life-threatening situations for our loved ones. This paper provides an idea in which one can use Wireless Sensor Network and Global System for Mobile Communication, to automate their house according to elderly comfort and by setting up security monitoring system for the time of emergencies. With the aim of providing our elders a safe and secure living. These smart homes automation based on elderly care, is integrated with many devices that can sense and control parameters to prevent the uncontrollable situations and many a times can even help to save someone's life. In this research paper, devices like temperature sensor, LPG sensor, contact sensor and fall detector sensors are used respectively to detect fire, gas leakage, to automate doors and to set up fall detection system which basically includes gyroscope and tri-axial accelerometer for better data extraction which will help to take preventive actions. For making this project user friendly, LabVIEW is used as graphical user interface (GUI).

KEYWORDS

Smart Home Automation, Wireless Sensor Network, Global System for Mobile Communication, Modem, Tactile sensor.

1. INTRODUCTION

An Intelligent home automation system is incorporated into modern smart homes to provide comfort, convenience, and security to elderly people when they must stay alone. As our loved ones grow elder with the time, many people tend to forget minute things which in turn may result into serious consequences, for example elderly people staying alone, may forget [1][2][3] to switch off gas cylinder which can cause LPG leakage and may lead to hazardous mishappening or may forget to close the doors which in turn can lead to thefts in home and in some cases a serious crime may take place or at any time they may need certain help for any medical reason. Thus, Automation for smart home based on Wireless Sensor Network and GSM is [1][2][3] designed and this can be helpful for elder people to save them from such mishappening and to provide them a safe and secure environment to live in. The field of wireless sensor network has become very attractive for scientific research and technological development. Since it can be easily [1][3] maintained and installed. This wireless sensor network consists of many smaller devices that are equipped with [1][2] various types of sensors along with some processing circuits such as PIC microcontroller and wireless transceivers. Such devices [1][2] are known as sensor nodes. Nodes are placed either inside the

field where we are interested to detect the change or a place very close to that, so that these sensors can sense the necessary change occurring. The [1][2][3] temperature, pressure, chemical activity are some of the crucial parameters which are needed to be detected constantly and the detected information is shared to the controller with the help of these nodes. In the Automation for smart home, such sensors which can detect the change in temperature, fall, LPG leakage and pressure are used. Many devices are integrated together to achieve this for example an inertial unit that basically [1][2][3][4] consists of a tri-axial accelerometer and gyroscope are used as a fall detector. In the development of wireless network technology, we opt for long battery life and simple protocols. Short distance wireless communication technologies include GSM modem, which in any case of emergency will send the information to first responders like nearby hospitals and relatives of concerned. [5][6][7] Among the cellular technologies GSM is preferred for the short communication between home appliances and the first responder of the user, this technology makes the system online almost all the time. GSM also provides high security infrastructure, without even using local network.

In this paper LM35 temperature sensor is used to detect person's body and for detecting the room temperature.

The sensor provides readings in centigrade for the variation in temperature, here LM35 is used in place of thermostat because of the very own reason that its comparatively of lower cost and apt for remote sensing applications. Here for fall detection accelerometers and gyroscopes sensors are used to detect acceleration and rotational motion respectively. The sensors like accelerometer and gyroscope serve their application in autopilot systems in airplanes and unmanned aerial vehicles respectively. Whereas the door and window sensors work on the principle of magnetism. In this when the door or the window is open the magnetic circuit breaks hence the circuit is considered open in this case, whereas [1][2][3] when the door or the window is closed the magnetic circuit is closed hence the circuit will give the not generate any warning.

2. SYSTEM OVERVIEW

2.1 Sensor Connection for Elderly Health Care

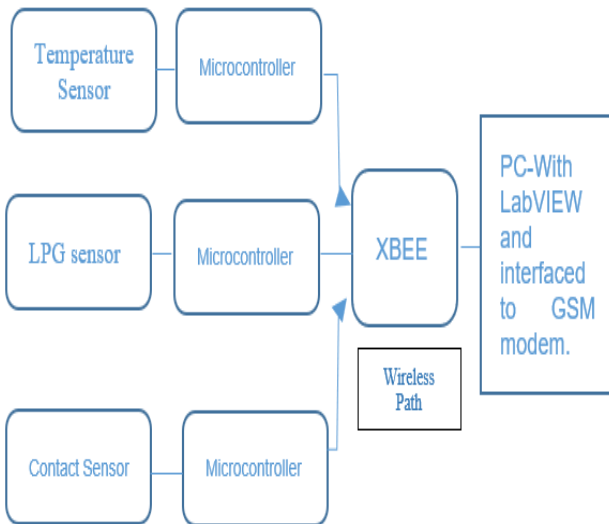


Fig.1. Sensor Connection

The above diagram is the fundamental block diagram of some primary sensors used in providing basic services like health care and security. These sensors, on detecting change, generate voltage which is fed to analog to digital input of PIC Microcontroller [8][9][10]. Then this is again given as input to XBee which is a wireless path. From XBee the data is fed into a computer in which LabVIEW software processes the data. This information gets displayed with LabVIEW and is compared with certain threshold below and above which the program is trained to generate certain warning message, which is transferred using GSM modem.

2.2 PROPOSED MODEL FOR SMART HOME AUTOMATION

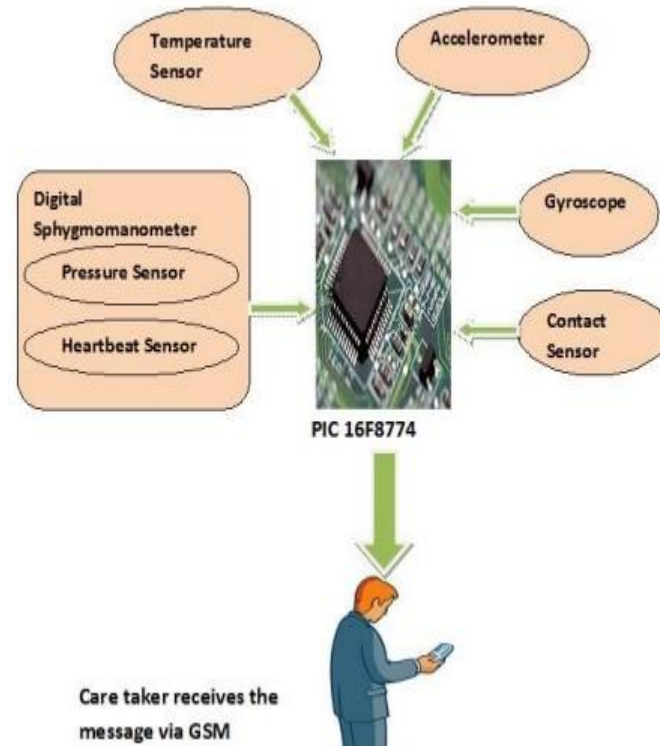


Fig. 2. Existing Model

The hardware for this model includes GSM Modem, LM35 Temperature Sensor, MQ-6 Gas sensor, PIC Microcontroller, contact sensor [Magnetic Contact Switch], Fall detection sensors [Accelerometer and Gyroscope]. This model works into two basic parts, first for personal health care and secondly for security and other comforts through smart home applications. The proposed model's first part consists of temperature sensor which is used to sense body temperature, LM38 pressure sensor which is used to sense the heart rate of person and fall detect sensor which includes an inertial unit which consists of tri-axial accelerometer and gyroscope which detects the accidental fall which may cause injuries. These are integrated into wearable accessories which are equipped with wireless communication technologies to send the important information to the respective caretaker. The second part of this model deals with home automation which includes LM35 temperature sensor it basically is used to sense the environment temperature in the range of -55 to +150 degree centigrade and performs two functions , first maintain the proper temperature check and second detect the chances of fire, [13][14] MQ-26 a Gas sensor which is used to detect LPG Gas leakage as this sensor is highly sensitive to even small concentrations of LPG, iso-butane and propane gases, contact sensor is used to check whether the door or window is open or close with the help of magnetic contact circuit[15]. GSM is modem used send the SMS to care takers. This model

constantly monitors the health condition and other proposed aims [15]. This data from sensor is send to PIC microcontroller to compare with the pre-existing data and this is used to check whether the life-threatening event has

occurred or not and this decision also determines whether to send the message to caretaker or not in those conditions [16].

3. GSM BASED HOME AUTOMATION

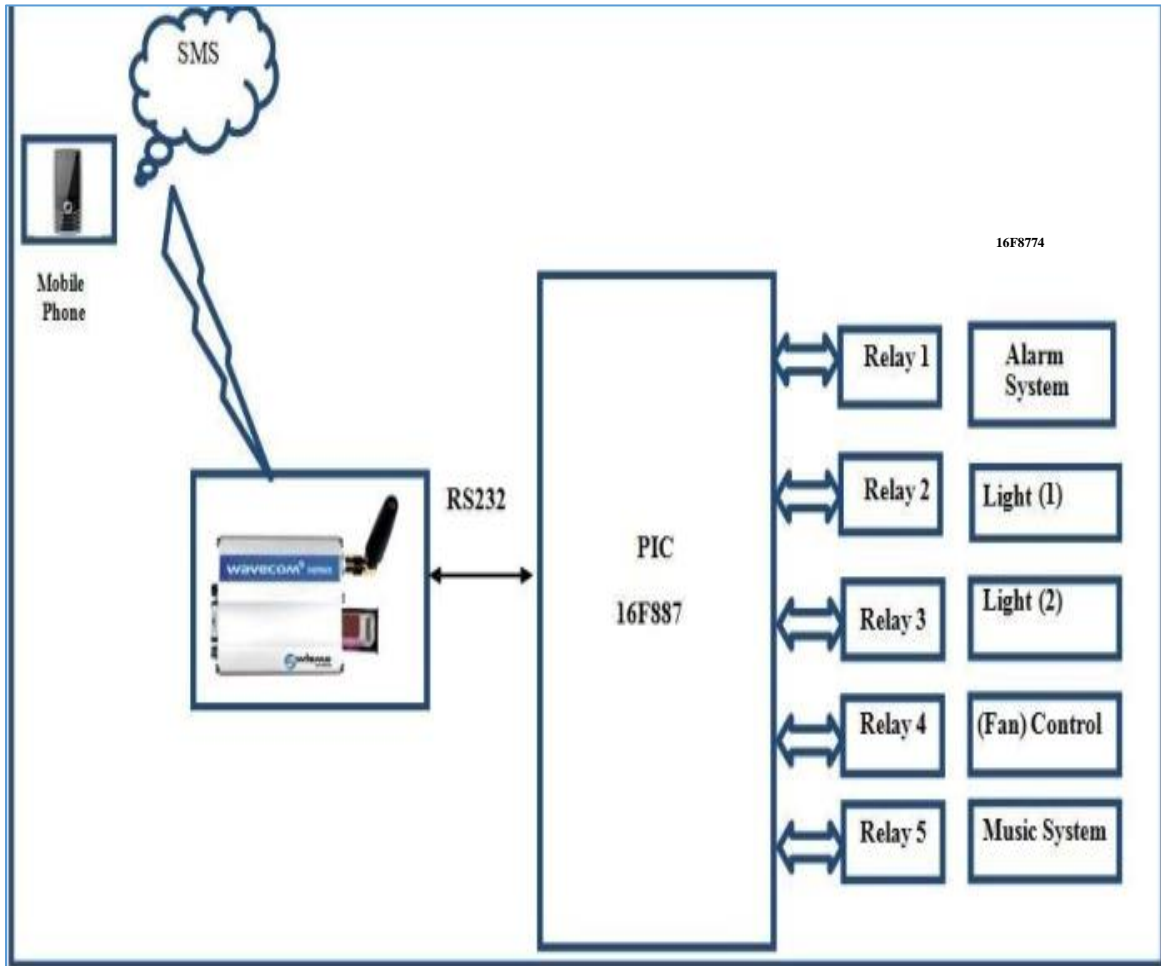


Fig. 3. System

[6] [7] The 8-bit PIC16F8774 microcontroller basically consists of timers, ADCs and USART. In this research paper, the microcontroller decodes the instructions received by it, to give commands to various devices, then it [6][7] sends signals to the driver power circuits to carry out related task. Here it is to be noted that the microcontroller performs dual operation

i.e., to switch on and off the devices. Also, along with the above stated microcontroller also provides feedback to give the status of the device whether it is on or off. Here since the battery isn't provided, we need to supply external power [6][7] which I can drive enough current through the circuit connections. A relay is used in this circuit, to make the output selection easier and compatible, as relay can provide different voltage load.

3.1 GSM SYSTEM SIMULATION

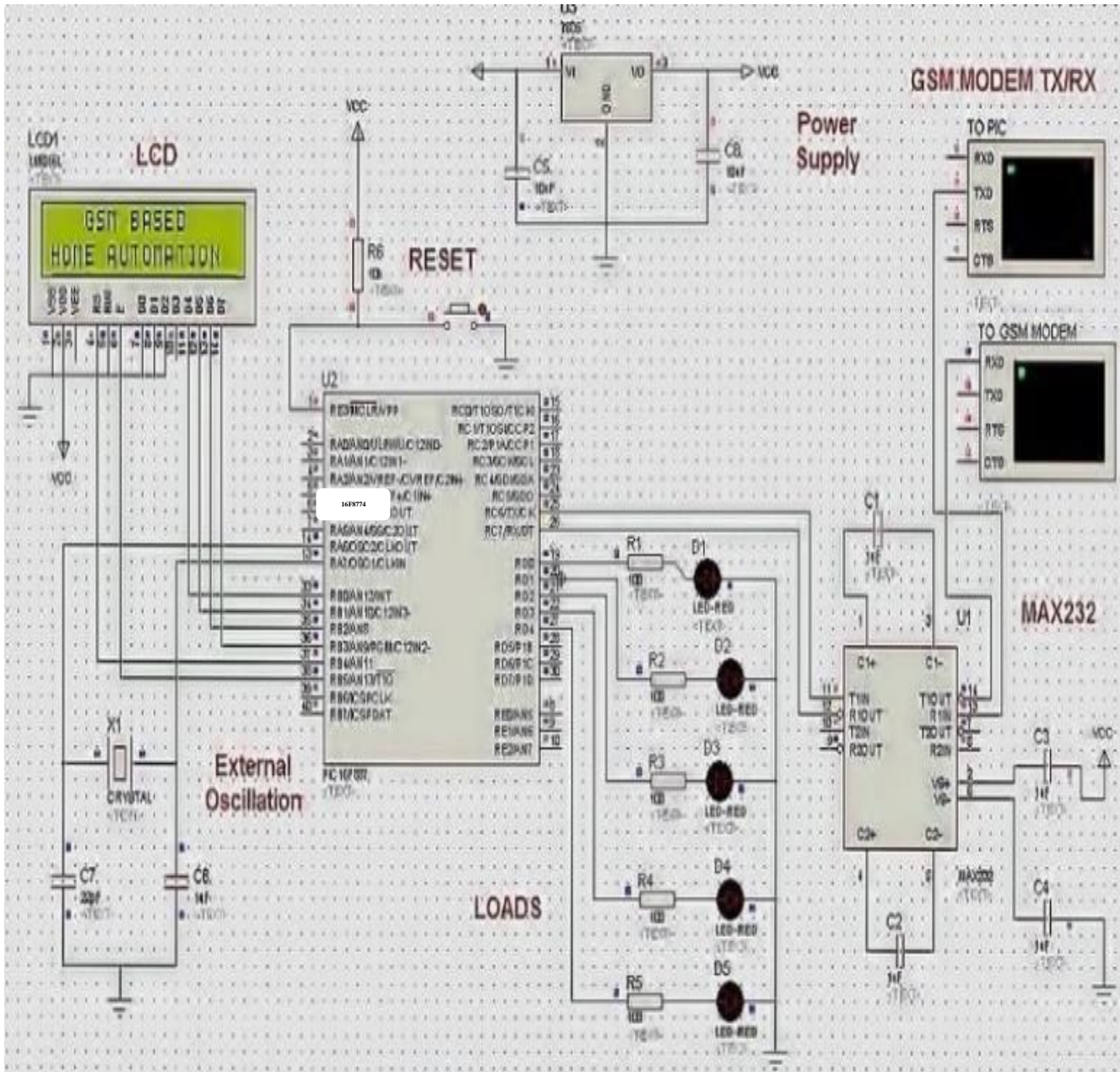


Fig. 4. Software simulation for the smart home automation system

The above figure represents simulation of GSM based automation of smart home system. The PIC16F877A is [4][5][6] integrated with the GSM modem by connecting it with physical ports of PC MAX232, it is placed to ensure proper transmission of data between the two terminals. These virtual terminals are used to monitor the text sent and received to the microcontroller during [4][5][6] transmission process and testing algorithm. Thus, the waveform thus generated during the transmission process is monitored from the oscilloscope [17][18].

3.2 USE OF GSM IN AUTOMATING HOME APPLIANCES

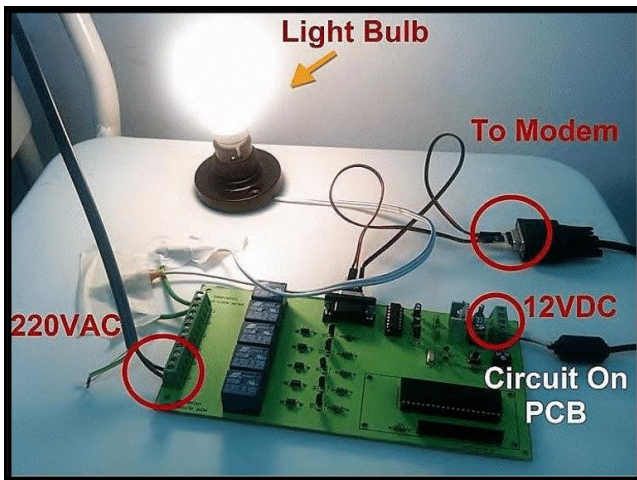


Fig. 5. GSM based Home Automation Model

To accomplish the second aim of this project, GSM technology along with PIC controller is used to operate home

appliances. The program in the microcontroller remains in sleep state while the new SMS reaches. When [6][7] the new text messages reach it compares the text with stored commands and if the received text matches with stored message, then the respective command will get executed, which in turn switches off and on the respective appliance. A Simulation using online tools was performed to test above idea. When the command was sent from the microcontroller to GSM modem as soon as the program initializes, the response is received from GSM and the display showed the desired response to be carried out, when PIC microcontroller was transmitting signals [19][20][21][22].

For example, if the someone wants to switch on the lights, a command can be sent from mobile in form of SMS which will then be detected by the GSM modem and then the relay set will perform the [16] operation to close the circuit, which will allow the current to start flowing in the circuit leading the lights to be switched on.



Fig. 6. Incoming SMS detection from GSM

4. HARDWARE IMPLEMENTATIONS FOR DETECTION USING SENSORS

A lot of tiny sensors are used to accomplish the aim of this project these are described as:

4.1 LM35 Temperature Sensor

LM35 is an accurate temperature sensor with the working range of -55 to +150 degree centigrade. [17][18] The output voltage of LM35 sensor is linearly proportional to temperature. This sensor does not require any specific calibration [amplification and etc] as it produces higher

output voltage. Here this sensor is basically used for two processes. Firstly, to detect the temperature of the person using it and secondly this sensor is used for detecting fire by sensing the environmental temperature.

4.2 Accelerometer

It is used to measure the acceleration in appropriate manner. Proper acceleration and coordinate acceleration are different from each other. The [1][2][3] force exerted due to acceleration is used to predict a person's posture in terms of static and dynamic state. This sensor is also used to measure the angle in which the person's body is tilted by using the gravitational force exerted by the earth on human body. When an object falls its acceleration force changes rapidly and this is sensed by this sensor and the corresponding data in form of alert message is generated and passed on to the caretaker to take necessary action on time.

4.3 Gyroscope

This sensor is used to measure the [1][2][3] rotatory motion of any object and basically measures the angular velocity of any object, in this case object will be the person whose motion is subjected to be detected, this sensor [1][2] basically provides the information about the rotation and position of any moving object. This sensor's parameters are unaffected by the gravitational force and any other electric or magnetic fields present in the environment as compared to the accelerometer which do gets affected with gravitational pull. Therefore, Gyroscope provides more accurate reading than the accelerometer when these are used separately. Although in this research these two sensors are combined to detect the fall and to differentiate fall and sleep, to get appropriate and accurate results.

4.4 LM38 Heartbeat sensor

This sensor is integrated with wearable accessories, to detect the overall wellbeing of the person staying alone, as the heartbeat is the crucial and considered to be most import, so this sensor is used for fulfilling the task of monitoring the heartbeat. LM38 is highly accurate sensor which is based on the principle of photo plethysmography. This sensor can measure the rate of blood flow in human body organ, along with it this sensor is also can be used for pulse measurement [23][24]. The heartbeat of the person is measured and then this data is transferred further to the microcontroller for the carrying out further processing of the information.

4.5 PIC Microcontroller

Programmable Interface Controller commonly termed as PIC [1][2][3] is basically a pre-built circuit that can be easily programmed to control various electrical devices like computers and phones etc. It is relatively cheap and is

available easily and can be easily connected with computers with the help of USB cable or power supply. PIC microcontroller can be programmed using high level language and one of the biggest advantages of using a microcontroller is that it can be reprogrammed easily and even the errors can be easily corrected. There is extensive collection of application where the microcontroller can be used. It also provides functionalities like flash memory capacity and serial programming.

4.6 MQ-6 Gas detecting Sensor

This sensor is used to detect the LPG Leakage as it is [16] highly sensitive to small concentrations of LPG, Isobutane, and propane gases. It is also useful in automating the house for elderly care as, they tend to forget things like switching off gas stove which can be dangerous for them hence this sensor finds an application in this project [25][26][27][28].

4.7 Contact Sensors for door and window

A magnetic contact switch is used for completing this task to provide the necessary security to the smart home. Many a times, old, aged people tend to forget minute things like closing the doors and windows which can lead to theft and even crime in certain cases, so to prevent such situations, this smart home project uses a magnetic contact [29][30] sensor is used to sense whether the door is properly closed or opened. The opening and closing of the circuit can be explained using below circuit diagram in Fig 2.

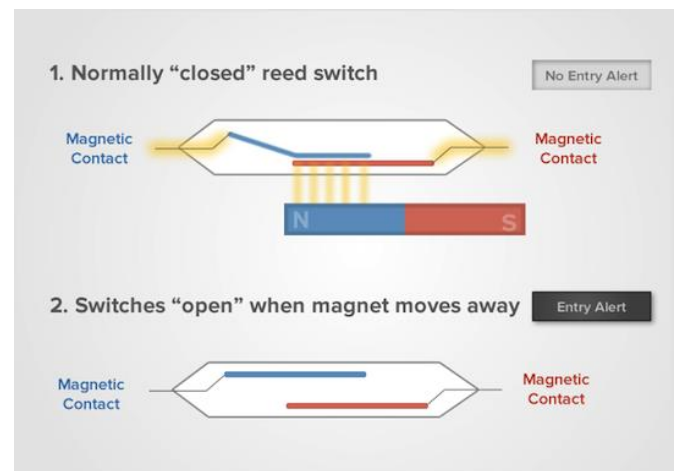


Fig. 7. Magnetic contact sensor circuit

When the magnet is moved away the switch is open therefore the door or the window is opened or not properly closed. Whereas when the magnet come closer the switch is closed and the door is closed properly. This [1][2][3] sensor works on the principle of basic magnetism laws.

5. ADVANTAGES OF THIS MODEL

The biggest benefit of using these technologies is that the overall cost of installing this system is less as compared with other technologies. Also, this sensor network is efficient enough to provide the users with high accuracy and less energy consumption as the components like PIC microcontroller and GSM uses less energy to carry out these tasks. Estimated cost of the system is flexible and can be brought down to around 25 lakhs. Cost of the above system depends mostly on construction of the house.

6. CONCLUSION

The whole idea of building a safe and secure house is being considered in this smart home for elderly care project and this is achieved using simple automation techniques [Wireless sensor network] which has the abilities like comparatively low data rates and power consumptions etc. In this paper an advanced system is designed in such a manner, where a special monitoring system is installed in house which keeps the record of person's health and provides them a safe environment to live in, with the main aim of avoiding all the deadly hazards which can occur in compact area like home. This system, which is developed using above technology is less power consuming as compared with other systems for achieving same purpose, as this project mainly uses sensors which are highly accurate but at the same time cost effective which is indeed its biggest benefit. The sensors provide wide range of usage from magnetic contact sensors which are used for determining the security threats to Gyroscopes and accelerometer which are used as a fall detector. All these elements are integrated such that to create a smart home which will be compatible and secure for all elder population who must stay alone in their house.

REFERENCES

- [1] G. Gu and G. Peng, "The survey of GSM wireless communication system," 2010 International Conference on Computer and Information Application, Tianjin, China, 2010, pp. 121-124, doi: [10.1109/ICCIA.2010.6141552](https://doi.org/10.1109/ICCIA.2010.6141552), <https://doi.org/10.1109/ICCIA.2010.6141552>
- [2] S. Tekinay, E. Chao and R. Richton, "Performance benchmarking for wireless location systems," in IEEE Communications Magazine, vol. 36, no. 4, pp. 72-76, April 1998, doi: [10.1109/35.667416](https://doi.org/10.1109/35.667416), <https://doi.org/10.1109/35.667416>
- [3] C. Drane, M. Macnaughtan and C. Scott, "Positioning GSM telephones," in IEEE Communications Magazine, vol. 36, no. 4, pp. 46-54, April 1998, doi: [10.1109/35.667413](https://doi.org/10.1109/35.667413), <https://ieeexplore.ieee.org/document/667413>
- [4] T. S. Rappaport, J. H. Reed and B. D. Woerner, "Position location using wireless communications on highways of the future," in IEEE Communications Magazine, vol. 34, no. 10, pp. 33-41, Oct. 1996, doi: [10.1109/35.544321](https://doi.org/10.1109/35.544321), <https://ieeexplore.ieee.org/document/544321>
- [5] Wang H, Huang X and Dodda G. Ticket-based mobile commerce system and its implementation. Proceedings of the 2nd ACM international workshop on Quality of service & security for wireless and mobile networks. (119-122). <https://doi.org/10.1145/1163673.1163695>
- [6] Ahmad, Barroon & Yakubu, Friday & Bagiwa, Mustapha & Abdullahi, Isyaku. (2011). Remote Home Management: An alternative for working at home while away. World of Computer Science and Information Technology. https://www.researchgate.net/publication/260434068_Remote_Home_Management_An_alternative_for_working_at_home_while_away
- [7] Haldun, H. & Daldal, Nihat. (2010). A Cellular Phone Based Home / Office Controller & Alarm System. https://www.researchgate.net/publication/251792676_A_Cellular_Phone_Based_Home_Office_Controller_Alarm_System
- [8] T. Begum, M. S. Hossain, M. B. Uddin and M. S. H. Chowdhury, "Design and development of activation and monitoring of home automation system via SMS through microcontroller," 2009 4th International Conference on Computers and Devices for Communication (CODEC), Kolkata, 2009, pp. 1-3. <https://ieeexplore.ieee.org/document/5407093>
- [9] A. Z. Alkar and U. Buhur, "An Internet based wireless home automation system for multifunctional devices," in IEEE Transactions on Consumer Electronics, vol. 51, no. 4, pp. 1169-1174, Nov. 2005, doi: [10.1109/TCE.2005.1561840](https://doi.org/10.1109/TCE.2005.1561840), <https://ieeexplore.ieee.org/document/1561840/reference#references>
- [10] Neng-Shiang Liang, L. -C. Fu and Chao-Lin Wu, "An integrated, flexible, and Internet-based control architecture for home automation system in the Internet era," Proceedings 2002 IEEE International Conference on Robotics and Automation (Cat. No.02CH37292), Washington, DC, USA, 2002, pp. 1101-1106 vol.2, doi: [10.1109/ROBOT.2002.1014690](https://doi.org/10.1109/ROBOT.2002.1014690), <https://ieeexplore.ieee.org/document/1014690>
- [11] R. J. C. Nunes and J. C. M. Delgado, "An Internet application for home automation," 2000 10th Mediterranean Electrotechnical Conference. Information Technology and Electrotechnology for the Mediterranean Countries. Proceedings. MeleCon 2000 (Cat. No.00CH37099), Lemesos, Cyprus, 2000, pp. 298-301 vol.1, doi: [10.1109/MELCON.2000.880425](https://doi.org/10.1109/MELCON.2000.880425), <https://ieeexplore.ieee.org/document/880425>
- [12] Kok Kiong Tan, Tong Heng Lee and Chai Yee Soh, "Internet-based monitoring of distributed control systems-An undergraduate experiment," in IEEE Transactions on Education, vol. 45, no. 2, pp. 128-134, May 2002, doi: [10.1109/TE.2002.1013876](https://doi.org/10.1109/TE.2002.1013876), <https://ieeexplore.ieee.org/document/1013876>
- [13] L. Wei, Y. Min, C. LiangLiang, and C. Ping, 'The Design of Intelligent Household Control System Based on Internet and GSM,' in Proc. 2011 Second International Conference on Networking and Distributed Computing (ICNDC), Beijing, pp.254-256.

- https://www.researchgate.net/publication/254034187_Design_of_intelligent_home_appliance_control_system_based_on_ARM_and_ZigBee
- [14] Hanwei Sensors, "MQ-6 Gas Sensor", MQ-6 datasheet.
- [15] Y. Zhai and X. Cheng, "Design of smart home remote monitoring system based on embedded system," 2011 IEEE 2nd International Conference on Computing, Control and Industrial Engineering, Wuhan, China, 2011, pp. 41-44, doi: 10.1109/CCIENG.2011.6008062. <https://ieeexplore.ieee.org/document/6008062>
- [16] Malhi, Karandeep & Mukhopadhyay, S.C. & Schnepfer, Julia & Haefke, Mathias & Ewald, Hartmut. (2012). A Zigbee-Based Wearable Physiological Parameters Monitoring System. Sensors Journal, IEEE. 12. 423 - 430. 10.1109/JSEN.2010.2091719. https://www.researchgate.net/publication/224193460_A_Zigbee-Based_Wearable_Physiological_Parameters_Monitoring_System
- [17] Perumal, Thinagaran & Sulaiman, md nasir & Sharif, Khaironi & Ramli, Abd Rahman & Leong, Chui. (2013). Development of an Embedded Smart Home Management Scheme. International Journal of Smart Home. https://www.researchgate.net/publication/236596917_Development_of_an_Embedded_Smart_Home_Management_Scheme
- [18] Texas Instruments, "LM35 Precision Centigrade Temperature Sensors", LM35 datasheet, Aug. 1999 [Revised Oct. 2013].
- [19] Positron Technologies, "GSM SIM 300 Module", SIM 300 datasheet, Dec. 2005. https://jiritcc.org/download/conferences/ICRTEST_2017/ICRTEST_2017_Track/1485156159_23-01-2017.pdf
- [20] A., Anbarasi & Ishwarya, M.. (2013). Design and implementation of smart home using sensor network. 2013 International Conference on Optical Imaging Sensor and Security, ICOSS 2013. 1-6. 10.1109/ICOISS.2013.6678399. https://www.researchgate.net/publication/269326899_Design_and_implementation_of_smart_home_using_sensor_network
- [21] Agarkhed, Jayashree & Ankalgi, Raviraj. (2016). Energy efficient smart home monitoring system in wireless sensor network. 1-7. 10.1109/ICCPCT.2016.7530369. https://www.researchgate.net/publication/305907195_Energy_efficient_smart_home_monitoring_system_in_wireless_sensor_network
- [22] Chan, Marie & Esteve, Daniel & Escriba, Christophe & Campo, Eric. (2008). A review of smart homes—Present state and future challenges. Computer methods and programs in biomedicine. 91. 55-81. 10.1016/j.cmpb.2008.02.001.
- https://www.researchgate.net/publication/5485733_A_review_of_smart_homes-Present_state_and_future_challenges
- [23] Hussain, Sajid & Schaffner, Scott & Moseychuck, Dyllon. (2009). Applications of Wireless Sensor Networks and RFID in a Smart Home Environment. Proceedings of the 7th Annual Communication Networks and Services Research Conference, CNSR 2009. 153-157. 10.1109/CNSR.2009.32. https://www.researchgate.net/publication/221365536_Applications_of_Wireless_Sensor_Networks_and_RFID_in_a_Smart_Home_Environment
- [24] Yamazaki, Tatsuya. (2007). The Ubiquitous Home. International Journal of Smart Home. 1. https://www.researchgate.net/publication/228771570_The_Ubiquitous_Home
- [25] R. S. Ransing and M. Rajput, "Smart home for elderly care, based on Wireless Sensor Network," 2015 International Conference on Nascent Technologies in the Engineering Field (ICNTE), Navi Mumbai, India, 2015, pp. 1-5, doi: 10.1109/ICNTE.2015.7029932. <https://ieeexplore.ieee.org/document/7029932>
- [26] K. Malhi, S. C. Mukhopadhyay, J. Schnepfer, M. Haefke and H. Ewald, "A Zigbee-Based Wearable Physiological Parameters Monitoring System," in IEEE Sensors Journal, vol. 12, no. 3, pp. 423-430, March 2012, doi: 10.1109/JSEN.2010.2091719. <https://ieeexplore.ieee.org/document/5629425>
- [27] V. Ricquebourg, D. Menga, D. Durand, B. Marhic, L. Delahoche and C. Loge, "The Smart Home Concept : our immediate future," 2006 1ST IEEE International Conference on E-Learning in Industrial Electronics, Hammamet, Tunisia, 2006, pp. 23-28, doi: 10.1109/ICELIE.2006.347206. <https://ieeexplore.ieee.org/document/4152762>
- [28] F. Rahman, A. Kumar, G. Nagendra and G. S. Gupta, "Network approach for physiological parameters measurement," in IEEE Transactions on Instrumentation and Measurement, vol. 54, no. 1, pp. 337-346, Feb. 2005, doi: 10.1109/TIM.2004.834595. <https://ieeexplore.ieee.org/document/1381836>
- [29] H. Zhu, G. F. Harris, J. J. Wertsch, W. J. Tompkins and J. G. Webster, "A microprocessor-based data-acquisition system for measuring plantar pressures from ambulatory subjects," in IEEE Transactions on Biomedical Engineering, vol. 38, no. 7, pp. 710-714, July 1991, doi: 10.1109/10.83573. <https://ieeexplore.ieee.org/document/83573/references#references>
- [30] Magnetic Door switch datasheet. https://en.wikipedia.org/wiki/Magnetic_switch

AUTHORS



Himanshu K Patel received the BE degree in Instrumentation and Control engineering from the Gujarat University India, in 1993, and the master's degree in electrical engineering from Nirma University in 2005, and the PhD degree in Instrumentation and Control engineering from the KSV University in 2012. He is currently

the Head of the Department and Associate Professor of Department of Electronics and Instrumentation Engineering, Nirma University, where he is also the Chief Coordinator of the Alumni forum. He has authored 05 books – all with international publishers, including Springer. He is also the recipient of three international awards and many recognitions. His current research interests include biomedical instrumentation, sensors, measurement

techniques and automation systems, power electronics and industrial drives efficiency.

Email: hkpatel@nirmauni.ac.in



Dipti Sharma is currently pursuing a BTech degree in Instrumentation and Control Engineering from Nirma University. She has designed a lot of real-life projects based on automation using python language and Machine learning.

Along with the projects she also possesses the interest in research in the field of Machine learning and Home Automation techniques.

Email: 19bci014@nirmauni.ac.in