

Automatic Door Lock System by Face Recognition

Alankar Rajendra Chaudhari¹, Charmi Jignesh Shah², Ainab Mushtaque Shivani³, Mihir Naresh Sheth⁴, Ram Kumar Solanki⁵, Dr. Anand Singh Rajawat⁶

^{1,2,3,4}B.Tech (Scholar), School of Computer Science & Engineering , Sandip University , Nashik , India

⁵Assistant Professor , School of Computer Science & Engineering , Sandip University , Nashik , India

⁶ Associate Professor , School of Computer Science & Engineering , Sandip University , Nashik , India

Email: ¹alankarc01@gmail.com, ²charmish783@gmail.com, ³shivanzainab@gmail.com, ⁴mihirsheth162000@gmail.com, ⁵ramkumar.solanki@sandipuniversity.edu.in, ⁶anandsingh.rajawat@sandipuniversity.edu.in

Abstract: *Today we deal with safety and safety problems in every element. So, we have to deal with these problems by utilizing upgraded innovation. In this job, we utilize the Deal with acknowledgment component to catch human pictures and suit with kept data source pictures. If it suits the licensed individual after that the system will open the door by an electromagnetic secure. They require a quick and precise face acknowledgment system that constantly enhances, which can spot intruders and limits all unapproved individuals from extremely protected locations, and helps reduce human mistakes.*

Deal with acknowledgment is one of the primary Protected Systems compared to the biometric pattern acknowledgment method which is utilized in a big range of applications. The moment and precision element are considered regarding the primary issue which defines the efficiency of automated dealing with acknowledgment in real-time atmospheres. Different services have been suggested utilizing multicore systems.

By thinking about today's difficulty, this offers the total building development and suggests an evaluation for a real-time deal with an acknowledgment system with the Ficherface formula. This formula transforms the picture from shade to greyscale picture and splits it into pixels and it'll be assigned throughout a matrix development and people pictures will be kept in the data source.

If a photo is spotted after the microcontroller will send out power to the electric motor chauffeur system after that the electromagnetic secure will open the door and it'll secure once again when there's no power provided to that system. Lastly, this paper wraps up the progressed applications accomplished by incorporating installed system designs versus the convention.

We have proposed a face recognition door lock system using Breadboard for security purposes. Implementation of the system is for monitoring whether any unknown person is entering the door. We have established communication with electronic devices through

face detection with the help of the Pi camera Breadboard platform. For software coding Python and Open CV libraries are used.

We have proposed the Haar classifier method for face detection to get an accurate and clear picture of an intruder. As soon as the person enters near the door, the pi camera captures the image, and the face detection process is done then if it matches with database images then the door is unlocked otherwise a message with the picture of a person will be sent to the registered mobile through GSM and LAN network.

Keywords: *Biometric Pattern, Electro-Magnetic, Microcontroller, ESP32-CAM, Voltage Regulator, Smart Home, Object Tracking.*

1. INTRODUCTION

In this new era of technology where people always try something new to make our life easier and for that we invest a lot of our capital and to protect all this we require a strong security management system that should not require continuous monitoring from humans and should be self-surveillance. Security is our right which no one can deny and justify, which requires lots of work and research. where security is much more important than anything and locks or other traditional ways of locks are not that successful at present date as digital locks provide a sense of information and allow us to increase the security to the next level security helps us to improve our standard of living.

Face recognition and detection is like an ocean of research and innovation, at present with the applications of image analysis and algorithm-based understanding. Face Recognition based door lock system we have proposed system. Facial recognition involves the detection and identification of the image. It uses an image-capturing technique in the system using the Fisher face algorithm. The Breadboard camera catches the live facial picture and compares it with the images which are stored in the database and provides a quick response time, it is just as polishing or brushing up the security of an organization to another level. The proposed work "Face Recognition-based Door Lock" will work as a technique that will be integrated into the door, of the room in which we want to be secured.

The objective of facial recognition is finding a series of data of similar faces in a set of training images in the database from the input image, If the image captured will match any of the images stored in the database, then the door will be unlocked else it will remain locked.

Nowadays, as technology is increasing, facilities for human beings are increasing. In day-to-day activities, the life of people has become very easier with the incorporation of many technologies. On the other hand, it also creates security issues [1]. Traditional door locks have a problem that almost anyone can break into your house. Hence it is a great challenge to overcome these problems. In general, to secure a home, people make use of CCTV. Images will store in the database so that action can be taken when any suspicious incident happens. This type of approach is passive [2]. But there is a need for an active approach. This type of approach is nothing but where actions can be taken immediately as soon as a security threat occurs [1]. Hence a smart IOT-based face recognition system is an idea developed, which recognizes the face of the person near the door and compares it with

the uploaded faces stored in the database [3].

If a person is detected then the door would open and welcomes them. If an unknown person enters, the owner would be alerted by message and mail with an intruder image. To develop this system, we have used Raspberry Pi, a Pi camera that will be installed near the door for recognition of the face of an intruder, a DC motor to open the door through a relay, LEDs to indicate whether the door is opened or not, GSM module is used to send messages to the registered mobile number.

2. Literature survey

Face recognition systems are used for Once many decades. it's gained popularity thanks to its applications. Designed deal with acknowledgment system utilizing Eigenfaces method that was initially designed by **Sirovich** and **Kirby**. This was an advancement for the Deal with Acknowledgment system and because of this, the base of Deal with Acknowledgment Formula was developed. They designed a close to actual time determining system that will spot and track a topic's head and likewise fete the individual by contrasting particular of deal with to people who are understood. Likewise suggested a deal with acknowledgment formula sustained Independent Element Evaluation. The PCA formula is relaxed on the real truth that essential info of the picture is included in support of smart connection in between pixels whereas ICA is relaxed on the real truth that some essential info might likewise be included within the high-purchase stats. Have suggested dealing with an acknowledgment system utilizing customized ICA for much far better delicacy. Suggested a deal with acknowledgment system utilizing PCA to evaluate back Dimensionality and utilized neural network for a brace. The neural network-based deal with acknowledgment systems are naturally influenced and birth like neurons of a population which brings indicates from one location to a various. a little bit like a neuron a perceptron determines the weighted amount of numerical inputs and identifies if an existing is honored or otherwise and the neural network needs a great deal of computational work. Thus from literary works inspection, it is removed that a great deal of formulas is suggested for dealing with acknowledgment systems. Therefore this paper suggests Dealing with the Acknowledgment System by incorporating 2 shown formulas for dealing with acknowledgment system PCA and LDA. Both these formulas birth computation of Eigen Worths and Eigen Vectors. Jacobi system is utilized to determine the Eigen Worths and Eigen Vectors. The uniqueness of this method is to prolong acknowledgment price and decreases acknowledgment time. Any type of actual time procedure that requires dealing with an acknowledgment system can utilize this method to create a Deal with Acknowledgment System utilizing any type of bedded system.

For decades, for science society using smart home is not a new term. As there is an advance in technology there is a fast increase in the field of home security automation. The control of smart systems for automatic door lock systems is done through Bluetooth, the Internet, etc. Most of the laptops, tablets, and mobiles have built-in adapters which in turn reduce the cost of the system, but it controls within the Bluetooth range. The system which is based on SMS technology has only two components i.e. GSM and microcontroller. Here microcontroller is acting like a bridge between the user, sensors, and actuators. The author **D Aishwarya** et al proposed a method for face detection by using an algorithm known as viola-jones and recognition of the face is done by the revised Gabor filter and multi-key point. Using Neural Networks, Nandini M et al proposed a facial recognition system. For training and to extract the local features like nose, eyes, shoulder, and mouth

they have used a backpropagation algorithm. Using MATLAB PCA (Principal component analysis). By using PCA, Eigenfaces are generated by changing the faces in the dataset. The distance of the person is calculated by the Euclidean distance method. If the distance is less, then it is a recognized face. After that, by using the GSM module the system generates an alert message to the owner.

3. Proposed system architecture

The main aim of the proposed system is to design cost-effective, great flexibility by connecting all modules to a system database and open-source home automation system using Python for various home and outdoor environments

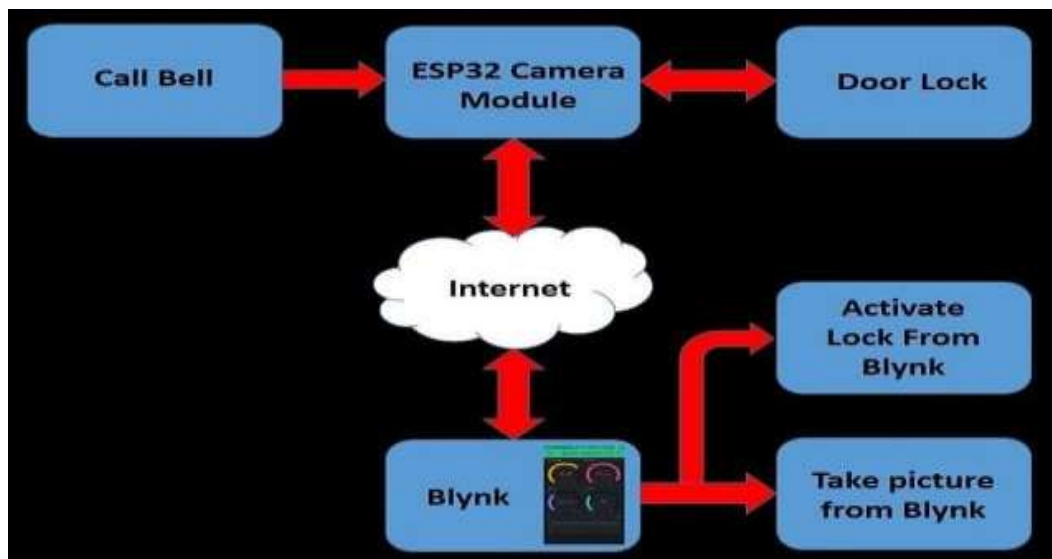


Figure No.1

Shown in the above Figure No.1, which contains Breadboard, ESP32-CAM, Electronic door lock 12V, 7805 voltage Regulator (5V), 10k Resistors (2no.), Capacitor 220Uf, Push-button, 12V DC adaptor.

The proposed system consists of the following main components: the ESP32-CAM module, a breadboard, Voltage Regulators, Capacitors, Power adaptors, Electronic door (Solenoid Lock). The ESP32-CAM module captures real-time video footage and processes it using computer vision algorithms to detect and recognize faces. The microcontroller controls the locking mechanism based on the results of the face recognition algorithm. The backend server manages user profiles, stores facial features, and communicates with the ESP32-CAM module for authentication purposes.

The main blocks of the proposed system are:

i. Breadboard

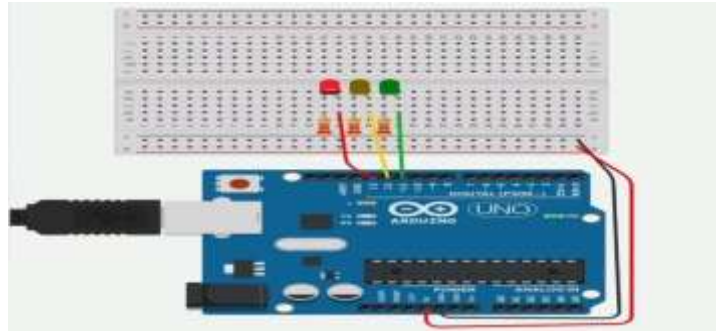


Figure No.2

Common use in the system on a chip (SoC) era is to obtain a microcontroller (MCU) on a pre-assembled printed circuit board (PCB) which exposes an array of input/output (IO) pins in a header suitable to plug into a breadboard, and then to prototype a circuit which exploits one or more of the MCU's peripherals, such as general-purpose input/output (GPIO), UART/USART serial transceivers, analog-to-digital converter (ADC), digital-to-analog converter (DAC), pulse-width modulation (PWM; used in motor control), Serial Peripheral Interface (SPI), or I²C.

ii. ESP-32 CAM



Figure No.3

The ESP32-CAM is a very small camera module with the ESP32-S chip that costs approximately \$10. Besides the OV2640 camera, and several GPIOs to connect peripherals, it also features a microSD card slot that can be useful to store images taken with the camera or to store files to serve to clients. The ESP32-CAM doesn't come with a USB connector, so you need an FTDI programmer to upload code through the U0R and U0T pins (serial pins).

iii. Electronic door lock 12V



Figure No.4

This 12V Cabinet Door Electromagnetic Solenoid Lock can be used for locking a sell-machine, storage shelf, file cabinet, etc. It is steady, durable, and energy-saving and had a long lifespan. In the anti-theft and shockproof design, the lock is better than other kinds of locks. After connecting the wires and when the current is available, the electric lock can control the door's opening and closing. The hidden way of unlocking can be used for an emergency. The lock works as the circuit disconnects, and it will unlock as the instant power- on.

iv. 7805 voltage Regulator (5V)



Figure No.5

Voltage regulators are very common in electronic circuits. They provide a constant output voltage for a varied input voltage. In our case, the 7805 IC is an iconic regulator IC that finds its application in most projects. The name 7805 signifies two meanings, "78" means that it is a positive voltage regulator, and "05" means that it provides 5V as output. So our 7805 will provide a +5V output voltage. The output current of this IC can go up to 1.5A. But, the IC suffers from heavy heat loss hence a Heat sink is recommended for projects that consume more current. For example, if the input voltage is 12V and you are consuming 1A, then $(12-5) * 1 = 7W$. This 7 Watts will be dissipated as heat.

v. 10k Resistors



Figure No. 6

10K Resistor 5% 10K Carbon Film Resistor 10K Resistor 1/4W Resistance 0.25 Watt Resistor 10K Ohm 5% Tolerance Fixed Resistors 2 Pin Leads. This is a 10K ohms carbon film resistor with a power rating of 0.25 Watts and a tolerance of 5%. Feature color code 4 bands, Axial Leads, With wire leads for through hole mounting; Stable performance, extensive resistance, small size, high operating temperature, Through Hole Mounting.

vi. Capacitor 220uF

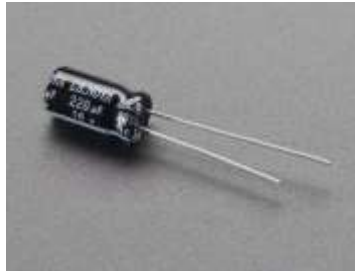


Figure No. 7

A capacitor is a passive element that can store a charge when a voltage is applied across it. The charge-storing capacity can be determined by the product of the capacitance of the capacitor and the voltage applied across it. The value of the voltage and capacitance are mentioned on the label of the capacitor. The electrolytic capacitor has polarity, polarity means it has designated positive and negative legs. The leg which is longer is positive pin and the shorter leg is negative. The negative pin has a negative symbol marked on it. They are the most widely used capacitor type out there and can be used in a wide range of applications like filter circuits, ripple smoothing, Resonant circuits, Isolation, and noise removal circuits. Care should be taken as swapping the legs or applying more voltage across its legs might result in overheating and even bursting of the capacitor.

vii. Push-Button



Figure No. 8

A push-button (also spelled pushbutton) or simply button is a simple switch mechanism to control some aspect of a machine or a process. Buttons are typically made out of hard material, usually plastic or metal.^[1] The surface is usually flat or shaped to accommodate the human finger or hand, to be easily depressed or pushed. Buttons are most often biased switches, although many unbiased buttons (due to their physical nature) still require a spring to return to their un-pushed state.

viii. 12V DC Adaptor



Figure No. 9

The power Adapter is a source of input supply to the project. It is an essential thing in any project. If we provide you with all your project requirements how can miss the power adapter? Here in this category, we stock power Adapter/ DC power supply with differential power output ratings ranging from 5V to 12V dc @ 1A to 5A. You can also find the replacement cable for your charger or Adapter.

4. Proposed Method For Face Detection

After preprocessing like resizing and cropping images, the Haar cascade classifier is used to detect whether there is a single face detected or not. Figure 3 demonstrates the flow chart for the proposed system. Edge, line, and center-surround are the features of Haar which are acting as inputs. By these cascade features the test of the image is done. The features of Haar are divided into various stages [9]. Stage by stage the window will be tested. Usually, the initial stages will have fewer Haar-like features. If the first stage window fails, then it is to be discarded and the next stages will not be tested. If all the stages successfully pass then it is considered to face is detected and checked with the images already stored in the database of Broadboard [9, 12, 13, and 14]. The advantage of Haar cascade classifiers is the fast detection speed compared to other classifiers.

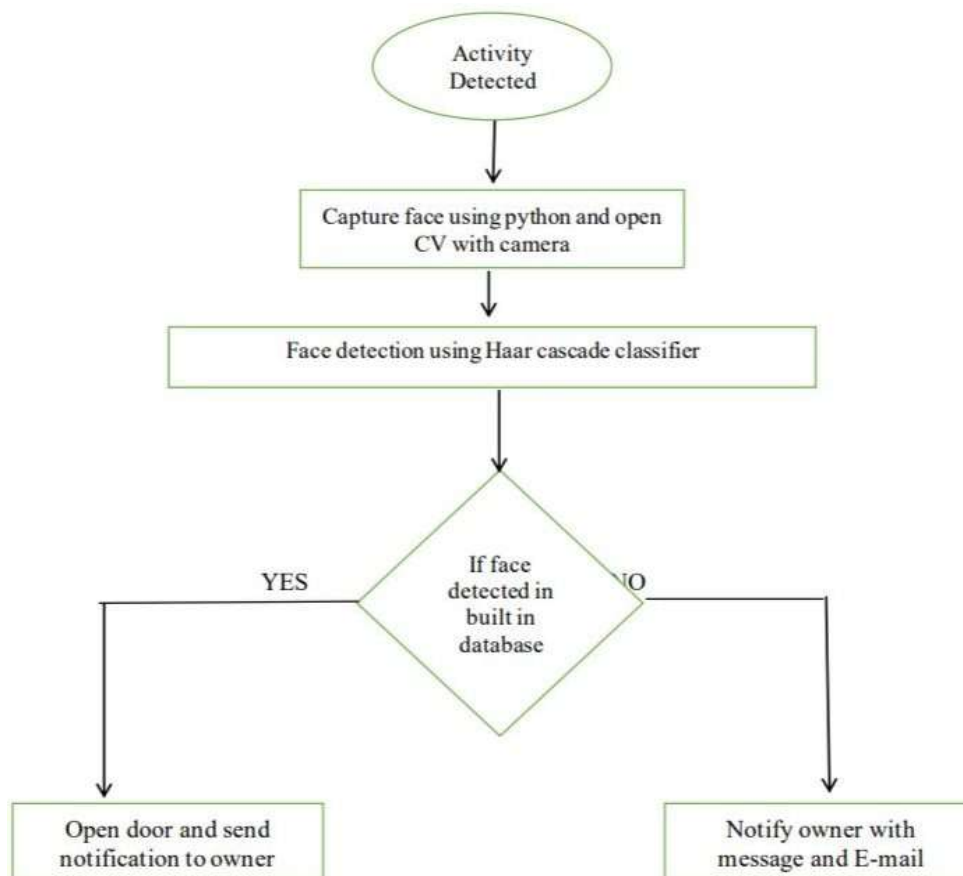


Figure No. 10

5. Experimental Result

When any motion is detected the Pi camera effectively captures the pictures. Real-time face detection is done by a cascade classifier. The system starts running once the picture is captured. The overall execution time is capturing images, detecting faces through a cascade classifier, and sending the message with the image of an unknown person to the owner.

6. Conclusion

In this paper, we have implemented a face-recognition door lock system. Recognizing faces is done by using cascade classifiers, which get high accuracy and will store in the database. For this testing, we have used 40 images only. Computer vision is used in the IOT. For security purposes, we have implemented real-time face detection by the Haar classifier. Thus this system can be useful for senior citizens living alone and for immobilized people. Hence the proposed system is practically easy to construct and easy to track the path.

7. References

- [1] Shaanxi M, Nanda C, Shaun A, Pattack, B (2015) Web based online embedded door access control and home security system based on face recognition. IEEE
- [2] Mulla M, Patil R (2015) Facial image based security system using PCA. IEEE
- [3] Jayavardhana G (2013) Internet of things (IOT): A vision, architectural elements, and future directions. *Future Gener Comput Syst Future Gener Comp Sy* 29: 1645- 1660.
- [4] Januzaj Y, Luna A, Ramaj V (2015) Real time access control based on facial recognition. *International conference on network security and computer science (ICNSCS-15)*. Antalya, Turkey.
- [5] Lwin H, Khaing A, Tun H (2015) Automatic door access system using face recognition. *Int J Sci Eng* 4: 2277-8616.
- [6] Chowdhury M, Nooman S (2013) Access control of door and home security by raspberry pi through Internet. *15: 412-317*.
- [7] Senthikumar G, Gopalkrishnan, K, Sathish, Kumar V (2014) Embedded image capturing system using raspberry pi system. *IJETTCS* 3: 213-215.
- [8] Çarıkçı M, Özen F (2012) A face recognition system based on eigen faces method 1: 118-123.
- [9] Jogdand S, Karanjkar M (2015) Implementation of automated door accessing system with face design and recognition. *Int J Mod Eng* 1: 319-386.
- [10] Sowmiya U, shafiq mansoor J (2015) Raspberry pi based home door security through 3g dongle. *Int J Eng* 3: 209-730.
- [11] Kartik J, Srimadhavan V (2013) SMS alert and embedded network video monitoring terminal. *IJSPTM* 2: 9-19.
- [12] P. Bhatia, S. Rajput, S. Pathak and S. Prasad, "IOT based facial recognition system for home ICRAEM 2020 IOP Conf. Series: Materials Science and Engineering 981 (2020) 032036 IOP Publishing doi:10.1088/1757-899X/981/3/032036 6 Security using LBPH algorithm," 2018 3rd International Conference on Inventive Computation Technologies (ICICT), Coimbatore, India, 2018, pp. 191-193, doi: 10.1109/ICICT43934.2018.9034420.

- [13] Aishwarya D, Dr. J Arokia Renjith Enhanced Home Security Using IOT and Raspberry Pi.
- [14] M.Nandini, P.Bhargavi, G.Raja Sekhar Face Recognition Using Neural Networks.
- [15] Mohammadjaved R. Mulla; Rohita P. Patil; S. K. Shah 2015.Facial Image Based
- [16] Security System using PCA.
- [17] Neetu Saini, zukhwinder Kaur, Hari Singh, A Review: Face Detection Methods and Algorithms, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, 2 (6), June – 2013.
- [18] Abaya, Wilson Feipeng, et al. "Low Cost Smart Security Camera with Night Vision Capability Using Raspberry Pi and Open CV." 2014 International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), IEEE, 2014, pp.1–6, DOI: 10.1109/HNICEM.2014.7016253.
- [19] Monkallas Praveena, Tallapelli Suresh, Face recognition system using raspberry pi and PCA International Journal of Scientific Engineering and Technology Research.
- [20] Tan, J.; Goyal, S.B.; Singh Rajawat, A.; Jan, T.; Azizi, N.; Prasad, M. Anti-Counterfeiting and Traceability Consensus Algorithm Based on Weightage to Contributors in a Food Supply Chain of Industry 4.0. Sustainability 2023, 15, 7855. <https://doi.org/10.3390/su15107855>
- [21] Rajawat, A.S. et al. (2023). Real-Time Driver Sleepiness Detection and Classification Using Fusion Deep Learning Algorithm. In: Singh, Y., Singh, P.K., Kolekar, M.H., Kar, A.K., Gonçalves, P.J.S. (eds) Proceedings of International Conference on Recent Innovations in Computing. Lecture Notes in Electrical Engineering, vol 1001. Springer, Singapore. https://doi.org/10.1007/978-981-19-9876-8_34.
- [22] Rajawat, A.S.; Goyal, S.B.; Bedi, P.; Verma, C.; Ionete, E.I.; Raboaca, M.S. 5G-Enabled Cyber-Physical Systems for Smart Transportation Using Blockchain Technology. Mathematics 2023, 11, 679. <https://doi.org/10.3390/math11030679>
- [23] Rajawat, A.S.; Goyal, S.B.; Chauhan, C.; Bedi, P.; Prasad, M.; Jan, T. Cognitive Adaptive Systems for Industrial Internet of Things Using Reinforcement Algorithm. Electronics 2023, 12, 217. <https://doi.org/10.3390/electronics12010217>.
- [24] Nagaraj, S.; Kathole, A.B.; Arya, L.; Tyagi, N.; Goyal, S.B.; Rajawat, A.S.; Raboaca, M.S.; Mihaltan, T.C.; Verma, C.; Suci, G. Improved Secure Encryption with Energy Optimization Using Random Permutation Pseudo Algorithm Based on Internet of Thing in Wireless Sensor Networks. Energies 2023, 16, 8. <https://doi.org/10.3390/en16010008>.
- [25] R. S. Chouhan et al., "Experimental Analysis for Position Estimation using Trilateration and RSSI in Industry 4.0," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 904-908, doi: 10.1109/SMART55829.2022.10047276.
- [26] Rajawat, A.S. et al. (2023). Real-Time Driver Sleepiness Detection and Classification Using Fusion Deep Learning Algorithm. In: Singh, Y., Singh, P.K., Kolekar, M.H., Kar, A.K., Gonçalves, P.J.S. (eds) Proceedings of International Conference on Recent Innovations in Computing. Lecture Notes in Electrical Engineering, vol 1001. Springer, Singapore. https://doi.org/10.1007/978-981-19-9876-8_34
- [27] S. Rajawat, S. B. Goyal, P. Bedi, N. B. Constantin, M. S. Raboaca and C. Verma, "Cyber-Physical System for Industrial Automation Using Quantum Deep Learning," 2022 11th International Conference on System Modeling & Advancement in Research

- Trends (SMART), Moradabad, India, 2022, pp. 897-903, doi: 10.1109/SMART55829.2022.10047730.
- [28] S. Rajawat et al., "Security Analysis for Threats to Patient Data in the Medical Internet of Things," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 248-253, doi: 10.1109/SMART55829.2022.10047322.
- [29] P. Pant et al., "Using Machine Learning for Industry 5.0 Efficiency Prediction Based on Security and Proposing Models to Enhance Efficiency," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 909-914, doi: 10.1109/SMART55829.2022.10047387.
- [30] P. Pant et al., "AI based Technologies for International Space Station and Space Data," 2022 11th International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2022, pp. 19-25, doi: 10.1109/SMART55829.2022.10046956
- [31] Rajawat, A.S.; Goyal, S.B.; Bedi, P.; Simoff, S.; Jan, T.; Prasad, M. Smart Scalable ML-Blockchain Framework for Large-Scale Clinical Information Sharing. *Appl. Sci.* 2022, 12, 10795. <https://doi.org/10.3390/app122110795>.
- [32] S. Rajawat et al., "Visual Cryptography and Blockchain for Protecting Against Phishing Attacks on Electronic Voting Systems," 2022 International Conference and Exposition on Electrical And Power Engineering (EPE), Iasi, Romania, 2022, pp. 663-666, doi: 10.1109/EPE56121.2022.9959765.
- [33] S. Rajawat et al., "Electrical Fault Detection for Industry 4.0 using Fusion deep Learning Algorithm," 2022 International Conference and Exposition on Electrical And Power Engineering (EPE), Iasi, Romania, 2022, pp. 658-662, doi: 10.1109/EPE56121.2022.9959762.
- [34] Rajawat, Anand Singh and Chauhan, Chetan and Goyal, S B and Bhaladhare, Pawan R and Rout, Dillip and Gaidhani, Abhay R, Utilization Of Renewable Energy For Industrial Applications Using Quantum Computing (August 11, 2022). Available at SSRN: <https://ssrn.com/abstract=4187814> or <http://dx.doi.org/10.2139/ssrn.4187814>
- [35] Anand Singh Rajawat, Pradeep Bedi, S. B. Goyal, Sandeep Kautish, Zhang Xihua, Hanan Aljuaid, Ali Wagdy Mohamed, "Dark Web Data Classification Using Neural Network", *Computational Intelligence and Neuroscience*, vol. 2022, Article ID 8393318, 11 pages, 2022. <https://doi.org/10.1155/2022/8393318>.
- [36] Piyush Pant, Anand Singh Rajawat, S.B. Goyal, Pradeep Bedi, Chaman Verma, Maria Simona Raboaca, Florentina Magda Enescu, Authentication and Authorization in Modern Web Apps for Data Security Using Nodejs and Role of Dark Web, *Procedia Computer Science*, Volume 215, 2022, Pages 781-790, ISSN 1877-0509, <https://doi.org/10.1016/j.procs.2022.12.080>.
- [37] Robin Singh Chouhan, Anand Singh Rajawat, SB Goyal, Pradeep Bedi , AI-Enabled Augmented Reality-Based Shared Collaborative Experience, *Book AI-Enabled Multiple-Criteria Decision-Making Approaches for Healthcare Management* Pages 85-96 Publisher IGI Global.
- [38] Anand Singh Rajawat, Pradeep Bedi, S. B. Goyal, Piyush Kumar Shukla, Atef Zaguia, Aakriti Jain, Mohammad Monirujjaman Khan, "Reformist Framework for Improving Human Security for Mobile Robots in Industry 4.0", *Mobile Information Systems*, vol. 2021, Article ID 4744220, 10 pages, 2021. <https://doi.org/10.1155/2021/4744220>

- [39] S. Srivastava and R. Kumar, "Indirect method to measure software quality using CK-OO suite," 2013 International Conference on Intelligent Systems and Signal Processing (ISSP), 2013, pp. 47-51, doi: 10.1109/ISSP.2013.6526872.
- [40] Ram Kumar, Gunja Varshney , Tourism Crisis Evaluation Using Fuzzy Artificial Neural network, International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1, Issue-NCAI2011, June 2011
- [41] Ram Kumar, Jasvinder Pal Singh, Gaurav Srivastava, "A Survey Paper on Altered Fingerprint Identification & Classification" International Journal of Electronics Communication and Computer Engineering Volume 3, Issue 5, ISSN (Online): 2249–071X, ISSN (Print): 2278–4209
- [42] Kumar, R., Singh, J.P., Srivastava, G. (2014). Altered Fingerprint Identification and Classification Using SP Detection and Fuzzy Classification. In: , et al. Proceedings of the Second International Conference on Soft Computing for Problem Solving (SocProS 2012), December 28-30, 2012. Advances in Intelligent Systems and Computing, vol 236. Springer, New Delhi. https://doi.org/10.1007/978-81-322-1602-5_139
- [43] Gite S.N, Dharmadhikari D.D, Ram Kumar," Educational Decision Making Based On GIS" International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-1, Issue-1, April 2012.
- [44] Ram Kumar, Sarvesh Kumar, Kolte V. S.," A Model for Intrusion Detection Based on Undefined Distance", International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1 Issue-5, November 2011
- [45] Vibhor Mahajan, Ashutosh Dwivedi, Sairaj Kulkarni,Md Abdullah Ali, Ram Kumar Solanki," Face Mask Detection Using Machine Learning", International Research Journal of Modernization in Engineering Technology and Science, Volume:04/Issue:05/May-2022
- [46] Kumar, Ram and Sonaje, Vaibhav P and Jadhav, Vandana and Kolpyakwar, Anirudha Anil and Ranjan, Mritunjay K and Solunke, Hiralal and Ghonge, Mangesh and Ghonge, Mangesh, Internet Of Things Security For Industrial Applications Using Computational Intelligence (August 11, 2022). Available at SSRN: <https://ssrn.com/abstract=4187998> or <http://dx.doi.org/10.2139/ssrn.4187998>
- [47] Kumar, Ram and Aher, Pushpalata and Zope, Sharmila and Patil, Nisha and Taskar, Avinash and Kale, Sunil M and Gadekar, Amit R, Intelligent Chat-Bot Using AI for Medical Care (August 11, 2022). Available at SSRN: <https://ssrn.com/abstract=4187948> or <http://dx.doi.org/10.2139/ssrn.4187948>
- [48] Kumar, Ram and Patil, Manoj, Improved the Image Enhancement Using Filtering and Wavelet Transformation Methodologies (July 22, 2022). Available at SSRN: <https://ssrn.com/abstract=4182372>
- [49] Ram Kumar, Manoj Eknath Patil ,," Improved the Image Enhancement Using Filtering and Wavelet Transformation Methodologies", Turkish Journal of Computer and Mathematics Education ,Vol.13 No.3(2022), 987-993.
- [50] Ram Kumar, Jasvinder Pal Singh, Gaurav Srivastava, "A Survey Paper on Altered Fingerprint Identification & Classification" International Journal of Electronics Communication and Computer Engineering ,Volume 3, Issue 5, ISSN (Online): 2249–071X, ISSN (Print): 2278–4209.
- [51] Chetna kwatra, Bukya Mohan Babu, M.Praveen, Dr T.Sampath Kumar, Ram Kumar Solanki ,Dr A V R Mayuri. (2023). Modified Cnn Based Heart Disease Detection Integrated With Iot. Journal of Pharmaceutical Negative Results, 993–1001. <https://doi.org/10.47750/pnr.2023.14.S02.120>

- [52] Solanki, R. K., Rajawat, A. S., Gadekar, A. R., & Patil, M. E. (2023). Building a Conversational Chatbot Using Machine Learning: Towards a More Intelligent Healthcare Application. In M. Garcia, M. Lopez Cabrera, & R. de Almeida (Eds.), *Handbook of Research on Instructional Technologies in Health Education and Allied Disciplines* (pp. 285-309). IGI Global. <https://doi.org/10.4018/978-1-6684-7164-7.ch013>
- [53] S. B. Goyal, A. S. Rajawat, R. K. Solanki, M. A. Majmi Zaaba and Z. A. Long, "Integrating AI With Cyber Security for Smart Industry 4.0 Application," 2023 International Conference on Inventive Computation Technologies (ICICT), Lalitpur, Nepal, 2023, pp. 1223-1232, doi: 10.1109/ICICT57646.2023.10134374.
- [54] Pardeshi, D., Rawat, P., Raj, A., Gadail, P., Solanki, R. K., & Bhaladhare, D. P. R. (2023). Efficient Approach for Detecting Cardiovascular Disease Using Machine Learning. *Int. J. of Aquatic Science*, 14(1), 308-321
- [55] Patle, S., Pal, S., Patil, S., Negi, S., Rout, D. D., & Solanki, D. R. K. (2023). Sun-Link Web Portal for Management for Sun Transportation. *Int. J. of Aquatic Science*, 14(1), 299-307.
- [56] Sayyed, T., Kodwani, S., Dodake, K., Adhayage, M., Solanki, R. K., & Bhaladhare, P. R. B. (2023). Intrusion Detection System. *Int. J. of Aquatic Science*, 14(1), 288-298.
- [57] Gupta, A., Sevak, H., Gupta, H., & Solanki, R. K. (2023). Swiggy Genie Clone Application. *Int. J. of Aquatic Science*, 14(1), 280-287.
- [58] Khode, K., Buwa, A., Borole, A., Gajbhiye, H., Gadekar, D. A., & Solanki, D. R. K. (2023). Live Stock Market Prediction Model Using Artificial Neural Network. *Int. J. of Aquatic Science*, 14(1), 333-340.
- [59] hire, S., Gorhe, S., Palod, T., Khalkar, A., Chauhan, D., & Solanki, D. K. (2023). First Copy Logo Detection System. *Int. J. of Aquatic Science*, 14(1), 322-332.