

IoT BASED MILITARY ROBOT USING RASPBERRY Pi3

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Abstract: *The system proposed in this project consists of a single unit, which will monitor the environment in various hazardous conditions and provide live video feedback. Basics of robotics like sensors and actuators, gives an overview on robotic construction. The proposed system is also able to capture real-time videos which are useful for surveillance for a specific person or area. Controlling of Robot is done using a Raspberry Pi3 processor. This robot is more comfortable for military applications such as surveillance of interested area. It will provide tactical advantage during hostage situations or in hostile grounds. It is capable of walking on any surface and providing monitoring over an area. With the help of high-quality video transmission, the surveillance become more effective and it detect the high temperature and also used to reduce the fire by using water sprinkler. Video quality is improvised in the proposed system. These will prove important in applications like robots for civil use and military robots.*

Keywords: *Raspberry Pi3; Servomotors; Application controlling; Bluetooth connectivity; Water sprinkler; PIR sensor.*

1. INTRODUCTION

In today's world the monitoring of military areas is essential due to increased attacks of the enemies but the quality of that monitoring i.e. surveillance is not that much satisfactory, this results in the increasing ratio of lives of the soldier in danger. Because of that it is necessary to improve the quality of surveillance through effective surveillance. This is done more effectively by high quality video transmission. In this project the quality of video is improved using Closed Circuit Cameras. For all this there is a need of the ground Robot which is able to move on the hills, muddy areas. By using Closed Circuit Cameras various technical advancements are took placed in surveillance [1]. Lots of crime scenes have been solved by using this technology but still, the crime rate has not reduced because of immobility of the surveillance equipment's. In this project design and development of the robot is done which will move from one place to another, it has capability of capturing real-time images and videos required for the surveillance. The main constraint in surveillance is mobility of the robot. This robot is also capable of doing housekeeping. And also, the water sprinkler made under this project and we can operate a robot there is no need for human to go even near the area on fire. We have used the light dependent resistors for detection of fire. It is the highly sensitive device and is capable for detecting very small fires too. The robot accommodates a water tank and sprinkler on itself to extinguish fire.

Further, the system proposed is interactive in nature, hence the user even while grooming up, can give voice commands, to get required and related information on screen, keeping

his/her hand free. There are related products available in market, but the main difference lies in the usability of the product. The available products are mostly passive in nature with little interactivity. The present Smartmirrors designed so far are almost passive in nature. These systems are capable of displaying the information on the screen. They have been designed mostly with Raspberry Pi, LCD (Liquid Crystal Display) or LED (Light Emitting Diodes) for information display. Few of them work on either voice based commands or Touch Commands or Mobile device commands. Some of the systems are also designed for providing security using PIR sensors. But the systems thus designed have more false alarm rate and sensing range is also very low.

The proposed system is an interactive system which displays the date, time on the screen. The display can be customized based on the requirement. The system accepts any of the commands namely voice, touch and mobile control commands and behaves interactively. The proposed system can be controlled by any of these commands. Whenever security systems and house hold appliances are embedded in to household devices like mirror, the usability of device will increase. It can be used for general use and also for specific use like providing security in home environment. Usually intruders and thieves look for security cameras. If they find cameras, they may destroy them and come to know that they were under security monitoring system. But for proposed system, intruder or thief will never come to know that he is under security observations.

Normal Cameras will be visible to intruder, but Smart mirror which just looks like an ordinary mirror will not catch an attention of the intruder. Thus, the camera fitted on top of the Smart Mirror will capture the photo of an intruder and be able to send an alert of the intrusion without knowledge to the intruder. The intruder will never come to know that he is under constant surveillances. Home automation are mainly created using intelligent IOT devices, IOT is an integrated system of communicating devices in which each device is capable of carrying out tasks by themselves. Smart mirror for home automation have great potential to enhance user experience for accessing and interacting with information. This system is very useful for physically challenged people, old people and children. Everyone can easily access this system easily even while doing their daily chores. This is one of the major advantages of the system.

The proposed system does human identification for detecting the intrusion detection. Once the intruder comes under the range of camera, the intrusion detection takes place. The range of pi-camera which is compatible with raspberry pi is approximately 8m to 10m. Human detection is done. The Human presence thus detected is informed to owner of the Smart mirror through alert message. The alert message consists of photo of intruder along-with the time stamp of time. The Raspberry Pi is to be connected to Wi-Fi and mobile device has to be connected to internet.

2. ROBOTICS

Robotics is the branch of engineering science & Technology related to robots, and their design, manufacture, application, and structural disposition. Robotics is related to electronics, mechanics, and software. Robotics research today is focused on developing systems that exhibit modularity, flexibility, redundancy, fault-tolerance, a general and extensible software environment and seamless connectivity to other machines, some researchers focus on completely automating a manufacturing process or a task, by providing sensor-based intelligence to the robot arm, while others try to solidify the analytical foundations on which many of the basic concepts in robotics are built. In this highly developing society time and man power are critical constraints for completion of task in large

scales. The automation is playing important role to save human efforts in most of the regular and frequently carried works.

One of the major and most commonly performed works is picking and placing of jobs from source to destination. Present day industry is increasingly turning towards computer- based automation mainly due to the need for increased productivity and delivery of end products with uniform quality. The inflexibility and generally high cost of hard-automation systems, which have been used for automated manufacturing tasks in the past, have led to a broad-based interest in the use of robots capable of performing a variety of manufacturing functions in a flexible environment and at lower costs. The use of Industrial Robots characterizes some of contemporary trends in automation of the manufacturing process. However, present day industrial robots also exhibit a monolithic mechanical structure and closed system software architecture. They are concentrated on simple repetitive tasks, which tend not to require high precision.

3. LITERATURE REVIEW

P. Raja, Swapnil Bagwari et al (2018) presented a MASS (military assistance and surveillance system) that uses different type of sensor to monitor the soldier such as their location, health conditions, surroundings, sending data to base station, etc. being a wearable device it monitors the pulse rate as well as send the respective data to the base station and by using GPS module the location can also be monitored by military base station. Since it is wearable installation will be cost effective and will add a heavy pack load for soldier. Minal S. Ghute, Kanchan P. Kamble, Mridul Korde et al (2018) described a military surveillance robot system consists of a single unit, which will monitor the environment in various hazardous conditions and provide live video feedback. Gyro sensor has been used to move robot in hilly areas, metal detection for landmines.

It uses Bluetooth connectivity for wireless communication through mobile application which make it range limited. Aditya Prakash, Raheewalambe et al (2018) described about a simple military surveillance robot with the commands for moving front, back, right, left and stop are being received from the remote controller and accordingly the input is fed to the Raspberry pi 3 which makes the robot setup respond as per the instructions given. The Kinect sensor works like a camera with an additional feature of depth measurement i.e., it depicts the distance of object from itself by representing the object in the form of grayscale values ranging from 0 to 255 where 0 amounts to black which implies the object is closer and 255 amounts to white which implies the object farther. Siva karteekboliseti, Mohammad patwary, Mohamed Abdel-maguid et al (2017) proposed RF sensing based target detector which is expected to give an energy efficient solution to the problem of target detection under the sensing conditions. The sensor nodes are required to operate in harsh sensing environments in the presence of clutter and interfering signals. Using a simple low complexity target detector at the individual sensor nodes may be considered where the sensor nodes can make a preliminary decision before transmitting the data to the control centre. This reduces the frequency of data exchange between the sensor nodes and the control centre thereby increasing the lifetime of the IoT. 70% reliability has been achieved. Ghanem Osman Elhaj Abdalla, T. Veeramanikandasamy et al (2017) implemented a Spy Robot for A Surveillance System using Internet Protocol of Raspberry Pi a Raspbian operating system-based spy robot platform with remote monitoring and control algorithm through Internet of Things (IoT). The information regarding the detection of living objects by PIR sensor is sent to the user through the web server and pi camera capture the moving object which is posted inside the web pages simultaneously. Majd Ghareeb, Alibazzi, mohamadraad, shamihabdulnabi et al (2017) presented Wirelessrobo-pi for landmine detection as a low-cost

automated mine detector that will replace the current human detectors in the mission of detecting and extracting mines in a suspected area of land.

This detector will wirelessly connect with a server to send the location of detected mines or metal and captured image of land where it is found. Since the detector is raspberry pi based, we can make it as IoT based for further communication. Widodo Budiharto et al (2014) designed a Tracked Robot with Remote Control for Surveillance, the performance of the robot is in terms of the distance and the capability to deliver video streaming from the output raspberry pi and 2.4 GHz Video transmitter.

Experimental results with various distance show that the best distance for transmitting the commands not more than 20 meters. The sensor system is ridiculously cheap because it only uses 1 distance sensor. The average speed raspberry pi to display a video streaming is 33 fps that sufficient for surveillance. The main weakness of type of ultrasonic sensor is the interference between different sensors and the limited ability to identify the obstacle. Andrea Claudi, Francesco Di Benedetto, Gianluca Dolcini, Luca Palazzo, Aldo Franco Dragoni et al (2012) proposes a mobile autonomous robot, called MARVIN, to be used in video surveillance applications. The main goal of the robot is to detect human faces in the monitored environment, and to autonomously move to keep a face in the exact center of the frame.

The architecture of the robot is conceived to achieve a good trade-off between reactivity and accuracy. In terms of speed, the experiments showed that LBP is suitable as real-time face-detection algorithm, processing a single frame containing 6 faces in about 40 ms. The performances of ORB are not sufficient to recommend its use under the conditions of the reference scenario. In terms of accuracy, LBP with a small search window can provide an accuracy of about 73%, with a considerable penalty in terms of timing performances. Change Zheng et al (2009) presented the mechanical design including a kind of miniature flexible driving mechanism, as Miniature autonomous surveillance robot BMS-1 for covert surveillance using set of sensors and the control system for tasks such as to secretly enter and hide in potentially dangerous region and feed information back. It uses pyroelectric sensors that are designed specifically for detection of human motion. This light sensor is much suitable for detection of cover because it is only sensitive to visible light and has low infrared and ultraviolet sensitivity without the help of optical filters. The output voltage of this sensor can be sampled by the ADC module of the DSP controller in BMS-1. In our robot, the two facing upward photovoltaic sensors are outfitted on the two ends of BMS-1. This allows for detection of dark location of BMS-1.

4. METHODOLOGY AND HARDWARE DESCRIPTION

4.1 Raspberry pi:

The raspberry pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to put the power of computing and digital making into the hands of people all over the world. If at the beginning the aims of Raspberry Pi project were leaned towards the promotion of teaching of basic computer science in schools and in developing countries, it rapidly expanded into a wider range of use, as the original model became very popular than anticipated. Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of doing everything you'd expect a desktop computer to do, from browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games.

The raspberry pi has the ability to interact with the outside world, and has been used in a widearray of digital maker projects, from music machines and parent detectors to weather stations andtweeting birdhouses with infra-red cameras. We want to see the raspberry pi being used by kids all over the world to learn to program and understand how computers work.

Several generations of raspberry pi have been released. All models feature a Broadcom system on a chip (soc) with an integrated ARM-compatible central processing unit (CPU) and on-chip graphics processing unit (GPU). Processor speed ranges from 700 MHz to 1.4GHz for the pi3 model B+ or 1.5GHz for pi 4; onboard memory ranges from 256 MiB to 1 GiB random-access memory (RAM), with up to 8 GiB available on the pi 4. Secure digital (SD) cards in microSDHC format (SDHC on early models) are used to store the operating system and program memory. The boards have one to five USB ports for video output, HDMI and composite video are supported, with a standard 3.5mm tip-ring-sleeve jack for audio output. Lower-level output is provided by a number of GPIO pins, which support common protocols like I2C. the B-models have an 8P8C Ethernet port and the pi 3, pi 4 and pi zero W have on board Wi-Fi 802.11n and Bluetooth.

The first generation (Raspberry pi model B) was released in february 2012, followed by simpler and cheaper model A. in 2014, the foundation released a board with an improved design, raspberry pi model B+. these boards are appropriately credit-card sized and represent the standard mainline form factor. Improved A+ and B+ models were released a year later. A "compute module" was released in april 2014 for embedded applications.

The raspberry pi 2, which featured a 900 MHz quad-core ARM cortex-A7 processor and 1 GiB RAM, was released in february 2015. A raspberry pi zero with smaller size and reduced input/output (i/o) and general-purpose (GPIO) capabilities was released in November 2015. On 28 february 2017, the raspberry pi zero W was launched, a version of the zero with Wi-Fi and Bluetooth capabilities, on 12 january 2018, the raspberry pi zero WH was launched. A version of the zero W with pre-soldered GPIO headers. Raspberry pi 3 model B was released in february 2016 with a 1.2GHz 64-bit quad-core processor, on-board 802.11n Wi-Fi, Bluetooth and USB boot capabilities. On pi day 2018, the raspberry pi 3 model B+ was launched with a faster 1.4GHz processor and a three-times faster gigabit Ethernet (throughput limited to ca. 300 Mbit/s by the internal USB 2.0 connections) or 2.4/5 GHz dual band 802.11ac Wi-Fi (100 Mbit/s). Other features are power over Ethernet (PoE) (with the add-on PoE HAT), USB boot and network boot (as SD card is no longer required).

Raspberry pi 4 model B was released in june 2019 with a 1.5 GHz 64-bit quad core ARM cortex-A72 processor, on-board 802.11ac Wi-Fi, Bluetooth 5, full gigabit Ethernet (throughput not limited), two USB 2.0 ports, two USB 3.0 ports, and dual-monitor support via a pair of micro HDMI (HDMI type D) ports for up to 4K resolution. The pi 4 is also powered via a USB-C port, enabling additional power to be provided to downstream peripherals, when used with an appropriate PSU. The initial raspberry pi 4 board has a design flaw where third-party e-marked USB cables, such as those used on apple macbooks, incorrectly identify it and refuse to provide power. Tom's hardware tested 14 different cables and found that 11 of them turned on and powered the pi without issue. The design flaw was fixed in revision 1.2 of the board, released in late 2019.

4.3. L298 IC:

The L298 integrates two power output stages (A,B). The power output stage is a bridge configuration and its outputs can drive an inductive load in common or differential mode, depending on the state of the inputs. The current that flows through the load comes out from the bridge at the sense output : an external resistor (RSA, RSB.) allows to detect the intensity of this current. Each bridge is driven by means of four gates the input of which are In1 ; In2 ; EnA and In3 ; In4; EnB. The In inputs set the bridge state when The En input is high ; a low state of the En input inhibits the bridge. All the inputs are TTL compatible. A non inductive capacitor, usually of 100 nF, must be foreseen between both Vs and Vss, to ground, as near as possible to GND pin. When the large capacitor of the power supply is too far from the IC, a second smaller one must be foreseen near the L298. The sense resistor, not of a wire wound type, must be grounded near the negative pole of Vs that must be near the GND pin of the IC. Each input must be connected to the source of the driving signals by means of a very short path. Turn-On and Turn-Off : Before to Turn- ON the Supply Voltage and before to Turn OFF, the Enable in-put must be driven to the Low state.



Fig. 4. L298

4.4. Inductive proximity sensor

Inductive proximity sensors enable the detection, without contact, of metal objects at distances of up to 60 mm. Their range of applications is very extensive and includes : the monitoring of machine parts (cams, mechanical stops, etc.), monitoring the flow of metal parts, counting, etc.



Fig. 5. Inductive Proximity Sensor

The above diagram indicates the internal structure of the sensor. Inductive proximity sensors are solely for the detection of metal objects. They basically comprise an oscillator whose windings constitute the sensing face. An alternating magnetic field is generated in front of these windings. When a metal object is placed within the magnetic field generated by the sensor, the resulting currents induced form an additional load and the oscillation ceases.

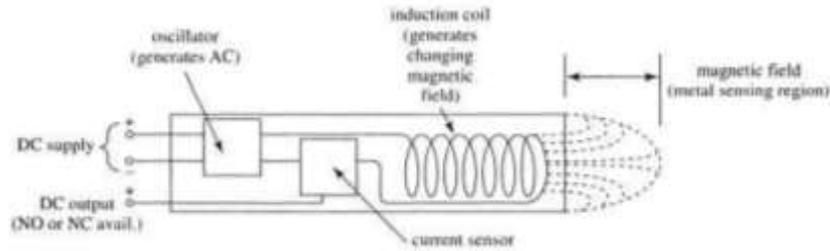


Fig. 6. Working Of The Sensor

The detection coil located at the front end of the sensor produces a high-frequency magnetic field as shown in the figure above. When an object (metallic) approaches this magnetic field, induced currents flow in the metal, causing thermal loss and resulting in the reduction or stopping of oscillations. This change in state is detected by an oscillation state sensing circuit which then operates the output circuit.

5. IMPLEMENTATION

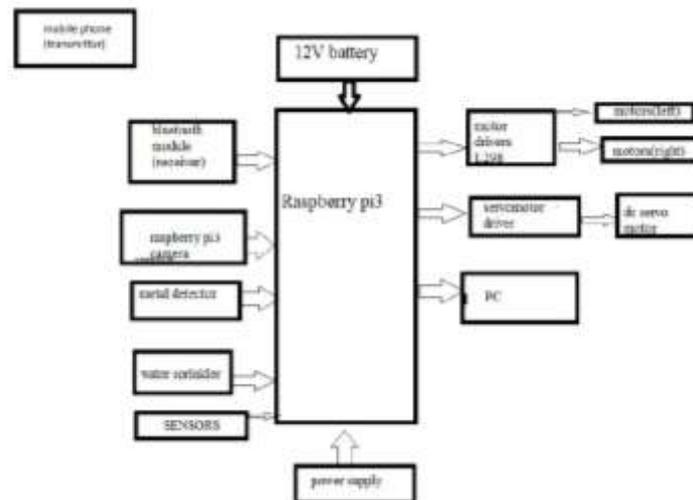


Fig. 7. Detailed Block Diagram.

The entire robot is based on autonomous programming along with smart app control so as to enable its controlling using mobile devices. The programming is fed to Raspberry Pi. The main components of the robot are 8 Servo Motors, Raspberry Pi3 model. Raspberry Pi is the main control board of the humanoid robot. Raspberry Pi is responsible for live video stream to the devices which are connected to a common Network and it is also responsible for speech synthesis so that it can interact with its user[2]. The output of Raspberry Pi programming is then fed to various sensors in order to make the robot to sense its surroundings. It has to be equipped with various kinds of sensors such as Ultrasonic Sensor, touch sensor, gyro sensor, IR sensor and several other components such as microphone, speaker, GSM and Bluetooth module. HCSR-04 model ultrasonic module was used in this work to sense obstructions from 1 cm to 4 meters distance. A gyro sensor is used here so as to stabilize the robot when it will move on muddy areas, hills or rough surfaces [3-4]. For transparent wireless serial connection HC-05 module is used. It has Bluetooth Serial Port Protocol module. Here the robot comes with Bluetooth connectivity which enables it to control wirelessly through mobile application and it also streams live video through a Wi-Fi

network which is on board through the Raspberry Pi and webcam. The Raspberry-Pi output is then fed to the camera, microphone, and speaker. The video quality is improved; this can be achieved by using Closed Circuit Cameras. This output is also responsible for speech synthesis so that it can interact with its user. The design of different parts of the proposed project is constructed by using PVC pipes.

The whole robot is powered by Lithium polymer battery which can drive this robot for up to half an hour. The Robot is driven by a single high torque metal geared side shaft 12-volt DC motor. The motor is connected to a server which is responsible for changing its direction[5-6]. The circuit diagram of propose project is shown in the fig. 4.1.1. The main structural components are the Servo Motors which enable it to move every part of its body. A main power distribution board is responsible forproviding different voltage levels to the different components of the robot [7]. PCB layout of onDetection.

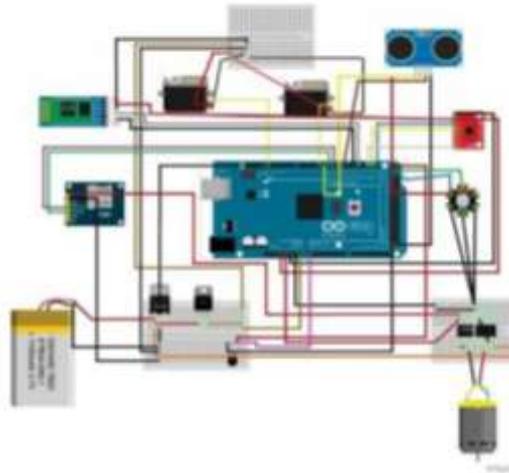


Fig. 8. Detailed Circuit Diagram

6. RESULT

The Robot is kept on a platform which is connected to aAluminium chassis the platform is keptstraight with help of 8 Servo Motors and pro Mini. Here the pro Mini is connected to a gyro sensorwhich gives that the knowledge of its orientation. That's robot is built on a hard Aluminium chassiswhich neighbors it to roll on ref trains and keep it balanced. The upper half of the robots body is paid toimitate human body it has to films through which it can interact and show some basic gestures. Theimplemented robot is shown in fig.5.It is implemented using PVC pipes and hence cost is low



Fig. 9. Hardware implementation of robot

7. CONCLUSION

This robot was built by keeping military applications in mind. So, it comes with basic videosurveillance and metal detection so that it can detect underground landmines etc. Further extensions can be made in the same projects such as home automation, telemedicine system. The robot can be equipped with interactive voice feedback. It is possible to install ME (medicalemergency) band in the robot to look after the health of an elderly person in the house.

8. REFERENCES

- [1] K.Kaneko,F.Kanehiro,S.Kajita,H.Hirukawa,T.Kawasaki, M.Hirata,K.Akachi,T.Isozumi, "Ho manoid robot HRP_2,"IEEE International Conference on robotics and automation,New Orleans,LA 2004.
- [2] Karthikeyan,R.S.Karthik,Prasanna VishalTR,S.Vignesh, "Snitch:Design and development of a mobile robot for surveillance and reconnaissance,"2015 International Conference on Innovations in Information Embedded and Communication Systems,ICIIECS 2015.
- [3] M.Karthikeyan, G.Sreeram, "Intelligent Exploration and Surveillance Robot In Defense Environment," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, Vol.3, Special Issue 1, February 2014.
- [4] Nagaraju Sakali,G. Nagendra, "Design and implementation of Web Surveillance Robot for Video Monitoring and Motion Detection,"IJESC,Vol. 7,Iss. 2, Feb. 2017.
- [5] P.Saucy,F.Mondana, "Keep On The Web:Open access to a mobile robot on the internet,"IEEE robotics and automation magazine, March 2000.
- [6] R.Thilagavathy,J.Murali,P.Kamal,P.ArunPandiyam, "Intelligent Unmanned Army Robot," IJARCET, Vol. 4, Iss. 2, February 2015.
- [7] W.Lao,J.Han and Peter H.N.De With, "Automatic video-based human motion analyzer for consumer surveillance system," IEEE transaction on consumer electronics,Vol. 55, 2009.
- [8] Vallabhuni Vijay, P. Chandra Shekar, V. Siva Nagaraju, S. China Venkateswarlu, and Shaik Sadulla, "High Performance 2:1, 4:1 And 8:1 Binary And Ternary Multiplexer Realization Using CNTFET Technology," Journal of Critical Reviews, vol. 7, iss. 6, 2020, pp. 1159–1163.
- [9] Sai Lakshmi, Taninki, Avireni Srinivasulu, and Pittala Chandra Shaker, "Implementation of power efficient flash analogue-to-digital converter," Active and Passive Electronic Components, 2014.
- [10] Kurra, Anil Kumar, and Usha Rani Nelakuditi, "A secure arbiter physical unclonable functions (PUFs) for device authentication and identification," Indonesian Journal of Electrical Engineering and Informatics (IJEEI), 7, no. 1, 2019, pp. 117–127.
- [11] Vallabhuni Vijay, V. Siva Nagaraju, M. Sai Greeshma, B. Revanth Reddy, U. Suresh Kumar, and, C. Surekha, "A Simple and Enhanced Low-Light Image Enhancement Process Using Effective Illumination Mapping Approach," Lecture Notes in Computational Vision and Biomechanics, Cham, Switzerland. 2019, pp. 975–984.
- [12] Kurra, A.K., and Sadulla, S., "Analysis of physical unclonable functions (PUFS) for secure key generation on smartcard chips," Journal of Advanced Research in Dynamical and Control Systems, 9, 2017, pp. 1735-1745.

- [13] Vallabhuni Vijay, "Second Generation Differential Current Conveyor (DCCII) And Its Applications," Vignana's Foundation for Science, Technology & Research (Deemed to be University), Guntur, 2017.
- [14] Rajeev Ratna Vallabhuni, J. Sravana, M. Saikumar, M. Sai Sriharsha, and D. Roja Rani, "An advanced computing architecture for binary to thermometer decoder using 18nm FinFET," 2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT), Tirunelveli, India, 20-22 August, 2020, pp. 510–515.
- [15] P. Chandra Shaker, V. Parameswaran, M. Srikanth, V. Vijay, V. Siva Nagaraju, S.C. Venkateswarlu, Sadulla Shaik, and Vallabhuni Rajeev Ratna, "Realization and Comparative analysis of Thermometer code based 4-Bit Encoder using 18nm FinFET Technology for Analog to Digital Converters," Advanced Intelligent Systems and Computing (AISC), 2020.
- [16] Mohammad Khadir, Kancharapu Chaitanya, S. Sushma, V. Preethi, and Vallabhuni Vijay, "Design Of Carry Select Adder Based On A Compact Carry Look Ahead Unit Using 18nm Finfet Technology," Journal of Critical Reviews, vol. 7, iss. 6, 2020, pp. 1164–1171.
- [17] Rajeev Ratna Vallabhuni, D.V.L. Sravya, M. Sree Shalini, and G. Uma Maheshwararao, "Design of Comparator using 18nm FinFET Technology for Analog to Digital Converters," 2020 7th International Conference on Smart Structures and Systems (ICSSS), Chennai, India, 23-24 July, 2020, pp. 318–323.
- [18] Shaik, Sadulla, Anil Kumar Kurra, and A. Surendar, "High secure buffer based physical unclonable functions (PUF's) for device authentication," *Telkomnika*, 17, no. 1, 2019.
- [19] P. Saritha, J. Vinitha, S. Sravya, V. Vijay, and E. Mahesh, "4-Bit Vedic Multiplier with 18nm FinFET Technology," 2020 International Conference on Electronics and Sustainable Communication Systems (ICESC), Coimbatore, India, 2020, pp. 1079–1084.
- [20] Vijay, V., J. Prathiba, S. Niranjana Reddy, and P. Praveen Kumar, "A REVIEW OF THE 0.09 μm STANDARD FULL ADDERS," *International Journal of VLSI Design & Communication Systems*, vol. 3, no. 3, 2012, p. 119.
- [21] Kurra, Anil, and Usha Rani Nelakuditi, "Design of a Reliable Current Starved Inverter Based Arbiter Physical Unclonable Functions (PUFs) for Hardware Cryptography," *Ingénierie des Systèmes d'Inf.*, 24, no. 4, 2019, pp. 445–454.
- [22] V. Vijay, and Avireni Srinivasulu, "Tunable Resistor and Grounded Capacitor Based Square Wave Generator Using CMOS DCCII," *International J. Control Theory and Applications*, vol. 8, 2015, pp. 1–11.
- [23] Kurra, Anil Kumar, and Usha Rani Nelakuditi, "A Decoder-Mux Based Arbiter Physical Unclonable Functions for Low Cost Security Applications," In 2019 International Conference on Communication and Electronics Systems (ICCES), 2019, pp. 1473–1477.
- [24] Shaik, Sadulla, Anil Kumar Kurra, and A. Surendar, "Statistical Analysis of Arbiter Physical Unclonable Functions using Reliable and Secure Transmission Gates," *International Journal of Simulation--Systems, Science & Technology*, 19, no. 4, 2018.
- [25] Rajeev Ratna Vallabhuni, K.C. Koteswaramma, B. Sadgurbabu, and Gowthamireddy A, "Comparative Validation of SRAM Cells Designed using 18nm FinFET for Memory Storing Applications," Proceedings of the 2nd International Conference on IoT, Social, Mobile, Analytics & Cloud in Computational Vision & Bio-Engineering (ISMAC-CVB 2020), 2020, pp. 1-10.

- [26] Vallabhuni Vijay, and Avireni Srinivasulu, "A low power waveform generator using DCCII with grounded capacitor," *International Journal of Public Sector Performance Management*, vol. 5, 2019, pp. 134–145.
- [27] P. Chandrashekar, R. Karthik, O. Koteswara Sai Krishna, and Ardhi Bhavana, "Design of low threshold Full Adder cell using CNTFET," *International Journal of Applied Engineering Research*, vol. 12, no. 12, 2017, pp. 3411–3415.
- [28] V. Vijay, and Avireni Srinivasulu, "A square wave generator using single CMOS DCCII," in *proceedings of the 2013 IEEE International SoC Design Conference (IEEE ISoCC-2013)*, Busan, South Korea, November 17-19, 2013, pp. 322–325.
- [29] Rajeev Ratna Vallabhuni, G. Yamini, T. Vinitha, and S. Sanath Reddy, "Performance analysis: D-Latch modules designed using 18nm FinFET Technology," *2020 International Conference on Smart Electronics and Communication (ICOSEC)*, Tholurpatti, India, 10-12, September 2020, pp. 1171–1176.
- [30] Sai Lakshmi, Taninki, Avireni Srinivasulu, and Pittala Chandra Shaker, "Implementation of power efficient flash analogue-to-digital converter," *Active and Passive Electronic Components*, 2014.
- [31] Vallabhuni Vijay, and Avireni Srinivasulu, "A Novel Square Wave Generator Using Second Generation Differential Current Conveyor," *Arabian Journal for Science and Engineering*, vol. 42, iss. 12, 2017, pp. 4983–4990.
- [32] Pittala Chandra Shaker, and Avireni Srinivasulu, "Quadrature oscillator using operational transresistance amplifier," *2014 International Conference on Applied Electronics*, Pilsen, Czech Republic, Sept. 2014, pp. 117–120.
- [33] V. Vijay, J. Prathiba, S. Niranjana reddy, Ch. Srivalli, and B. Subbarami reddy, "Performance evaluation of the CMOS Full adders in TDK 90 nm Technology," *International Journal of Systems, Algorithms & Applications*, vol. 2, iss. 1, 2012, pp. 711.
- [34] Pittala Chandra Shaker, and Avireni Srinivasulu, "Two simple sinusoidal oscillators using single operational transresistance amplifier," In *2015 3rd International Conference on Signal Processing, Communication and Networking (ICSCN)*, Chennai, India, March 2015, pp. 1–5.
- [35] Rajeev Ratna Vallabhuni, S. Lakshmanachari, G. Avanthi, and Vallabhuni Vijay, "Smart Cart Shopping System with an RFID Interface for Human Assistance," *Proceedings of the Third International Conference on Intelligent Sustainable Systems [ICISS 2020]*, Palladam, India, December 4-5, 2020, pp. 497-501.
- [36] K. Nagalakshmi, Avireni Srinivasulu, Cristian Ravariu, V. Vijay, V. V. Krishna, "A novel simple schmitt trigger circuit using CDTA and its application as a square-triangular waveform generator," *J. Mod. Technol. Eng.*, vol. 3, 2018, pp. 205-216.
- [37] V. Vijay, and Avireni Srinivasulu, "A DCCII Based Square Wave Generator With Grounded Capacitor," in *proceedings of the 2016 IEEE International Conference on Circuits, Power and Computing Technologies (IEEE ICCPCT-2016)*, Kumaracoil, India, March 18-19, 2016, pp. 1–4.
- [38] Krishna, VVS Vijay, A. Monisha, Sk Sadulla, and J. Prathiba, "Design and implementation of an automatic beverages vending machine and its performance evaluation using Xilinx ISE and Cadence," In *2013 Fourth International Conference on Computing, Communications and Networking Technologies (ICCCNT)*, IEEE, 2013, pp. 1–6.
- [39] Vallabhuni Rajeev Ratna, P. Shruthi, G. Kavya, and S. Siri Chandana, "6T Transistor SRAM Cell designed using 18nm FinFET Technology," *Proceedings of the Third International Conference on Intelligent Sustainable Systems [ICISS 2020]*, Palladam, India, December 4-5, 2020, pp. 1181-1186.

- [40] Rajeev Ratna Vallabhuni, A. Karthik, CH. V. Sai Kumar, B. Varun, P. Veerendra, and Srisailam Nayak, "Comparative Analysis of 8-Bit Manchester Carry Chain Adder Using FinFET at 18nm Technology," Proceedings of the Third International Conference on Intelligent Sustainable Systems [ICISS 2020], Palladam, India, December 4-5, 2020, pp. 1158-1162.
- [41] Manchala Sreeja, Vallabhuni Vijay, "A Unique Approach To Provide Security For Women By Using Smart Device," European Journal of Molecular & Clinical Medicine, vol. 7, iss. 1, 2020, pp. 3669-3683.
- [42] V. Vijay, and Avireni Srinivasulu, "Grounded Resistor and Capacitor based Square Wave Generator using CMOS DCCII," in proceedings of the 2016 IEEE International Conference on Inventive Computation Technologies (IEEE ICICT-2016), Coimbatore, India, August 26-27, 2016, pp. 79-82.
- [43] V. Siva Nagaraju, P. Ashok Babu, Vallabhuni Rajeev Ratna, Ramya Mariserla, "Design and Implementation of Low Power 32-bit Comparator," Proceedings of the International Conference on IoT Based Control Networks and Intelligent Systems (ICICNIS 2020), Palai, India, December 10-11, 2020, pp. 1-8.
- [44] B.M.S Rani, Divyasree Mikkili, Rajeev Ratna Vallabhuni, Chandra Shaker Pittala, Vijay Vallabhuni, Suneetha Bobbillaipati, H. Bhavani Naga Prasanna, "Retinal Vascular Disease Detection from Retinal Fundus Images Using Machine Learning," Australia patent 2020101450.
- [45] Venkateswarlu, S.C., Kumar, N.U., Kumar, N.S., Karthik, A., and Vijay, V., "Implementation of Area optimized Low power Multiplication and Accumulation," International Journal of Innovative Technology and Exploring Engineering (IJITEE), vol. 9, iss. 9, 2019, pp. 2278-3075.
- [46] Vallabhuni Rajeev Ratna, M. Saritha, Saipreethi. N, V. Vijay, P. Chandra Shaker, M. Divya, Shaik Sadulla, "High Speed Energy Efficient Multiplier Using 20nm FinFET Technology," Proceedings of the International Conference on IoT Based Control Networks and Intelligent Systems (ICICNIS 2020), Palai, India, December 10-11, 2020, pp. 1-8.