Grenze International Journal of Engineering and Technology, June Issue

Design & Development of a Robotic Vacuum Cleaner for Domestic Applications

Yogesh Desai[1], Mallikarjun[2], Sujal Karbhari[3], Ravi G[4], Pavithra G[5] and T.C. Manjunath[6]
[1-4]Second Year UG BE (ECE) IV Sem Students, Department of Electronics & Communication Engineering, Dayananda Sagar College of Engineering, Bangalore
[5]Associate Professor, Department of Electronics & Communication Engineering, Dayananda Sagar College of Engineering, Bangalore
[6]Professor, Department of Electronics & Communication Engineering, Dayananda Sagar College of Engineering, Bangalore
Email: tcmanju@iitbombay.org

Abstract*— The project titled "Design & Development of a Robotic Vacuum Cleaner for Domestic Applications" aims to create an efficient, autonomous cleaning solution tailored for home environments. Utilizing an Arduino microcontroller, the system integrates various sensors, including ultrasonic and infrared, to enable obstacle detection and path planning. The robotic vacuum cleaner is designed to navigate autonomously, ensuring thorough floor cleaning while avoiding obstacles and optimizing cleaning paths. The project focuses on developing a cost-effective, user-friendly device that enhances home automation and convenience. The system's design, coding, and assembly processes are meticulously documented, providing a comprehensive guide for future enhancements such as wireless control and advanced navigation algorithms. This innovative approach leverages microcontroller technology to deliver a practical, smart home appliance that significantly reduces manual cleaning efforts, contributing to the advancement of domestic robotics and smart home technologies. This paper presents the design and implementation of development of a vacuum cleaner robot using an Arduino with an Android smartphone. Vacuum cleaner robot is designed to make cleaning process become easier rather than by using a manual vacuum. The main idea is primarily by having the sensor to sense any object like wall and dust. Then send the output data to an Arduino that will control the robot vacuum movement. To facilitate targeted functions interactivity in conjunction with high quality sensors plays essential roles. Meanwhile, for the manually controlled cleaning mode operation, the user can control the movement of the robot vacuum by using an Android smartphone through android application. The major aim of the system is to provide cleaning assistance to individuals who cannot manage to do the same due to various reasons. As it's already known that a vacuum's suction is caused by a difference in air pressure. A fan/exhaust driven by an electric motor (as desired) reduces the pressure inside the suction creating module. Atmospheric pressure then pushes the air through the surface and into the nozzle, hence collecting the dust in the collector.

***Index Terms*— Robotic vacuum cleaner, Domestic applications, Arduino microcontroller, Home automation, Autonomous cleaning, Obstacle detection, Path planning, Ultrasonic sensors, Infrared sensors, Motor control, Smart home technology, Cost-effective solution, Automatic floor cleaning, Microcontroller-based system, Robotics and automation**

I. INTRODUCTION

In an age where technology intertwines seamlessly with everyday life, the concept of the smart home has evolved

Grenze ID: 01.GIJET.10.2.492

from a futuristic dream to a tangible reality. Among the myriads of innovative home automation projects, the robotic vacuum cleaner stands out as a fusion of practicality and elegance. Cleaning the floor from dust is one of the routine activities carried out every day. This activity is not only at home but also in offices and shopping centres. Various types of technology have been created to facilitate human activities in their work every day. One of them is the technology developed in robotics technology [1][2].
Robots can replace human activities that regularly or occasionally must be done at unscheduled times. In terms of cleaning the floor, it is necessary to develop robots as a substitute for floor cleaning officers. The Arduino programming involved here is to interface and control the motion of the motors and subsequently the wheels of the moving robot. We have also incorporated a servo motor wheel to maximize the degrees of freedom of the system. We use reuseable and durable components like a plastic bottle, medical gauze, etc, thus establishing the economic factor of the system. We what to establish that the user can easily make the system and have it at his/her disposal whenever required [3][4].

II. METHODOLOGY

This robotic vacuum cleaner includes components like motor drivers, Bluetooth module and vacuum cleaner which are connected to microcontroller and the power supply through battery is given. The microcontroller controls the wheels and motors for obstacle detection and to move in a particular direction as directed. Bluetooth Module is used to control the robot through the area required. Input command is given from mobile through Bluetooth application. The hardware components of robot and application are integrated using microcontroller. There are already pre-defined variables stored in the Arduino Uno to perform desired actions [5][6].
The Arduino Uno sends the command to motor driver and ESC (Electronic speed controller). The Motion of brushless DC motor and geared motor is controlled through Arduino. The Motion of brushless DC motor and geared motor is controlled through Arduino. A Bluetooth module (HC-05) is used to receive the signals which contain information regarding which direction the robot should move. A mobile interface can be used to transmit these signals via Bluetooth. Here we have used a mobile application. The battery is used to power the motor so that the fan starts rotating. The fan can be connected such that there are two possible outcomes during rotation: expulsion of air; and suction of air. It is an eco-accommodating cleaner, it can work productively regarding covering region, time and cost [7][8].

III. TOOLS USED (HARDWARE/SOFTWARE)

Arduino Uno, Bluetooth Module, Moto Driver Sheild ,12V Lead Acid Battery ,30 & 100 rpm Geared Motor, IRFZ44N MOSFET, Toggle switches, Vacuum blades, Servo Motor, Ultrasonic Sensors, Wheels [9][10].

IV. APPLICATIONS & ADVANTAGES

Advantages [11][12]

- Cleans without human interference. Robotic vacuum cleaner is convenient and saves time. It is good at detecting boundaries.
- Compared to traditional vacuums, robotic vacuums are much quieter.
- Using mobile application as a remote- control device, you can control the robot much easier.
- Robotic vacuum cleaners are easy to store and easy to carry.
- Robotic vacuum cleaners are economical and cost-efficient.

Applications [13][14]

- Residential Cleaning: Ideal for daily maintenance of floors in homes, particularly in living rooms, kitchens, and bedrooms.
- Elderly or Disabled Individuals*: Provides a practical solution for individuals who may have difficulty operating a traditional vacuum cleaner.
- Commercial Spaces: Smaller retail stores and boutique shops can use robotic vacuums to maintain cleanliness without constant manual intervention.
- Laboratories and Research Facilities: Helps in maintaining clean and sterile environments, which are crucial in scientific research settings.
- Warehouses and Storage Areas: Smaller robotic vacuums can be used to clean office areas within larger warehouses, ensuring that employee workspaces remain clean [30].

V. EXPECTED OUTPUT

The expected outcome is functioning of the robot to serve the cleaning purpose efficiently. To be able to control the robot via Bluetooth connectivity. Implementation of ultra sonic sensors for Automation [15][16].

1. The IEEE paper "Towards implementing efficient autonomous vacuum cleaning systems" [2020] acknowledges that existing autonomous vacuum cleaners often suffer from limitations in: Navigation: They may rely on random movement patterns, leading to missed areas and inefficiencies. Obstacle Avoidance: Limited ability to navigate around furniture and objects can hinder thorough cleaning. Mapping and Coverage: Difficulty creating accurate maps of the environment and ensuring complete floor coverage reduces cleaning effectiveness.
2. The IEEE paper "A smart autonomous floor cleaner with an Android-based controller" [2017] by Anshu Prakash Murdan and Pawan Kumar Ramkissoon. Focus on User Control and Smart Features. The paper explores the design of a smart autonomous floor cleaner controlled using an Android application. This user-friendly approach allows for: Remote Control: Users can operate the cleaner remotely via their Android device, providing flexibility and convenience. Scheduling: The ability to schedule cleaning sessions through the app enhances automation and user control over cleaning routines.
3. "Robotic Vacuum Cleaner Using Arduino with Wi-Fi" [2018], this IEEE paper explores the development of a budget-friendly and Wi-Fi controlled autonomous vacuum cleaner. Focus on Accessibility and Control.

VI. ARDUINO PLATFORM [21][22]

The paper likely details the design of a robotic vacuum cleaner using Arduino, a popular open-source microcontroller platform. This choice makes the project potentially more affordable and accessible for hobbyists and makers compared to using high-end robotics controllers. Wi-Fi Integration: The inclusion of Wi-Fi connectivity suggests the possibility of remote control and potentially smartphone app integration for user convenience. The Fig. 1 shows the block-diagram of the robotic vacuum cleaner. The Fig. 2 shows the circuit diagram of the proposed robotic vacuum cleaner

1. *Arduino Setup:* Begin by setting up your Arduino with the necessary operating system (like IDE) and ensure its connected to a motors and wheels.
2. *Design and Layout*: Plan the design and covering of your cleaner model, including the size of the model using 3D printing, the placement of components, and any additional features you want to include.
3. *Hardware Assembly*: Assemble the hardware components, including the servo motor, Bluetooth module, Arduino, HC-05 sensor and any additional peripherals or sensors you want to incorporate.
4. *Software Configuration*: Install and configure software to code the Arduino and initializing the functions using the code to all the motors.
5. *Testing and Optimization*: Test the cleaner to ensure all components are working correctly. Optimize the software and hardware configuration as needed to improve functionality and user experience.

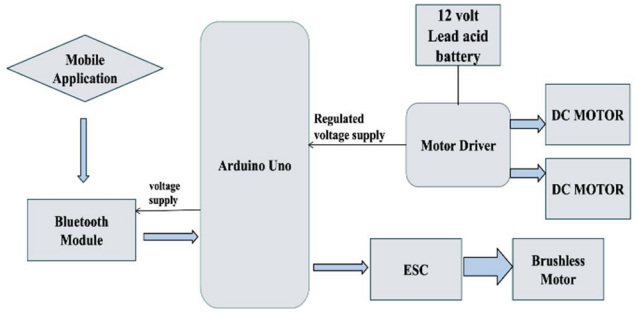

Fig. 1: Block-diagram of the robotic vacuum cleaner

VII. HARDWARE [19][20]

- *Arduino uno:* The Arduino uno serves as the core processing unit for the robotic cleaner, handling data processing, and controlling the movement of the cleaner.
- *Bluetooth Module*: The HC-05 Bluetooth Module acts as a bridge between two devices, enabling them to establish a secure and efficient communication channel. It provides seamless connectivity between devices; this module boasts outstanding capabilities that cater to a wide range of applications.

- *Geared Motor*: A geared motor is a mechanical device consisting of an electric motor and a speed reducer. Gear motors are used in a wide range of industrial and commercial sectors, where efficient power transmission, high torque and speed control are required.
- *Motor Driver:* This L298N Motor Driver Module is a high-power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.
- *Lead Acid Battery*: A lead acid battery is a rechargeable battery that uses lead and sulfuric acid to function. It consists of two electrodes submerged in an electrolyte of sulfuric acid. The positive electrode is made of grains of metallic lead oxide, while the negative electrode is attached to a grid of metallic lead.

VIII. SOFTWARE [17][18]

- *Arduino IDE*: The Arduino Software (IDE) makes it easy to write code and upload it to the board offline.
- *Module Dependencies*: Depending on the desired functionalities, additional software modules may be required.
- *Fussion 360*: Fusion 360 is an integrated 3D modelling, CAD, CAM, CAE, PCB, collaboration and data management platform whereas AutoCAD is a 2D and 3D CAD drafting software used for 3D printing.

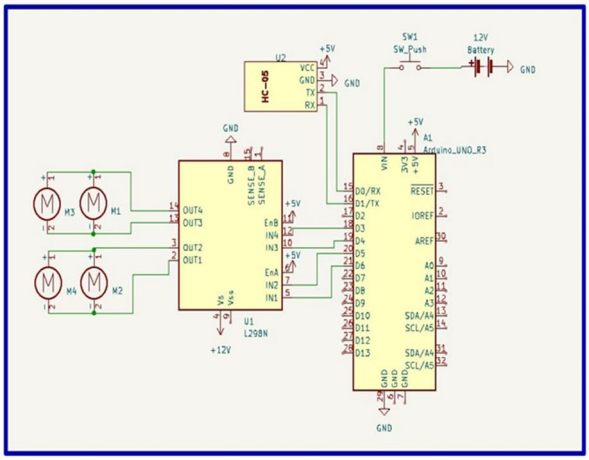

Fig. 2 : Circuit diagram of the proposed robotic vaccum cleaner

IX. CONCLUSIONS

In conclusion, the "*Design & Development of a Robotic Vacuum Cleaner for Domestic Applications*" project successfully showcases the potential of integrating Arduino microcontroller technology with robotics to create an efficient and autonomous cleaning solution. The system's ability to navigate and clean a home environment independently, using a combination of ultrasonic and infrared sensors for obstacle detection and path planning, highlights significant advancements in home automation. The project has demonstrated that a cost-effective, user-friendly robotic vacuum cleaner can be developed to perform essential cleaning tasks, reducing manual effort and enhancing daily convenience for users [24][25].

The meticulous documentation of the design, coding, and assembly processes provides a valuable foundation for future improvements and innovations. Potential enhancements such as wireless control, advanced navigation algorithms, and additional cleaning functionalities can further increase the system's effectiveness and adaptability to different domestic environments. This project not only contributes to the field of domestic robotics but also underscores the broader implications of integrating smart technologies into everyday life, paving the way for more sophisticated and efficient home automation solutions [26][27].

This mini project presents the design and implementation of a sophisticated robotic vacuum cleaner using Arduino uno. The robotic cleaner serves as a multifunctional cleaning process like vacuum and mopping essential for daily activities. Utilizing Arduino uno for the processing unit of the vacuum cleaner to control the movement of the cleaner module. Further development to this model can be made automatic using Ultrasonic sensors. Development of this device will be extremely useful for individuals that are not able to constantly move from one place to another (such as elderly person or people with physical disabilities); or can be used by people who might constantly not be available at home [28][29].

REFERENCES

[1] P.B. Jarande, S.P. Murakar, N. Vast and N.P. Ubale, S.S. Saraf, "Robotic Vacuum Cleaner Using Arduino with Wifi", 2018 Second International Conference on Inventive Communication and Computational Technologies (ICICCT), Coimbatore, India, 2018.

[2] Anshu Prakash Murdan and Pawan Kumar Ramkissoon, "A smart autonomous floor cleaner with an Android-based controller", 2020 3rd International Conference on Emerging Trends in Electrical, Electronic and Communications Engineering (ELECOM), Balaclava, Mauritius.

[3] W.H.C. Wickramaarachchi, M.A.P. Chamikara and R.A.C.H. Ratnayake, "Towards implementing efficient autonomous vacuum cleaning systems", 2017 IEEE International Conference on Industrial and Information Systems (ICIIS), Peradeniya, Sri Lanka.

[4] Dr. J.Hameed Hussain, R.Sharavanan for "Floor Cleaning Machine By Remote Control", 2017.

[5] Akanksha Vyas, Satyam Chourasia, Shubham Antapurkar, and Raghvendra Prasad. "Arduino Based Dry & Wet Automatic Floor Cleaner", 2018.

[6] Sagaragouda, Sahana. G. Malagali, Srujana C.H., Dr. Pavithra G., Dr. T.C.Manjunath, "Connecting safety on the railway tracks : A novel train accident prevention strategy & its implementation in Indian Railways", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 1-5, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.001

[7] Sharon Rodrigues, Shubhangi Saha, Siddhant Singh, Vipul Singh, Dr. Pavithra G., Dr. T.C.Manjunath, "Advaya Bot - Radiologist assistant robot development & its usage in healthcare applications", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 6-11, Nov-Dec. 2023. DOI: https://doi.org/10.46647/ijetms.2023.v07i06.002

[8] K. Nanda Kiran, Kumari Ayush, Kishore V.M., Vinod Kumar Malkapure, Dr. Pavithra G., Dr. T.C.Manjunath, "SILKBOT : Orchestrating Silk Symphony - A Comprehensive Approach towards Silk Production and Enhancement in Sericulture Applications", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 17-22, Nov-Dec. 2023. DOI :

[9] Madan Kumar C., Manvanth G., Mohan Y., Nagesh B.R., Dr. Pavithra G., Dr. T.C.Manjunath, "Dhenu Svasthya Bot: An AI driven well-being and health monitoring setup for science and engineering applications", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 23-28, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.004

[10] Vaishanavi Patil, Vaibhav V.K., Thyagaraj B.G., Suprith Gowda G., Dr. Pavithra G., Dr. T.C.Manjunath, "MUG MAGIC - Design and Development of Low-Cost Mini Tea and Coffee Machine using AI-ML concepts", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, pp. 29-34, Impact Factor 5.672 (2022), Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.006

[11] Geethanjali G.C., Dr. Pavithra G., Dr. T.C.Manjunath, "Design Of Voltage Level Shifter Using Regulated Cross Coupled Pull Up Networks", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, pp. 35-39, Impact Factor 5.672 (2022), Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.007

[12] Lakshmi N., Dr. Pavithra G., Dr. T.C.Manjunath, "Design Of Three Stage Comparator Using 90nm Technology", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 40-43, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.008

[13] Afira Ansari, Akshat Kumar, Ananth Agarwal, Anupriya D., Dr. Pavithra G., Dr. T.C.Manjunath, "Development Of Solar Powered Cold Storage For Agricultural Purposes", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 44-49, Nov-Dec. 2023.

[14] Madhushree K., Keerthana M., Poornima J., R. Kavya, Padmavathi M., Dr. Pavithra G., Dr. T.C.Manjunath, "An Advanced Multi-Functional Robotic dog with Enhanced Sensory and Communication Proficiencies", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 50-56, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.010

[15] Akanksha Dash, Amrutha G., Krutika S. Ganpur, Sneha Chatter, Dr. Pavithra G., Dr. T.C.Manjunath, "Hardware Prototype Development Of a Robotic Car To Avoid Obstacles", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 57-61, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.011

[16] S.G. Swathi, Aliya Bhandari, Srushti M. Bapparad, Kavya A., Dr. Pavithra G., Dr. T.C.Manjunath, "A Speech Cum Audio Controlled Robotic System Development For Generic Purposes", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 62-66, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.012

[17] Anagha, Jhanavi M., Khushi M.S., Nithin Kumar S., Dr. Pavithra G., Dr. T.C.Manjunath, "Development Of a Human Condition System To Check Various Biological Parameters", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 67-71, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.013

[18] Apeksha U., Chithrashree G.S., Divya N.M., Shalmali S. Mankikar, Dr. Pavithra G., Dr. T.C.Manjunath, "Secure LoRa Wireless Communication for Soldier Tracking with the help of Interfacing Two Arduino Uno Devices in Military

Operations", International Journal of Engineering Technology and Management Sciences (IJETMS), Impact Factor 5.672 (2022), Vol. 7, Issue 6, ISSN: 2581-4621, pp. 72-76, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.014

[19] Biswendu Biswas, Madan V.L., Rakesh B.S., Prathik Chandrapal, Dr. Pavithra G., Dr. T.C.Manjunath, "A New Concept Of Surveying Of Navigation Using High Speed Moving Drones Using UAS", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 77-81, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.015

[20] Kavya, Sanjana S., Sangireddy Harika, Teju Raju Gaddadaguli, Dr. Pavithra G., Dr. T.C.Manjunath, "Creating a Low Cost Flying Drone Using The Concepts Of Radio Frequencies", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 82-86, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.016

[21] Leena Jeyakumar, Prerana Aithal, Vismitha R., Pradhan Aithal, Dr. Pavithra G., Dr. T.C.Manjunath, "Conceptual View Of Designing a Smart Intelligent Connecting Link (Bridge) Between 2 Islands Over a Water Surface", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 87-91, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.017

[22] Mallikarjun, Sujal S. Karbhari, Ravi Gorentla, Ajaykumar B.M., Dr. Pavithra G., Dr. T.C.Manjunath, "Design & Development Of a Dc Charging Unit For Various Engineering Applications", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 92-95, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.018

[23] Abhishek, Sujith M.S., Jeevan D., Pulluru Kamalesh, Dr. Pavithra G., Dr. T.C.Manjunath, "TARA Development for Small Industrial Applications", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 96-100, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.019

[24] Vivek Agarwal, Aniruddh D.P., Harshith S., Ojas Rajesh Kinkale, Dr. Ninu Rachel Phillip, Dr. T.C.Manjunath, Dr. Pavithra G., "Design Of a Sensor Web-Based Interface System For Social Connect Networks", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 101-106, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.020

[25] Yogesh A. Desai, Priyansh Kashyap, Kshitij Prasad, Thrisha Karaning, Dr. Pavithra G., Dr. T.C.Manjunath, "Development Of a Liquid/Fluid Removing System Module For Medical Hospitals Using IoT", International Journal of Engineering Technology and Management Sciences (IJETMS), Vol. 7, Issue 6, ISSN: 2581-4621, Impact Factor 5.672 (2022), pp. 107-110, Nov-Dec. 2023. DOI : https://doi.org/10.46647/ijetms.2023.v07i06.021

[26] Vaishnavi Patil, Dr. Pavithra G., Dr. T.C. Manjunath, "Simulation & design of a VLSI embedded system using Verilog Coding with Modelsim approach in FPGA scenarios for AI applications in automotive sectors", Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology, ISSN : 1001-4055, Vol. 44, No. 3, pp. 862 – 870, Jul. - Sept. 2023.

[27] Deekshitha P., Dr. T.C.Manjunath, Dr. Pavithra G.., "Detection of brain tumour using Deep Learning Architecture integrated with Raspberry pi based embedded systems in the field of bio-medical Engineering", Q3 Scopus Indexed Journal, Korean Journal of Physiology and Pharmacology (Korean J. Physiol. Pharmacol., KJPP), ISSN:1226-4512, E-ISSN:2093-3827, SJR 2022 0.42, H-Index 37, CiteScore 2022 - 3.1, Vol. 27, Issue 2 / 3, pp. 69-77, Aug. 2023, DOI:10.25463/kjpp.27.1.2023.9

[28] Darshan R., Dr. Pavithra G., Dr. T. C. Manjunath, "Design, development & the Implementation of a explosive detector mobile robot that could be used for applications in defense activities using the concepts of AI-ML, Computer Vision & Pattern Recognition", Scopus Journal Q3, Schimago Ranking SJR 2022 0.32, H-Index 24, Tuijin Jishu/Journal of Propulsion Technology, ISSN : 1001-4055, Vol. 44, No. 4, pp. 4919 – 4934, Jul. - Aug. 2023.

[29] H. Altan, M. E. Altun, and A. Cavdar, "Development of a Smart Vacuum Cleaner with Arduino," in Proc. 6th Int. Conf. on Advanced Computing and Communication Systems (ICACCS), Coimbatore, India, 2020, pp. 201-205.

[30] J. S. Lee, K. W. Lee, and H. G. Kim, "Design and Implementation of an Autonomous Cleaning Robot Using Arduino," in Proc. 2019 IEEE Int. Conf. on Consumer Electronics (ICCE), Las Vegas, NV, USA, 2019, pp. 456-457.