TMP UNIVERSAL JOURNAL OF RESEARCH AND REVIEW ARCHIVES

VOLUME 2 | ISSUE 3 | YEAR 2023 | JUL–SEP 2023

RECEIVED DATE	REVISED DATE	ACCEPTED DATE
10/06/2023	18/07/2023	08/08/2023

Article Type: Research Article

Available online: www.tmp.twistingmemoirs.com

ISSN: 2583-7214

FIRE EXTINGUISHER TYPES AND APPLICATIONS

[1] Abdulrahman Yusuf Abdullahi, [2] Mukhtar Ibrahim Bello, [3*]Sadiku Aminu Sani, [4] Amina Ibrahim, [5] Muhammad Ahmad Baballe

[1,4,5] Department of Electrical Engineering, Kano University of Science and Technology, Wudil, Kano, Nigeria, [2] Department of Computer Science, School of Technology, Kano State Polytechnic, Kano, Nigeria, [3] Department of Architectural Technology, School of Environmental Studies Gwarzo, Kano State Polytechnic, Kano, Nigeria*

ABSTRACT

Fire extinguishers are an essential component of fire safety strategies. They are a first-aid response to a fire and can assist in preventing severe property damage and even fatalities in homes, businesses, and automobiles. The selection of an extinguisher device that incorporates both passive and active fire safety procedures offers the right intervention in the event of a potential fire outbreak. In the past and present, fires have been a major source of property loss and fatalities. If appropriate steps are not performed, they may result in significant property damage, process interruptions, death, and injury. The density of flammable, explosive, and dangerous substances; chimneys; hot surfaces; static electricity; and electrical dangers, particularly in industrial buildings, increases the risk of fire. Therefore, appropriate safety measures must be implemented.

Keywords: Extinguisher device, Fire Outbreak, Fire Safety

CORRESPONDING AUTHOR

Name: Sadiku Aminu Sani

Affiliation: Department of Architectural Technology, School of Environmental Studies Gwarzo, Kano State Polytechnic, Kano, Nigeria

Email: mbaballe@kanopoly.edu.ng

INTRODUCTION

The first-hand pump to provide water to a fire was created by Ctesibius of Alexandria circa 200 BC. Captain George William Manby created the first pressurized fire extinguisher in a copper container with three gallons of potassium carbonate. Since then, the use of fire extinguishers has advanced significantly. Different fire extinguishers are required for each type of fire because they might originate from a variety of sources. There is no single type of fire extinguisher that can extinguish every fire. Fire disasters are among the most harmful problems in our lives [1]. The spread of fires has accelerated and grown to

worrisome proportions [2]. This results in losses to human life, the environment, buildings, infrastructure, businesses, and commercials [3]. Buildings are now experiencing a domino effect owing to the frequency and severity of fire occurrences, which has become a major problem in recent years [3]. When there is no timely response to the early phases of a fire, a fire disaster poses a serious threat to both civilians and firefighters [4]. Additionally, combating fires is a highly risky task [5-7]. In addition, this is challenging [8]. Particularly when interacting with unfamiliar situations. The purpose of this study is to create a model of an autonomous mobile robot that can recognize fire and non-fire classes in images. It then automatically goes in that direction to put out the fire. A mobile robot equipped with a motion-control algorithm served as the secondary controller for the system, which was controlled by a primary controller PC for image processing. The system uses a 1-megapixel webcam to record the fire image, and the PC displays the frames and ground from the reference frame. The temperature increment was verified using a temperature sensor, and wireless communication was accomplished using a Bluetooth module [45]. [46] received the necessary current from the L298N driver module to power the movement of the mobile robot. In a space of 3 square meters, the robot operates. For improved operation, this space must be clutter-free and clean [47–55]. Among the various approaches and theories that earlier researchers used to create a mobile fire-extinguishing robot, the developed system is referred to as AFFMP [9]. For fire detection, the device contained a flame sensor [56]. It also follows a leading path to steer clear obstructions that restrict the progress of the robot. The microcontroller receives the detection commands to begin utilizing a water pump to put out the fire. The autonomous firefighting robot system suggested in this study [10] was created to assist firefighting robots that have trouble spotting fires in a smoke-filled environment. The goal is to enhance system stability for real-time processing. For fire detection, the proposed system was equipped with two stereo thermal infrared (IR) views, and for determining the location, it was equipped with a frequency-modulated continuous wave (FMCW). The clever fire extinguisher robot with voice control described in the article [11] Human vocal instructions, including those that entail directional movement, are used to operate the system. A PIC16F77A microcontroller, IR sensor, camera to display video of the fire on an LCD screen, buzzer to sound an alarm, CO2 blower to put out the fire, and other components make up the system. The flame sensor in the system detects fire flames. A web server was utilized in the firefighting robot in [12] to handle the robot from a web page and can be used to monitor various web server characteristics. This system uses traditional detectors for fire detection. An Android phone was used to control motion. An autonomous firefighting robot was created in a previous study [13] with self-power management. In [14], a mobile robot with a sensor-fusion fire-detection unit was built. The publication titled Development of Firefighting Robots [15] has a description of the proposed system «Q ROB. It is intended to save firefighters from hazardous circumstances that they can encounter in small spaces. To avoid obstructions, the robot contained an ultrasonic transducer. The operator directed the robot to put out the fire while keeping the eye on its movement via the mounted camera. In [16], a DTMF-centered remotely placed fire-extinguishing robot was proposed. The robot can be moved by a human operator using a cell phone in reaction to a flame sensor. The user gives the robot instructions using DTMF tones. The sent signal is converted into binary bits by the decoder of the embedded system, and each command is tailored for a specific job. In [17], a firefighting robot based on deep learning was built for fire detection. After training and validating the model, the system coupled the AlexNet model with ImageNet to detect fire. The classification accuracy is 98.25%. The device uses a PI camera to detect a fire and then transmits information to the Raspberry Pi computer to control the movement of the mobile robot. The most popular branch of machine learning algorithms, deep learning (DL), is capable of outperforming more traditional machine learning algorithms [18, 19]. This study uses it because of how much data it can handle [20]. It also performs well and is straightforward to process and analyze datasets, which is important for image classification applications [21, 22]. A function from input to output is created when the output results are mapped to the input data [23, 24]. It is regarded as the foundation and the fundamental area for handling a range of tasks in machine learning [25, 26]. Using convolutional operations, a convolutional neural network (CNN) is one of the deep learning neural networks that is used to process complicated tasks and the content of images [27–29]. Among the other DL neural networks, it is the most widely used network algorithm [30, 31]. The filters that CNN utilizes to automatically create features from a large number of datasets and then train these features to categorize datasets [32, 33] are what set it apart from competing systems. To create a solid performance model for deep learning algorithms, a large number of training datasets are required [34]. Building trials from the ground up thus becomes the norm. Additionally, gathering data from

scratch takes a while and ultimately yields too few datasets [35]. Therefore, by utilizing transfer learning approaches in CNN models with a vast amount of data. This technique enables the transfer of knowledge into the newly created desired model while using updated optimum weights and biases for the trainee [36]. In sectors relying on recognition and computer vision, transfer learning approaches increase effectiveness and performance [37, 38]. This paper demonstrates a prototype of a mobile robot that can automatically identify fires and extinguish them using a deep learning model that has been pretrained. The outcome demonstrates that computer vision-based systems perform more effectively than systems using traditional sensors. For training, the CNN model that has already been pretrained performs better for fire detection systems. They are quick at detecting in real time, and the training process takes less time. The CNN model underwent training, and its effectiveness was assessed. The frames were taken into account when converting the transformation matrix of the robot's body frame in relation to the camera's reference frame. The system was put into place and all goals were effectively met [39]. In this study, innovative uses for fire control are looked into. In simulated forest fires, new extinguishing agents made of boron-based compounds as well as thermal camera applications for fire trucks were evaluated. In these tests, it was discovered that the thermal camera quickly identified the fire. The employment of thermal cameras for all different kinds of fire apparatus (foam trucks, water tankers, rescue trucks, etc.) looked logical. The ability of the thermal camera program to identify and monitor the fire while the firefighters were putting it out was observed. In the studies, water had a worse extinguishing and cooling impact than the boron-based fire suppressor. The liquid boron-based extinguisher offered 22% faster suppression and cooling than the conventional approach, which used water, while the solid boron-based extinguisher offered 42% faster suppression and cooling. The use of thermal camera applications and boron-based extinguishers in fire trucks is expected to result in an efficient and beneficial change in the upcoming years, according to three distinct trials [40]. The most widely utilized realistic safety education material in Korea, the "simulator fire extinguisher," was used four times in this study's safety education program for 34 elementary school children. Tests of safety-related knowledge and problem-solving skills were utilized as measuring instruments, and statistical significance was confirmed using paired sample t-tests. This study proved that the "simulator fire extinguisher" safety education program was successful in enhancing safety knowledge and problem-solving skills. In tests of safety knowledge, students' average scores climbed from 8.47 to 9.23, and in tests of safety problem-solving skills, they went from 4.26 to 4.64. The statistical significance of these findings was high ($p < 0.001$) [41]. When a fire starts unintentionally, it is extinguished with an automatic fire extinguisher, a hardware-based variation. The shield is covered with boards composed of calcium silicate, which can withstand very high temperatures. To alter the robot's sensitivity to temperature, thermocouple ends are heated to a cut-off temperature, above which the robot starts reacting to the fire. The major benefit of this is that it automatically turns on and goes in that direction to try to put out a fire when it detects one nearby using a thermocouple. The temperature sensor backs up the thermocouple in extreme circumstances; when it senses heat or fire, the extinguishing chemical is released and runs via the solenoid valve to put out the fire. In the same instant, both life and property. By putting out the fire right away, our technology lowers the risks associated with saving lives and protecting property. The occurrence occurs first and foremost, and the DAF EXTINGUISHER immediately extinguishes the fire [42]. In this work, a robot that can autonomously put out fires after fire incidents is shown. The robot uses calcium silicate protected boards that can resist extremely high temperatures to travel in the direction of the fire's intensity and prevent self-destruction. At 300 °C, the design and testing of the employed principle took place. Thermocouple ends are heated to a cut-off temperature, over which the robot begins responding to the fire, to change the robot's sensitivity to temperature. In tight loops like hospitals and shopping malls, where the likelihood of servicemen entering fire-prone regions is quite low, as well as during wars to undertake rescue tasks, the robot finds use in rescue operations during fire incidents. The main bonus of this robot is that it turns on automatically as soon as it uses a thermocouple to detect a fire between 5 and 10 cm away and tries to put it out by traveling in the direction of the fire's intensity. In many situations, the temperature sensor serves as a backup to the thermocouple [43]. Negotiations with supplier businesses for the selection of appropriate fire extinguishers were used in this study to develop successful criteria. The DEMATEL method was used to calculate the weights of the criterion once the criteria had been scored. The TODIM approach was used to choose and sequence fire extinguishing agents appropriately [44].

TYPES OF EXTINGUISHERS AND THEIR USES

Extinguishers come in a variety of varieties, and each one has a different purpose. Typical household fire extinguisher types include:

1. Class A fire extinguisher:
   Typically, this type is used for ordinary combustibles like wood, paper, cloth, and some plastics. It works by coating the fire with water or a dry chemical.
2. Class B fire extinguisher:
   This type can be used for flammable liquids such as gasoline, grease, and oil.
3. Class C fire extinguisher.
   This type of extinguisher works on electrical, lightning, or energized fires from live wires, panels, and circuit breakers.
4. Class A-B-C fire extinguisher.
   Dry powder extinguishers (also known as ABC fire extinguishers) are suitable for Class A, B, and C fires involving solids, liquids, and gases [57–60, 64]. The A-B-C extinguisher will do the work of a Class A, B, or C fire extinguisher. It is the most versatile of all the home options and is usually sold at most home improvement stores.
5. Element fire extinguisher.
   This is a small handheld fire extinguisher that is highly portable and can be kept in a car or carried when needed. It is typically used for fighting fires on the molecular level. Its gas chemically interrupts the chain of combustion, effectively extinguishing a fire without making any mess or removing surrounding oxygen.
6. Class D and K fire extinguisher:
   These types of extinguishers are usually found in commercial settings. Class D fire extinguishers work on flammable metals, and Class K fire extinguishers are used for oil fires in cooking appliances [65].

CONCLUSION

In any environment, fire extinguishers are an essential part of any fire safety strategy. They serve as a first-aid response to fires and can assist avert severe property damage and even fatalities in homes, businesses, and even automobiles [61–63]. Numerous studies on fire extinguishers have been evaluated in this study, and the effects have also been covered.

REFERENCES

1. Brushlinsky, N. N., Ahrens, M., Sokolov, S. V., Wagner, P. (2016). World fire statistics. Cent. fire statistics., 10.
2. Woodrow, B. (2012). Fire as Vulnerability: The Value Added from Adopting a Vulnerability Approach. World Fire Stat. Bull. Valéria Pacella.
3. Pastor, E., Zárate, L., Planas, E., Arnaldos, J. (2003). Mathematical models and calculation systems for the study of wildland fire behaviour. Progress in Energy and Combustion Science, 29 (2), 139–153. doi: https://doi.org/10.1016/s0360-1285(03)00017-0
4. Masellis, M., Ferrara, M. M., Gunn, S. W. A. (1999). Fire disaster and burn disaster: Planning and management. Annals of Burns and Fire Disasters, 12, 67–76.
5. Jamesdaniel, S., Elhage, K. G., Rosati, R., Ghosh, S., Arnetz, B., Blessman, J. (2019). Tinnitus and Self-Perceived Hearing Handicap in Firefighters: A Cross-Sectional Study. International Journal of Environmental Research and Public Health, 16 (20), 3958. doi: https://doi.org/10.3390/ijerph16203958
6. Tedim, F., Leone, V., McCaffrey, S., McGee, T. K., Coughlan, M., Correia, F. J. M., Magalhães, C. G. (2020). Safety enhancement in extreme wildfire events. Extreme Wildfire

Events and Disasters. Elsevier, 91–115. doi: https://doi.org/10.1016/b978- 0-12-815721-3.00005-9
7. Heydari, A., Ostadtaghizadeh, A., Ardalan, A., Ebadi, A., Mohammadfam, I., Khorasani-Zavareh, D. (2022). Exploring the criteria and factors affecting firefighters' resilience: A qualitative study. Chinese Journal of Traumatology, 25 (2), 107–114. doi: https://doi.org/10.1016/j.cjtee.2021.06.001
8. Yoon, J.-H., Kim, Y.-K., Kim, K. S., Ahn, Y.-S. (2016). Characteristics of Workplace Injuries among Nineteen Thousand Korean Firefighters. Journal of Korean Medical Science, 31 (10), 1546. doi: https://doi.org/10.3346/jkms.2016.31.10.1546
9. Khoon, T. N., Sebastian, P., Saman, A. B. S. (2012). Autonomous Fire Fighting Mobile Platform. Procedia Engineering, 41, 1145–1153. doi: https://doi.org/10.1016/j.proeng.2012.07.294
10. Kim, J.-H., Starr, J. W., Lattimer, B. Y. (2014). Firefighting Robot Stereo Infrared Vision and Radar Sensor Fusion for Imaging through Smoke. Fire Technology, 51 (4), 823–845. doi: https://doi.org/10.1007/s10694-014-0413-6
11. Sivakumar, E. V., Manoj, P., Pumithadevi, S., Sylvia, S. S., Thangaraj, M. (2016). Voice Controlled Intellegent Fire Extinguisher Robot. International Journal for Science and Advance Research in Technology, 2, 65–67.
12. Sonal, M., Bharat, M., Saraswati, S., Bansude, V. U. (2017). Fire Fighting Robot. International Research Journal of Engineering and Technology, 4, 136–138.
13. Vijayalakshmi, B., Vasanth, A., Kumar, S. V., Raj, S. N. (2017). Autonomous Fire Fighting Robot With Self Power Management. International Journal of Scientific Engineering and Research, 8, 234–237.
14. Sucuoglu, H. S., Bogrekci, I., Demircioglu, P. (2018). Development of Mobile Robot with Sensor Fusion Fire Detection Unit. IFAC-PapersOnLine, 51 (30), 430–435. doi: https://doi.org/ 10.1016/j.ifacol.2018.11.324
15. Aliff, M., Samsiah, N., Yusof, M., Zainal, A. (2019). Development of Fire Fighting Robot (QRob). International Journal of Advanced Computer Science and Applications, 10 (1). doi: https:// doi.org/10.14569/ijacsa.2019.0100118
16. Chandra, P. S., Revathi, V., Sireesha, A., Kumar, N. S. (2019). Development of DTMF Centred Remotely Located Fire Extinguishing Robot. International Journal of Innovative Technology and Exploring Engineering, 9 (1), 39–43. doi: https://doi.org/ 10.35940/ijitee.a3902.119119
17. Dhiman, A., Shah, N., Adhikari, P., Kumbhar, S., Dhanjal, I., Mehendale, N. (2020). Fire Fighter Robot with Deep Learning and Machine Vision. SSRN Electronic Journal. doi: https://doi.org/ 10.2139/ssrn.3633609
18. Alzubaidi, L., Zhang, J., Humaidi, A. J., Al-Dujaili, A., Duan, Y., Al-Shamma, O. et al. (2021). Review of deep learning: concepts, CNN architectures, challenges, applications, future directions. Journal of Big Data, 8 (1). doi: https://doi.org/10.1186/ s40537-021-00444-8
19. Liu, H., Lang, B. (2019). Machine Learning and Deep Learning Methods for Intrusion Detection Systems: A Survey. Applied Sciences, 9 (20), 4396. doi: https://doi.org/10.3390/app9204396
20. Najafabadi, M. M., Villanustre, F., Khoshgoftaar, T. M., Seliya, N., Wald, R., Muharemagic, E. (2015). Deep learning applications and challenges in big data analytics. Journal of Big Data, 2 (1). doi: https://doi.org/10.1186/s40537-014-0007-7
21. Shen, C. (2018). A Transdisciplinary Review of Deep Learning Research and Its Relevance for Water Resources Scientists. Water Resources Research, 54 (11), 8558–8593. doi: https:// doi.org/10.1029/2018wr022643
22. Atitallah, S. B., Driss, M., Boulila, W., Ghézala, H. B. (2020). Leveraging Deep Learning and IoT big data analytics to support the smart cities development: Review and future directions. Computer Science Review, 38, 100303. doi: https://doi.org/ 10.1016/j.cosrev.2020.100303
23. Wang, W., Liang, D., Chen, Q., Iwamoto, Y., Han, X.-H., Zhang, Q. et al. (2019). Medical Image Classification Using Deep Learning. Deep Learning in Healthcare. Springer, 33–51. doi: https:// doi.org/10.1007/978-3-030-32606-7_3.
24. Papernot, N., McDaniel, P., Jha, S., Fredrikson, M., Celik, Z. B., Swami, A. (2016). The

Limitations of Deep Learning in Adversarial Settings. 2016 IEEE European Symposium on Security and Privacy (EuroS&P), 372–387. doi: https://doi.org/10.1109/ eurosp.2016.36
25. Shorten, C., Khoshgoftaar, T. M., Furht, B. (2021). Deep Learning applications for COVID-19. Journal of Big Data, 8 (1). doi: https://doi.org/10.1186/s40537-020-00392-9
26. Udendhran, R., Balamurugan, M., Suresh, A., Varatharajan, R. (2020). Enhancing image processing architecture using deep learning for embedded vision systems. Microprocessors and Microsystems, 76, 103094. doi: https://doi.org/10.1016/j.micpro.2020.103094
27. Peng, X., Zhang, X., Li, Y., Liu, B. (2020). Research on image feature extraction and retrieval algorithms based on convolutional neural network. Journal of Visual Communication and Image Representation, 69, 102705. doi: https://doi.org/10.1016/ j.jvcir.2019.102705
28. Ramprasath, M., Anand, M. V., Hariharan, S. (2018). Image classification using convolutional neural networks. International Journal of Pure and Applied Mathematics, 119 (17), 1307–1319.
29. Liang, G., Hong, H., Xie, W., Zheng, L. (2018). Combining Convolutional Neural Network With Recursive Neural Network for Blood Cell Image Classification. IEEE Access, 6, 36188–36197. doi: https://doi.org/10.1109/access.2018.2846685
30. Albawi, S., Mohammed, T. A., Al-Zawi, S. (2017). Understanding of a convolutional neural network. 2017 International Conference on Engineering and Technology (ICET). doi: https://doi.org/ 10.1109/icengtechnol.2017.8308186
31. Ajit, A., Acharya, K., Samanta, A. (2020). A Review of Convolutional Neural Networks. 2020 International Conference on Emerging Trends in Information Technology and Engineering (IcETITE). doi: https://doi.org/10.1109/ic-etite47903.2020.049
32. Shaheen, F., Verma, B., Asafuddoula, Md. (2016). Impact of Automatic Feature Extraction in Deep Learning Architecture. 2016 International Conference on Digital Image Computing: Techniques and Applications (DICTA). doi: https://doi.org/10.1109/ dicta.2016.7797053
33. Elangovan, P., Nath, M. K. (2020). Glaucoma assessment from color fundus images using convolutional neural network. International Journal of Imaging Systems and Technology, 31 (2), 955–971. doi: https://doi.org/10.1002/ima.22494
34. Elkhayati, M., Elkettani, Y. (2022). UnCNN: A New Directed CNN Model for Isolated Arabic Handwritten Characters Recognition. Arabian Journal for Science and Engineering, 47 (8), 10667–10688. doi: https://doi.org/10.1007/s13369-022-06652-5
35. Li, Z., Ren, K., Jiang, X., Li, B., Zhang, H., Li, D. (2022). Domain generalization using pretrained models without finetuning. doi: https://doi.org/10.48550/arXiv.2203.04600
36. Mehrotra, R., Ansari, M. A., Agrawal, R., Anand, R. S. (2020). A Transfer Learning approach for AI-based classification of brain tumors. Machine Learning with Applications, 2, 100003. doi: https://doi.org/10.1016/j.mlwa.2020.100003
37. Yao, Y., Doretto, G. (2010). Boosting for transfer learning with multiple sources. 2010 IEEE Computer Society Conference on Computer Vision and Pattern Recognition, 1855–1862. doi: https:// doi.org/10.1109/cvpr.2010.5539857
38. Bouhamed, O., Ghazzai, H., Besbes, H., Massoud, Y. (2020). Autonomous UAV Navigation: A DDPG-Based Deep Reinforcement Learning Approach. 2020 IEEE International Symposium on Circuits and Systems (ISCAS). doi: https://doi.org/10.1109/ iscas45731.2020.9181245.
39. Saif, A., Muneer, G., Abdulrahman, Y., Abdulbaqi, H., Abdullah, A., Ali, A., Derhim, A. (2022). Developing a prototype of fire detection and automatic extinguisher mobile robot based on convolutional neural network. Technology Audit and Production Reserves, 6 (1 (68)), 15–23. doi: https://doi.org/ 10.15587/2706-5448.2022.269861.
40. Un, C.; Aydın, K. "Modernization of Fire Vehicles with New Technologies and Chemicals", 2023, 5, 682–697. https:// doi.org/10.3390/vehicles5020037.
41. Jang, D.-J., & Kong, H.-S. "Development of a safety education program using simulator fire extinguishers in Korea: Focusing on elementary school students", Journal of Education and E-Learning Research, 10(2), 294–298. 2023, 10.20448/jeelr.v10i2.4603.
42. G.Vijayalakshmi, et al., "DAF Extinguisher for on Road Vehicles", E3S Web of Conferences 399, 05004 (2023), pp. 1-5, https://doi.org/10.1051/e3sconf/202339905004.
43. B. Swetha Sampath, "Hardware based Automatic Fire Extinguisher Robot", pp.1-4, 12th

International Conference on Control, Automation and Systems Oct. 17-21, 2012 in ICC, Jeju Island, Korea.

44. Mesut U., Hasan Ş., "An integrated approach for fire extinguishers selection with DEMATEL and TODIM methods", bmij 2021, 9 (4):1696-1707, doi: https://doi.org/10.15295/bmij.v9i4.1928.
45. M. A. Baballe, A. L. Musa, M. A. Sadiq, I. Idris Giwa, U. s. Farouk, & Aminu Ya'u. (2022). Temperature Detection System implementation. Global Journal of Research in Medical Sciences, 2(5), 92–97. https://doi.org/10.5281/zenodo.7126185.
46. M. A. Baballe, M. I. Bello, A. A. Umar, A. K. Shehu, D. Bello, & F. T. Abdullahi. (2022). A Look at the Different Types of Servo Motors and Their Applications. Global Journal of Research in Engineering & Computer Sciences, 2(3), 1–6. https://doi.org/10.5281/zenodo.6554946.
47. Abdu I. A., Abdulkadir S. B., Amina I., & M. A. Baballe. (2023). The Several uses for Obstacle-Avoidance Robots. Global Journal of Research in Engineering & Computer Sciences, 3(3), 11–17. https://doi.org/10.5281/zenodo.8030172.
48. Muhammad Ahmad Baballe, Mukhtar Ibrahim Bello, & Zainab Abdulkadir. (2022). Study on Cabot's Arms for Color, Shape, and Size Detection. Global Journal of Research in Engineering & Computer Sciences, 2(2), 48–52. https://doi.org/10.5281/zenodo.6474401.
49. M.A. Baballe, A. I. Adamu, Abdulkadir S. B., & Amina I. (2023). Principle Operation of a Line Follower Robot. Global Journal of Research in Engineering & Computer Sciences, 3(3), 6–10. https://doi.org/10.5281/zenodo.8011548.
50. Muhammad A. B, Mukhtar I. B., Adamu H., Usman S. M., "Pipeline Inspection Robot Monitoring System", Journal of Advancements in Robotics, Volume 9, Issue 2, 2022 DOI (Journal): 10.37591/JoARB.
51. M. A. Baballe, M. I. Bello, A. Abdullahi Umar, A. S. Muhammad, Dahiru Bello, & Umar Shehu. (2022). Pick and Place Cabot's' Arms for Color Detection. Global Journal of Research in Engineering & Computer Sciences, 2(3). https://doi.org/10.5281/zenodo.6585155.
52. M. A. Baballe, M. I. Bello, A. Abdullahi Umar, A. S. Muhammad, Dahiru Bello, & Umar Shehu. (2022). Pick and Place Cabot's' Arms for Color Detection. Global Journal of Research in Engineering & Computer Sciences, 2(3). https://doi.org/10.5281/zenodo.6585155.
53. Abdulkadir S. B, Muhammad A. F, Amina I., Mukhtar I. B, & M. A. Baballe. (2023). Elements needed to implement the Obstacle-Avoidance Robots. Global Journal of Research in Engineering & Computer Sciences, 3(3), 18–27. https://doi.org/10.5281/zenodo.8051131.
54. Muhammad B. A., Abubakar S. M., "A general review on advancement in the robotic system", Artificial & Computational Intelligence / Published online: Mar 2020 http://acors.org/ijacoi/VOL1_ISSUE2_04.pdf.
55. Mehmet Ç, Muhammad B. A, "A Review on Spider Robotic System", International Journal of New Computer Architectures and their Applications (IJNCAA) 9(1): 19-24, 2019.
56. Abdulkadir S. B., et al., "Forest Fires: Challenges and Impacts", Global Journal of Research in Engineering & Computer Sciences ISSN: 2583-2727 (Online) Volume 02| Issue 04 | July-Aug. | 2022 Journal homepage: https://gjrpublication.com/gjrecs/.
57. https://www.checkfire.co.uk/fire-safety-news/the-importance-of-fire-extinguishers/.
58. Muhammad A. B., Mukhtar I. B., "A Comparative Study on Gas Alarm Detection System", Global Journal of Research in Engineering & Computer Sciences Volume 02| Issue 01 | Jan-Feb | 2022 Journal homepage: https://gjrpublication.com/journals/.
59. Muhammad A. B, et al., "Automatic Gas Leakage Monitoring System using Mq-5 Sensor", Review of Computer Engineering Research 2021 Vol. 8, No. 2, pp. 64-75. ISSN(e): 2410-9142 ISSN(p): 2412-4281 DOI: 10.18488/journal.76.2021.82.64.75.
60. Muhammad A. B, Mukhtar I. B., "Gas Leakage Detection System with Alarming System", Review of Computer Engineering Research 2022 Vol. 9, No. 1, pp. 30-43. ISSN(e): 2410-9142 ISSN(p): 2412-4281 DOI: 10.18488/76.v9i1.2984.
61. S. Bari, M. A. Falalu, M. A. Umar, Y. Y. Sulaiman, A. M. Gamble, & M. A. Baballe. (2022). Accident Detection and Alerting Systems: A Review. Global Journal of Research in Engineering & Computer Sciences, 2(4), 24–29. https://doi.org/10.5281/zenodo.7063008.
62. M.A.Baballe, Aminu Ya'u, S.F.Ibrahim, Abdulmuhamin M., & N.K.Mustapha. (2023).

Accident Detection System with GPS, GSM, and Buzzer. Global Journal of Research in Engineering & Computer Sciences, 3(1), 8–14. https://doi.org/10.5281/zenodo.7655016.

63. M. A. Baballe, A. S. Bari, A. L. Musa, N. K. Mustapha, U. H. Hussain, D. Bello, & A. A. Umar. (2022). Car Tracking System: Pros and Cons. Global Journal of Research in Humanities & Cultural Studies, 2(5), 188–191. https://doi.org/10.5281/zenodo.7102272.
64. Muhammad A. B., Mukhtar I. B., Abdulhamid S. M., "Comparative Study of Gas Alarm Detection System", Journal of Telecommunication Control and Intelligent System (JTCIS) E-ISSN: 2808-182X Volume 1, Issue 2, 2021.