Remotely Controlled Firefighting Robot with ESP32-CAM Module

Ayman Yahya
Department of Electrical Engineering
Palestine Technical University-Kadoorie
Tulkarm, Palestine

Arbad Sarhan
Department of Electrical Engineering
Palestine Technical University-Kadoorie
Tulkarm, Palestine

Lewaa Omar
Department of Electrical Engineering
Palestine Technical University-Kadoorie
Tulkarm, Palestine

Majd Derar
Department of Electrical Engineering
Palestine Technical University-Kadoorie
Tulkarm, Palestine

Bassam Al-Qadi
Department of Electrical Engineering
Palestine Technical University-Kadoorie
Tulkarm, Palestine
b.qaddi@ptuk.edu.ps

Samer Alsadi
Department of Electrical Engineering
Palestine Technical University-Kadoorie
Tulkarm, Palestine
s.alsadi@ptuk.edu.ps

Tareq Foqha
Department of Electrical Engineering
Arab American University
Jenin, Palestine
tareq.fuqaha@aaup.edu

Louai A. Maghrabi
Department of Software Engineering,
College of Engineering,
University of Business and Technology
Jeddah, Saudi Arabia
l.maghrabi@ubt.edu.sa

Mohammad Kanan
College of Engineering
University of Business and Technology
Jeddah, Saudi Arabia
Coolege of Engineering
Zarqa University
Zarqa, Jordan
m.kanan@ubt.edu.sa

***Abstract*—Firefighting is one of the most dangerous professions due to its unsafe and constantly changing environment. Firefighters may be required to operate under conditions with an elevated level of uncertainty and must make time-critical decisions using insufficient information. Firefighting robots are specialized robots that are designed to assist with firefighting and rescue operations. These robots can be used to enter hazardous environments that may be too dangerous for human firefighters, such as buildings that are on fire or have collapsed. In this study, we propose a prototype for a remotely controlled firefighting robot that is equipped with a water pump. The robot uses Wi-Fi based ESP32-CAM module that will assist the firefighting and rescue operations by providing a video streaming from the fire environment. This will help the operator to make the correct decisions and movements to perform the firefighting task effectively. In addition, the camera module will provide the operator with updated information on the environmental conditions and will help search for trapped people.**

Keywords—Firefighting Robot, ESP32, Water pump.

I. Introduction

Firefighting robots are specialized robots that are designed to assist with firefighting and rescue operations. These robots can be used to enter hazardous environments that may be too dangerous for human firefighters, such as buildings that are on fire or have collapsed [1], [2].

There are several types of firefighting robots, each designed to perform specific tasks. Some firefighting robots are equipped with sensors and cameras to help locate the source of the fire and determine the best course of action. Other robots are equipped with extinguishers or water cannons to help put out the fire. Moreover, other robots are designed to assist with rescue operations, such as searching for and rescuing people who are trapped in a burning building [3], [4].

Firefighting robots can be controlled remotely by a human operator, or they can be programmed to perform certain tasks autonomously. They can be used in a variety of settings and can be equipped with several types of equipment and tools to help them perform their tasks effectively. Overall, firefighting robots are a valuable tool in the fight against fires and can help to keep human firefighters safe while they work to protect lives and property [5]–[11].

When developing and producing robots for tasks in harsh environments, careful consideration is essential in analyzing physical prototypes. These prototypes are known for their agile motion and exceptional ability to navigate challenging terrain without continuous tracks [12]. Firefighting is one of the most dangerous professions due to its unsafe and constantly changing environment. Firefighters may be required to operate under conditions with an elevated level of uncertainty and must make time-critical decisions using insufficient information [13]–[16].

Firefighters are required to make time-critical decisions. Firefighting robots are a valuable tool in the fight against fires and can help to keep human firefighters safe. In this study, a prototype for a firefighting robot that can be remotely controlled using Wi-Fi network is proposed. The robot prototype uses ESP32-CAM Module for real-time video streaming of the fire environment to assist the firefighter to make the necessary actions of fire extinguishing in the real-time. In addition, the video streaming allows the firefighter to get real-time information on the trapped individuals in the fire environment.

Objectives of this study are summarized as follows:

- Design a remotely controlled firefighting robot system.
- Design a robot system that can assist in rescue operations such as searching for people who are trapped in a burning building.
- Design a robot system that can save time and reduce losses when a fire occurs.

II. METHODOLOGY

The robot model dimensions are 35*35*5 cm, where metal sheet with a thickness of 5 mm was implemented, to withstand shocks with a reasonable weight, and it insulates heat wells shown in Fig. 1.

Fig. 1. Model implementation.

After implementing the initial design, various tests on the newly proposed model were conducted to make sure that the motors are suitable for the design as shown in Fig. 2. Then, the model was plated as shown in Fig. 3.

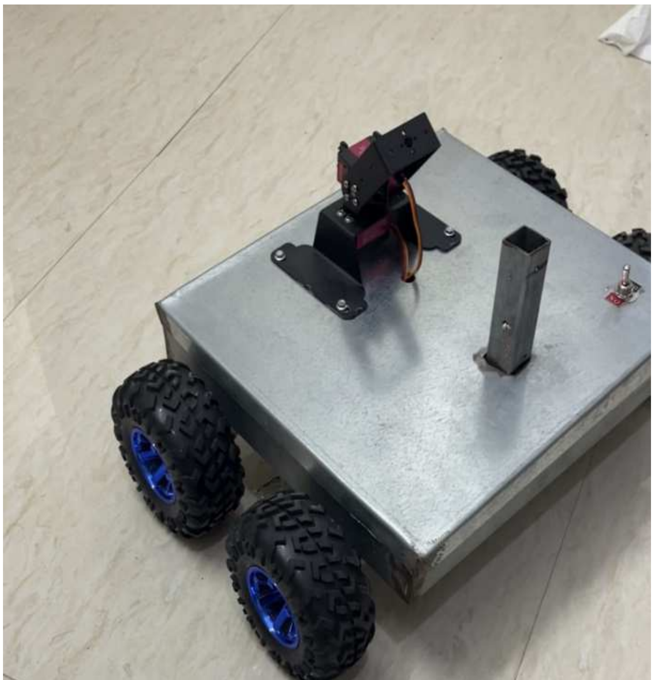

Fig. 2. Initial model testing.

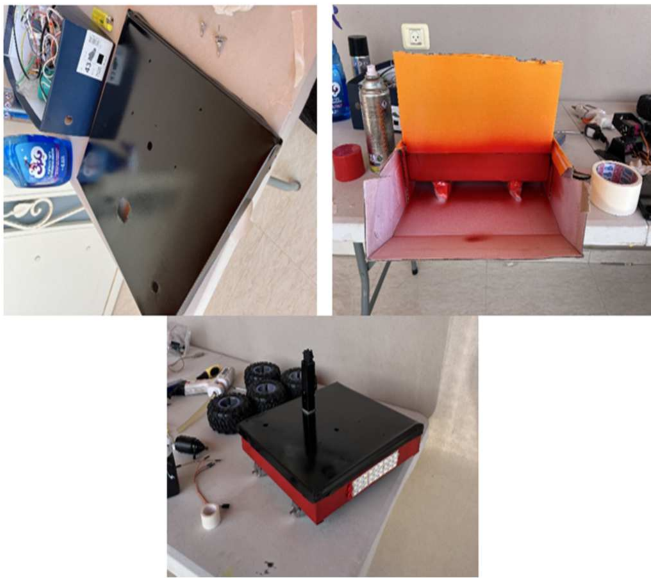

Fig. 3. Plating process.

Then, the internal circuitry was implemented and fixed to sustain any vibration or shock as shown in Fig. 4. The robot operation depends on two things: the camera module and the water pump which were finally installed as shown in Fig. 5 and Fig. 6.

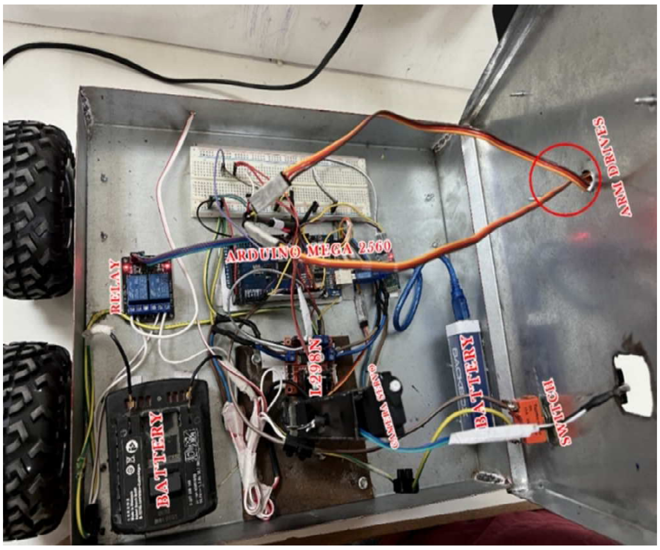

Fig. 4. The internal circuitry.

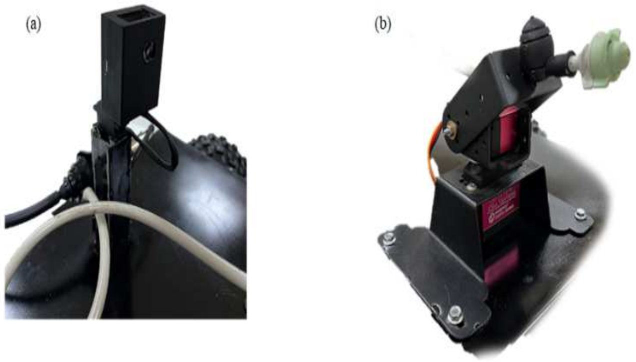

Fig. 5. (a) ESP32 camera installation (b) The water pump arm.

Fig. 6. The final form of the robot.

III. RESULTS

In this section, the main tasks of the robot prototype were tested and evaluated. In Fig. 7, the direction of robot motion, direction of the water pump arm and pumping tasks were tested.

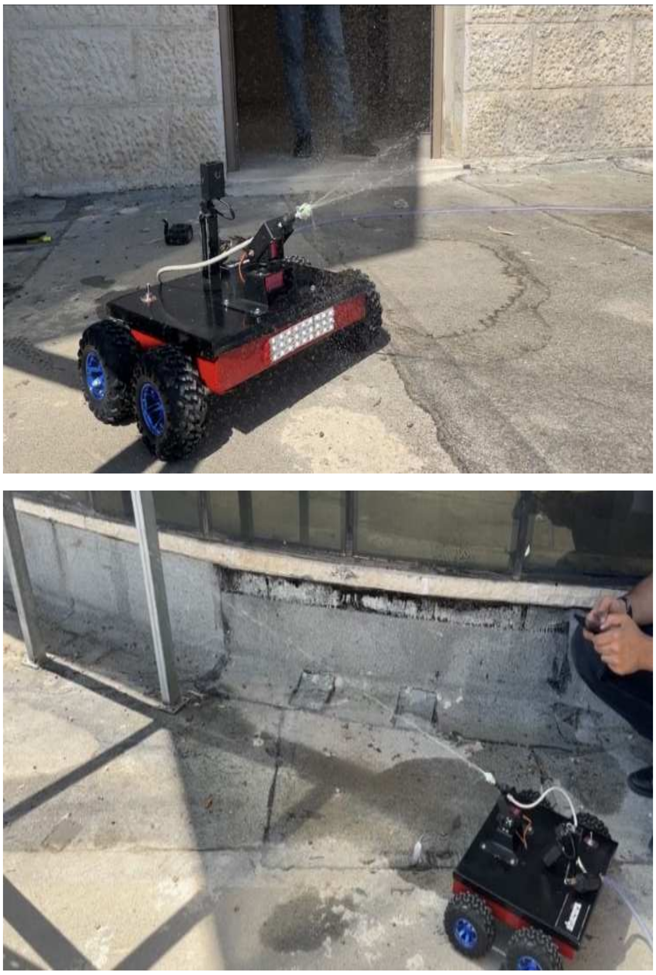

Fig. 7. Testing direction of robot motion, direction of the water pump arm and pumping tasks.

Fig. 8 illustrates the video streaming from the camera module and the application where the used can control the robot motion and tasks.

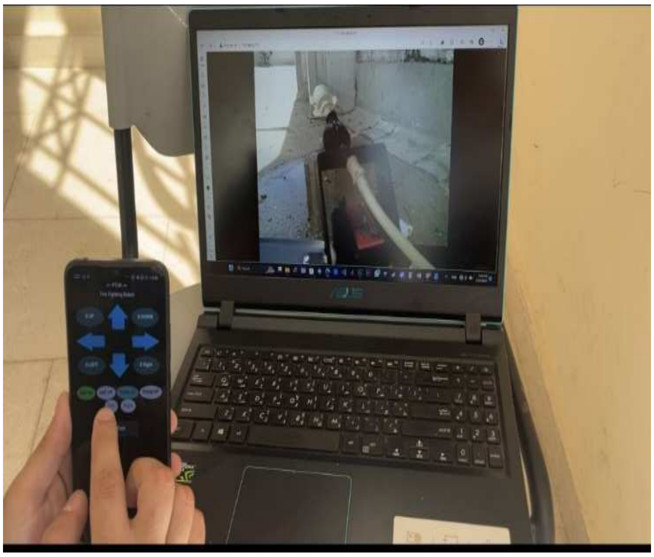

Fig. 8. Testing the cameral module and the control application.

All living things need energy to grow. Humans and animals get energy from food, while plants get energy from sunlight through photosynthesis, which shows how light affects plant growth, as it is without light, plants cannot produce the energy they need to grow. In addition to its effect on photosynthesis, light also influences plant growth in other ways. Plants grown in the shade, as opposed to those in complete darkness, show different responses. Moderate shading tends to decrease water loss (transpiration) more than it reduces photosynthesis. As a result, shaded plants may be taller and have larger leaves because they have better access to water. Increased shading leads to a more significant reduction in photosynthesis, resulting in weaker plants.

IV. CONCLUSIONS

In this study, authors presented a prototype for a remotely controlled firefighting robot. The robot is equipped with a water pump and a camera module that allows for continuous video streaming from the fire environment through Wi-Fi network, which can help the operator to perform efficient fire extinguishing tasks and to get updated information from the environment regarding trapped people to help in evacuation. The proposed robot prototype is simple, efficient, and user-friendly because it allows the operator to control the robot motion and to perform firefighting tasks through a mobile application.

REFERENCES

[1] Y. F. Nassar and S. Y. Alsadi, "Assessment of solar energy potential in Gaza Strip-Palestine," Sustainable energy technologies and assessments, vol. 31, pp. 318–328, 2019.

[2] A. A. Makhzom et al., "Estimation of CO2 emission factor for power industry sector in Libya," in 2023 8th International Engineering Conference on Renewable Energy & Sustainability (ieCRES), IEEE, 2023, pp. 1–6.

[3] T. Foqha et al., "Optimal Coordination of Directional Overcurrent Relays Using Hybrid Firefly–Genetic Algorithm," Energies (Basel), vol. 16, no. 14, p. 5328, 2023.

[4] T. Foqha, S. Alsadi, A. Elrashidi, and N. Salman, "Optimizing Firefly Algorithm for Directional Overcurrent Relay Coordination: A case study on the Impact of Parameter Settings," Information

Sciences Letters, vol. 12, no. 7, pp. 3205–3227, Jul. 2023, doi: 10.18576/isl/120745.

[5] Y. F. Nassar, H. J. El-Khozondar, S. O. Belhaj, S. Y. Alsadi, and N. M. Abuhamoud, “View Factors in Horizontal Plane Fixed-Mode Solar PV Fields,” Front Energy Res, vol. 10, p. 859075, 2022.

[6] S. Alsadi and T. Foqha, “Mass flow rate optimization in solar heating systems based on a flat-plate solar collector: A case study,” 2021.

[7] Y. Nassar, S. Alsadi, K. A. Ali, A. H. Yousef, and A. F. Massoud, “Numerical analysis and optimization of area contribution of the PV cells in the PV/T flat-plate solar air heating collector,” 2019.

[8] K. Abdulmawjood, S. Alsadi, S. S. Refaat, and W. G. Morsi, “Characteristic study of solar photovoltaic array under different partial shading conditions,” IEEE Access, vol. 10, pp. 6856–6866, 2022.

[9] S. Y. Alsadi and Y. F. Nassar, “A numerical simulation of a stationary solar field augmented by plane reflectors: Optimum design parameters,” Smart grid and renewable energy, vol. 8, no. 7, pp. 221–239, 2017.

[10] S. Alsadi, Y. Nassar, and A. Ali, “General polynomial for optimizing the tilt angle of flat solar energy harvesters based on ASHRAE clear sky model in mid and high latitudes,” 2016.

[11] T. Foqha, S. Alsadi, S. S. Refaat, and K. Abdulmawjood, “Experimental Validation of a Mitigation Method of Ferranti Effect in Transmission Line,” IEEE Access, vol. 11, pp. 15878–15895, 2023.

[12] Attar, Hani, et al. "Zoomorphic mobile robot development for vertical movement based on the geometrical family caterpillar." Computational Intelligence and Neuroscience 2022 (2022).

[13] S. Y. Alsadi and Y. F. Nassar, “Estimation of solar irradiance on solar fields: an analytical approach and experimental results,” IEEE Trans Sustain Energy, vol. 8, no. 4, pp. 1601–1608, 2017.

[14] Y. F. Nassar, A. A. Hafez, and S. Y. Alsadi, “Multi-factorial comparison for 24 distinct transposition models for inclined surface solar irradiance computation in the state of Palestine: A case study,” Front Energy Res, vol. 7, p. 163, 2020.

[15] W. G. Hopkins, Plant development. Infobase Publishing, 2006.

[16] T. Foqha et al., “A New Iterative Approach for Designing Passive Harmonic Filters for Variable Frequency Drives,” Appl. Math, vol. 17, no. 3, pp. 453–468, 2023.

[17] M. Kanan, et al. "Voltage Profile Power Quality Effects In Radial Distribution Feeder Medium Voltage 33kilovolt And Remedial Measures." International Journal Of Scientific & Technology Research Volume 9, Issue 02, February 2020.