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Exploration Robot using Artificial Intelligence

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Abstract
This research paper introduces a robot created to assist in search and rescue missions, in disaster stricken areas following events such as earthquakes, floods or conflicts. Conventional search methods often fall short. Pose risks when trying to locate survivors trapped under collapsed structures. This robot powered by AI tackles this challenge by blending control with a compact agile design. Its small stature enables it to maneuver through spaces and gaps amid the debris where survivors are typically located. With a camera and sophisticated AI algorithms onboard the robot can identify signs of life like movement heat signals or even faint noises. This leads to an enhancement in the effectiveness and safety of search and rescue efforts compared to excavation or depending solely on visual scans. The upcoming sections of this report will delve into the robots design and development process delving into its capabilities and the specific AI methods utilized. We will discuss the impact of this technology, in saving lives during disasters and promoting rescue missions for first responders.

Keywords: 1- Robotics; 2- YOLO-V8;3- Artificial intelligence; 4- Raspberry Pi ;5- Preserving.

1. Introduction

In the century there have been 522 significant earthquakes [1]. leading to a worldwide death toll exceeding 430,000 [2]. The majority of deaths occur due, to buildings collapsing and trapping people beneath the rubble. Indeed, an unhurt and healthy adult who has access to fresh air can often live for around 72 hours. The survival percentage for survivors may be much higher, at 80%, if they are rescued within 48 hours of a collapse. However, after 72 hours, the survival rate decreases rapidly and exponentially. [3] The time restriction may be significantly reduced as a result of a scarcity of air supply, ambient temperature, the health status of the casualty, and other factors. Hence, in order to decrease the number of deaths after a natural calamity, it is crucial to promptly identify those who have survived and are trapped inside fallen buildings. The present search strategy relies on survivors' testimonies to determine the potential existence of fatalities under the debris. Rescue operations often follow a series of sequential phases. Initially, the rescue team use canines to gain entry into the designated location in order to conduct a thorough search for any individuals who may have been harmed and are visible on the surface. Following the incident the team involved in the rescue used video cameras to examine the situation, beneath the rubble. Their main aim is to verify if there are people trapped underneath [4]. However their key focus is to assess two factors in the search area; identifying spots where survivors could be found and determining the stability of the debris volume [5]. This assessment is subjective. May change due to instability and uncertain conditions beneath the rubble. Rescue workers face risks when entering collapsed buildings due, to aftershocks that could further weaken the structures integrity. Rescue workers are, at risk of experiencing forms of stress [6]. Physical, cognitive, emotional or behavioral. Thus it's vital for rescue teams to swiftly locate people trapped under debris without entering the area. To enhance safety and speed up victim identification during rescue missions a specialized robot has been developed. This robot, equipped with AI technology known as the YOLO V8 model can accurately. Categorize human bodies using sophisticated algorithms. It also utilizes cues to detect individuals and assess their movements while employing waves for navigation, around obstacles. This innovation aims to ensure the safety of both those needing rescue and the rescuers themselves.

1.1 .Issue Description:

- Applications and Use Cases: Investigate the many situations and contexts in which exploration robots may be used, such as disaster response, planetary exploration, deep-sea research, and industrial inspection.
- issues and Limitations: Exploring the technological, ethical, and logistical issues of deploying AI-powered exploration robots, such as navigation in complicated terrain, data privacy concerns, and human-robot interaction.
- Future Trends and consequences: Discussing the future development of exploration robots, prospective advances in AI capabilities, and the larger consequences for society, such as safety, efficiency, and ethical concerns.

1.2 .Objective :

- Develop sophisticated autonomous robots by incorporating artificial intelligence technologies.
- Artificial intelligence abilities enhance the ability to make well-considered and logical decisions, as well as improve communication and engagement.
- Develop precise and logical programs and rapidly analyze data using exceptional research and exploration methods.
- Preserving human lives

2. Methods

The functionality of this robot will be explained through the diagrams and tools used to create it. The processing method that takes place within the TPU, which is the robot's brain or controller, will also be described.

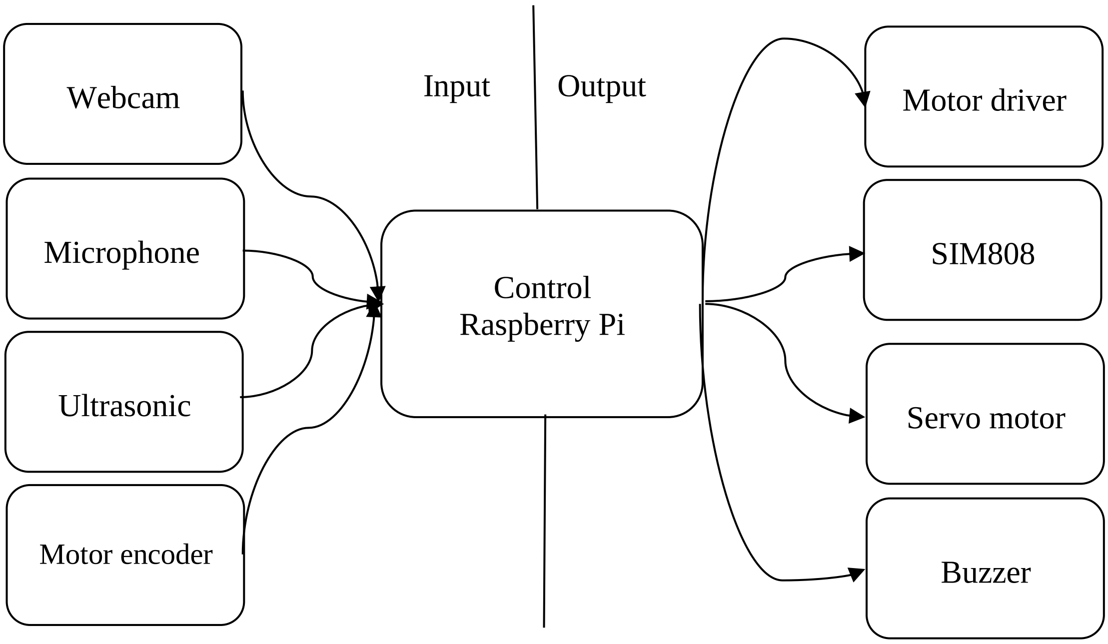

Fig 1 General architecture of the project

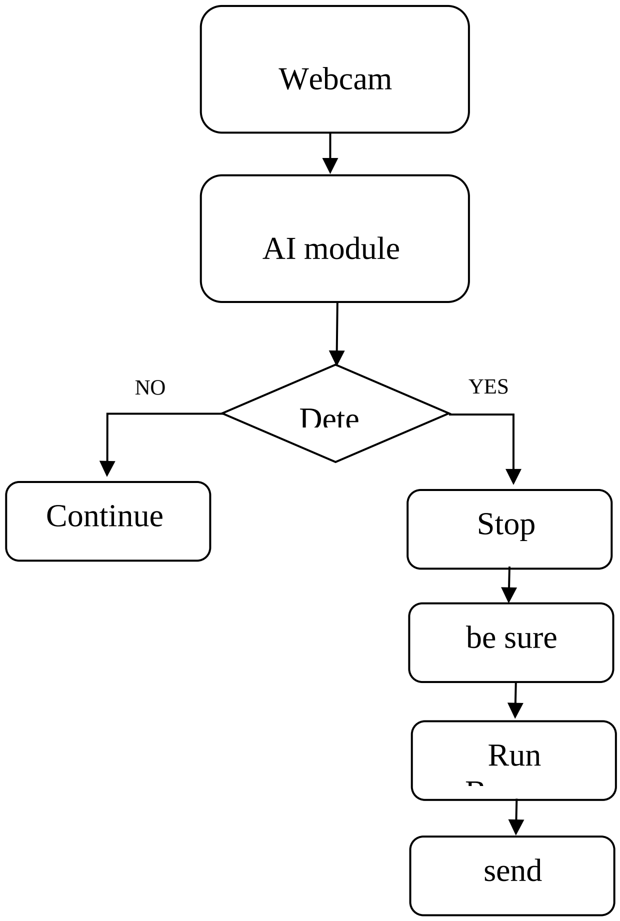

Fig2 How to process internal images

No.	**components**	Number
1	Raspberry Pi 4 8GB	1
2	Motor with encoder	4
3	Motor driver	1
4	Webcam	1
5	Servo motor	1
6	Ultrasonic	1
7	lithium Battery	4
8	3D printing structure	1
9	SIM808 module	1
10	Microphone	1
11	LED	2
12	Metal 4WD Vehicle Chassis	1

Table 1 Physical components of the robot

2.1 YOLO-V8

Within In the field of computer vision the challenge of accurately identifying objects has always been a hurdle. The YOLO series, known for its innovation, in this area has been a leader in revolutionizing object identification with each version. The latest release, YOLO v8 represents a step. This article delves into the details of YOLO v8 exploring its principles different versions available and how it surpasses previous iterations .At the core of YOLO v8 is the use of a network that can predict bounding boxes and class probabilities directly from entire images in one shot. This approach sets it apart from methods that break down images into parts for processing. By analyzing the image at once YOLO v8 achieves speed and efficiency making it essential for real time applications such, as autonomous driving and surveillance .Additionally YOLO v8 offers customized versions tailored to needs. For instance YOLO v8 Tiny is optimized for scenarios where resourcesre limited. It prioritizes speed over precision, which's particularly useful, for tasks requiring rapid responses. The YOLO v8 Small model strikes a balance between quickness and accuracy making it suitable, for scenarios. The YOLO v8 [7]. Standard model strikes a balance, between speed and accuracy effectively handling scenarios and objects. On the hand the YOLO v8 Large model stands out as a top tier option that prioritizes both precision and processing speed making it ideal for applications requiring levels of accuracy. The advancements in technology are propelling the evolution of YOLO v8. The enhancements introduced in YOLO v8 represent a leap forward. Through the integration of network architectures and training methodologies YOLO v8 excels in object detection with precision. It excels at recognizing objects of their positions lighting conditions or orientations. Despite its increased complexity YOLO v8 maintains processing speed to ensure responses in dynamic and high speed environments. Moreover it exhibits performance when dealing with partially visible or obstructed objects underscoring its reliability in real world scenarios. Additionally YOLO v8 is meticulously designed to leverage technologies like GPUs and specialized accelerators to optimize resource utilization and enhance efficiency while reducing inference times. The Significance of YOLO v8 in Computer VisionYOLO v8 represents a milestone, in the advancement of object detection techniques. The impressive achievement, in computer vision lies in its ability to seamlessly blend speed, accuracy and adaptability across scenarios. The emergence of YOLO v8 has opened up boundless opportunities in the fields of artificial intelligence and computer vision. YOLO v8 is positioned to become a fundamental technology, influencing the future of real-time object identification and introducing a new age of potential. The transition from YOLO-to-YOLO v8 represents more than simply a development, but rather a significant advancement towards a future in which smart robots effortlessly engage with the intricacies of the physical world.[8][11]

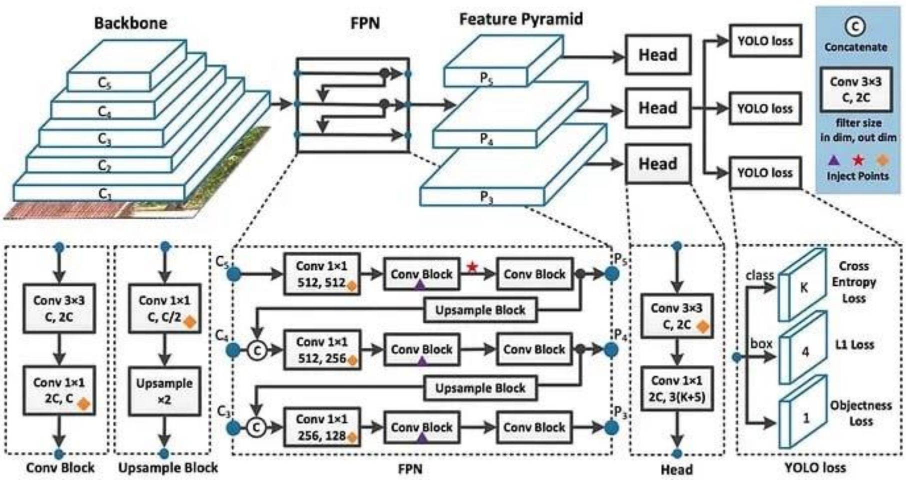

Fig 3 A picture showing a work plan YOLOv8.

2.2 Raspberry Pi

In recent times, Single Board Computers (SBCs), particularly Raspberry Pi (RPi) devices, are widely utilized due to their affordability, energy efficiency, and successful integration in various applications. Consequently, it is crucial to assess their performance in order to gain a deeper understanding of the suitability of RPis in addressing problems across different fields of knowledge. This study delves into a comparison and hands on exploration of the capabilities of five models, within the RPi family (RPi Zero W, RPi Zero 2 W, RPi 3B RPi 3B+ and RPi 4B) in various scenarios and setups. To conduct our range of experiments on RPis we made use of both our custom benchmarking tools and existing open source tools. These resources enabled us to run tests that closely mirror real world demands [13] . We assessed aspects such as CPU speed and temperature under conditions, processor efficiency during resource heavy tasks like audio processing and file compression as well, as cryptographic functions . Additionally, we assessed the performance of memory and microSD storage when performing read and write operations, measured TCP throughput across different WiFi bands, and determined TCP latency for transmitting a specific payload from a source to a destination .

The experimental results demonstrated that the RPi 4B exhibited superior performance compared to the other Single Board Computers (SBCs) that were examined. Furthermore, our investigation revealed that the RPi Zero 2 W when overclocked, together with the RPi 3B and RPi 3B+, exhibited comparable levels of performance. The RPi Zero 2 W demonstrated significantly greater capability compared to its predecessor, the RPi Zero W. It appears to be an ideal choice for an upgrade, as it shares the same physical dimensions and can be easily swapped .

The purpose of this study is to provide guidance to researchers and amateurs in choosing suitable RPis for their projects.[14][15].

Fig 4 Raspberry Pi components

2.3 3D printing structure

A special external structure has been designed for this robot so that all its contents are arranged, and in addition to that, it provides a web angle from where you can see the target.

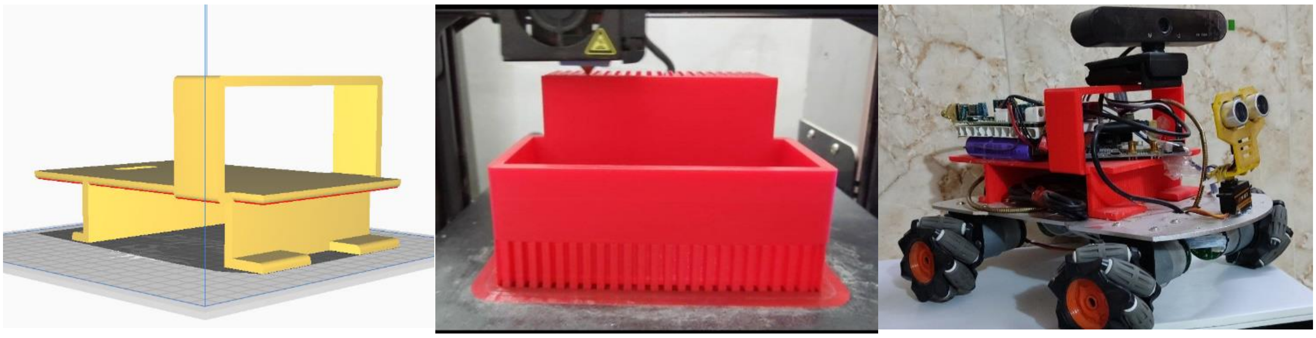

Fig 5 Stages of designing and printing the external structure

2.4 SIM808 module

The SIM808 module combines GSM, GPRS, and GPS functionality. It is based on SIMCOM's newest GSM/GPS module SIM808, which supports the GSM/GPRS Quad-Band network and incorporates GPS technology for satellite navigation. It has ultra-low power consumption in sleep mode and is equipped with a charging circuit for Li-Ion batteries, resulting in a super-long standby duration and making it ideal for projects that employ rechargeable Li-Ion batteries. It has a high GPS reception sensitivity, with 22 tracking and 66 acquisition receiver channels. The module is controlled by an AT command via UART and supports both 3.3V and 5V logical levels. The module is readily applicable to real-time tracking applications. The GPS coordinates (longitude and latitude) are read and then sent to a web server via an HTTP request. Then, using any internet browser, you can load the PHP website, such as Google Maps, to see the position in real time. You transmit the location by SMS message. The module has several helpful capabilities, and it can be connected to an Arduino or a Raspberry Pi via the TX and RX ports. It may be powered by a 5V battery power source or a lithium-ion battery.[16][17]

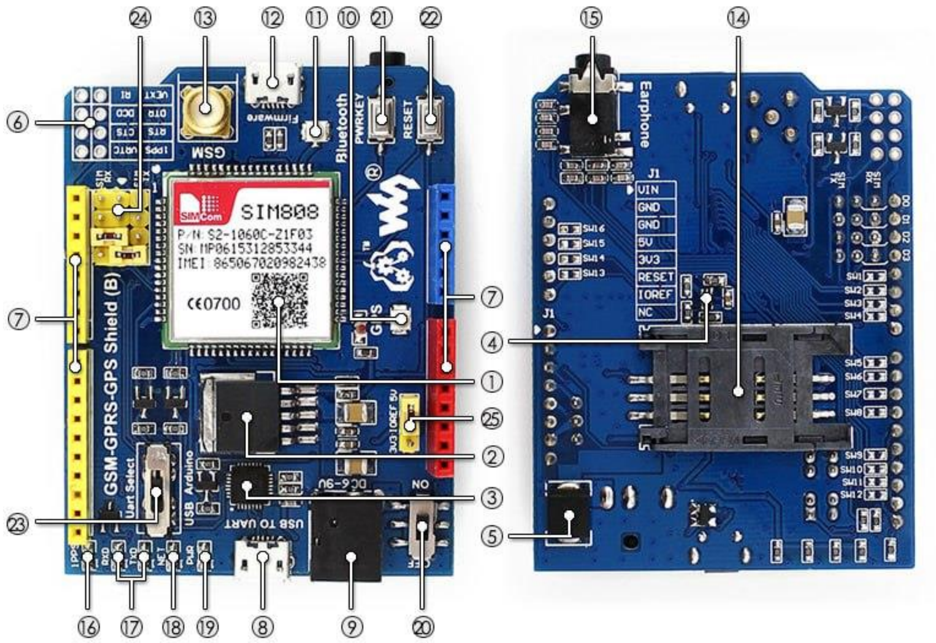

Fig 6 SIM808 components

2.5 Motor with encoder

The term "Gear Motor with Encoder DC 12V 201RPM" denotes a specific category of DC motors that are frequently employed in robotics, automation, and motion control. These motors are supplied with a gear mechanism and an encoder.[18]

Fig 7 Motor with encoder components

3. RESULT AND DISCUSSION

This robot was evaluated based on the results demonstrated and was compared to other research papers and its high efficiency.

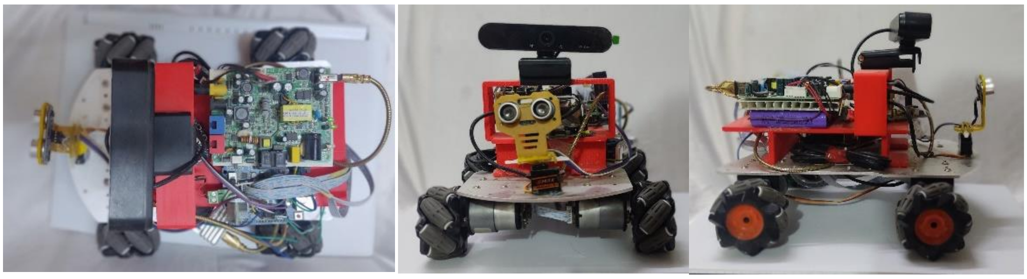

Fig 8. The final appearance of the robot after connecting all components

AI Module

As previously mentioned, YOLOv8 was used in this research paper. To clarify the differences between YOLOv8 and YOLOv5, let's compare them before discussing the results. [7][8][9][10]

Feature	YOLOv5	YOLOv8
Release Date	June 2020	Likely late 2023 or early 2024
Focus	Balance between accuracy and speed	Improved accuracy over previous models
Reported Advantages	Faster inference speed	Potentially higher mAP (mean Average Precision)
Techniques	Focus module, Path Aggregation Network (PAN)	Wasserstein Distance Loss, FasterNext, Context Aggravation
Model Sizes (Examples)	YOLOv5s (small)	YOLOv8s (smaller/similar size)
Reported FPS (Examples)	YOLOv5s: ~60 FPS (on specific GPU)	YOLOv8s: Potentially higher FPS
Reported mAP (Examples)	YOLOv5s: ~0.45 (on specific dataset)	YOLOv8s: Potentially higher mAP

Table 2 Comparison between YOLOv5 and YOLOv8.

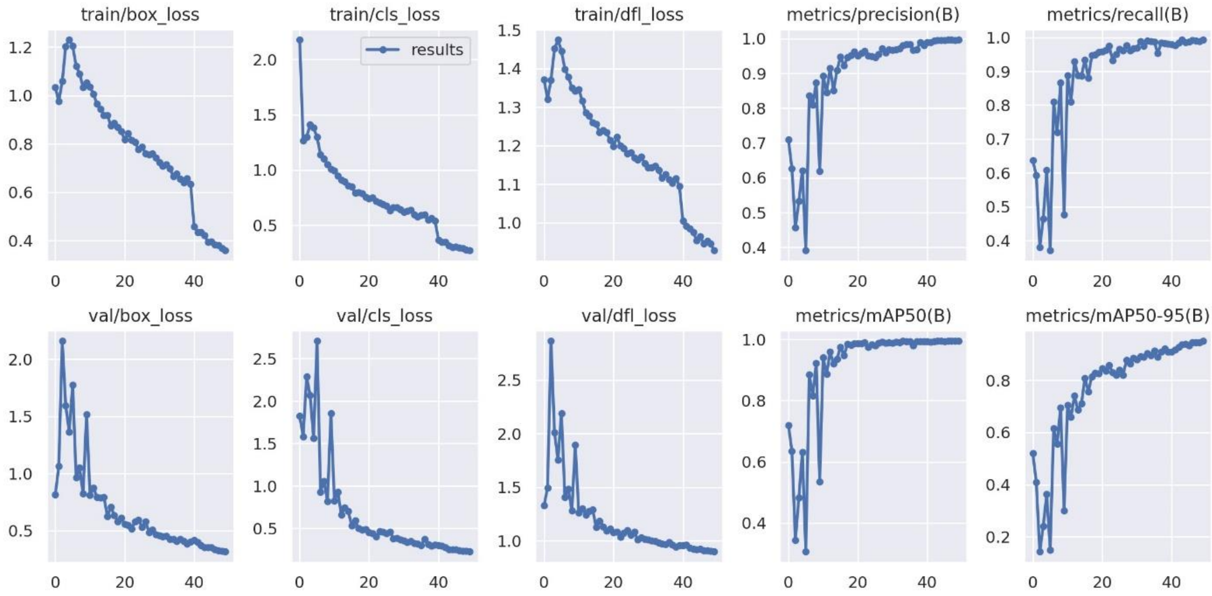

Fig 9 Artificial intelligence module training results

First row (training):
The graph most likely represents the box loss, which quantifies the alignment between the anticipated bounding boxes and the actual bounding boxes of objects. Smaller values indicate superior performance. The graph most likely represents the classification loss, which quantifies the model's ability to categorize the objects observed within the bounding boxes. Smaller values indicate superior performance. The word "train/dfl loss" is not commonly used in YOLO language. It is possible that a specialized loss function is utilized throughout the training process, which is specific to the particular implementation. The graph most likely represents the precision measure, which may have been averaged across various classes, for the bounding boxes. Precision is the measure of the proportion of correctly detected objects (true positives) to the overall number of positive predictions, which includes both true positives and false positives. Greater values indicate superior performance. The graph most likely displays the recall measure for the bounding boxes, potentially averaged across various classes. Recall is the measure of the proportion of correctly detected objects (true positives) to the total number of genuine positive cases. Greater values indicate superior performance. [12]

Validation is performed on the bottom row.
Validation metrics are depicted in comparable graphs, which evaluate the model's performance on a distinct dataset that was not utilized for training. It is ideal for the validation metrics to exhibit similar patterns as the training metrics in order to prevent overfitting.
The metrics mAP50(B) and mAP50-95(B) are being referred to. These figures likely depict the average precision (mAP) at various intersection over union (IoU) levels, potentially including 50% and 50%-95%. The mean Average accuracy (mAP) is a widely used measurement for evaluating object detection algorithms. It takes into account both accuracy and recall at various Intersection over Union (IoU) thresholds. A higher mean Average Precision (mAP) value suggests superior overall detection performance.[12]

Fig 10 Artificial intelligence module test

The figure above demonstrates that the AI module exhibits exceptional efficiency, to the extent that it can accurately identify a person's hand even when it is partially concealed by a wall. The model exhibits an exceptionally low error rate. Furthermore, although the colors in the photographs may seem alike, the module is capable of successfully discerning between them. Given the high level of efficiency of this module, it is clear that it will necessitate a substantial amount of processing power. Therefore, TensorFlow Lite was required in order to allow the model to operate on TPUs.

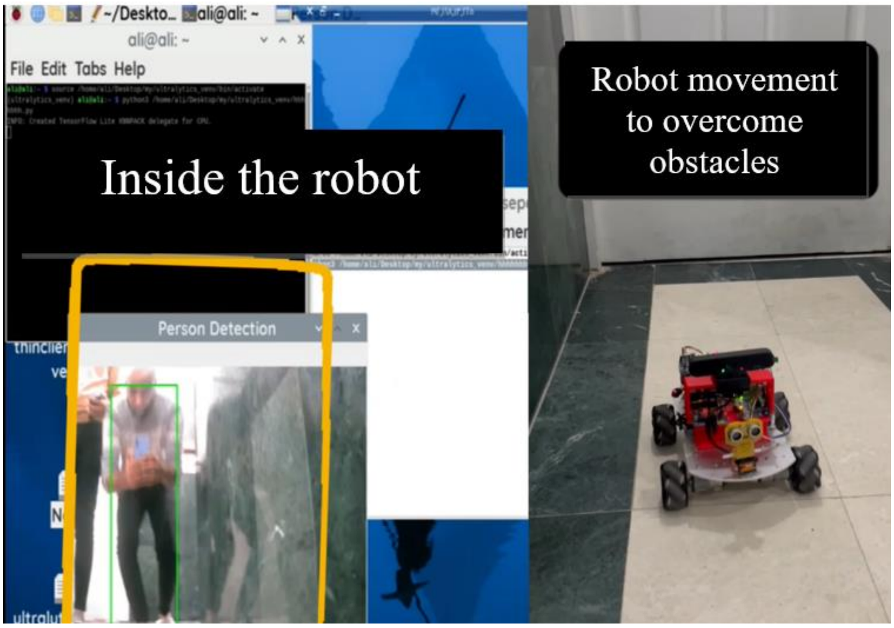

Fig 11 The operation of robots and their synchronization, such as hardware and software

Concerning the real implementation of the paradigm, this prototype showcases the functioning mechanism. The figure above depicts the process. Once the robot detects something, it stops and sends its exact location to the person or place observing it.

8. Conclusion

This paper highlights the substantial progress made in disaster response technology through the creation of an exploratory robot that utilizes artificial intelligence. This robot presents a viable option for quickly detecting and assisting survivors stuck in disaster zones by integrating a compact design with advanced AI algorithms like YOLO-V8. The incorporation of technology such as Raspberry Pi, SIM808 module, and motor with encoder improves its capability in navigation, communication, and obstacle avoidance. After conducting tests and evaluations it is evident that the AI system, YOLO V8 shows impressive performance in accurately identifying various objects, including people even in challenging scenarios, like partial obstruction. These advanced capabilities significantly enhance the efficiency of the search robot in locating survivors and potential dangers. Moreover the practicality and success of the prototype are evidenced in its real world application as it navigates obstacles effectively and transmits information about identified items or individuals. The integration of features such as webcams ultrasonic sensors and communication modules enables interaction and data exchange with rescue teams or monitoring centers.
In essence the study suggests that the search robot holds promise for revolutionizing search and rescue operations during emergencies. The swift and accurate functions of this technology in finding survivors while minimizing risks to rescuers underscore its potential to save lives and mitigate disaster impacts. With technology continually advancing, enhancements and adaptations to search robots like this one will undoubtedly play a role in enhancing the efficacy and efficiency of disaster response efforts, in the future.

Acknowledgements
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