AI-UDA Robot: Artificial Intelligence Unmanned Delivery of Ayuda using Visual Semantic SLAM and Sensor Fusion Navigation on an Embedded GPU

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ABSTRACT - In times of the deep health crisis aggravated by the extreme socioeconomic pain during the novel coronavirus pandemic, distribution of relief packages from the LGUs provide aid among the affected individuals by the community quarantine. Without proper guidelines and restrictions, the risk of rapid local transmission of the virus may be the aftermath of these programs. In this study, the proponents proposed to develop an Artificial Intelligence Unmanned Delivery of Ayuda using Visual Semantic SLAM and Sensor Fusion Navigation on an Embedded GPU for relief assistance delivery in barangays called AI-UDA Robot. The system offers automated delivery that limits person to person contact during relief packages distribution which lessens the rapid spread of the virus. Semantic Segmentation, ORB-SLAM, and GPS Fusion are used to develop a 3D Semantic Map for the target barangay's 3D semantic map. Offline and online mobile application for Android and iOS were also developed in this study to monitor load distribution, destination allocation, and will also serve as the remote controller of the AI-UDA Robot. The AI-UDA Robot for limited contact delivery is an approach towards the world of Automated ground vehicles.

Key words: Visual Semantic SLAM, Sensor Fusion Navigation on an Embedded GPU, Semantic Segmentation, ORB-SLAM, GPS Fusion

I. INTRODUCTION

The development of industrial robots originated in mid-Twentieth Century factories where they increased the efficiency of manufacturing. Their implementation was an extension of earlier industrial automation such as the first industrial robot in 1954 by George Devol. His robot was able to transfer objects from one point to another within a distance span of 12 feet [1].

The development of different techniques for autonomous navigation in real-world environments comprises one of the vital trends in the current research on robotics. In recent years, computer systems technology and artificial intelligence have developed rapidly, and research in the field of autonomous mobile robots has continued to grow with the development of artificial intelligence.

The technological advancements that allowed robots to automate private industrial spaces, such as machine learning and advanced sensors, now enable autonomous delivery robots (ADVs) to travel unassisted outdoors and deliver packages, meals, groceries, and other retail purchases to people's homes [2].

The AI-UDA Robot for limited contact delivery is an approach towards the world of automated ground vehicles. The robot would replace the conventional way of transporting materials within an allocated space. It will ensure a faster, safer, and dependable way of delivering goods and packages independently. The development of this autonomous system will be an alternative labor force for transportation of relief packages in a community. The system also will help to lessen the effort of every frontline worker in disinfecting the packed goods to be delivered

II. RELATED WORKS

A study shows that autonomous navigation for BOTs are controlled by GPS Signals that are received by UBLOX GPS Modules. GPS modules can communicate with 50 satellites for positioning and tracking. The accuracy offered by the UBLOX GPS Modules when all satellites are connected is 3m. UBLOX chips make GPS Modules serve its ultimate purpose with built-in battery back-up and built-in high gain antennas [3].

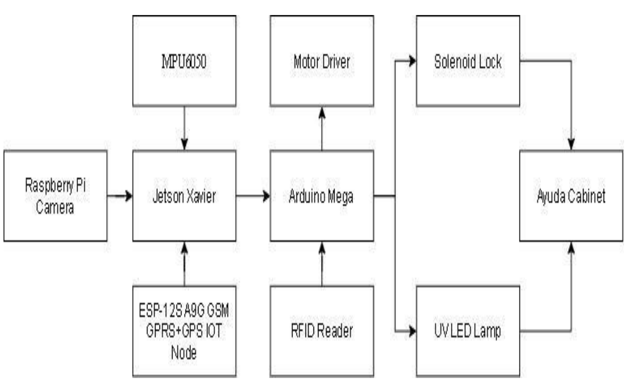
In another study that focuses on Vehicle and Pedestrian detection, Computer Vision Algorithm for image recognition and Simultaneous performance of multiple neural networks is done using a Jetson Nano (GPU). It was used to recognize objects in complex rural areas through embedded systems and verified accuracy and processing time [4].

Another study shows that robot control using an android application can also be used to control a bot from anywhere in the world at any time with the use of the internet. It states that the movement of the robot as well as the live streaming will not affect the movement and navigation. The android device attached as the camera of the bot and the robot itself will not be affected by the distance from its Android device controller as long as two devices have direct internet access [5].

Another study shows the germicidal effectiveness of UV lamps in disinfecting surfaces. It aimed to identify the effectiveness of UV Light against the wide range spread of different medically important bacteria, bacterial spores, and fungi under defined conditions. UV light distance from the surfaces and appropriate time of exposure are highly important recommendations for the disinfection process to be efficient and to properly follow standard safety guidelines. It is also identified that using germicidal UV lamps bacteria reduction is highly effective in a distance of 8 feet with exposure time of 30 minutes [6].

According to the study that focuses on the effects of contactless transportation of goods during the time of pandemic, to avoid a person-to-person interactions, an autonomous logistic vehicle is the preferred choice. The autonomous vehicle is designed to have an autonomous navigation capability by combining different algorithms and hardware systems. However, in times of failures, a human driver is still needed immediately for vehicle control [7].

III. SYSTEM ARCHITECTURE



This study focuses mainly on providing the SLAM and Navigation for the autonomous self-driving delivery of AI-UDA Robot, this requires knowledge on Machine learning Algorithms on embedded GPU device for the perception of the robot to its environment and safe driving to its target location of delivery. A vision and sensor fusion of GPS and Camera will be developed and will be used to gather data from the environment of the robot. The data will be the input for Visual and Sensor fusion-based SLAM and Navigation Algorithms wherein the output will be the 3D semantic Map of target area, localization, sensing of the environment and path for navigation. A NVIDIA Jetson Xavier NX will be used as the main processing unit of the system while an Arduino Mega will be used as the controller for the steering and throttle of the AI-UDA Robot. The user may control the robot using a mobile application for the manual control, video streaming and assignment of target location for each ayuda stored inside a QR-code UV light disinfection container.

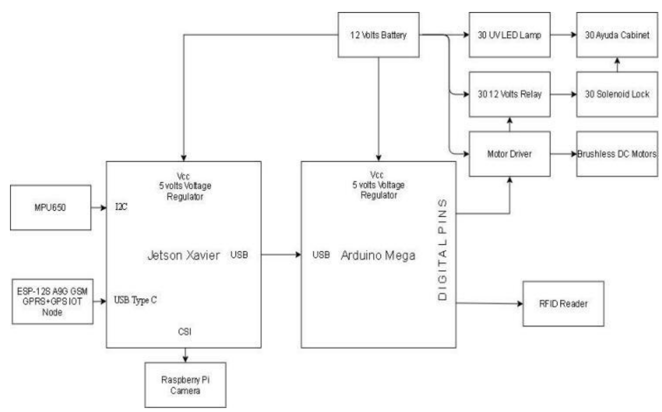


Figure 2: Circuit Diagram

The figure shown above is composed of Jetson AGX Xavier, Sensor Fusion, 12 volts battery, Arduino Mega, and the QRcode UV light disinfection Ayuda Cabinet. The Jetson AGX Xavier serves as the Main Control Unit, it contains the program for the Sensor fusion Processing, Database and Algorithm for decision making. The Arduino Microcontroller and motor driver will serve as the main controller for steering and throttle of the robot. It will be connected to the Jetson AGX Xavier via Serial Communication where it will receive information and make the appropriate adjustments to the control of steering and throttle. A 12 volts rechargeable battery with high current rating will be used as the main source of power for the whole electronics components used in the system.

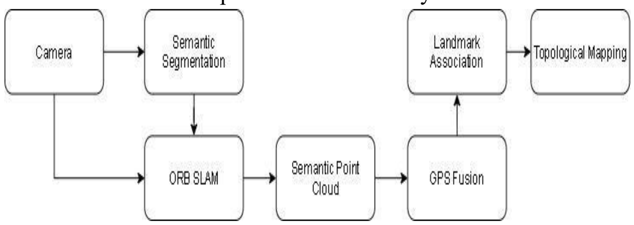


Figure 3: Block Diagram for the Semantic Segmentation

Figure 3 shows the block diagram for the Visual Semantic SLAM. It starts by capturing the frames for the current environment of the robot, then it will be inputted to the Semantic Segmentation Algorithms to classify each pixel for their semantic labels. Next the 3D reconstruction of the environment is achieved by ORB SLAM. Next is fusion of GPS coordinates and landmarks to the develop 3D Map with segmentation to develop the topological map of the target areas with semantic 3D Maps and landmarks.

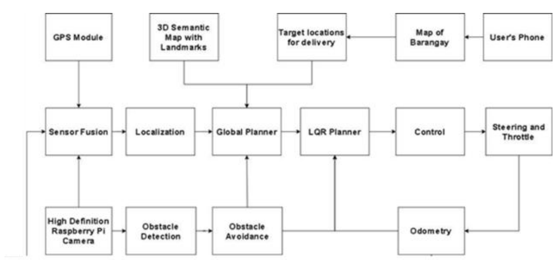


Figure 4: Flowchart of Visual Semantic

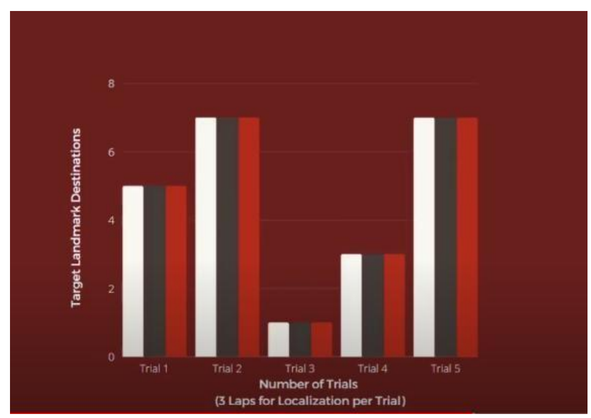
SLAM and Sensor Fusion Navigation.

The user will assign individually the target locations of each AIUDA containers in the developed AI-UDA Robot mobile application. The AI-UDA robot will drive autonomously to the target location by localizing first its start current location with the sensor fusion of Camera, and GPS module. Localization is done by matching semantic landmarks in the vehicle's environment with features from 3D semantic to determine exactly where it is in real time. It is also done by knowing the orientation and positioning in the 3D semantic map and using the GPS coordinates of the robot. The camera and the use of deep neural networks can determine obstacles and apply obstacle avoidance to it. After knowing the current location and obstacle around the robot, the next step the robot will do is the Global Path Planner, the algorithms for generating waypoints for the target location. Inside the Global Path Planner is the Linear Quadratic Regulator Planner it is used for the trajectory planning of the robot and for calculation of the right amount of steering and throttle of the robot's wheel. The robot will repeat the process until it arrives to the target location.

IV. RESULTS AND DISCUSSION

A. Target Landmark Destinations

As shown on the graph below, there are 7 target landmark destinations for the AIUDA robot, house numbers 2094-2074, 2073-2059, 2058-2040, 2039-2028, 2027-2009, 2008-1995, and 1994-1972. On the 5th trial the AIUDA robot localized all the 7 landmarks, from 2094-2074 to 1994-1972. There are some variables that affect the localization, the weather, light intensity, and other obstructions on the road such as bikes, motorcycles, and cars.



B. Data Results

After some trials and laps of localization, the AIUDA robot completely localized all the 7 target landmark destinations, house numbers 2094-2074, 2073-2059, 2058-2040, 2039-2028, 2027-2009, 2008-1995, and 1994-1972. Upon testing, the researchers come up with 7 successful localizations out of 7 target landmarks. Also, 24 identified resident locations out of 24 target resident locations.

V. CONCLUSION

The study's purpose is to create a mechanism that may aid our frontline workers in distributing relief packages during times of crisis, such as the Coronavirus Pandemic, and reduce the risk of person-to-person transmission, which might hasten the virus's spread.

ORB-SLAM is appropriate for mapping and localization even in outdoor contexts, according to the study's findings. By adding a calibration threshold depending on the steering angle of the AI-UDA Body, the produced commands from the Navigation Algorithm for robot automation may be enhanced. The created Mobile Application for Android and iOS may be used to allocate Ayuda slots, monitor the AI-UDA robot, and control it remotely in both online and offline modes.

Finally, the QR Code System was effectively installed for resident identification and container assignment. Every component of the AI-UDA robot is functioning, allowing the system to properly transport AI/Unmanned to its intended area and occupants

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