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

Armas, Alexia Marie L., Calpo, Sean Patrick L., Ison, Michael Jay F., Nacion, Andrew Stephen A., Tayson, Russelle A., Ramos, John Peter M.,

Technological University of the Philippines-Manila
Manila, Philippines

*johnpeter_ramos@tup.edu.ph

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 front line worker in disinfecting the packed goods to be delivered

II. STATEMENT OF THE PROBLEM

The COVID-19 pandemic, as the global health crisis which has taken a lot of lives recently, describes itself as the biggest challenge a country may face. A lot of differences were faced ever since the pandemic started and social rule were implemented making physical contact were prohibited and very limited. While a lot of people started their battle with the virus, researchers are starting to formulate various studies that may help to make human lives a little more normal during these trying times.

III. METHODOLOGY

The methodology of the study follows a linear flow to generate a developed system and design for a solution to the problem at hand. It started with all necessary study on current issues that could be addressed, as well as applicable technologies that can be used to come up with a solution.

A. Conceptual Framework

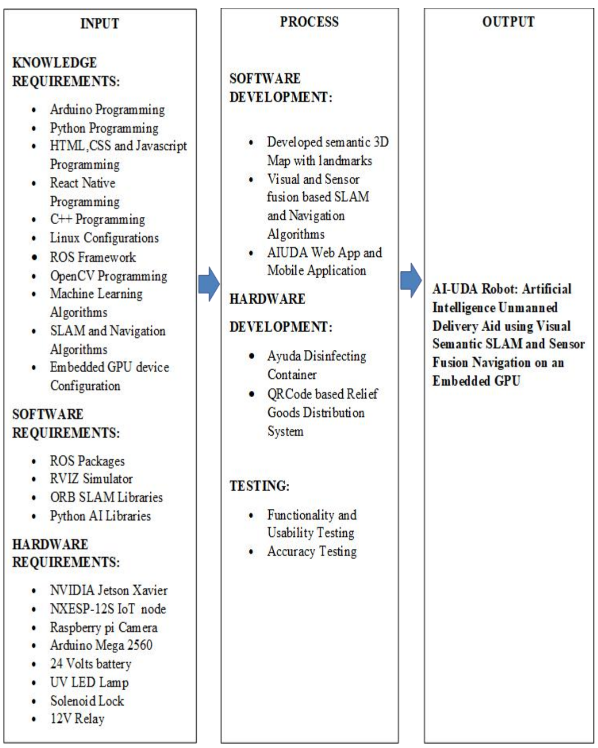


FIGURE 1. CONCEPTUAL FRAMEWORK OF THE STUDY

The figure shows the main sections of the study that is composed of INPUT – PROCESS – OUTPUT. 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 QRcode UV light disinfection container.

B. Research Process Flow

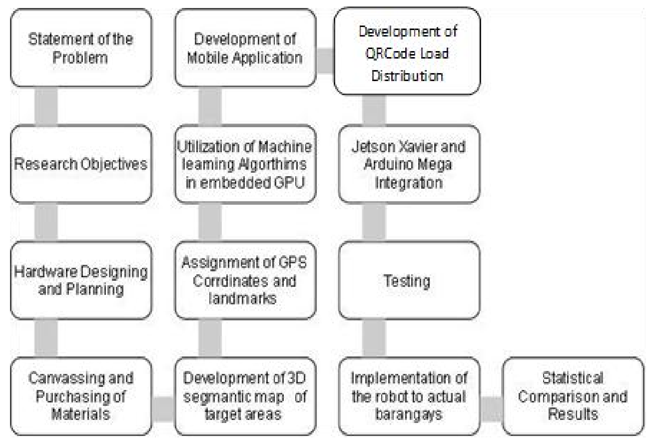


FIGURE 2. THE PROCESS FLOW OF THE STUDY

C. Hardware Design

This section represents the tangible part of the proposed research study. It is composed of the design of circuit diagrams, both inner and outer structures of Ayuda Containers.

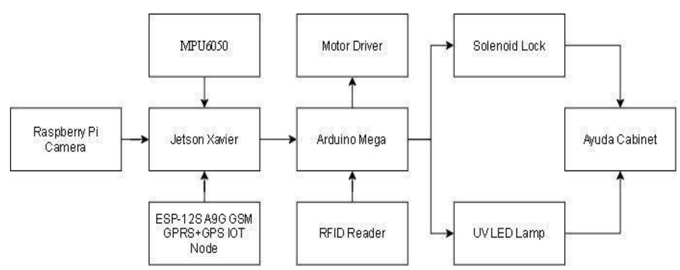


FIGURE 3. PROJECT FLOW DIAGRAM

IV. DESIGN DEVELOPMENT

A. Mobile Application Overview

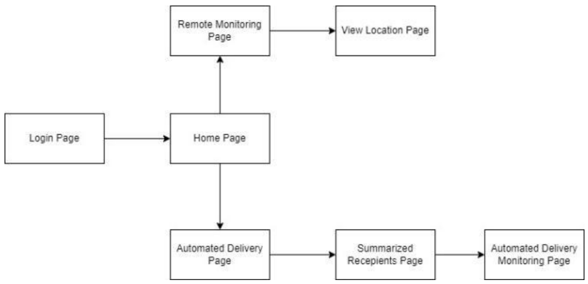


FIGURE 1. BLOCK DIAGRAM OF AIUDA MOBILE APPLICATION REMOTE MONITORING AND AUTOMATED DELIVERY SYSTEM

Figure 1 displays the block diagram of the AIUDA mobile application, which includes a login authentication page, a page for remote control and monitoring of the AIUDA robot, and a page for automated delivery, where recipients of relief supplies can be selected and the automated delivery process can be initiated.

B. AIUDA Mobile Application Authentication

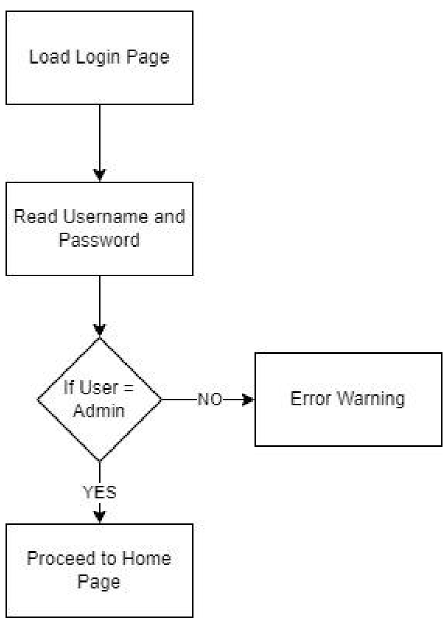


FIGURE 2. BLOCK DIAGRAM OF AIUDA MOBILE APPLICATION AUTHENTICATION

Figure 2 displays the AIUDA Mobile Application app's authentication process. The Login Page will load initially when the AIUDA Application is opened. Username and Password are requested on the login screen. The developers imported the AIUDA App's backend with the AIUDA Admin Credentials hardcoded in. To access the homepage, the user credentials must match the hardcoded admin credentials. The AIUDA app will display an error message if the user credentials do not match the admin credentials.

C. AIUDA Mobile Application Home Page

In this page, the user of AIUDA App can decide if he wants to proceed to remote monitoring page for controlling and monitoring manually the AIUDA robot or proceed to Automated Delivery page for autonomous delivery to recipients of packages.

D. AIUDA Mobile Application Remote Monitoring Page – Controllers

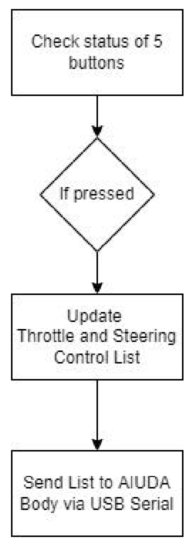


FIGURE 3. BLOCK DIAGRAM OF REMOTE MONITORING PAGE MANUAL CONTROL

The manual AIUDA Robot control process flow is shown in Fig. 3 for the Remote Monitoring Page. The backend will change the throttle value if the up or down button is pushed. It will either be 1 or -1 for the values. When the stop button is pressed, the throttle value is changed to 0. The backend will change the Steering value if the left or right button is pressed. The right button raises angle value by 5 while the left button reduces it by 5. The maximum steering angles range between -60 and 60 degrees. Every time a button is pressed, the backend sends, in Python List Format, the combined steering and throttle data to the AIUDA Body microcontroller over USB Serial.

E. AIUDA Mobile Application Remote Monitoring Page – Video Feed

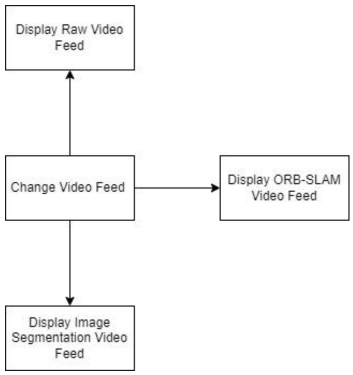


FIGURE 4. BLOCK DIAGRAM OF DIFFERENT VIDEO FEED IN REMOTE MONITORING PAGE

The camera feed or raw video from the Raspberry Pi camera will be displayed when the Remote Monitoring Page has loaded. The orb-slam video feed view, image segmentation video feed view, and raw video feed view may all be accessed by pressing the change display button. Every time a button is touched, the video publisher in ROS Framework will modify the video's URL.

F. AIUDA Mobile Application View Location Page

FIGURE 5. BLOCK DIAGRAM OF DISPLAYING LOCATION OF AIUDA ROBOT IN VIDEO LOCATION PAGE

Through UART connection, the Web App running on the Nvidia Jetson Xavier NX requests GPS coordinates from the GPS GSRM Module. The GPS coordinates is searched using the Google Map API. The location of the GPS coordinates is then shown on a Google Map.

G. AIUDA Mobile Application Automated Delivery Page – Recipient Assignment

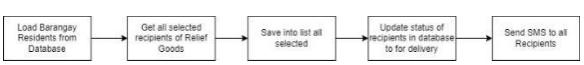


FIGURE 6. BLOCK DIAGRAM OF RECEPIENT ASSIGNMENT IN MOBILE APPLICATION

The mobile application instructs the AIUDA robot to designate the receivers of the aid items, as shown in Figure 6. The mobile app loads all the users from the SQLite Cloud database and displays them in a table along with their status. All of the chosen recipients will be stored into a list of recipients when the user presses the assigned resident's button. If the resident is found on the list, the resident's database status will be changed to Delivery. Additionally, the chosen receivers will get an SMS alerting them that they would soon receive aid supplies.

H. AIUDA Mobile Application Automated Delivery Page – Delivery Preparation

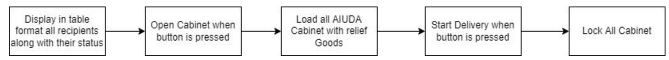


FIGURE 7. BLOCK DIAGRAM OF LOADING RELIEF GOODS INTO AIUDA CABINET USING MOBILE APPLICATION

Relief supplies may be put into the AIUDA cabinet via the mobile application, as shown in Figure 7's block diagram. All the recipients will be presented in a summary table with their status after being selected on the Recipient Assignment page. The AIUDA administrator can use the mobile application to open either the upper or bottom cabinet of the AIUDA cabinet. When the start delivery button is pressed after installing the relief supplies, the AIUDA cabinet deactivates all solenoid locks, locks all cabinets, and starts the delivery process.

I. AIUDA Mobile Application Automated Delivery Page – Delivering Mode

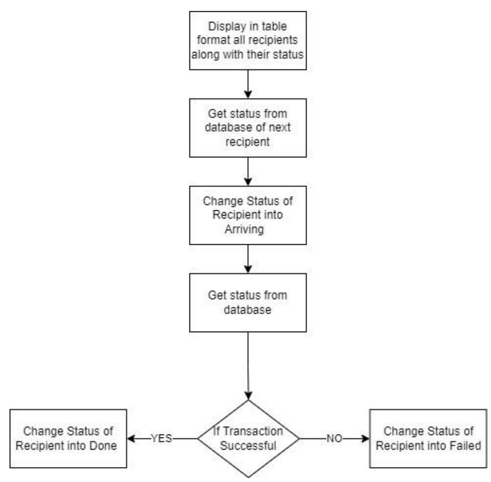


FIGURE 8. BLOCK DIAGRAM OF AUTONOMOUS DELIVERY RECIPIENT STATUS UPDATE

The block diagram in Figure 8 illustrates how the AIUDA facilitator may keep track of the receivers' state during autonomous delivery. The status of each chosen receiver will be listed in a table style. The mobile application will acquire the AIUDA Robot's arrival information from the database and update the recipient's status when it arrives. The AIUDA robot will wait five minutes after reaching its location for the recipient's pick-up time. The mobile application will change the status to failed if the recipient does not pick up the relief supplies within five minutes; otherwise, it will update to success, and the AIUDA robot will go on to another delivery location.

J. GUI Design

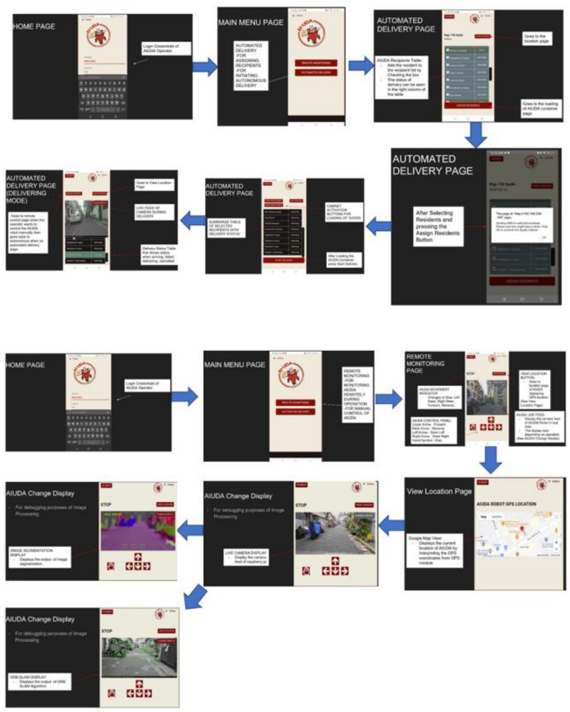
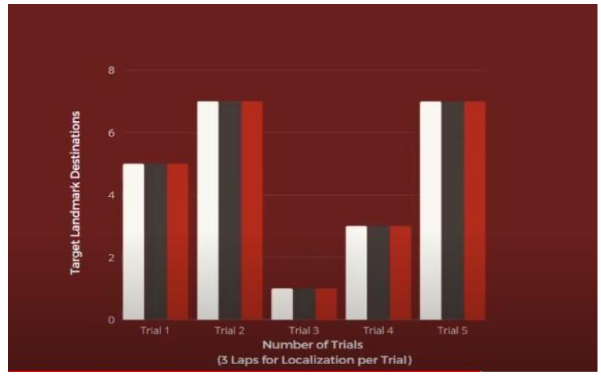


FIGURE 9. GUI DESIGN OF AIUDA APPLICATION

V. 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.

VI. CONCLUSION

The study's purpose is to create a mechanism that may aid our front-line 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

VII. RECOMMENDATIONS

According to the advice offered to the study's proponents, future researchers should include a battery monitoring system, improved materials so that the robot can accept more slots, and the robot's structural integrity. It was also proposed that a distance counter be included so that the research proponents may keep track of each delivery session.

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