**Project Proposal**

**Project Name: Autonomous Ground Vehicle for Real-Time Human Survival Detection**

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**Problem Statement:**

In modern autonomous vehicle systems, detecting and classifying objects is important for navigating safely and effectively, especially in potentially hazardous situations. Our Senior Design Project aims to develop an Autonomous Ground Vehicle (AGV) capable of detecting and identifying human survivors within its ground operational environment. The vehicle’s job is to identify people that survived a catastrophe by detecting the presence of heartbeat and body temperature. The project aims to perform search and rescue missions in disaster scenarios, where timely detection of survivors can be the difference between life and death. The primary objective of our project is to create a reliable detection system that accurately identifies human survivors, avoiding potential misclassification that could delay rescue efforts. Today, there is a lack of detection systems that provide the accuracy required to identify entities in challenging environments. Therefore, our primary objective is to develop a reliable system that will not classify human survivors improperly, will map out their location in relation to the AGV, and relay this information to a ground station.

A literature review revealed that it is really important for AGVs to use the right sensors, communication protocols, and frameworks for detecting and classifying human survivors. For instance, to make the system communicate efficiently, previous research has shown that communication systems like ‘Profinet’ provide reliable wireless data transmission between AGVs and external systems, making it a possible candidate for the implementation of our project (Nesti, 2023). Considering sensors, research shows that both radar and LiDAR have their advantages since radar offers good range and performance in bad weather conditions, whereas LiDAR provides a high-resolution 3D mapping of the AGVs' environment. This makes radar more suitable for military applications that require precision and reliability, and LiDAR for environments that require real-time object detection and classification. However, as radar is complex and susceptible to interference, LiDAR provides more security (Vargas, 2021). Moreover, recent research has shown promising developments in optimizing bandwidth using LiDAR (Mahboob, 2023), and (Müller, 2023). Despite this previous research, our project will integrate the best options within radar to accomplish the goal in the most effective and inexpensive way for this project, enhancing the AGV's ability to move in complex environments and providing security.

**Stakeholders:**

**Primary stakeholders:** The main stakeholder is our product owner, Dr. T, and Embry-Riddle Aeronautical University. This project can also benefit search and rescue organizations, who can use the AGV to identify survivors quickly in disaster zones. Moreover, emergency response teams would benefit from this project by having a reliable tool for locating survivors, improving rescue success rates.

**Secondary stakeholders:** Civilians in disaster-affected areas, as the AGV could enhance the effectiveness of rescue missions and reduce response times. Moreover, government agencies involved in disaster management could also benefit from this project, as an AGV could reduce the resources and manpower needed in rescue missions.

**Proposed Solution:**

The goal of this project is to design and develop an Autonomous Ground Vehicle (AGV) capable of detecting human survivors in disaster environments by recognizing the presence of heartbeat and body temperature. The scope of the project is going to include the development of an AGV equipped with real-time detection and classification of humans, integration of communication protocols to transmit data between the AGV and external systems, implementation of algorithms to classify survivors, rigorous testing of the AGV to evaluate its capabilities and performance. The scope of the project will not include autonomous medical intervention, or deployment in active disaster relief operations. This project will be performed by three subteams: communication, hardware, and software. Each team will be responsible for developing a specific component of the AGV, making sure to integrate and collaborate with each of the other teams. The paragraphs below will analyze and describe each team’s objectives and proposed solutions in more depth.

**Communication Team**

The goal of the communication team is to develop a reliable and efficient data transmission system that allows interaction between the Autonomous Ground Vehicle and external systems. This system will provide real-time transmission of data and information regarding human survival detection. The goal is to develop a system that can support fast, reliable, and secure data transfer between the vehicle’s sensors and the ground station. The project will use raspberry pi 5 to transmit real-time data using the LoRa modulation scheme. The system will ensure low-latency and minimize signal interference within disaster zones.

The ground station will use a raspberry pi 5 to communicate with the raspberry pi on the robot. It will provide graphical interfaces and can be customized with object detection, mapping, and rover identification. Moreover, the ground station will allow the user to send commands to the AGV and adjust it in real time. Communication will happen via the LoRa modulation scheme. Finally, it will save all the data related to object detection and classification for later analysis.

**Hardware Team**

The hardware team is responsible for developing the physical Autonomous Ground Vehicle, ensuring that components such as the chassis, motors, control units, communications systems, and power systems, are all securely connected to each other, satisfy voltage and power constraints, and are properly wired and grounded. The hardware team is also responsible for assisting in the development of the external ground station from which the AGV will communicate, following the same requirements previously listed.

The AGV will use four independently-controlled motors for movement, and will utilize both pivot and differential steering to control tight or longer turns, respectively. Aluminum structure framework will be used for the chassis. The AGV will also have the capabilities to be controlled both manually, which will provide support for functionality testing, and autonomously, provided by the Software Team. Electrical components will be connected through insulated cables. A monolithic robotic arm positioned on the rover will allow for the movement of the sensors to detect signs of life, with the intent to allow the arm to reach through debris to allow sensors to properly capture data.

Additionally, the Hardware Team will conduct physical testing of the AGV to ensure the capabilities developed and implemented are functional, and satisfy the requirements and scope of the project. In the event that all requirements are met for the hardware team, and the scope remains unchanged, improvements will be made to the physical structure to increase its strength and integrity. Further, more rigorous testing will also be conducted to ensure its reliability in the event that any future development or application of this AGV will be plausible.

**Software Team**

The purpose of the software team is to develop programs to receive camera detection information and configure it into an object tracking system. This information will be used to identify objects and bodies in the surrounding area. Once this information is received, software programs will be implemented to decide what the robot should do, which could be a change in its speed, direction, and who to alert.

To manage the robotic systems, including obstacle avoidance, algorithms will be developed to control the motors using a second Raspberry Pi in Python. The main responsibilities of motor control will be sending select signals to turn each wheel on or off for robot navigation. Developed algorithms will be used to read and publish the results of the QR code reading. Additionally, motor control algorithms will be developed via Linux. Preliminary testing for controlling the robot motors will be done using Arduino in C. This code will be converted to Python for the Raspberry Pi operational usage.

The software team will use Peer-2-Peer (P2P) connection for communication between the Raspberry Pi used for controlling motor movements and the Raspberry Pi used for ground station communication for the robot. This method of communication will enable direct communication between the devices without the use of a server. The two devices will use the same network with assigned IP addresses to facilitate communication.

The project will follow a two-semester development cycle:

**Semester 1:** The focus during the first semester will be on system architecture, sensor selection, and initial development of the vehicle.

1. **Communication Team:**

* Research and selection of communication protocols, such as LoRa modulation, for data exchange between the AGV and external systems
* Research and test of potential wireless communication challenges, such as interference
* Implementation of the ground station
* Implementation of a basic version of the communication between the AGV and the ground station
* Use of simulated environments to evaluate data transfer reliability and speed
* Real-time communication for data exchange
* Update documentation

1. **Hardware Team:**

* Inspect current condition and capabilities of the robot
* Research frame materials to improve the structure of the robot
* Research different types of hardware/sensors to include on the robot
* Develop ground movement capabilities
* Develop robotic armature capabilities
* Develop a “wishlist” of capabilities and additions to include on the robot
* Evaluate power constraints
* Document work done on the robot
* Integrate components from Software Team and Communication Team and provide feedback with respect to possible hardware constraints

1. **Software Team:**

* Develop and algorithms for robot motor control and obstacle avoidance
* Utilize P2P communication algorithms to connect 2 Raspberry Pi devices
* Test robot motor controls and obstacle avoidance
* Develop preliminary algorithms in Python for object tracking and detection
* Determine range of P2P connection between Raspberry Pis
* Develop algorithms for various motor movements in certain situations
* Develop preliminary software analysis documentation
* Develop preliminary requirements

**Semester 2:** The second semester will focus on finalizing the system, including testing and performance optimization.

1. **Communication Team**

* Optimization of communication for real-time detection (low latency)
* Testing on the communication system using real-world data
* Integration of the communication system with the navigation and object detection systems to test that everything works between teams
* Finalization of communication modules to interact with software and hardware components
* Final Documentation

1. **Hardware Team:**

* Finalize construction of AGV, to include integration of all communication and software components
* Finalize construction of ground station
* Optimize AGV through rigorous physical tests, to include collisions, vibrations, and movement on different natural terrains
* Finalize documentation of work done
* Clean up the appearance of the robot

1. **Software Team:**

* Implement developed object detection and tracking algorithms with robot camera
* Error handling for communication failures and recovery
* Test and refine motor movement algorithms for certain situations
* Implement and test motor algorithms for unprecedented events
* Finalize requirements and software documentation
* Implement motor movement algorithms for autonomy

**Proposed Project Budget:**

The proposed project budget is $1,302

2 Rpi 5 LoRa hat: 70$

<https://www.amazon.com/SX1262-LoRa-HAT-Transmission-Communication/dp/B07W83FCCZ>

2 Batteries: 86$

<https://www.amazon.com/Talentcell-LF8011-Rechargeable-Phosphate-Batteries/dp/B0CNLKKL9C/ref=sr_1_5?crid=1XGH3AB0OAAKW&dib=eyJ2IjoiMSJ9.8jZxKXrzefpmPEME6T2kWCOS8NTXOLfEKS14ssX_BV1G6h5cbC8eWrWC0ADsayoiHBpV8BJRYHIL8oIhP8Ii4xMbbeTqWfFDhCjSpn17RXQpF4foGMbQ9tnIQwhG7Xi50-884UYxqog1wllM0DBZPdYfa9uISP7gFbYdnp--h60o4ZKLKD_aksrnHimF9VVnb_nSYaqOlTEAeLAYfgGYHDcjtL8xQPawyO4eosuWRu4HGhjUrZc9IR59OGr605nMUjW-G9CuoYZS1nbWZ33Emr8KoGnGiHsS8v2dA2w3wf4.thR2d1sizt8vdnPf0oVgjKLEJH0307qnHwFAG00vusM&dib_tag=se&keywords=battery+24v&qid=1727204346&sprefix=battery+24v%2Caps%2C115&sr=8-5>

3x Radar: 450$

<https://www.ti.com/tool/IWR6843AOPEVM>

2x Raspberry Pi 5: 160$

<https://www.sparkfun.com/products/23551?src=raspberrypi>

1x Heartbeat Sensor: 37$

<https://www.digikey.com/en/products/detail/seeed-technology-co.,-ltd/101990981/16570945>

1x Thermal Camera: 67$

<https://www.amazon.com/Waveshare-Thermal-Camera-Communicating-Interface/dp/B07ZKJPZ7Z/ref=sims_dp_d_dex_ai_speed_loc_mtl_v5_t1_d_sccl_3_1/141-0573587-0075959?pd_rd_w=1kkFz&content-id=amzn1.sym.526d27b3-2efe-4f81-8a09-4d61e1515e3b&pf_rd_p=526d27b3-2efe-4f81-8a09-4d61e1515e3b&pf_rd_r=WCJN5RTAZY5DV2SAYSXK&pd_rd_wg=xlN7f&pd_rd_r=4a4f609c-2303-4723-8710-264b3fcf2775&pd_rd_i=B07ZKJPZ7Z&psc=1>

1x Camera: 21$

<https://www.amazon.com/IMX219-Raspberry-MIPI-CSI-Interface-Flexible/dp/B0CPLBRZNS/ref=sr_1_11?crid=2AZ0MDPA00U1I&dib=eyJ2IjoiMSJ9.JhH-ae3rMW_ScOTA9gNl1gXxIwYIEyGKgRJBmClwuBxhSxe1KghTlUyFpPW8zjNrQWYLih7H20FyOyLspDjrYQfPdxVlUKnqsPJOJIN0vaGCGT1LVeoxjKsjoFg7OCBTZwSYqbd5p6qJGmF_ayhvUotVExjCIWuHTVhHilMh6nUYZj9edLC4nHYEvxzLJAgxVF1H3YBEvY3njQ6c1TZpsPtEO-u_wFx4IRP6EQtCmG2VEh-x_y3clVQGwNdC6IQcYHaG185fPIxbJdHbtGhGHwExsMmYJ9qnZmrEh_UQ18k.dnrktNiwfCqXNtptQqJ-wlYETjCJtu7v1AyaeQAAB54&dib_tag=se&keywords=camera+able+to+interface+with+rpi5&qid=1729296289&s=electronics&sprefix=camera+able+to+interface+with+rpi5%2Celectronics%2C97&sr=1-11>

1x Speaker: 17$

<https://www.amazon.com/Raspberry-Driver-Free-Recording-Playback-Microphone/dp/B0CN1C1VPR/ref=sr_1_5?crid=P6IF9PAP0SBD&dib=eyJ2IjoiMSJ9.sTGtQhoaczxvBLA3ZuwGmyfJTH5DL8JSxz9t9cPecumUDx12LL1DL9UqqlyjPaUIwdZIwc-vV5MhAhNt8EjbRnoz3KCu6RYxFrvcRuczjGgMDTF7x0Wui51h2WRuW-48vBPiGaVDOMYqQppn6S_HR4FIVlIC5kFcXuMnpmvHkiYqc9sxDcwTfGKDXgsEHaU6_M5ajM6WqWvziy-Eqzao_uIfw_OTsv-rgX1u3aALEQ1lg6xMC26kK4QnItUe5UxooBe58lkVCviUCCt9KkcaqRbWBNl7p98spTUq-GyYdtQ.0tOJvIUYi8mk9xrI2Qzm-QjH9oxaZ6dkDQH0s3ln4Zw&dib_tag=se&keywords=raspberry+pi+5+speaker&qid=1729296396&s=electronics&sprefix=raspberry+pi+5+speaker%2Celectronics%2C119&sr=1-5>

1x Motor Controller: 125$

<https://www.dfrobot.com/product-307.html>

1x Robotic Arm: 200$

[Amazon.com: Robotic Arm for Arduino Coding Programming 6DOF xArm 1S STEM Educational Building Robot Arm Kits, 6 AXIS Full Metal Robotic Arm Wireless Handle/PC/App/Mouse Control Learning Robot : Toys & Games](https://www.amazon.com/dp/B0793PFGCY?ref=cm_sw_r_cso_cp_apin_dp_GF1VJWZAMQD8D219VJZE&ref_=cm_sw_r_cso_cp_apin_dp_GF1VJWZAMQD8D219VJZE&skipTwisterOG=1&social_share=cm_sw_r_cso_cp_apin_dp_GF1VJWZAMQD8D219VJZE&starsLeft=1&th=1)

1x Battery Charger: 57$

<https://www.amazon.com/Lead-Acid-Portable-Maintainer-Desulfator-Motorcycle/dp/B09ZLD6RJ5/ref=mp_s_a_1_3?dib=eyJ2IjoiMSJ9.ipnFf0_1Qsut1MpWuRjGsJM5mG2cl6Uu6FHhJrVJhUTvfmfI1ElfXtlNK_cvRenDhgLO8u5CEGTJ1h4aJDjMk4GJ-bNEZe_CPLk_MIdK1EEyzqjhE2Pt5p36hIgZ-aw70irDo3_GDDVXgW4H7isVfrfv0ezFXUQEMW38MNTxZwDlrbOF0Gp60Rrbf95VMRrmfNatrPBU9uRiFzJrTJjptg.hSmA1C2oWX3WskjAFZ09cmpt7HSuCjZJBv0Fmlg3S2k&dib_tag=se&keywords=life+po4+battery+charger&qid=1729298210&sr=8-3>

2x Additional Wires: 12$

[Amazon.com: 120pcs Multicolored Dupont Wire 40pin Male to Female, 40pin Male to Male, 40pin Female to Female Breadboard Jumper Ribbon Cables Kit Compatible with Arduino Projects : Electronics](https://www.amazon.com/California-JOS-Breadboard-Optional-Multicolored/dp/B0BRTJXND9/ref=asc_df_B0BRTJXND9/?tag=hyprod-20&linkCode=df0&hvadid=692875362841&hvpos=&hvnetw=g&hvrand=12794137141121750466&hvpone=&hvptwo=&hvqmt=&hvdev=m&hvdvcmdl=&hvlocint=&hvlocphy=9011498&hvtargid=pla-2281435179058&psc=1&mcid=c4b4c2c0dbb63cb69080f6f17c73e841&hvocijid=12794137141121750466-B0BRTJXND9-&hvexpln=73)

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