Decentralized Intelligent Coordinating Visualization System

Jerry Lee and Justin Le

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Thesis

Exploration of new environments has always challenged humanity. The dark, unending depths of the ocean; the high, freezing tops of mountains; the hot, fiery temperatures of volcanoes; space, the final frontier; We are limited with where we can go by harsh conditions and unknown variables of unexplored and dangerous habitats. Our idea so to create an solution for this exploration so we can accurately map an large area without risking any human lives. Along with removing the risk of danger, our idea will also allow areas to be explored and mapped much more efficiently than using traditional methods. It could reduce costs of exploration or general mapping of an area, greatly increase reliability, and allow for much more important data to be retrieved that would otherwise be easily overlooked.

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1 Purpose

The idea behind our project is to design something very much like a Mars rover. It would autonomously roam while mapping the area. Our idea is to have multiple "rovers" roam at once rather than just one single rover, and have them all interconnected so they split the work and build one single map of the area. This idea of multiple systems working together also gives a fail-safe plan in case one of them breaks down in the middle of an exploration. We have previously seen projects done where sensors like lidar [2] sensors are connected to a stepper motor, and as the motor rotates the lidar, it creates a 2D map of obstacles relative to its current position. We would like to do something similar with lidar and various other sensors, as well as cameras to create a 3D map [1] of the area, rather than 2D. Instead of just seeing obstructions but having no idea what the obstructions really are, we would like to identify the obstacles and objects rendered. One example to help visualize our idea is to look at the Goal-Line Technology[3] used in soccer. One type of Goal-Line Technology, called the Hawk-Eye [4], uses cameras placed throughout the stadium to triangulate and track the location of the ball. The software records the balls path and stores the information within a database where a graphic image of the balls path is rendered. Using the image rendered with data taken from multiple cameras at different angles and locations throughout the stadium, the software is able to determine if the ball has crossed the goal line, deeming it a goal or no goal. Our idea to render such an image from multiple different points is similar. It is an ambitious and difficult idea for an project so we would like to start early and see if it is a viable idea we can accomplish within a senior design term or if we should explore other options.

2 Objective

Our objective is to have multiple rovers built with the software implemented and fully functional. Ideally, we would have 3 or so rovers built and connected under a decentralized network, all using our software and creating one single map of an large area. The map should be in 3 dimensions, allowing us to see what obstacles, objects, and terrain lie in the map. Ideally, we would also create software that will allow us to view this 3 dimensional map as seen on self-driving cars.[5]

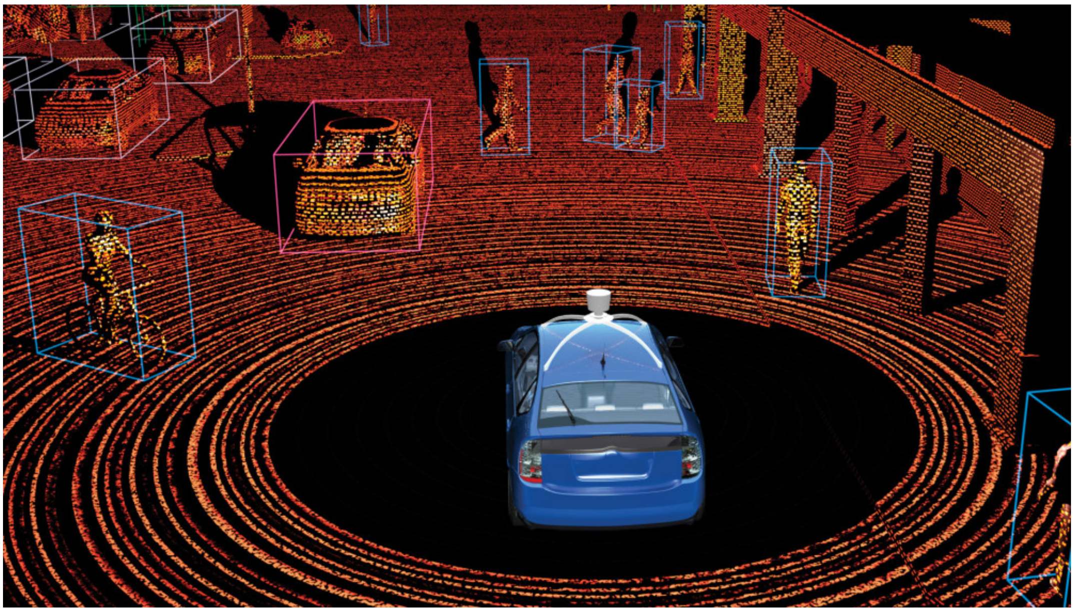

Fig. 1 Autonomous Car using LIDAR

Our idea will be built on land rovers but we would ideally build the software so it could be applicable in multiple areas such as with drones for high altitudes and landless places, or underwater submarines.

After our initial fully-functional prototype build is finished, we hope to add additional features such as using the 3D mapping to build a fully interactive map either on a web application or mobile application with augmented reality (AR). This way we can use the data we collected to not only make a static 3D map but also with the added feature of being able to place yourself in the mapped environment and use machine vision to have every object captured by the system to be identifiable.

3 Approach

Our initial step will be researching various machine-to-machine communications in order to find out the feasibility of addition communication protocols. We would ideally want to figure out the best protocol to use for intercommunication amongst systems without the need of a host source in order to create a fully decentralized system.

The next step will be to create a complete theoretical design of each rover. This will include schematics and documentation of our hardware to see if our design will work when we do build it, any issues we may encounter, and how we will implement our ideas and software into the rovers. We will also begin our initial designs of the software so when we begin the software development phase, we will know exactly how we want to implement it. Additionally, having our software planned out from the beginning of this project will let us take it into account when selecting what hardware we will need. We may need more computing power, more memory, more sensors for extra data points, or many other possibilities.

Once designs have been completed and finalized, we will begin the hardware phase. Ideally, we would not want to spend a very long time with hardware as software can take up a lot of our limited time. We will implement and test the hardware as quickly as possible to meet deadlines and reach our goals with software in the later phases of the project. While the hardware portion is being developed, we will also begin development of firmware to ensure the functionalities of our devices. We will also begin actual development of the software so if there are any pressing issues from the software with the hardware that we may not have anticipated in the initial design phase, we can resolve the issues immediately.

With the hardware being complete up to what is planned, we will completely engage ourselves in the software development. We will begin with implementation of the imaging software with the hardware components on one single system. After completing imaging software, we will try to develop the software to create a map with that image. We will then move to a decentralized communication between the multiple nodes. After we accomplish communication, we will further develop the software to use all nodes on the network to create one single map. We will have also have to implement algorithms that will allow the rovers to properly split a area to map so that no two rovers will cover the same areas.

If we successfully complete our software as planned for this project, we will not stop at what we have. We plan to further refine and develop our software so that it can be modular and placed into any given system (autonomous submarines, autonomous drones). With the software developed to the fullest, there is a great deal of potential for numerous applications where it could be of great benefit.

4 Responsibility

At the moment we currently have two undergraduate students and an advisor working on this proposed project but are hoping to add a couple more to the team once we gain momentum.

Student's Responsibilities: Along with specific responsibilities, all students will be researching and developing key ideas to enable Machine-To-Machine telecommunication and synchronization amongst systems. Below is a rough list of each student's core responsibilities, these responsibilities will overlap with each other. Also please note that this team is still in the midst of trying to add a couple high-level software members to the team.

Jerry Lee (3rd Year Computer Engineering Major):
- Team Leader, in charge of making sure time lines or up to date and deadlines are met.
- Electrical design and schematics
- Communication Protocols
- Micro Controllers Specialist
- Routing Protocols
- Firmware implementation
- Machine Learning & Machine Vision
- Autonomous Movement
- Intel NUCs Research

Justin Le (3rd Year Computer Engineering Major):
- Electrical design and schematics
- Intercommunication protocols
- Firmware implementation
- Machine Vision & 3D Mapping
- I2C, SPI and RTOS implementation
- Machine Learning
- Data Collecting

Extra Members (Preferably Computer Science and Engineering Major):
- Machine Vision & 3D Mapping
- Routing Protocols
- Machine Learning
- User Interface Software

- Data Handling

Advisor's Responsibilities: The advisor will take a stand-back approach and assist in the design when needed. Will help bounce and confirm brainstormed ideas. Will ensure deadlines are reached.

5 Timeline

Task Name	Summer I	Summer II	Fall	Winter	Spring
Research Phase					
- Wireless Communication					
- Goal-Line Technology					
- Lidar 3D Mapping					
- Autonomous Vehicles					
- Processing Speeds					
Design Phase					
- Hardware Schematics					
- Software Design Outline					
- Mechanical Systems					
- CAD					
Build Phase					
- Hardware					
- Software					
- Firmware					
Debug					
Add Additional features					

6 Itemized Budget

Below is a break down of our expected expenditures. The budget consists of mainly materials that are needed to build and design ideally 3 rovers. Intel's Nucs will be needed in order to handle the immense amount of processing power needed to compute 3D mappings along with the interconnection communication amongst the rovers. Each sensor has their own purpose, Ultra Sonic for vertical detection, Infrared for environmental detection for autonomous movement and Lidar for 3D mapping. Each of the electronic component set is crucial because the design will need a lot of power usage testing both on paper and hands on such that we will need a wide variety of components to get the best results. The device may be running on upwards of 20-30 Volts and 2-3 Amps so static dissipative gloves are requested for safety of the students. We plan on 3D printing mounts and platforms for the rovers which is why 3D Printing Costs are on the list. All prices are rounded down to the nearest dollar for clarity sake.

Quantity	Item	Cost
6	Motors	$300.00
6	Servo Motors	$180.00
3	Intel Nucs	$900.00
3	Motor Controllers	$120.00
4	Micro Controllers	$400.00
3	Cameras	$300.00
6	Sets of Infrared Sensors	$600.00
3	Lidar Sensors	$500.00
6	Sets of Ultra Sonic Sensors	$24.00
3	Lithium Ion Batteries	$50.00
3	Chassis	$350.00
2	Pairs of Static Dissipative Gloves	$42.00
3	Voltage Regulators	$5.00
1 Set	Capacitors Set	$20.00
1 Set	Inductors Set	$20.00
1 Set	Resistors Set	$24.00
1 Set	Transistors & Diodes Set	$20.00
1	Presentation Material	$20.00
1	3D Printing Costs	$30.00
3	CAN Transceiver	$600.00
	TOTAL COSTS (w/o adjustments for sales tax)	**$4,525.00**

References

[1] 3D City Modelling from LIDAR Data
`http://www.gdmc.nl/3dtopo/documents/RGI-011-142.pdf`

[2] What is LiDAR and How Does it Work?
`https://www.3dlasermapping.com/what-is-lidar-and-how-does-it-work/`

[3] Goal-line Technology
`https://en.wikipedia.org/wiki/Goal-line_technology`

[4] Hawk-Eye
`https://en.wikipedia.org/wiki/Hawk-Eye`

[5] HOW AUTONOMOUS CARS MAP THE ENVIRONMENT
`https://www.smallworldsocial.com/how-autonomous-cars-map-the-environment/`