Project Description Document

Team Name: Black Ops SWARM

Brief Project Description: Our Senior Design Project is to create an autonomous mobile distributed computing network between Unmanned Ground Vehicles (UGV). Our team of engineers is responsible for communications, controls, autonomous movement, circuitry, and PCB design for the UGV's. The project will be geared towards improving upon the current Senior Design B team, Smile Cloud 9, that is currently working with Professor Xie on Swarm Artificial Intelligence capabilities.

Team Structure [5 members]: Lauren Dominic Bolo-Dave, Arrian Farahani, Yenhung Chen, Cameron Douma, Reginald Capanzana

Lauren Dominic Bolo-Dave - B.S. Computer Engineering
Project Manager (Hardware & Software):
Dominic has always had a strong interest in A.I. development through the means of software coding. Although his main focus is developing software and aiding the software leads, he also has knowledge in developing hardware, allowing him to be flexible and aid the electrical engineering leads. As project manager he facilitates communication and cooperation among the team, ensuring that all goals are attained through organization and overseeing the team's progress. He hopes to use this project as a gateway to gain more knowledge in A.I./robotic development and apply it to his future endeavours. In furthering his interests, he also aims to strengthen other crucial skills such as leadership, accountability, and critical thinking.

Arrian Farahani - B.S. Electrical Engineering
Hardware Lead (Circuit Design & Controls):
Arrian has a strong interest in circuit design and systems engineering. He sees this project as an opportunity to do research and gain extensive knowledge on UAVs which he can relate to as he will be working with unmanned aerial vehicles this summer. He wants this project to teach him valuable engineering and problem solving skills pertaining to unmanned vehicles so that he can apply them to the work he'll be doing this summer. His main function as a team member is to design the PCB that will implement all hardware aspects of the UGV.

Yenhung Chen – B.S. Electrical Engineering
Hardware Lead (Hardware (Circuits, Motor, Feedback and Control system)):
Yenhung started to have a strong interest in hardware when he had a LED pattern design event in a class in high school. He had trained his soldering and PCB skills at that moment. After learning a deeper knowledge about hardware (motors, feedback and control system, etc), he finds this is a good chance to apply his knowledge to this senior design project. He strongly believes that he will not only learn academic skills and knowledge from this project, but also get a nice experience about cooperating with other teammates.

Cameron Douma - B.S. Computer Engineering
Software Lead (Image Processing & Autonomous Movement):
Cameron has a strong interest in software development as well as image processing. She is currently taking COMPE565 as one of her electives where the focus is mainly on image and video compression. This project will give her the opportunity to gain hands on experience from knowledge accumulated throughout these past four years. Her primary function on this team is to work with the other software leads to develop the communication networks as well as lead the image processing application.

Reginald Capanzana - B.S. Computer Engineering
Software Lead (Communications & Autonomous Movement):
Reginald has a strong interest in software development in AI and computer networking. He sees this project as an opportunity to employ the knowledge he has gained from his coursework and internship. At his internship, he has been working on communications software so his experience will be valuable in establishing the communications between the UGVs. He sees this project as an opportunity to learn how to develop AI software and refine his skills as a developer. His primary function on the team is to lead the software development for communications and to help develop the autonomous movement for the UGV.

Problem Statement:
Computational tasks such as large matrix algebra proves to be a formidable task for one node to handle. Multiple nodes in a network makes it possible to alleviate task loads between each other thus optimizing the time to complete a task. In order to supplement Dr. Xie's SysteMs & InteLligEnce (SMILE) Laboratory research on dynamic networks and distributed computing, our team will design and implement robots in order to divide time extensive computational tasks amongst each other.

Need
In order to decrease the time it takes to perform a large computational task, the Swarm team will design and implement Swarm-AI topology by using a master rover to break up tasks between multiple slave rovers. The master rover must then be able to communicate these tasks to the slave rovers and get the individual results back in return. There is a great need for autonomous UGV swarms in situations such as security and surveillance, search and rescue, environmental mapping, disaster management, or military applications.

Initial User Requirements

Table 1 - Initial User Requirements. 5 is highest priority.

Priority Level	User Requirements	Justification	Info Source

5	Autonomous Movement	The UGV must be able to move autonomously with the hardware implemented	Previous Group's documentation on controls for UGVs
4	Battery Life	The UGV must be able to withstand an hour battery life from one charge	Experience powering PCBs and microcontrollers
4	Maneuverability	The UGV must be able to move forward, backwards, and rotate 360 degrees in multiple different dry environments	The idea came from our group
5	Affordability	UGV must cost under $500	Dr. Xie (Advisor)
3	Flexibility	Accommodates multiple UGV's added into network when compatible with components	Dr. Xie (Advisor)
3	Programmability	Microcontroller reprogrammable through WiFi or ethernet connection to suit user need	Dr. Xie (Advisor)
4	UGV Communication	UGVs must use Xbee to send and receive messages between each other through wireless means	The idea came from our group
2	Documentation	PCB Design, Software Implementation, Instructions manual, Device specs	The idea came from our group

Engineering Specifications

Engineering specifications and proposed validation techniques are shown in Table 2 below.

Table 2 - Engineering Specifications

Requirements	Value	Validation
Battery	15 Volts	Measuring power supplied under a load using a DMM
DC-DC Converter (5V) -Regulator	15VDC step down to 5VD to power motor drivers, Jetson Nano, and Arduino board	Measuring step down voltages at the branches after the rectifiers using a DMM
DC-DC Converter (3.3V) -Regulator	5VDC-15VDC step down to 3.3VDC to power Xbee	Measuring step down voltages at the branches after the rectifier using a DMM
Motor Drivers	4.5V to supply the movement of the motors	Viewing axle movement on the UGV chassis and measuring voltage with DMM
Switching Diodes	Provides a unidirectional bridge rectifier to supply current to all 4 axles	Motor movement inspection
Ferrite Beads	High frequency noise suppression	Measure noise using an oscilloscope
16Mhz Crystal Oscillator	Provides stable clock cycle for Arduino	Measuring clock cycle using an oscilloscope
Hardware Design Element-Camera	Targeted Hardware Element	Inspection
Hardware Design Element-Motion Sensors	Targeted Hardware Element	Inspection
Jetson Nano AI Computer	-128-Core Maxwell GPU -Quad-core Arm A57 processor @ 1.43 Ghz -Power Supply - 5V/4A	Present on board, interface provided by previous team
Arduino Nano Input Voltage	7-12 Volts	Verify using a DMM
Xbee Communications	127-bit packet	Send a 127-bit packet between each node and verify that the packets are

		identical
Autonomous Movement	UGV achieves autonomous movement to help with completion of tasks	Load python code onto UGV and test in the lab by observing the UGV
Object Detection & Avoidance	UGV must detect an object through sensors & cameras and avoid them	Load python code onto UGV and test in the lab by creating “obstacle course” for UGV
Communication between rovers	Rovers must be able to communication tasks and results between each other	Sending and receiving a 127-bit packet

Block Diagram

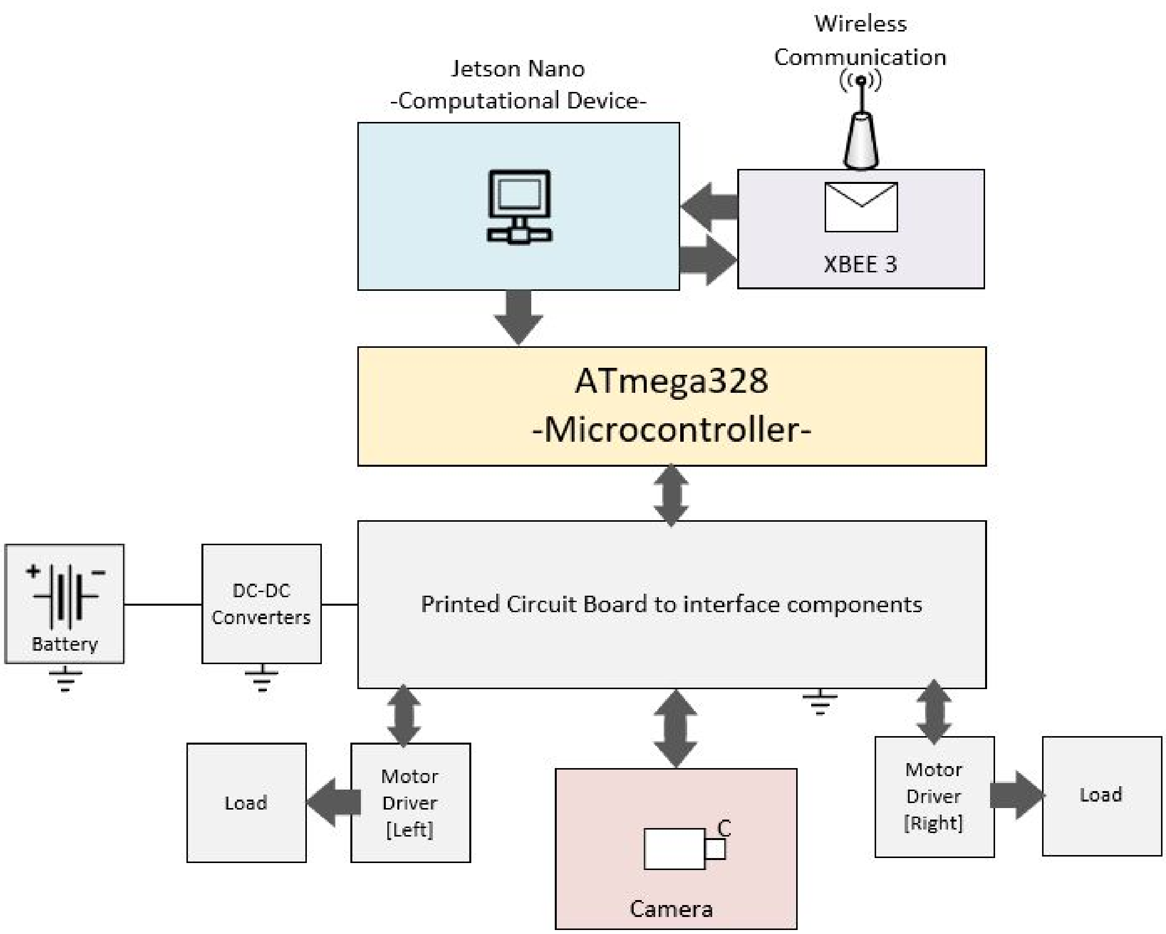

Figure 1 - Block Diagram - UGV Swarm

Physical Description

Figure 2 shows a proposed example of our UGV from an aerial view.

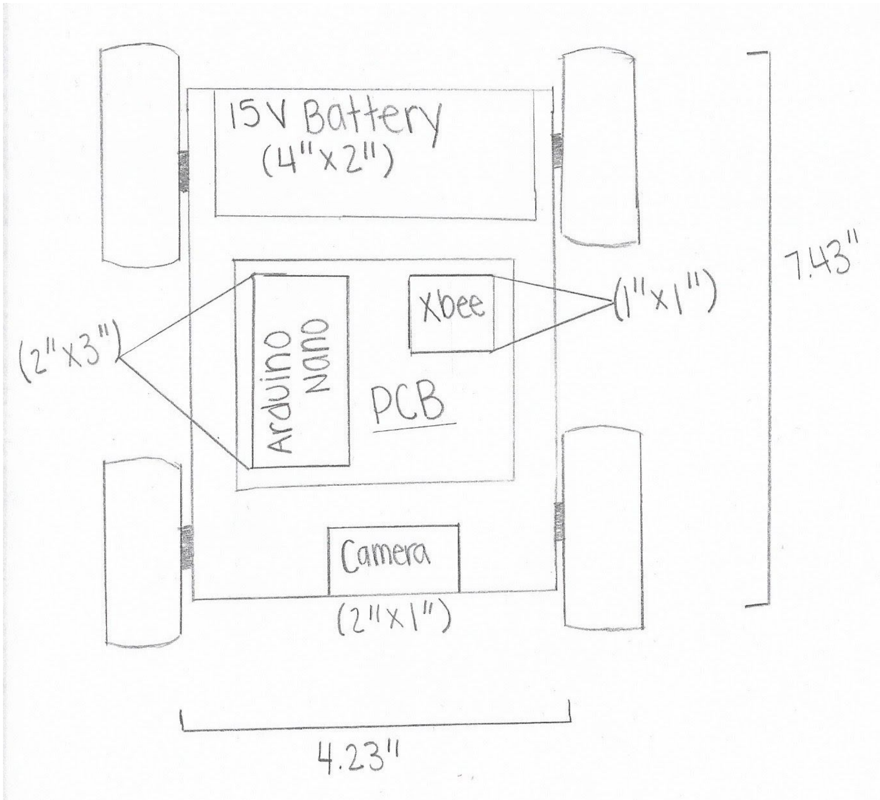

Figure 2 - Ground Rover (Aerial View)

Figure 3 shows a proposed example of our UGV from a side view.

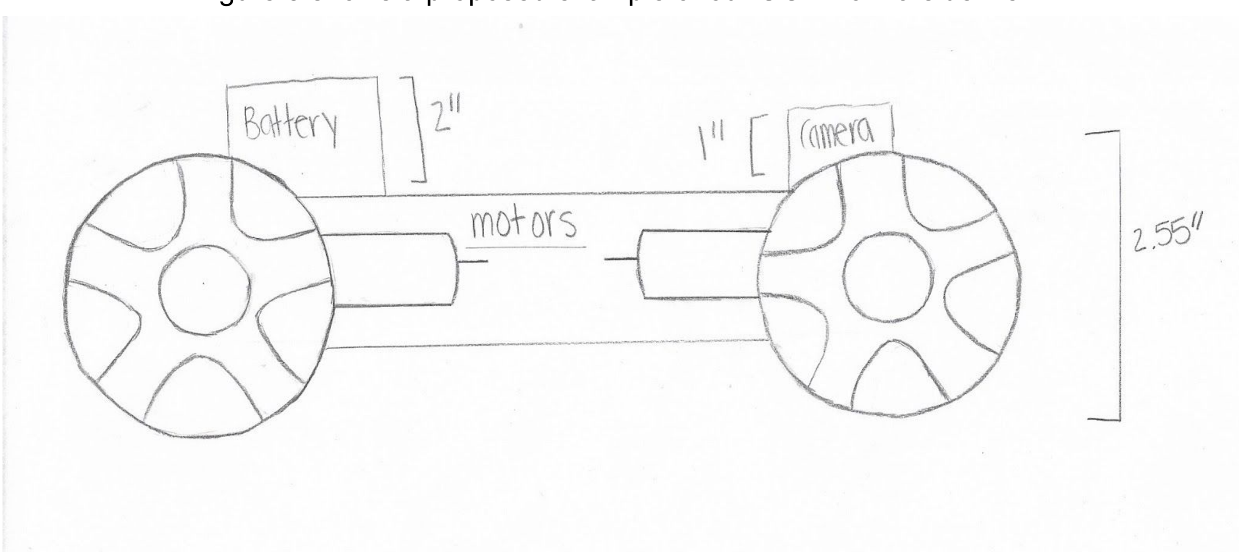

Figure 3 - Ground Rover (Side View)

Resources

The resources shown in Table 3 are needed to complete the project. These needs will be satisfied by the strategy shown in the second column of the table.

Table 3 - Resources to complete project

Resource	Strategy
Robot Operating System (R.O.S.)	Free open-source software.
Schematic and PCB Design software	KiCad is available at no cost.
PCB Fabrication	The PCBs will be manufactured by JLCPCB from China due to the complexity of our boards.
Basic Lab Test Equipment	Located in the Senior Project Laboratory.
Soldering Equipment	Located in the Senior Project Laboratory.
Facility for testing autonomous operation	Located in Professor Xie's SMILE Laboratory.
Block Diagram	Microsoft Visio.
Rovers	Rover parts provided by Dr. Xie's SMILE Laboratory.

Additional Knowledge

Successful completion of the project depends on team members gaining knowledge as outlined in Table 4.

Table 4 - Additional Knowledge required to complete the project

Knowledge	Resource	Strategy
Autonomous Movement Capabilities	Dominic Bolo, Cameron Douma, Reginald Capanzana	Research implementation techniques and algorithms for small autonomous vehicles.
Python	Dominic Bolo, Cameron Douma, Reginald Capanzana	Learn Python programming language.
Image Processing	Cameron Douma, Reginald Capanzana	As part of COMPE565.

Circuit Design	Arrian Farahani, Yenhung Chen	Requires brush-up of circuit design, microelectronics, and control systems.
PCB Design / Fabrication	Arrian Farahani, Yenhung Chen	Professor Dorr’s KiCad lecture and additional research if needed.
Communications	Arrian Farahani, Reginald Capanzana, Cameron Douma	Leverage Dr. Xie for help as she specializes in communications.
Robot Operating Systems	Everyone	Research how to simulate the UGV models for object detection, path planning, and communications

Safety Assessment

Safety risks and mitigation strategies shown in Table 5 below.

Table 5 - Safety - Risks and mitigation

Activity	Risk	Mitigation
Ground Rover testing	Potentially injuring engineers	Dedicated net system in the Smile laboratory to create a barrier between equipment and engineers.
Soldering	Potential scalding injury	Training provided in EE330lab.
Power supply	Damage circuits	Optimal circuit design with careful planning to prevent said errors.
High motor temperature	Burn UGV	Heatsink and correctly placed location.

Anticipated Costs

The anticipated costs of the project are shown in Table 6 below.

Table 6 - Anticipated Costs

Item	Cost	Description
Jetson Nano Developer Kit	$99.00	AI computer that gives you the compute performance to run modern AI applications
Junior Runt Rover (Chassis)	$60.00	Two rovers ($30 each)
PCB Design	$60.00	Two PCBs ($30 each, 1 per rover)
Xbee3	$32.00	Two Xbee3 modules ($16 each, 1 per rover)
Arduino Nano	$41.40	Two Arduinos ($20.70 each, 1 per rover)
Motor(s)	$16.00	4 L298N Motor Drive Controllers ($4 each)
Image Sensing Camera	Waiting for quote	USB connected camera compatible with Jetson Nano
Passive Electrical components	$56.00	DC Converters, Resistors, Diodes
Total Cost	$364.40	Anticipated costs can be expected to change throughout project durations

Funding

With the aid of our advisor, Dr. Xie, she has committed to our anticipated cost through the means of grants and funding.

Advisor

We have already confirmed Dr. Xie as our team's advisor. Dr. Xie conducts research in computing networks at the SysteMe and InteLligEnce (SMILE) lab at SDSU. Dr. Xie currently has a senior design team working on a project for her that she would like us to take over for the next semester.