Project Proposal

Project Name: BID4R Rover Model

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Problem Statement:

The Biologically Inspired Resilient Systems Test Arena (BIRSTA) currently operates with a swarm of 50 rovers powered by AA batteries, providing a short operational time of approximately 15 minutes. This limits the testing and research capabilities of the system, as the rovers require frequent recharging or battery replacements. The goal of this project is to develop a power distribution system using Lithium Polymer (LiPo) batteries, significantly extending the operational time to 60 minutes. Additionally, a wireless charging system will be introduced, enabling convenient recharging without manual cable connections.

In this project, we will focus on upgrading a single rover as a proof-of-concept, which can later be applied to the entire swarm. This approach will serve as a model for future upgrades while ensuring that the rover operates for extended periods and charges safely and efficiently.

Stakeholders:

- **Primary Stakeholders:**
  - Dr. Watson (Principal Investigator) at the Biologically-Inspired Design for Resilience Lab.
  - Research team working on BID4R swarm robotics.
- **Secondary Stakeholders:**
  - Other academic research groups working on robotic swarms.
  - Engineers interested in sustainable power systems for small robots.

Proposed Solution:

This project will focus on designing and implementing a power distribution system and a wireless charging protocol for one of the rovers from the BIRSTA swarm. The tasks to be completed are:

-Power Distribution System:
Design and implement a new power distribution system for the rover, incorporating a 3000 mAh 3.7V LiPo battery. This will replace the existing AA batteries and extend the operational time to 60 minutes per charge. The system will also ensure stable power delivery to all critical components, such as the Arduino Nano 33 IoT, Pixy2 camera, and proximity sensors.

-Wireless Charging Station:
Implement a Qi wireless charging station and integrate the receiver into the rover's system. The goal is to allow for wireless charging when the rover is manually placed near the charging station, eliminating the need for direct cable connections. The robot itself will not autonomously drive to the charging station but will be capable of charging wirelessly once positioned at the designated location. Additionally, cooling mechanisms, such as fans, will be integrated into the charging system to prevent the LiPo battery from overheating during the charging process.

-Structural Modifications:
As part of the power upgrade, the current 4-tier rover structure will be reduced to a 3-tier structure if possible. This modification will simplify the design and make room for the new battery mount and wireless charging receiver. The mount will be 3D printed, ensuring stability and balance for the rover during operation, while also considering heat dissipation and ease of assembly/disassembly.

- Battery Mount Design:
Develop a 3D-printed battery mount for the LiPo battery and wireless charging receiver. The mount will be designed to ensure stability during operation, protect the battery, and prevent damage to other rover components. It will also be lightweight to maintain the rover's balance while operating on the test arena platform.

- Algorithm Development:
Create a battery-monitoring algorithm that tracks the rover's battery life and facilitates wireless charging when necessary. The system will include safety features such as monitoring battery temperature and adjusting the charging rate to prevent overheating and prolong battery life.

- Model Rover Development:
Although the original project requirement is to upgrade 50 rovers, this project will focus on a single model rover. This proof-of-concept will demonstrate successful power distribution and wireless charging integration, serving as the foundation for future upgrades across the entire swarm.

Out of Scope:

- Modifications to the remaining 49 rovers in the swarm will be out of scope for this project.
- Development of additional functionalities, such as autonomous navigation to charging stations, will not be included.

Semester 1:

- Complete the design and testing of the power distribution system using LiPo batteries.
- Implement wireless charging on the rover and validate its performance.
- Develop and test the 3D-printed battery mount, ensuring stable operation and proper heat dissipation.
- Run a demonstration showcasing continuous operation for 60 minutes and successful wireless charging integration.

Proposed Project Budget:

Item number	Item name	Item quantity	Unit price	Total price	Order links	Store
1	Mini 3-Layer Round Robot Chassis Kit - 2WD with DC Motors	1	$22.46	$22.46	Mini 3-Layer Round Robot Chassis Kit - 2WD with DC Motors : ID 3244 : Adafruit Industries, Unique & fun DIY electronics and kits	Adafruit
2	Adafruit DRV8833 motor controller	1	$5.36	$5.36	Adafruit DRV8833 DC/Stepper Motor Driver Breakout Board : ID 3297 : Adafruit Industries, Unique & fun DIY electronics and kits	Adafruit
4	Arduino nano 33 IoT with headers	1	$27	$27	Amazon.com: Arduino Nano 33 IoT [ABX00027] : Electronics	Amazon
5	Pixy2 camera systems	1	$69.90	$69.90	Amazon.com: Charmed Labs Pixy2 Smart Vision Sensor - Object Tracking Camera for Arduino, Raspberry Pi, BeagleBone Black : Electronics	Amazon
6	APA106 LED	1	$35.99	$35.99	https://pmdway.com/products/apa106-addressable-rgb-through-hole-leds?srslid=AfmBOooSUnz6BY_YL7-x0MGSsp34AVLufrYcjlj04FuvAYABTla0C3	
7	Wireless charging receiver (adafruit)	1	$13.46	$13.46	Universal Qi Wireless Receiver Module : ID 1901 : Adafruit Industries, Unique & fun DIY electronics and kits	Adafruit
8	Wireless charging transmitter (adafruit)	1	$24.26	$24.26	Universal Qi Wireless Charging Transmitter : ID 2162 : Adafruit Industries, Unique & fun DIY electronics and kits	Adafruit
9	LiPo batteries 3000 mAh 3.7V (4 pack)	1	$35.14	$35.14	4x 3.7V Lithium Lipo Battery 3000mAh JST1.25 Connector for Arduino Nodemcu ESP32 | eBay	Ebay
10	Small Breadboard (12 pack)	1	$7.49	$7.49	LampVPath [12Packs] 170 Points Mini Small solderless breadboard Compatible for Proto Shield: Amazon.com: Industrial & Scientific	Amazon
11	Breadboard wiring	1	$15.19	$15.19	TUOFENG 22 awg Wire Solid Core Hookup Wires-6 Different Colored Jumper Wire 30ft or 9m Each, 22 Gauge Tinned Copper Wire PVC (OD: 1.60mm) Hook up Wire Kit - Amazon.com	Amazon
12	Jumper connector wires (camera) (10 cm)	1	$6.98	$6.98	Amazon.com: EDGELEC 120pcs 10cm Breadboard Jumper Wires Assorted Kit, 15cm 20cm 30cm 40cm 50cm 100cm Optional Dupont Wire 3.9 inch Male to Female Male to Male Female to Female Multicolored Ribbon Cable : Electronics	Amazon
13	Jumper connector wires (motors) (20 cm)	1	$5.99	$5.99	Amazon.com: ZYAMY 10PCS 2P Dupont Line 2 Pins 2.54mm Pitch Female to Female Dupont Cable Connector Multicolor Jumper Wire for Breadboard 20CM : Electronics	Amazon
14	Resistors	1	$9.99	$9.99	https://www.amazon.com/Elegoo-Values-Resistor-Assortment-Compliant/dp/B072BL2VX1?ref_=ast_sto_dp	Amazon
15	Inventory: screws #4-40, 3/8 in (pack of 200)	1	$8.03	$8.03	Glvaner #4-40 x 3/8" (200 pcs) Pan Head Machine Screws, 18/8 Stainless Steel 304, Phillips Drive Cross Round Head Machine Screws, Fully Threaded, Machine Coarse Thread: Amazon.com: Industrial & Scientific	Amazon
16	Inventory: screws #4-40 (pack of 25)	1	$5.49	$5.49	uxcell #4-40x1/4" Pan Head Machine Screws, 304 Stainless Steel 18-8 Screw, Phillips Drive, Fully Threaded, Bright Finish, Pack of 25: Amazon.com: Industrial & Scientific	Amazon
17	Proximity sensors	1	$6.75	$6.75	VCNL4010 Proximity/Light sensor : ID 466 : Adafruit Industries, Unique & fun DIY electronics and kits	Adafruit
	Final Total			$299		

References:

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5- Z. T. H. Tse, Y. Gao, K. B. Farley, H. Bai, and T. M. Fisher, "Electric Vehicle Wireless Charging Technology: A State-of-the-Art Review of Magnetic Coupling Systems," Wireless Power Transfer, vol. 7, no. 1, pp. 1-17, 2020. [Online]. Available: https://www.cambridge.org/core/journals/wireless-power-transfer/article/electric-vehicle-wireless-charging-technology-a-stateoftheart-review-of-magnetic-coupling-systems/FA955A930533CFABCA307C972DC94317. [Accessed: 29-Sep-2024].

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