ARtPUT: Autonomous Rover to Pick Up Trash

Progress Report 4: Starting Building Process

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Materials and Methods

Materials:

- DFRobot Devastator Tank Mobile Robot Platform serving as the tracked mobile base
- Raspberry Pi 4 Model B as the primary onboard computer for vision, navigation, and logging
- Arduino UNO for low-level motor, servo, and sensor control
- USB RGB camera with depth-sensing capability for object detection and grasp planning
- Ultrasonic sensors for short-range obstacle detection
- NEO-6M GPS module for position logging and route tracking
- Digital compass (magnetometer) for heading correction
- Infrared sensor for bin fill-level detection
- Two-finger robotic gripper actuated by a servo motor
- 12V DC suction pump with relay module
- Suction-assisted collection bin with approximately 500–1000 mL capacity
- L298N motor drivers for drive motors
- Buck converters for voltage regulation
- Two 11.1 V Li-Po batteries to power onboard systems
- Wireless telemetry and onboard data logging storage
- Cones, measuring tape, stopwatch, and field notebook for controlled outdoor testing

Procedure:

1. Dataset & training: To train an object-detection model (YOLO/SSD-style), gather and label a significant number of photos of the target litter types in the target park. Use artificial occlusions to enhance.
2. Software stack: Put in place a perception pipeline (object detection on RGB-D + depth clustering), SLAM-based localization (Lidar + odometry), and a manipulation controller that translates detected object pose to a grasp technique. We'll test two modes of perception manipulation: Vision-only bounding-box grasping (A); vision plus depth-point-cloud grasp planning (B).
3. Three 10 m × 10 m test plots in a public park with low pedestrian traffic are chosen for the test. A fixed number (N = 20) of different litter items are placed in each plot at random locations (pre-approved with park authority). Mark the start and goal points.
4. Trials: For each mode (A, B) run 10 trials per plot (total 60 runs), each trial starting from the same location, time-limited to 15 minutes or until bin full. Rotate item arrangements between trials. Record video, sensor logs, and manual observer notes.
5. Baseline: Include 10 human-assisted pickup runs (human uses same route, picks items by hand) for performance comparison.

Data Collection Methods:

- Automated logs: timestamps of detections, attempted grasps, success/failure flags, battery consumption, distance travelled.
- Manual annotations: items missed, misclassifications, pedestrian interactions, environmental notes (wetness, wind).
- Post-run bin content check to count unique items collected.

Safety Concerns:

- The use of electronics and batteries in our project presents a risk of burns and electrical shock.
- The gears in our system may catch onto our limbs and clothing, potentially crushing our limbs.
- The rover may move erratically and hit someone, causing a harmful impact.
- We may drop heavy objects on our feet.

Risk Mitigation:

- We will always wear safety glasses, gloves, and proper footwear while working on our project.
- We will not wear baggy clothes that could potentially get caught in gears.
- There will always be a supervising adult while we are working on our project.
- The rover will always be fully powered off when working on it.

Data Analysis

Extensive progress has been made on this project. For one, most of our materials from the supply order form have arrived. The DFRobot mobile base actually arrived, which was a relief for our group because that meant we didn't have to worry about getting a new base (a process that would've been time-consuming, because we would have to make sure that all of the parts are compatible with this new base). We are missing some key pieces still, like the Raspbery Pi and the two-finger robotic gripper. In fact, the gripper we intended to use was actually backlogged until later in February or March. We are currently looking for alternatives for that key piece, just in case it doesn't come in the near future. However, with the arrival of the DFRobot rover, we could now begin the building process, meaning that we didn't necessarily need the AutoCAD model anymore (that was for the event that we didn't have a rover for an extended period of time). We spent one day finishing the suspension of the robot, as well as attaching the motors. The next step in the building process was to add the wheels and tracks, and then to assemble the body of the rover. The base of the rover is now built, which means now all we have to worry about is figuring out how to mount all of the accessories onto it.

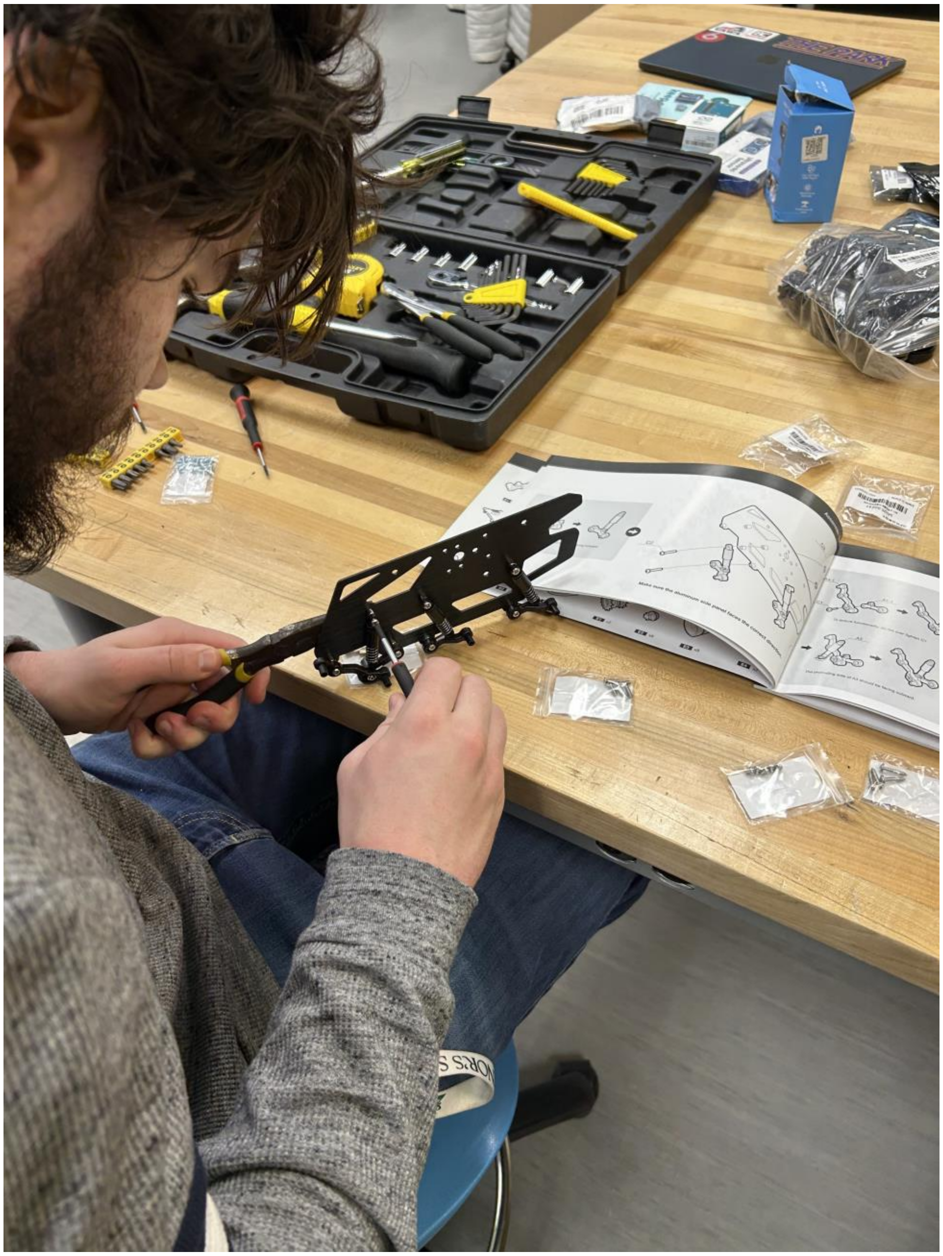

Figure 1. This is a picture of Dylan working on the suspension of the rover.

Figure 2. This is a picture of Dylan and Brendan posing with some of the robot's parts that were built.

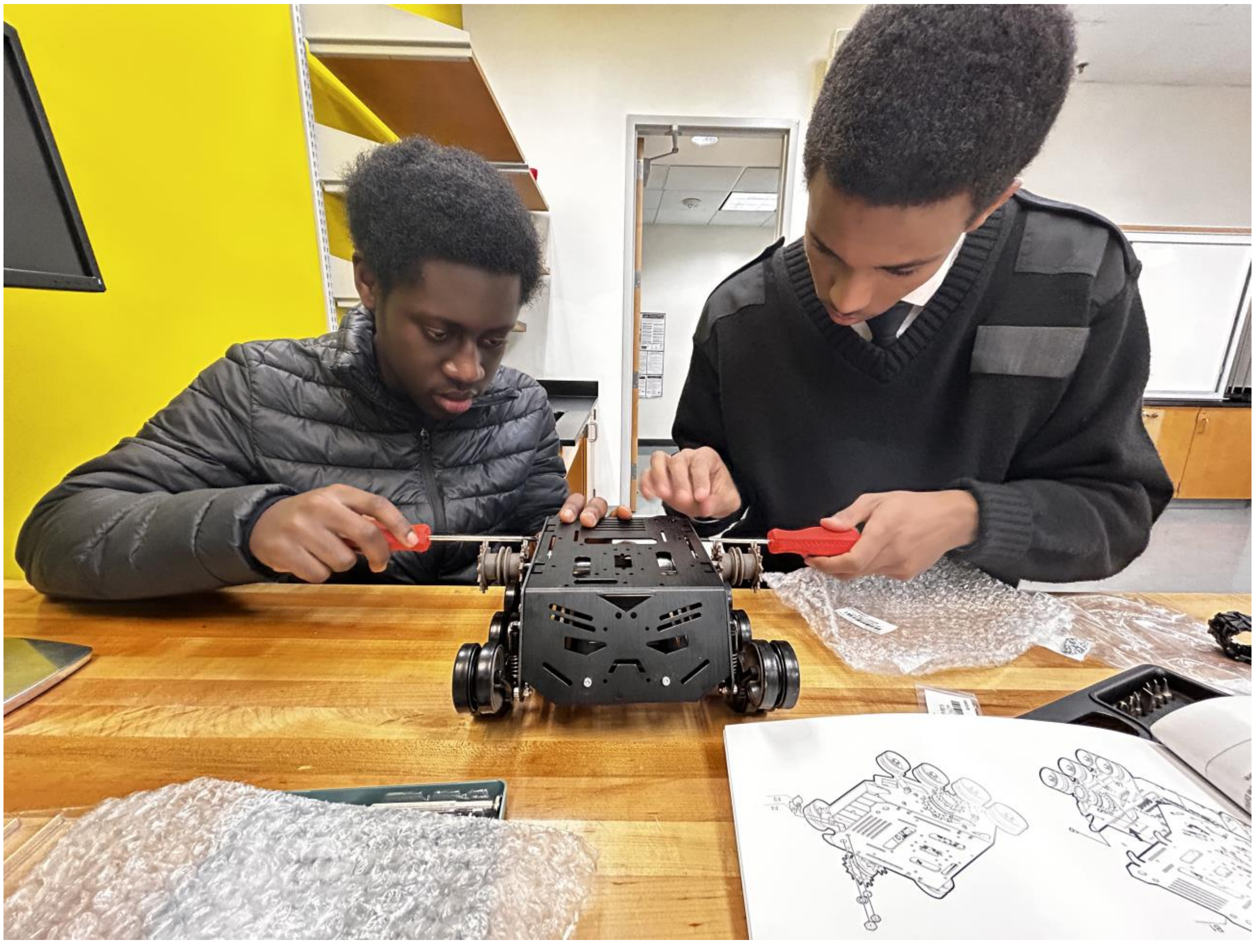

Figure 3: This is a picture of Brendan and Bokre putting the rover together.

Figure 4. This is the finished rover base, without any of the attachments or accessories on it yet.

There were also advancements made with the machine-learning algorithm. We’ve begun to refurbish an algorithm made by Bokre during a project he had done in the past. That algorithm was used to identify and classify different species of ticks. This revamping of the algorithm starts with finding many pictures of common trash items and putting them into the algorithm’s library.

These are things like cigarette butts, plastic water bottles, and fast-food wrapping/packaging. Now, this algorithm had a decent success rate back then and fit the purpose it needed to. However, for this project, it will need to be refined and adjusted for it to be satisfactory for our rover’s use. The goals for the next progress report are the following: figure out how and where to put the different sensors and controllers on the base, continue to make progress of the machine-learning algorithm, and confirm that all our parts are either already here, arriving, or soon-to-be arriving.

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