NOVEL LOCOMOTION ROBOT

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OVERVIEW

The robot is made up of three main parts – the chassis, rack and pinion actuators, and electrical equipment. There are 16 actuators scattered along the faces of the chassis. All actuator assemblies are identical and create the same movement. The electrical equipment is mounted onto support beams spanning the center of the chassis. The equipment is positioned in the center of the robot and is compact enough for the actuators to retract completely. Methods of fabrication, assembly, and interactions for these three components were overseen by the Mechanical Engineering team for this project.

CHASSIS

Fig 1. Assembled robot with both halves intact.

Components

The chassis is made up of three main parts – plywood face panels, PVC edges, and ABS plastic corner joints. The plywood is 1/8” birch that is laser cut. The jigsaw-like grooves are made along the edges of the faces to interlock with the PVC. Circles are cut in the middle of the plywood faces to reduce weight and allow for access inside the robot. Three of the faces, however, are intentionally left solid to allow for extra room to attach the electrical equipment. On the other hand, one of the robot faces is intentionally left open to allow for a larger access panel inside the robot. Note that this did not have a major effect on the location of the center of gravity because this is only a minor reduction in weight on one side. Additionally, no triangle faces were made because the PVC connected in a triangle is already rigid enough for its intended application, meaning the extra weight of the wood was not necessary. Discarding the triangle faces leaves more room for access inside the robot.

The PVC sides were cut to length with a miter saw and jigsaw grooves were cut with a mill. These grooves are complementary to the edges of the plywood, allowing for the PVC to be correctly positioned onto the plywood. Additionally, a 17/32 drill bit was used to place holes through the middle of the PVC where the actuator assemblies will be located.

The corner joints were 3D printed with ABS filament.

Assembly

All components were assembled using *ClearWeld Quick-setting two-part epoxy*. The chassis was left in two large halves, however. One of the top edges is left free for ease of access to the inside components. This is not an issue, however, because the tight fit between the PVC, corner joints, and panels are enough to grip the pieces together during rolling. If more aggressive rolling is desired, a strip of tape around the halves will ensure a tight hold. Additionally, ¼” neoprene foam is applied along the edges to soften the rolling.

ACTUATORS

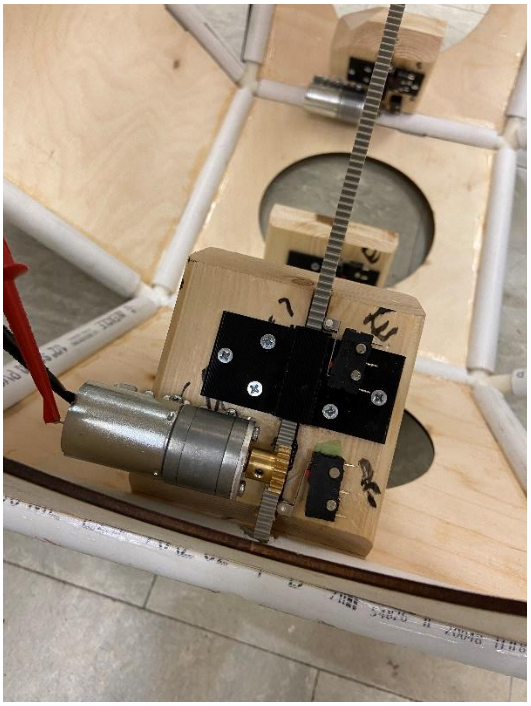

Fig 2. Complete and integrated actuator assembly on chassis.

Components

The actuator assemblies are made up of several components: a mounting block, motor, D-shaft pinion, 3D printed bracket & ramp, limit switches, plastic rack, motor bracket, and steel support beam. The main structure which holds all components is the lumber mounting block. A 2in x 4in x 8ft piece of lumber was cut into 16 equal pieces with the miter saw at a 22.5° angle (complementary angle of 67.5°). In addition, the slit on the mounting block was made with the table saw to allow the rack to slide through. The black bracket and ramps were designed in NX, and 3D printed with PLA material. The bracket was implemented after initially testing the actuator assembly and realizing the force exerted on the motor was causing it to stall. The ramps were designed as a solution to the limit switches provided by the Electrical Engineering team, which trigger the motors on or off when the rack is at a certain length. This ensures that the actuators stop extending once the robot rolls over and stop retracting once the rack lies flush with the surface of the robot. All these components, along with the vendor products, make up a single actuator assembly and the same process was repeated 16 times. An efficient procedure was done on a single block first to avoid variability.

Vendor Components

The motor, pinion, rack, and steel beam were purchased from vendors. The motor is a 20.4:1 metal gearmotor with a 4mm D shaft. Dimensioned 25Dx50L mm and powered with 12V. Specifications for the motor can be found on Pololu here: https://www.pololu.com/product/3203.

The rack and pinion are both 20-degree pressure angle, 0.8 module. Specifications for the rack can be found on McMaster here: https://www.mcmaster.com/2662N56/. The pinion has a pitch diameter of 13.6mm and includes a set screw. Specifications for the pinion can be found on McMaster here: https://www.mcmaster.com/2664N437/.

The steel beam that supports the rack is dimensioned 3/16" x 3/16" and can be found on McMaster here: https://www.mcmaster.com/8962K32/.

Assembly

All the components but the limit switches were assembled using screws. The screws allow for the actuator assemblies to be disassembled in case issues are faced. The limit switches were secured using nails for a more secure positioning as their placement is very sensitive. Wax was distributed along the slit to allow for a smooth contact between the wood and the steel beam.

The limit switches provided by the ECE team were implemented simultaneously with the 3D printed brackets. Integrating the limit switches into the actuator assembly was challenging because up to this point, actuator assembly was about complete. However, to avoid changing the design, the geometry of the rack was used to our advantage. To trigger the motors movement, the limit switches must be either clicked in or released. The top limit switch would be triggered when released by placing it as close as possible to the rack. In movement, once the end of the rack is reached, the limit switch will open, and the rack is signaled to stop extending. On the other end of the mounting block, a ramp was epoxied to the rack and would trigger a second opened limit switch. This signals the motor to stop retracting. The ECE team was responsible for programming the motors and limit switches.

Integration with Chassis

The actuator assemblies are positioned along 16 edges of the robot. These are positioned along two of the linear paths of the rhombicuboctahedron shape. The actuators for both linear paths were placed in a pattern on the same side of each plywood panel.

When aligning the mounting block onto the panel, the rack was extended through the hole in the PVC. To allow for the rack to slide, the set screw in the pinion needs to be loosened, as the gear ratio in the motor is too high to be able to back drive. With the mounting blocks positioned roughly parallel to the PVC, and the rack sliding smoothly through the clearance hole, the position was held and two #8 x 1-5/8" wood screws were driven through the face and into the mounting block. If there was too much friction on the rack, the set screw was loosened more, wax was added to the groove in the mounting block, and the hole in the PVC was filed down to give more clearance.

EQUIPMENT MOUNTING

Primary Components

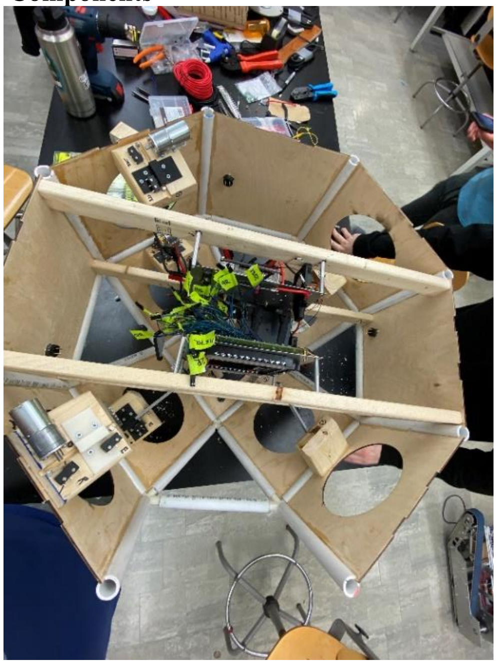

Fig 3. Electrical equipment attached to support beams.

The electrical equipment is mounted primarily to the four support beams that span across the center of the robot. These beams are 1x2" cut to length. The electrical equipment is made up of two panels with standoffs on each corner. The standoffs are two inches in length and connect to the support beams, positioning the panels between the beams. Holes were drilled into the beams, along with clearance holes that go halfway through the thickness of the beam. If needed to be removed, a screwdriver will fit through the clearance hole of the beams, and screws are used to secure the standoffs. Additionally, these two panels have wiring connecting to all of the motors, limit switches, and other electrical equipment scattered along the chassis. This equipment consists of the stop buttons and ultra-wideband boards.

Stop Buttons

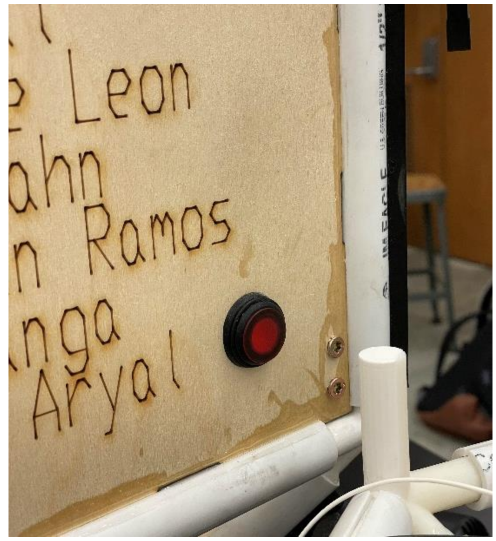

Fig 4. Stop button mounted to solid panel of chassis.

Four stop buttons are positioned around the chassis of the robot. Placed on the three solid panels and one of the hole panels, these buttons are scattered evenly around the robot. If for any reason the robot needs to be stopped during its movement, these buttons should be pressed. There is a light in the button that corresponds to off / on.

Ultra-Wideband Housing

Four 3D printed shells were designed to house the ultra-wide band boards and its components: switch and battery. These housings are placed inside the chassis. Mounted to the three solid panels and one of the hole panels, these boards are scattered evenly around the robot. It is important that metal does not cover these boards, as they will block the signal of the ultra-wideband and the robot will lose sense of its location relative to the other ultra-wideband signals positioned in the testing environment.

