Experiment M11
RC Retrieval Vehicle
Procedure

Deliverables: Checked lab notebook.

Overview

In this lab, you will add a robotic arm to your RC vehicle and use it to retrieve an empty soda can and place it in 4 inch tall basket. The arm will have a gripper on the end for grasping the can, and a shoulder joint for raising and lowering it. Both will be actuated by RC servos. You will have the option of choosing a regular servo with position control or a continuous servo with speed control for the shoulder joint. The should joint will be enhanced by implementing a 4-bar mechanism to provide increased mechanical advantage and holding torque.

Subsystem A: Electric Powertrain

You will begin by reassembling the electrical powertrain—the system that distributes electrical power from the battery to the motors—as you did in the previous lab.

CAUTION: Lithium batteries pose a serious fire risk. Follow all instructions carefully when building your circuit. Do NOT intentionally modify or damage the battery in any way.

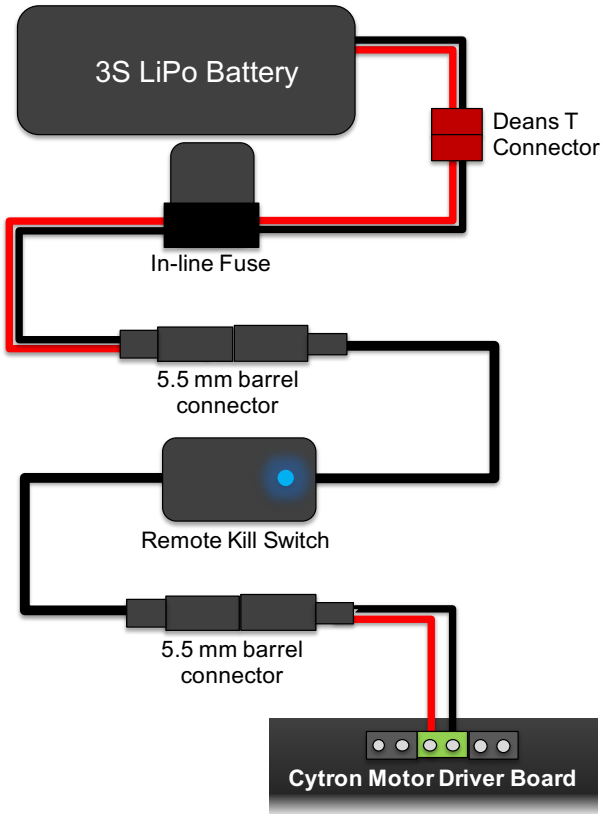

Figure 1 – A 3S LiPo battery is connected to a Cytron dual motor driver board. Between them are a series of safety features that regulate the flow of power.

Safety First: You must wear safety glasses when working with lithium batteries.

Procedure

Rebuild the electrical power train, as you did last week in lab, following the instructions are listed below.

1. Connect a female 5.5 mm barrel connector to the green screw terminals on the Cytron motor driver board. The red wire goes to the + terminal, and the black wire goes to the – terminal.
2. Locate the 3S LiPo battery. Take it over to the counter top and plug the connector with the four small wires into the battery charger and balancer. You should see all three LEDs light up green, indicating that each of the three cells in the 3S battery are fully charged. If not, ask the lab instructor or TA for help.
3. The red Deans T connector on the battery is our first safety feature. It prevents you from connecting the battery in the reverse polarity, which often results in a short circuit and a fire. Connect the battery to the in-line fuse.
4. The in-line fuse is our second safety feature. It contains a sacrificial metal filament that will melt and break the circuit in the event of a short circuit. Connect the fuse to the remote kill switch via the 5.5 mm barrel connector.
5. The remote kill switch is our third safety feature. It allows the system to be shut down with a small remote control in the event of an emergency.
6. Connect the male end of 5.5 mm barrel on the remote switch to the barrel connector you connected to the motor driver board. The system should now look like Fig. 1.
7. Test the remote kill switch. You should be able to toggle the Cytron motor driver board ON and OFF with the remote key fob.
8. Download the user manual for the Cytron motor driver board from the lab webpage. Read Section 8.1 – RC Input Mode.
9. Connect the RC receiver and motors to the motor driver board, as shown on page 15 of the manual.
10. Turn the system ON with the remote kill switch. Turn ON the RC transmitter, and check that it binds correctly with the receiver.
11. Test it by using the joysticks on the remote control to adjust the speed of the motors.
12. **Demonstrate the working subsystem to the TA, so you can be awarded points on your score sheet.**
13. Use the remote kill switch to turn OFF the electrical powertrain subsystem. Disconnect the motors from the Cytron board. Leave the rest of the subsystem intact, and set it off to the side.

Subsystem B: Robotic Gripper

Safety First: You must wear safety glasses when working with lithium batteries.

Procedure

1. Assemble the robotic gripper. Refer to the 2 minute instructional video on the product webpage. https://www.servocity.com/standard-gripper-kit-a/
2. Use M3 screws, nuts, and washers to attach the gripper to a piece of GoBilda low-side U-channel. Choose the length wisely, as this will be the length of your mechanical arm.
3. Connect the gripper servo to the RC receiver. You should be able to open and close it with the RC transmitter.
4. Determine which channels on the receiver corresponds to the small knobs on the top of the RC transmitter. Connect the gripper servo to one of these channels, so you may open and close it with one of the small knobs.
5. **Demonstrate this working subsystem to the TA, so you can be awarded points on your score sheet.**

Subsystem C: Mechanical Arm

You will now mount a servo to the chassis and mount the arm to the servo using the same GoBilda servo block that you used in the previous RC system lab.

1. Assemble the GoBilda servo block, as you did in the previous lab, and use the GoBilda hardware to mount it to the vehicle chassis.
   a. **Design Decision:** Choose either a regular servo (position control) or a continuous servo (speed control).
   b. You may need to rearrange the electrical power train to make room for the mechanical arm.
   c. Various examples for mounting the servo block can be found on the product page linked below.

      https://www.servocity.com/compact-servoblock-43mm-width-for-standard-size-h25t-spline-servo-hub-shaft/
2. Use M4 screws to attach the robotic arm to the servo hub. Note that the goal is to pick up an empty soda can and place it in a shallow basket.
3. Connect the servo to the RC receiver. You should be able to control it with the RC transmitter.
4. Test the remote control of the mechanical arm. Determine what controls will be the most use-friendly.
5. **Demonstrate the working subsystem to the TA by raising and lowering the arm with the remote control, so you can be awarded points on your score sheet.**

Design Challenge 1 – 4-bar Mechanism

As you probably noticed, the servo does not have very good holding torque, and the arm tends to sag down to the ground. The user control is also a bit too sensitive and small adjustments on the RC transmitter result in large swings of the arm. You will alleviate these deficiencies by incorporating a 4-bar mechanism to provide increased holding torque and mechanical advantage. It should also make the controls more user friendly.

- Remove the arm from the servo hub. Use the GoBilda hinge to create a revolute joint on the end of arm.
- Use additional GoBilda hardware to create a 4-bar mechanism. Refer to the M11 lecture video for additional details.
- Do not directly copy the mechanism from the video. Be creative. Be original. Come up with something better.
- If you are using a regular servo with position control, use the remote to check the range before you connect any linkages. That is, make sure the servo shaft is not already at or near the limit of travel, which would prevent it from rotating any further.
- The 4-bar mechanism should increase the mechanical advantage and allow for finer user control. It should also allow for enough range that a soda can may be lifted from the ground and placed into a 4" tall basket.
- **Demonstrate your working 4-bar mechanism to the TA to receive credit on the score sheet.**

Design Challenge 2 – Retrieval

The final goal is for the vehicle to drive to a soda can, pick it up with the mechanical arm, and deliver it to a 4" tall basket.

Safety First! – Your vehicle must have foam corner pads on the corners of the chassis.

- Make sure the electric power train, motor driver board, and RC receiver are all properly connected and securely fastened to the vehicle chassis.
- You should be able to drive the vehicle with the remote control as you did in the previous lab.
- Test the system in the hallway. Modify the remote control connections to make it more user-friendly.
- **Demonstrate to the TA that you are able to pick up a soda can from a random location and place it in the basket.**

Clean-up

- Disconnect the RC receiver and battery from the vehicle. Leave the rest of the vehicle intact. You will use it again next week for the M12 – Autonomous Vehicle lab. Place the vehicle up in the cabinet above your lab bench.
- Place the battery back in the flame retardant LiPo bag on the counter top.
- Put anything that belongs in your tool kit back into the tote bin.

Data Analysis and Deliverables

You do NOT have to write a tech memo for this lab. Rather, you will need to drive your vehicle around a race track on the South Quad. Only the students who complete 2 laps in less than the average time will receive full credit. (See score sheet.)

Appendix A

Equipment

- 3S LiPo battery, 5200 mAh, fully charged
- 5A In-line fuses with Deans T connectors
- Remote kill switches with key fobs
- Cytron dual motor driver board - SmartDriveDuo-10 MDDS10
- DC motors (greartisan 37mm)
    - 100 RPM
    - 200 RPM
    - 550 RPM
- BaneBots Wheels, Hub Mount, 60A, Black
    - 2" x 0.8"
    - 2-7/8" x 0.8"
    - 3-7/8" x 0.8"
    - 4-7/8" x 0.8"
- BaneBots T81 Hub, 6mm Shaft with retaining rings
- Retaining ring pliers
- Flysky FS-i6X 2.4G 10CH Radio Transmitter and Receiver iA10B – Amazon Part # B0B3T2R65X
- 2020 T-slot rail, various lengths
- Fasteners for 2020 T-slot rail
- Caster wheels
- Pillow block bearings for 6mm shafts
- 6 mm steel shafts
- Tape measure