Manipulators

With these examples we will demonstrate some basic designs to accomplish each of the game piece challenges involved in the 2018 FIRST Global game "Energy Impact" to:

1. Collect fuel cubes and deliver them to scoring areas
2. Obtain solar collectors and deliver them to the scoring area
3. Rotate the wind turbine crank several turns until it becomes active

These scoring opportunities will require you to create mechanisms in order to effectively score points. These mechanisms will be used to manipulate both game pieces and field elements, so we will refer to them as manipulators.

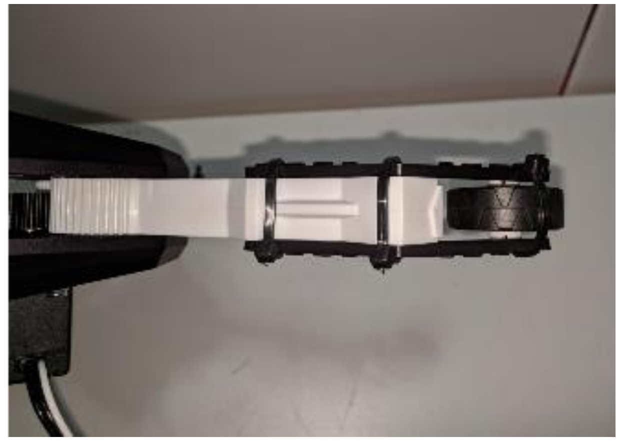
Example 1: The Claw

We can use the Grasper Claw Assembly to create a simple mechanism that will grasp both fuel cubes and solar panels. This is the simplest manipulator we can create since the assembly has already been provided to us.

First we will create two arm assemblies that will act like fingers to grip the game pieces. This example creates a very basic arm, but you should experiment with alternative designs to obtain optimal performance. You will notice from trial fitting parts that none of the fasteners included in the kit are long enough to pass through the holes in the arms and secure other parts. The rules allow for additional M3 fasteners up to 50mm length; use these if you have access to them. This example only uses parts found in the provided kit, so we will make due with cable ties to hold the parts together.

The basic arm assembly is created from just 4 parts: a gear arm, two 135 degree plastic brackets, and a 30mm traction wheel. The plastic brackets are placed on opposite sides of the the gear arm with the wheel between them. The traction wheel is included to provide grip on the game pieces. Alternatives to traction wheels could be used for grip, such as pieces of surgical tubing or polyurethane round belt.

The next step is to fit a servo gear adapter onto one of the smart servos. This servo is then installed onto one of the side plates of the claw assembly. The whole assembly is then put together, with the two side plates holding everything together. In the example we will mount this on the end of one of the extrusion pieces. The travel range of the arms can be changed by rotating the position of them relative to the servo during assembly, or purely with software.

In operation, the claw works best if it closes a couple of centimeters tighter than the width of the game piece. This gives a powerful clamping force to keep the game piece secure. Experiment to determine what works best for you. In the pictures below you can see example of the claw in operation. Note that the short dimension of the solar panel is close enough to the width of a fuel cube that a properly set up claw can collect either piece with the same settings. The claw can also close further to pinch a solar panel across its thickness.

Additional Ideas:

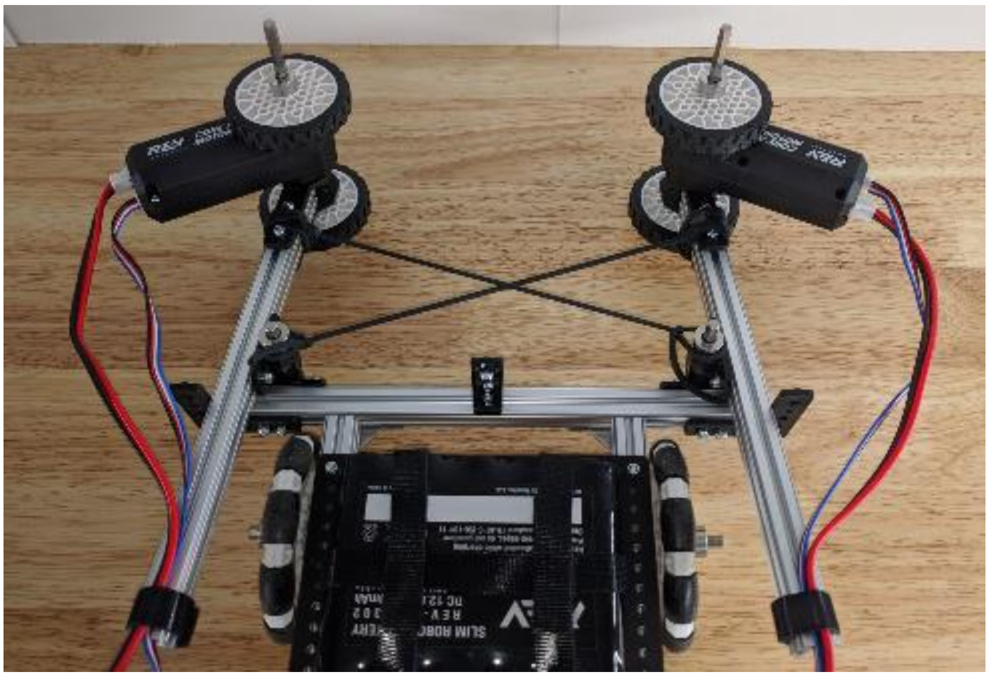
- Create several different claw travel levels to grasp different game elements (cubes, length of solar panel, thickness of solar panel) programmed to individual game pad buttons.
- 4 wheels will provide a more stable grip that is less likely to allow the game piece to rotate.
- Mount the claw to a lift or arm to reach different heights.
- Spreading the arms 180 degrees apart can provide a good tool to push fuel cubes into scoring areas.

Example 2: Active Wheel Intake

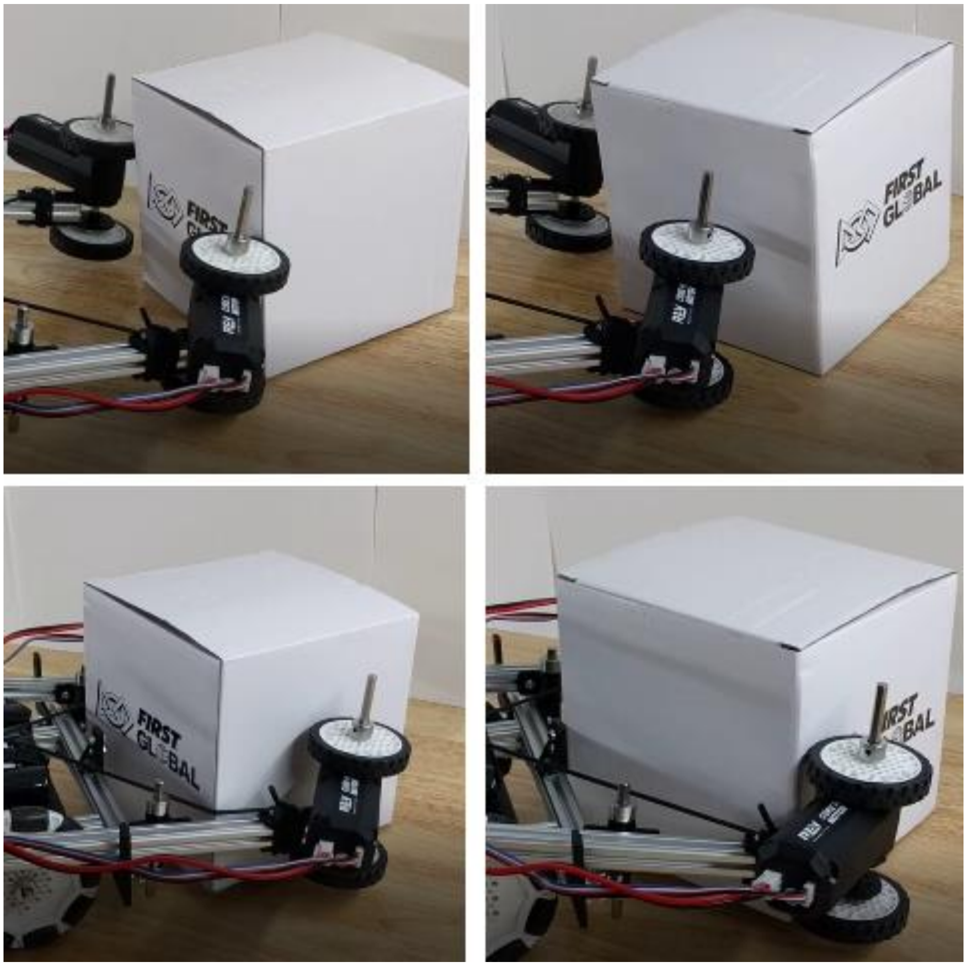
An alternative to grasping fuel cubes with a claw is use an active intake mechanism with powered wheels. This is similar in operation to the machines used to launch tennis balls or baseballs for practice, and is often seen in the other robotics competitions for collecting game pieces quickly and reliably. This example will demonstrate a simple direct-drive wheel intake that you can use for experimentation.

We will start by using a plastic rod end bracket to attach a hex core motor to the end of a 22.5cm extrusion, angled 45 degrees from extrusion. Opposite the motor you want to attach another plastic rode end bracket to use as a bearing support. Now insert a 13.5cm hex shaft through the motor and install a through bore bearing on the side opposite the motor. Now press a 60mm traction wheel onto each end of the shaft, with a single hex spacer between the bearing and wheel on the side opposite the motor. Install shaft collars on both sides of the shaft to secure the wheels. Mirror this design to create the second half of the intake. You will also want to create a pivot for each arm, which in this case was made with a pair of pillow blocks, associated bearings, a hex shaft, and shaft collars. See the assembly pictures below.

Now we will install the intake arms on the practice bot and create a method to control the pivoting of the hinges. The picture below shows how this done. The hinges are mounted on an extrusion that runs across the width of the front of the robot, but they could also be attached to the sides or to vertical supports. The excess shaft length should be on the top side to keep the lower wheel as close to the ground as possible. Sections of surgical tubing are tied between the arms near the motors and a fixed point on the bot to pull the arms closed. This will provide a clamping force for traction and to hold game pieces in place while still allowing the arms to rotate outward for misaligned game pieces. A pair of 90 degree angle brackets are installed at the ends of the cross bar to limit the inward rotation of the arms. This limit should be set by testing where it will allow best intake of game pieces.



The motors should be programmed to rotate in opposite directions at the same speed. Running the motors one way will pull game pieces in toward the robot and reversing the rotation will push the game pieces back out. When properly adjusted the wheel intake will pull in fuel cubes at any orientation and also pull in solar panels that are flat on the ground. Operation is demonstrated in the pictures below.



Additional ideas:

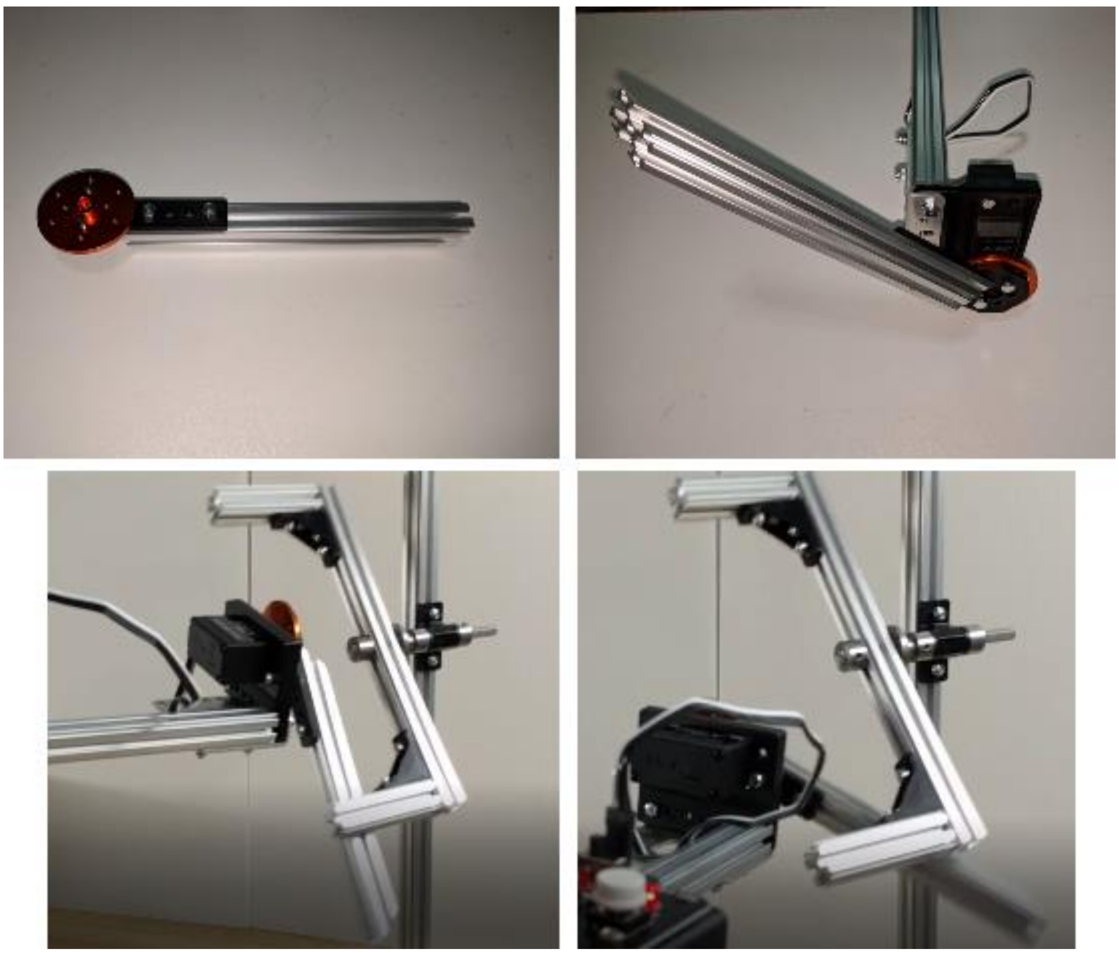
1. The example intake places the motors in a vulnerable location and also places a lot of weight at the ends of the arms. This can be improved by using a gears, chain, and tubing and pulleys to drive the intake remotely.
2. Larger intake wheels will make operation easier but take up much more room.
3. A contact sensor can be used on the crossbar to stop the motors once a game piece has been pulled into the robot.
4. The intake can be mounted on a lifting mechanism to place game pieces at greater heights.
5. Experiment with arm length, arm spacing, tubing tension, and other adjustments to optimize performance.

Example 3: Windmill Driver

A very simple device can be created with a smart servo to drive the windmill. This is a compact, light weight way to accomplish the task and it can be mounted directly to your robot at the correct height to engage with the windmill crank. You will need to program the servo to operate in continuous rotation mode in order to achieve the necessary number of turns.

This example will show two very easy methods to engage the windmill crank from either the axial direction or the radial direction. We will start with the radial method first. For this we will simply thread two M3x16 screws into an aluminum servo horn from the servo side, as far apart as the holes allow. Over the exposed threads of the screws you can slide sections of polyurethane round belt a few centimeters long which will engage with the cross bar on the windmill. It helps to bend the tubing out at an angle from the center of the servo rotation axis, which can be done by carefully heating the tubing to soften it before allowing it to cool at the desired angle. The pictures below demonstrate how the axial method works.

While the axial design shown is very compact it does require good precision in lining up with the windmill to operate properly. This can be improved upon with further experimentation and modification. Alternatively, we can create a design that engages radially with the windmill to improve ease of use on the game field. Instead of the screws and tubing we will install a single 15cm extrusion onto the aluminum servo horn with a plastic rod end bracket. A greater width extrusion that extends both directions from the servo could be used instead, but this provides no real benefit over the single sided design. Experimentation with this design will demonstrate that alignment is far less critical to properly engage the windmill crank than with the axial drive. In fact, even aligning off center and 20-30 degree off of the rotation axis is no problem. This design is shown in the pictures below.



Additional ideas:

1. Try different sizes and shapes of attachments to the servo to optimize effectiveness.
2. Extent the attachment out from the servo so that the servo and its mounting does not need to fit. inside the windmill crank radius during operation