Neo Manipulator

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Servo

Idea

Use a waterproof servo with some type of mechanism that converts rotational motion to linear motion.

Variations

Use a rack and pinion mechanism

In this design the pinion would be connected to a high-torque servo with 180, 360, or continuous motion.

- Pros
  - Simple
  - Compact
  - Realistic to print with MDF
  - Semi-precise control of the arm's position
- Cons
  - Requires proper lubrication
  - Can be slower then other linear motion mechanisms
  - Mechanical complexity may increase with higher torque or larger rack
  - Requires careful calibration

Use a worm screw mechanism

In this design, a worm screw drives a nut that moves linearly. The worm screw can also prevent backdrive, solving the issue of stripping out servos and destroying the arm.

- Pros
  - High torque transmission
  - Can prevent backdriving, ensuring the arm holds its position
  - Self-locking possible
  - Suitable for high-load
- Cons
  - More complex design
  - Requires lubrication
  - Can still be slower compared to other linear motion mechanisms
  - Lower efficiency than lead screws

Use a lead screw mechanism

In this design, a lead screw and nut convert rotational motion to linear motion with reduced friction compared to worm screws.

- Pros
  - High efficiency
  - Can be faster than other linear motion mechanisms
  - High accuracy
  - Simplicity in between **rack and pinion** and **worm screw**
- Cons
  - May backdrive
  - Requires careful calibration
  - May wear over time

Use a cable driven mechanism

In this design, a servo or other motor is used to drive a cable that pulls the arm along a linear path.

- Pros
  - Lightweight
  - Compact
  - Flexible
- Cons
  - Wear over time
  - Limited strength
  - Potentially more complex
  - Maintenance
    - Regular maintenance and tension adjustment are required to keep the system functional

Hydraulics

Idea

Use hydraulic fluid to actuate a piston or cylinder that moves the arm linearly. Hydraulic systems can provide powerful force with relatively small actuators.

Pros

- High power-to-weight ratio
- Precise and smooth control
- Compact

Cons

- Complexity
  - Requires pumps, reservoirs, and hoses
- Leakage risk
  - Requires sealing
  - A leak would be catastrophic in competition
- Weight
  - Due to the high complexity the multitude of parts might put us into the next weight class

Electrical Linear Actuators

Idea

Use an electrical linear actuator to drive the arm mechanism directly.

Pros

- Compact
- Precise control
- Simpler to program directly
- No fluid required
  - Unlike hydraulics or pneumatics, electric actuators don't need fluids that means less complexity and no fear of leaks

Cons

- Limited force
- Speed
  - Not a very big issue
- Wear and tear
  - Breakage is a possibility but less likely compared to fluid-based systems

DC Motor

Idea

Use a DC motor with a gear mechanism (e.g., lead screw, rack and pinion, or belt system) to convert rotary motion into linear motion.

Pros

- Compact
- Efficient
- Relatively cheap

Cons

- Backdriving
  - A brake would need to be implemented
- Imprecise
- Limited power

Note

All of the same pros and cons from the section on servo mechanisms apply

Pneumatics

Idea

Use compressed air to actuate a piston or cylinder for linear motion. Pneumatic actuators are lighter than hydraulic systems and can be more responsive.

Pros

- Lightweight
  - Lighter than hydraulic
- Fast response
  - Not as important as strength
- Simplicity
  - Compared to hydraulics

Cons

- Limited power
  - Weaker than hydraulics
  - Still pretty strong
- Requires pressurized air
  - Compressed air tanks or a compressor are required
  - This adds complexity and weight
- Risk of Leakage
  - Similar to hydraulics, a leak would be catastrophic