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Groundhog: In-Pipe Robot With Screw Drive Mechanism

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Introduction

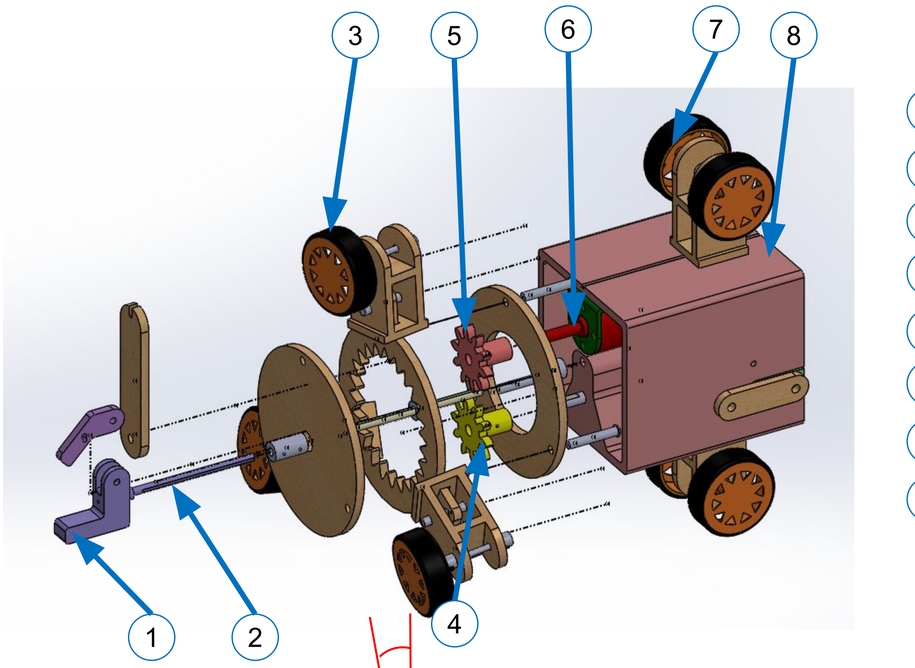
- This project explores the potential application of screw drive, a rotor powered by a single actuator, in an in-pipe robot design. A novel design of the screw drive allows a gripper unit to be installed in front of the screw drive. A prototype robot is fabricated and validated. Due to the use of a single driving actuator, the mechanism can be miniaturized, allowing broader range of applications.

Screw Drive

- Our screw drive consists of three passive wheels in contact with the inner pipe wall, mounted on a ring gear that rotates about the robots center axis. The wheels are positioned at an angle of 10 degrees offset from the front face of the robot - when the rotor spins, the wheels track a helical, “screw” motion that drives the entire system forward. The screw drive is driven by an off-centered gear powered by the DC motor installed in the stator.

Gripper

- The gripper is installed in front of the rotating screw drive. The gripper is cable actuated, which is controlled by a servo motor in the main body - the off-centered design of the screw drive facilitates this setup, as the gripper cable is passed through the center of the screw drive and a slot cut in the bore shaft.



Materials + Process

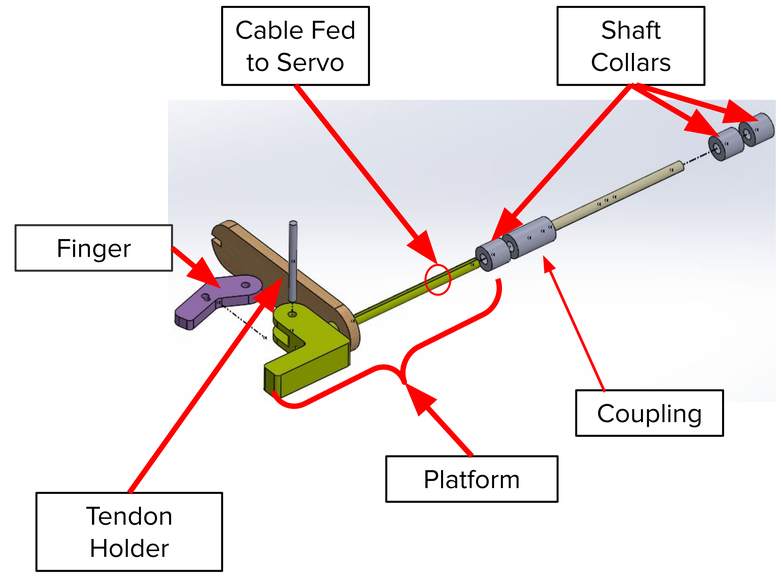
- Laser cutter
  - Plywood with ⅛” thickness
  - Efficient prototyping technique to design planar parts
- Ultimaker 3D Printer
  - PLA materials
  - Delivers more complex geometry
  - Efficiency in making quick edits

References

T. Nishimura, A. Kakogawa and S. Ma, "Pathway selection mechanism of a screw drive in-pipe robot in T-branches," *2012 IEEE International Conference on Automation Science and Engineering (CASE)*, 2012.

Design and Parts

1. Gripper: end effector of the robot
2. Cable Guide: bore shaft used as a guide for gripper cable
3. Tilted Wheels: passive wheels positioned tilted to drive
4. Passive Gear: gear to increase stability of the screw drive
5. Active Gear: gear to provide rotations of the screw drive
6. Screw Drive Motor: the only motor used to drive forward
7. Passive Main Body Wheels: wheels holding the body in pipe
8. Main Body: chassis houses the motor and servo motor



Conclusion + Future Improvement

- The robot can conquer straight pipe using one driving motor
- Brainstorm different designs and think about how Geometric-tolerancing come into play
- Operate in a variable-diameter pipe
  - Add spring system to the legs
  - Add linear actuators in the legs for a larger diameter pipe
- Achieve steering ability
  - Add a rotational degree of freedom for the screw drive
  - Navigate through T branches and elbows
- Enhance gripping ability
  - Gripper should be able to rotate and perform difficult gripping task