Low Resource Bronchoscope

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Project Importance

Within the last two decades there has been a rapidly increasing demand for healthcare services in low-income countries.

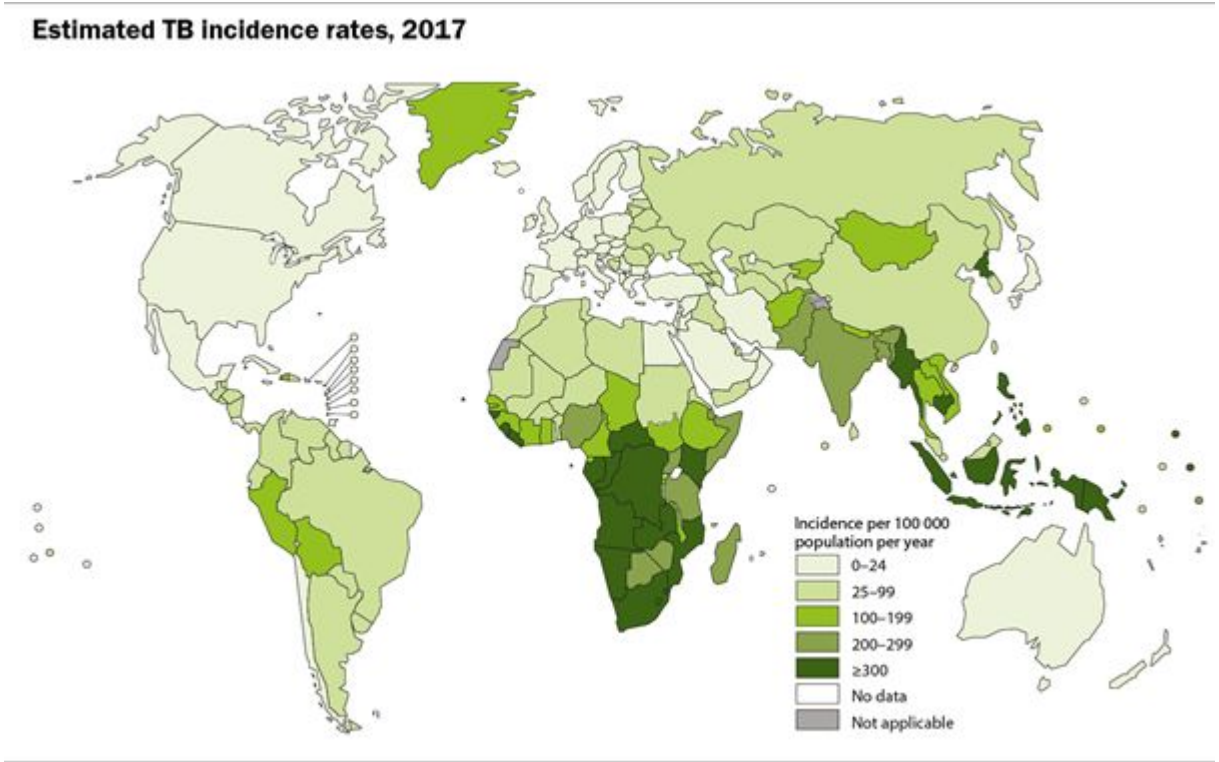
1. Geopolitical reasons: natural and manmade disasters
2. Burden of illness exceeding existing healthcare capacity
3. Lack of healthcare infrastructure
    a. Scarcity of medical facilities, shortage of medication and medical equipment

Respiratory diseases are leading causes of death in low resource areas

The burden of Tuberculosis (TB) is the highest in low-resource areas and was one of the top 10 leading killers in 2018

Estimated 10.6M new cases and 1.5M deaths

Treatment success rate is 85% in 2018



Bronchoscope collects a purer sample and better identifies origin of bacteria

- More than one third pulmonary TB patients cannot produce sputum
- Even when produced, there is an inadequate volume or quality in up to 20% of the case

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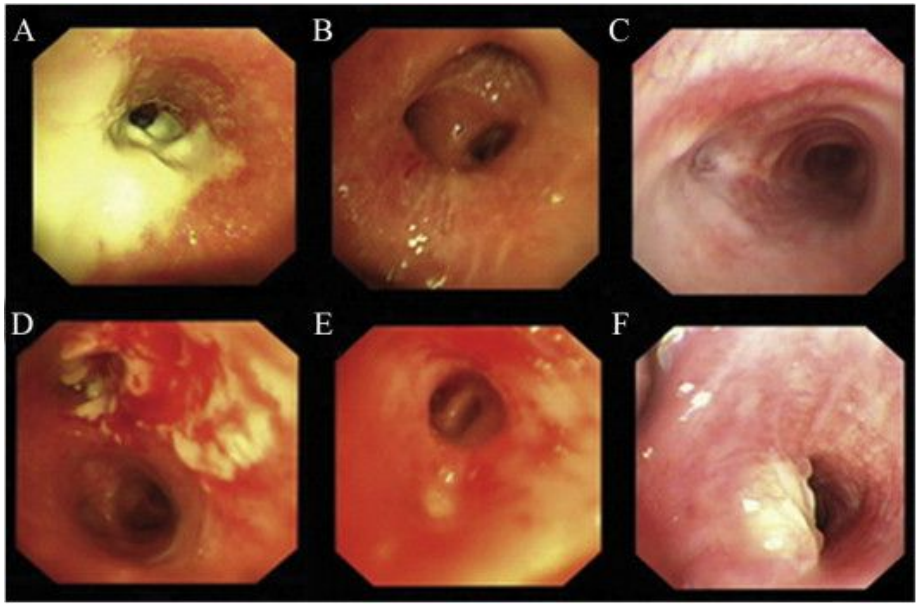

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- More than one third pulmonary TB patients cannot produce sputum
- Even when produced, there is an inadequate volume or quality in up to 20% of the case

- Bronchoscope allows sputum to be collected at the suspected TB source
  - Allows doctors to explore airways and collect adequate volume/quality
  - 2015 Review: 83% - 92% sensitivity and 91% - 98% specificity

Current Market

- Two major players in the reusable bronchoscope field
  - Olympus - high baseline cost: 7,000-15,000 USD
  - Pentax - lower base cost: 4,000 USD

Additional Cost Factors

Cleaning costs between 100 and 300 USD

Reusable vs Single Use probes

- Single use probes are easier to use
- Reusable probes have lower cost per procedure

Key Differences

Our Device

1. Decreased Video Quality

800x800 pixel resolution at 60 fps

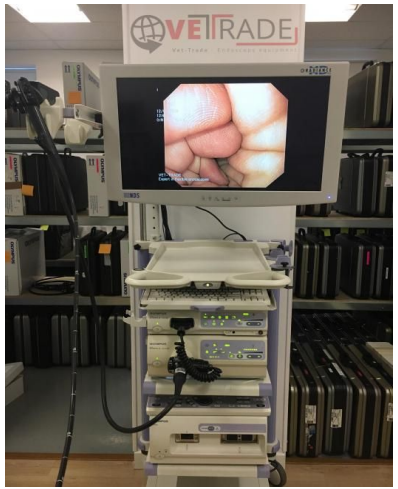
Capable of edge detection

Current Devices

1. HD Video Quality

26-inch full HD LCD Panel

Built in software for blood vessel visualization



Key Differences

Our Device

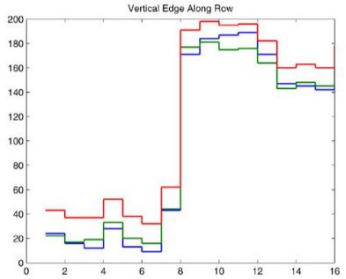
1. Decreased Video Quality

   800x800 pixel resolution at 60 fps

   Capable of **edge detection**.

An **edge** is an area in an image where there's a difference in intensity, color, texture, etc.

- Dark veins of blood vessels vs lighter colored surrounding tissue.
- Can create a histogram of the RGB color levels with OpenCV software.

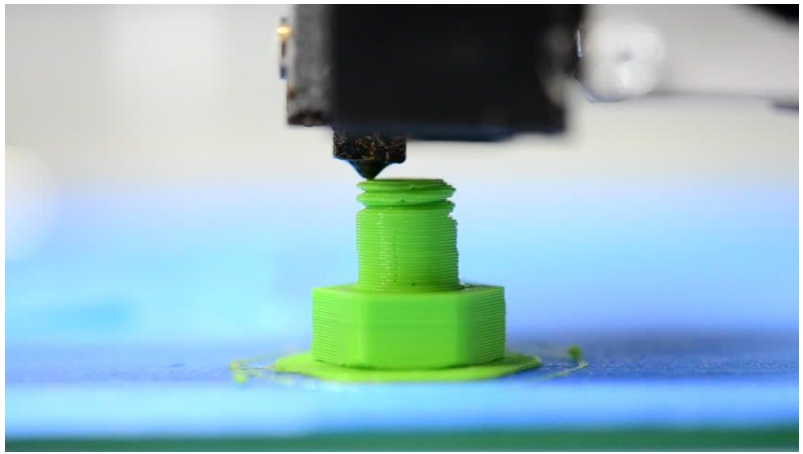


Key Differences

Our Device

1. Decreased Video Quality
2. Lower Material Quality

ABS or PLA (plastic) body



Current Devices

1. HD Video Quality
2. Higher Material Quality

Proprietary body material with polymer coating (polycarbonates, polypropylene, polyethylene)

- Versatile plastics with low moisture absorption
- Heat resistance
- Chemical and bacteria resistant

Key Differences

Our Device	Current Devices
1. Decreased Video Quality 2. Lower Material Quality 3. Reduced Functionality	1. HD Video Quality 2. Higher Material Quality 3. More Functionality
Max angulation: 90°/90° (up/down) 90°/90° (left/right)	Maximum angulation: 210°/130° (up/down) 120°/120° (left/right)
Available Functions: suction and camera	Available Functions: biopsy/suction, air channel, water channel, fiber optic image bundle

Problem Statement

We aim to design and develop a bronchoscope that is more cost efficient, portable, and durable than current devices on the market and can also be controlled with common appliances such as iPhone and iPad technology for universal ease of use and increased availability.

Needs Assessment

Functionality
- Match competitor specifications as closely as possible
- Equipped with a companion application with integrated IP modules

Cost Reduction
- Materials and hardware shall be selected to reduce cost without large sacrifices to performance
- The main probe shall be reusable with a single use outer sheath to eliminate reprocessing fees

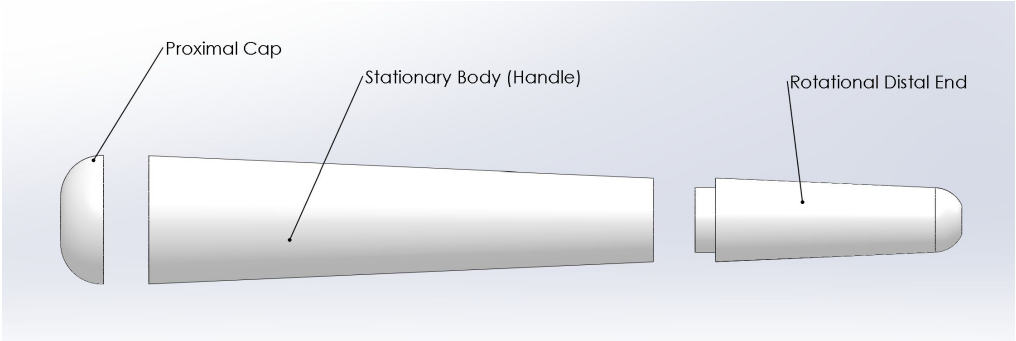
Ease of Use
- Intuitive control system that non-professionals can learn to operate
- Integrated IP modules shall aid non-professionals in point-of-care diagnostics
- Parts will be easily replaceable in case of failure

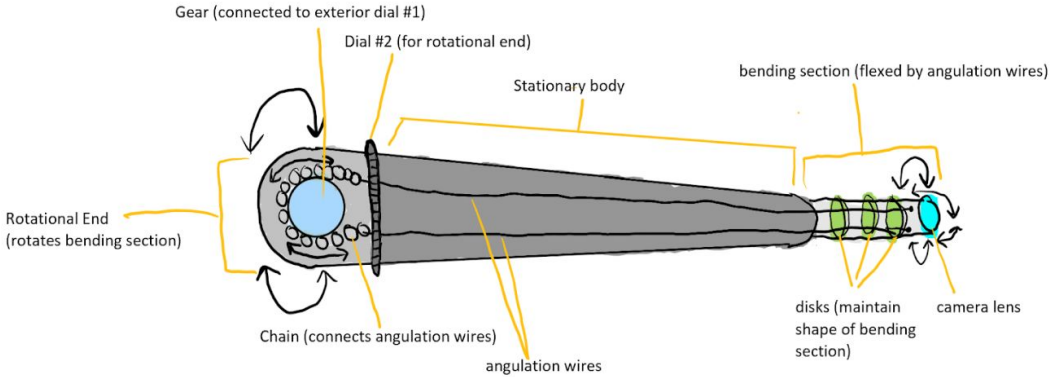
Portable
- Powered using single cell batteries
- Coiled to save space during transport

Durable
- Electronics and optics shall be properly insulated within the main probe
- Parts shall be optimized for durability for lower replacement costs

Mechanical Design #1

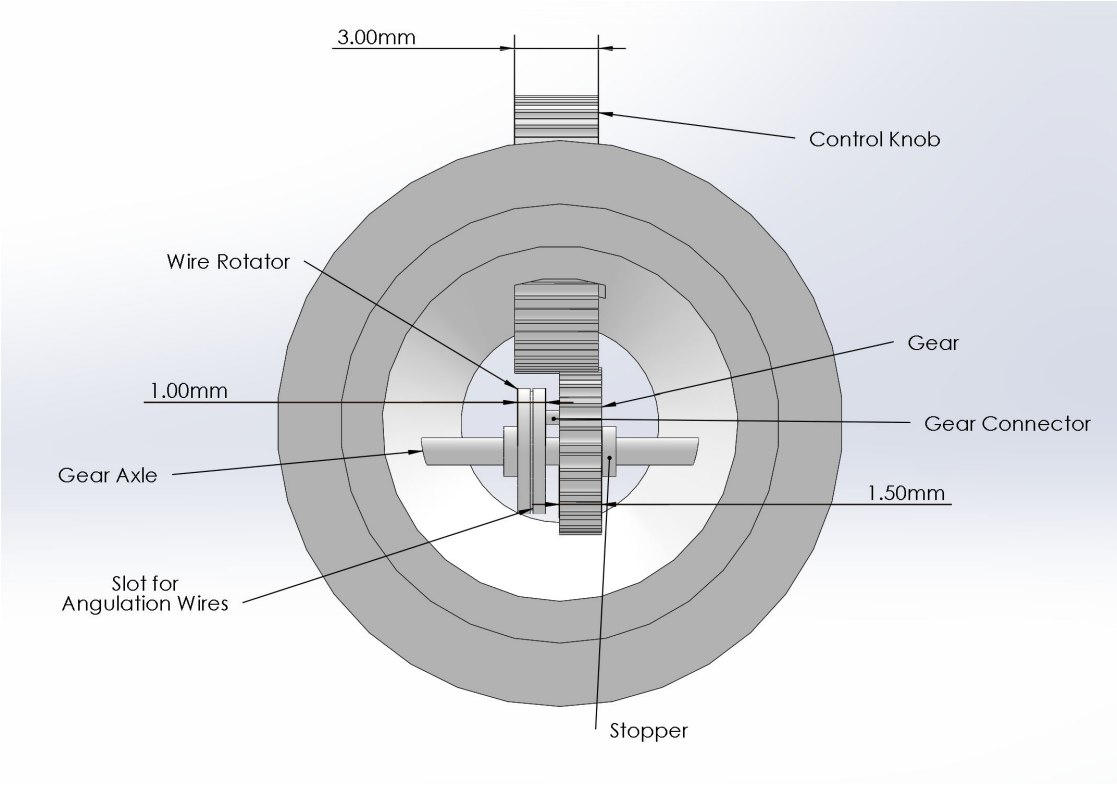
- Last Presentation
  - Developed models for
    - Proximal cap
    - Stationary Body
    - Rotational Distal End





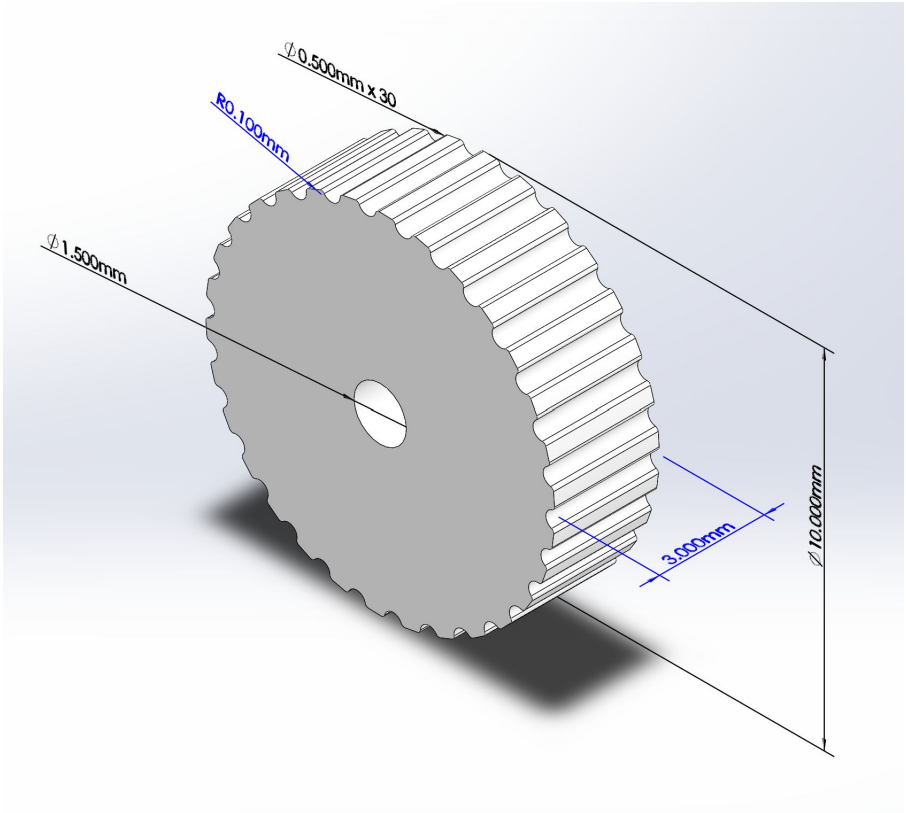
Control System #1

- New Models
  - Control Knob
  - Gear and Wire Rotator
  - Updated Rotational Distal End
    - Added Gear Axle, Knob Axle, and Slot for Knob



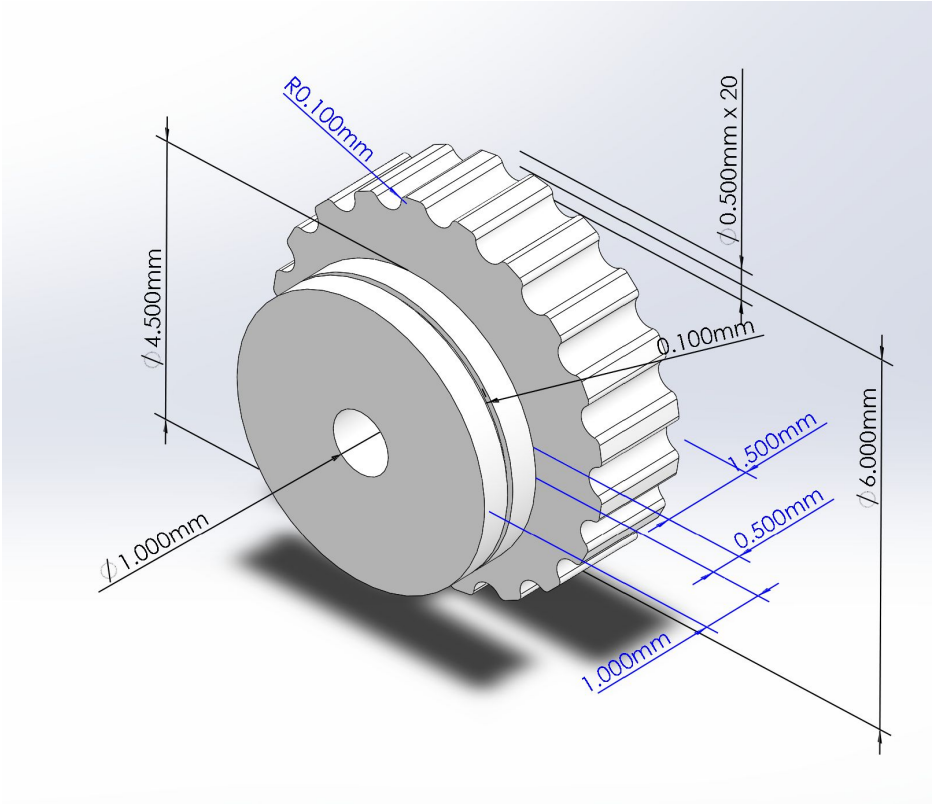
Control Knob

- 10mm diameter
- 3mm thickness
  - Sized for comfortable user control
  - Within constraints of rotational piece
    - ~3mm into ~9.5mm diameter @ site of mechanism
- 1.5mm hole to fit knob axle (1.48mm diameter)
- 30 x 0.5mm grooves to move gear



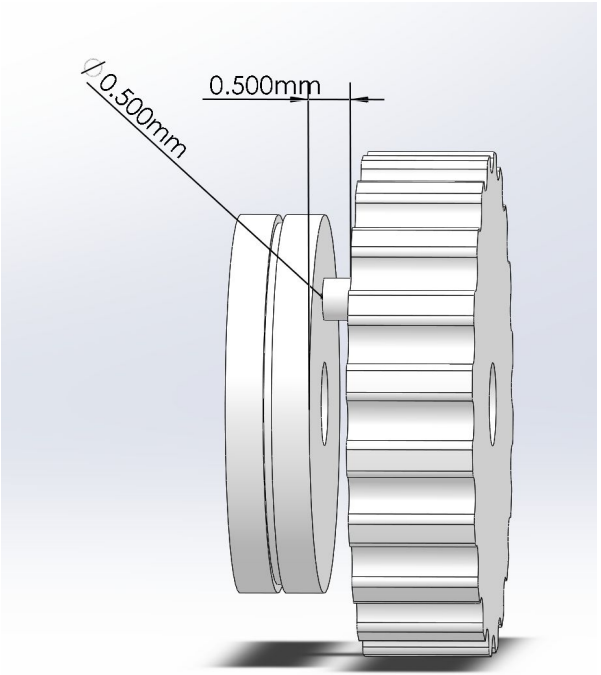
Gear and Wire Rotator

- Gear similar to control knob but scaled down
  - 20 x 0.5 grooves to interlock with control knob
  - 6mm diameter to reach control knob and remain within constraints of rotational piece (~9.5mm diameter)
  - 1.5mm thickness to allow room for wire rotator
- Wire rotator for angulation wires
  - 4.5mm diameter to avoid contact with control knob
- 1mm hole through both to fit Gear Axle (0.98mm diameter)



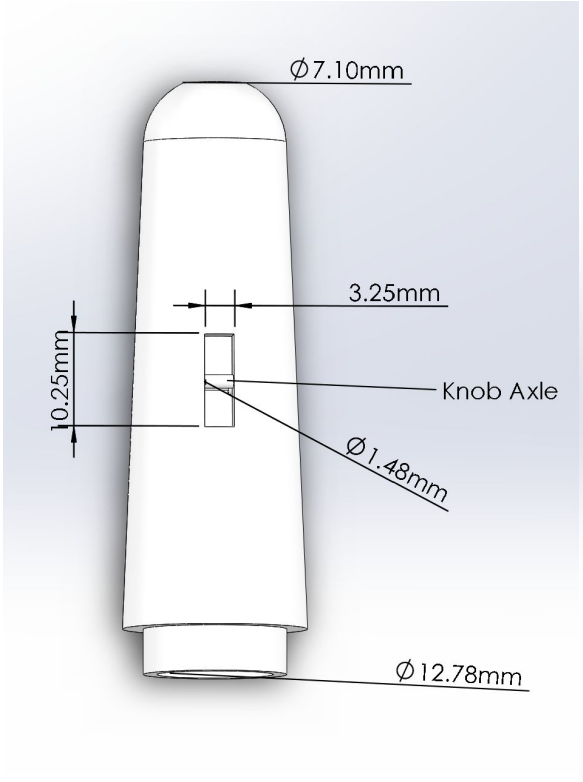
Gear Connector

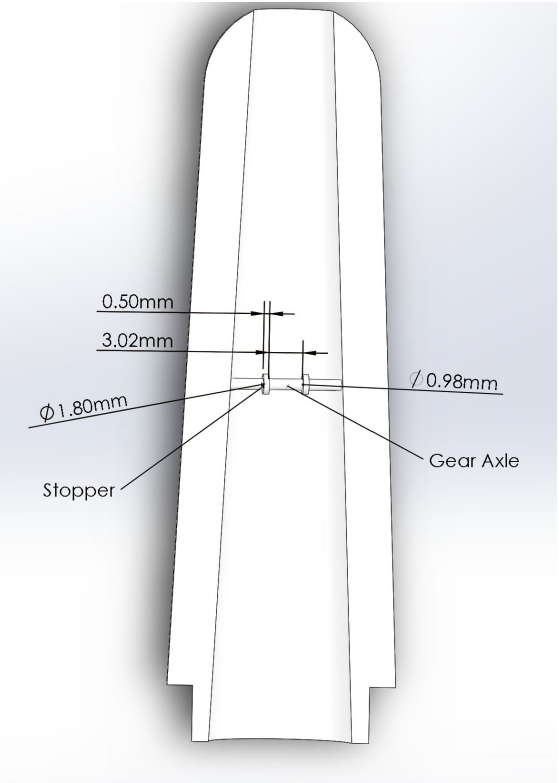
- Connection between Gear and Wire Rotator
  - Makes angulation of wires possible
- 0.5mm length to minimize overall distance taken up by mechanism
  - 3mm total in space ~9.5mm diameter



Rotational Distal End

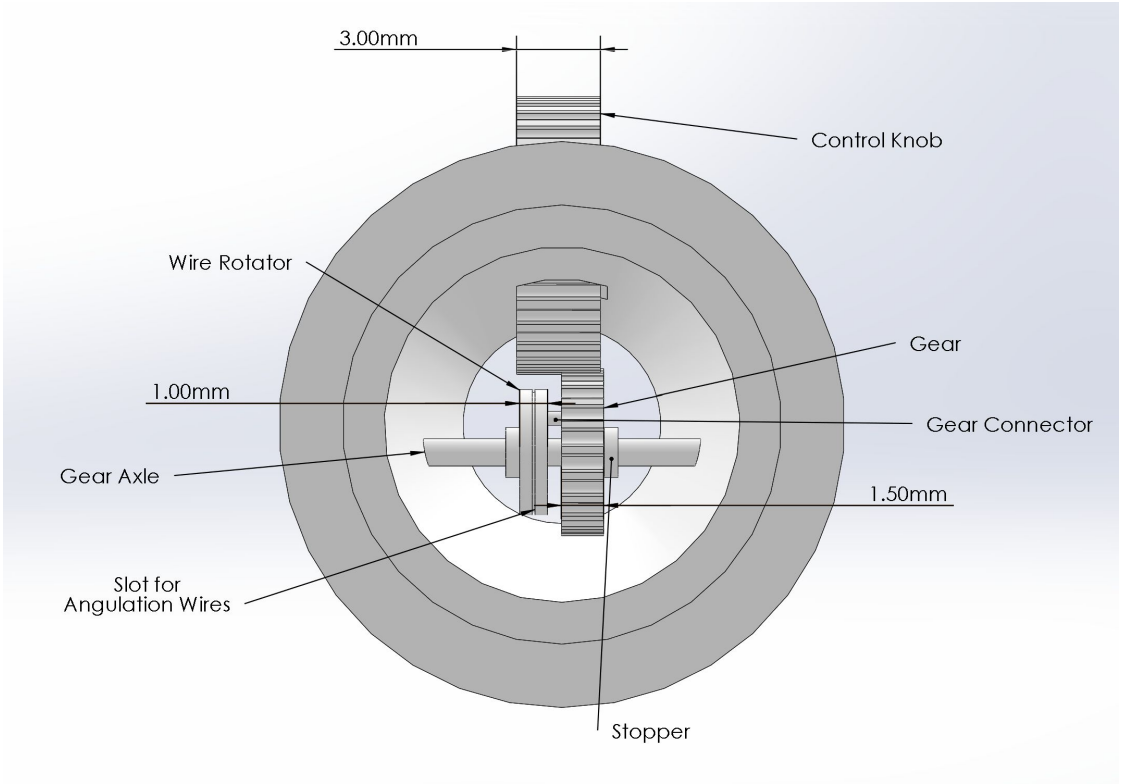
- Slot at top of piece to fit control knob (0.25mm extra to allow movement
- Knob axle at middle of slot
  - 0.02mm smaller than knob hole to allow movement
- Gear axle inside piece
  - 0.02mm smaller than gear and wire rotator holes to allow movement
  - Stoppers added to restrict horizontal gear shifting





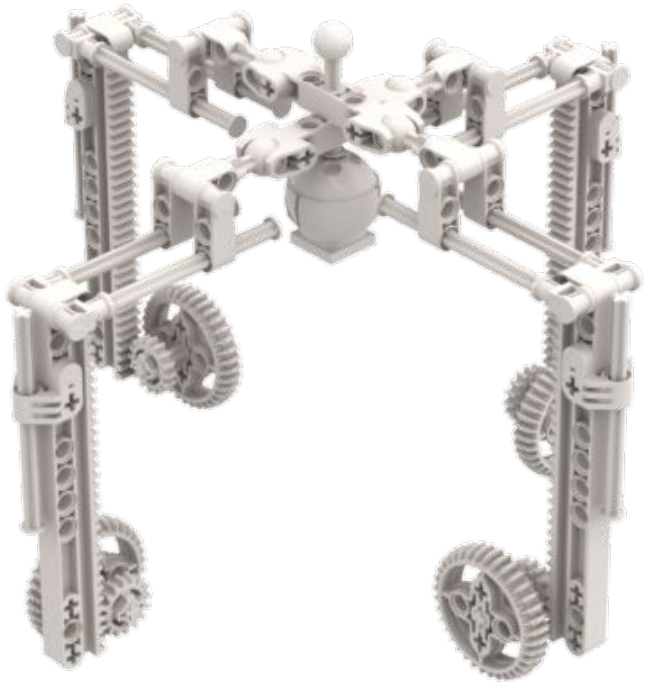
Overall Control Mechanism #1

- Control Knob rotates Gear due to interlocking grooves
- Gear rotates Wire Rotator due to Gear Connector
- Wire Rotator pulls angulation wires
  - Wires run through discs in insertion tube
  - Allows for bending in 2 opposite directions
- Next Steps
  - 3D print mechanism
  - Design connection between rotational piece and main body



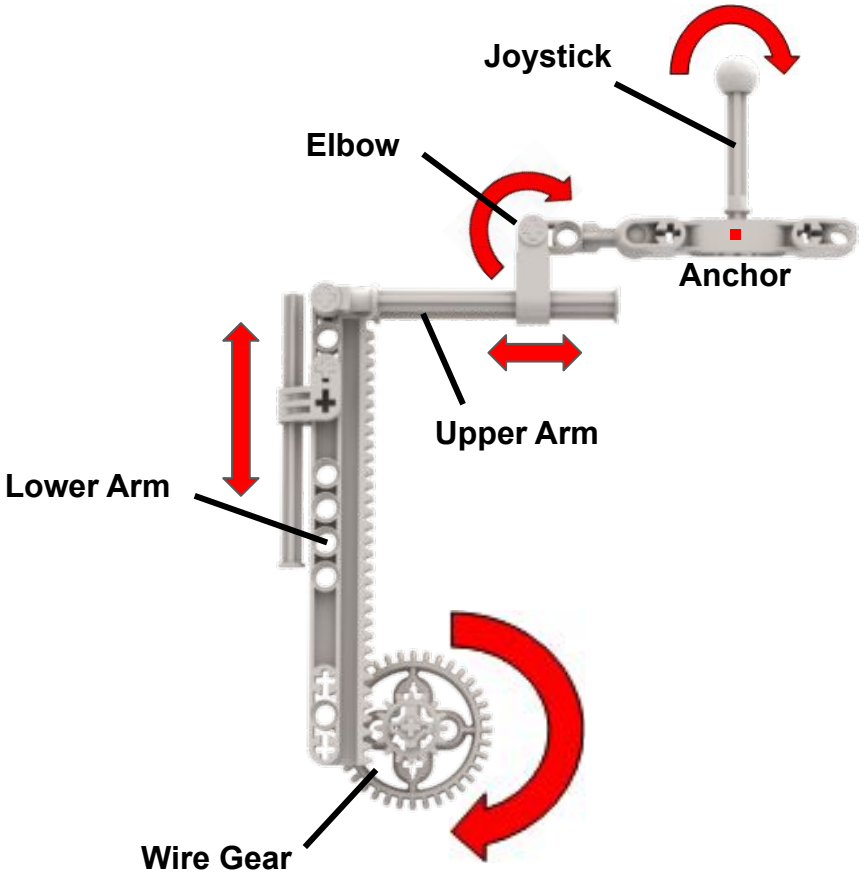
Control System #2

- LEGO large scale prototype
  - Allows for 2 axis control of bending arm
  - In future would be created using custom parts
    - Modeled using solidworks
    - 3D printed
- Parameters
  - Final housing measures 5.5x5.5 inches
  - Parts cost under $40
- Order Delay
  - Several parts backordered
  - Delivery date now set at this Friday



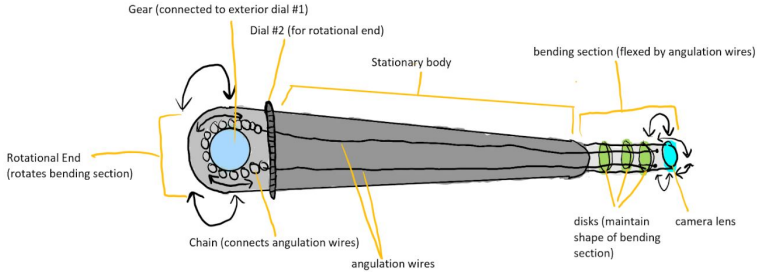
Control System #2

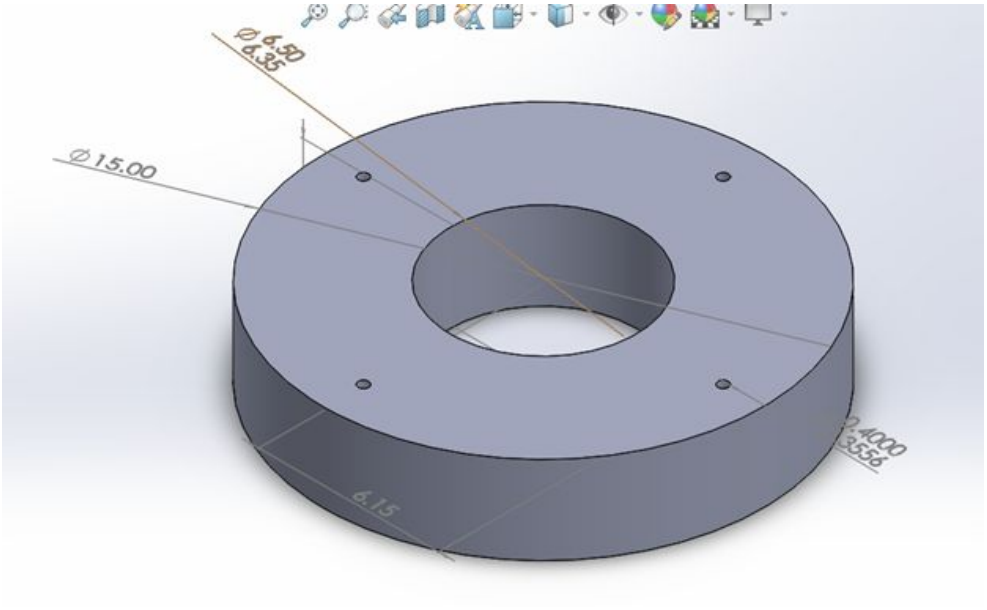
1. Joystick initiates movement
2. Pivot about anchor cause elbow to hinge
3. Elbow hinging translates lower arm in the vertical axis with movement of the upper arm compensating for horizontal offset
4. Toothed lower arm turns small diameter wire gear
5. Small diameter gear is geared up to a larger wire spool for enhanced movement
6. Wire spool controls one of 4 angulation wires attached to insertion tube disks



Preliminary Disk Design

- Control Mechanism rely on disks for angulation to occur
- Controlling variables are the inner diameter of the disk and the hole diameter
- Piping-¼”
- Fishing line-.014”





Prototype Iterations

1st Iteration

Created using a laser cutter

Quickly manufactured but thickness is difficult to tune and was too bulky to use

2nd Iteration

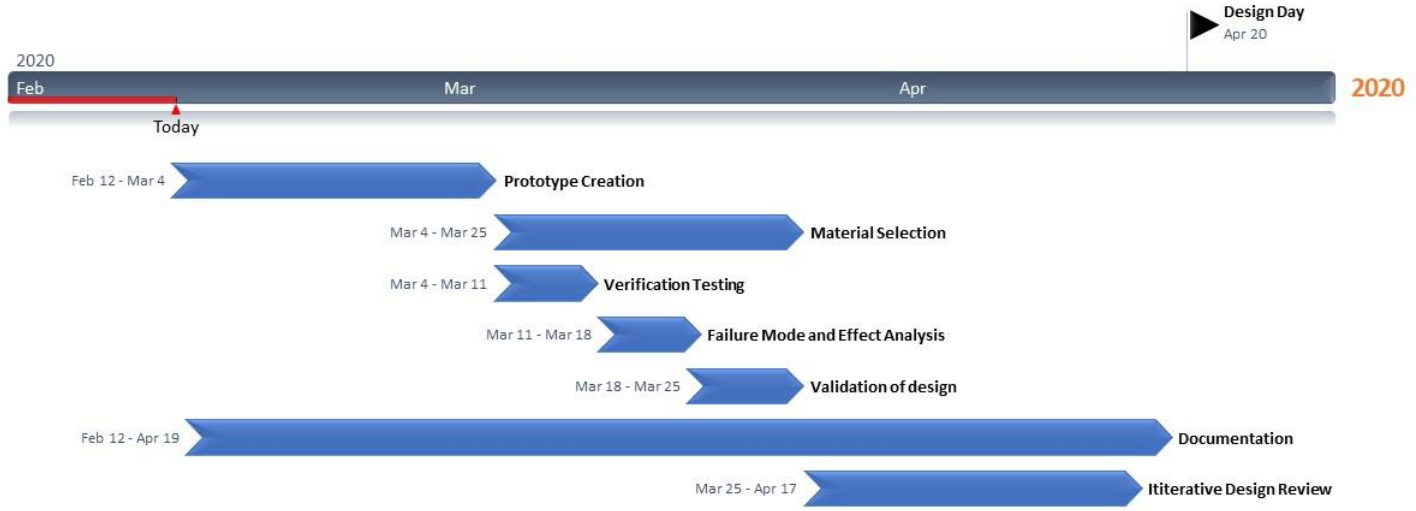
Created using a 3D printer

Thickness was easier to tune but the 3D printer lacked resolution to create holes for angulation wires

3rd Iteration

Same manufacturing process as the 2nd iteration, but created holes manually through a drill press

Gantt Chart


Design Day
Apr 20
2020
Feb
Mar
Apr
2020
Today
Feb 12 - Mar 4
Prototype Creation
Mar 4 - Mar 25
Material Selection
Mar 4 - Mar 11
Verification Testing
Mar 11 - Mar 18
Failure Mode and Effect Analysis
Mar 18 - Mar 25
Validation of design
Feb 12 - Apr 19
Documentation
Mar 25 - Apr 17
Ititerative Design Review

Sources

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