Low Resource Bronchoscope

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Current Need

According to a Lancet review article published in 2010, there is an increasing demand for healthcare services in low-income countries.

1. Geopolitical reasons: natural and manmade disasters
2. Scarcity of resources
3. Burden of illness exceeding existing healthcare capacity

Respiratory diseases are leading causes of death and disability

Chronic respiratory diseases (COPD and asthma)

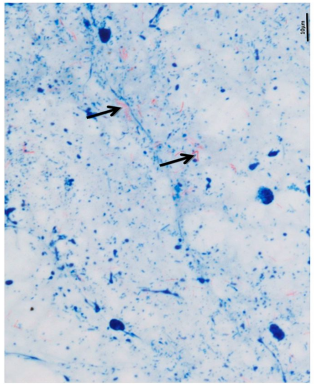
Burden of TB is highest in low-resource areas

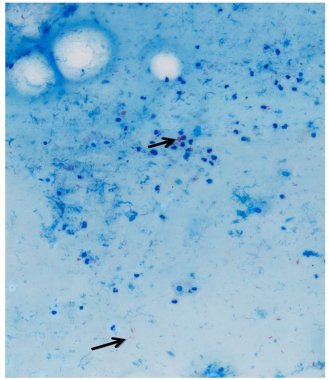
- 10.6M people in 2016 and 1M were children

Diagnosis through sputum sample

Why Use a Bronchoscope

- Producing sputum samples is difficult
  - More than one third pulmonary TB patients cannot produce sputum
  - Even produced, 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: 83.3% - 92.6% sensitivity and 91.7% - 98% specificity





Market

- Valued at roughly 12.4 million USD and expected to double in 7 years
- Two major players in the reusable bronchoscope field
  - Olympus - high baseline cost: 7,000-15,000 USD
  - Pentax - lower base cost: 4,000 USD
- 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

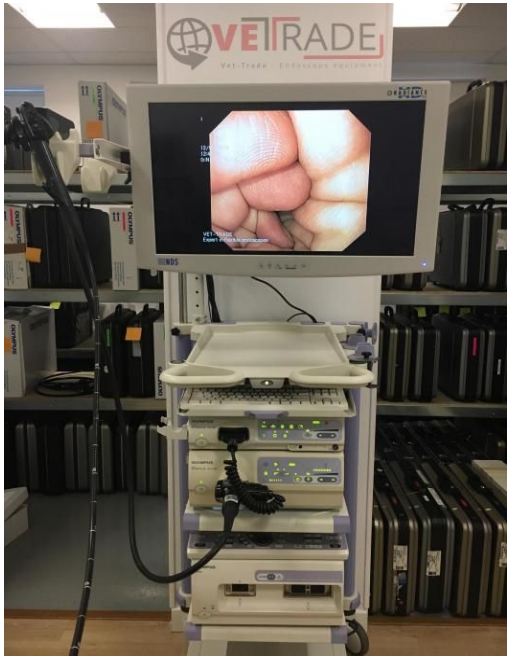
Our Place in the Market

Lower Costs

- Decreased video quality
- Cheaper material
- Reducing functionality

Wider Reach

- Simpler use
- Increased portability
- Easier to integrate within low-resource environments



Problem Statement

We aim to design and develop a fiberoptic 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 competitors' specifications as closely as possible
- Equipped with a companion application

Cost Reduction
- Materials and hardware shall be selected to reduce cost without large sacrifices to performance
- The device shall be reusable with a single use outer sheath to eliminate reprocessing
- Parts shall be durable and easily replaceable in case of failure

Ease of Use
- More intuitive control scheme than current bronchoscopes
- Integrated with a companion application for real-time video streaming

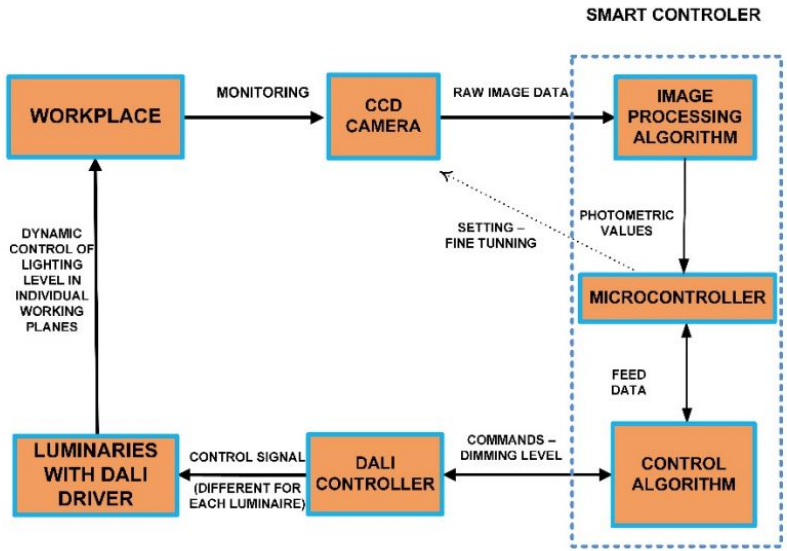
Portable
- Powered using single cell batteries
- Coiled to save space during transport

Durable
- Hardware shall be properly insulated
- Parts should be optimized for durability to lower replacement costs

Electrical Design - Overview

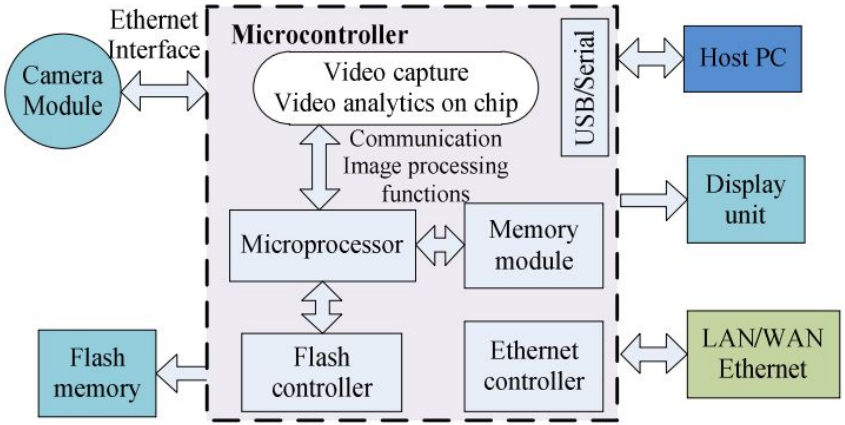
- Microcontroller is external.
  - Eliminates the need for it to be connected to the handle.

- Two part process:
  - **Camera → Microcontroller**
    Processes the image.
  - **Microcontroller → User**
    Encodes data and broadcasts it back to the host.



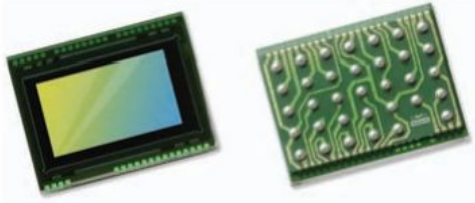
Electrical Design

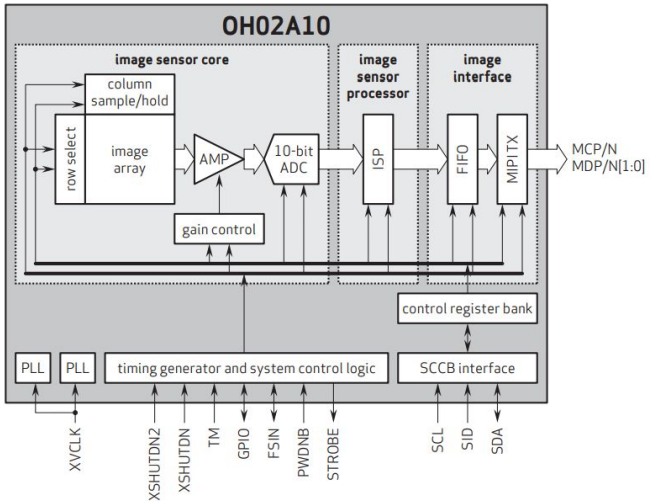
- CCD Camera - OH02A10
  - These cameras are frequently used for endoscopic purposes.
- Microcontroller - Raspberry Pi 3
  - Supports real-time communication.
  - Connects via ethernet to external peripherals, such as monitors or TVs.



Electrical Design - Camera

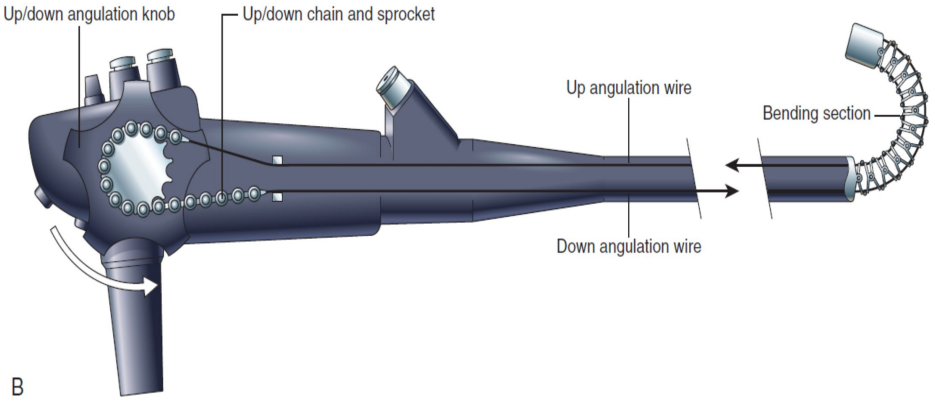
- OmniVision OH02A10
  - Small form factor:
    - 3.8 x 2.9 mm chip package
  - High quality imaging
    - 60 fps at 1080p resolution
    - 90 fps at 720p resolution
  - Low heat dissipation:
    - 90 mW when recording 60 fps 1080p
  - MIPI interface gives and Rasp Pi compatibility
- OpenCV
  - Open source computer vision package
  - Can be run on multiple platforms
    - Rasp Pi included





Mechanical Design - Novel Approach to Pre-existing Designs

- Choose elements that
  - Are easy to manufacture
    - Reduce costs
  - Easy to repair
    - Consider low-resource environments
  - Are essential for necessary functionality
    - Full rotation and flexibility of tip
  - Simplify design
    - Limited time and resources to prototype



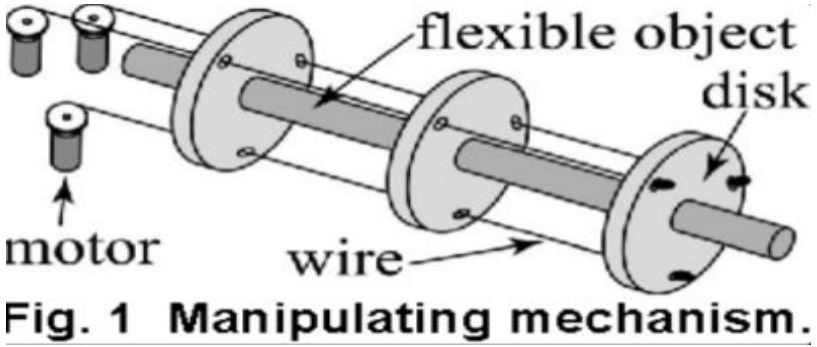
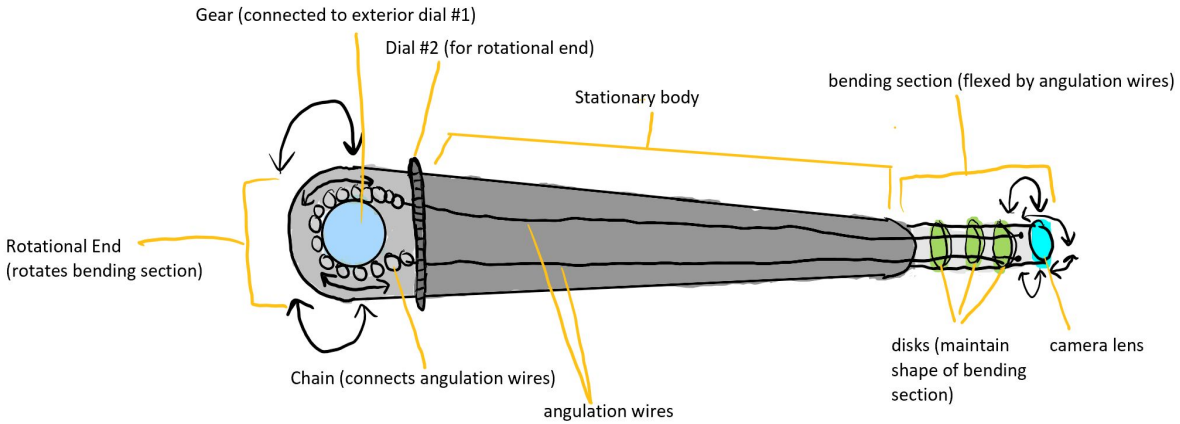


Fig. 1 Manipulating mechanism.

Mechanical Design - Option 1

- Bending section consists of plastic disks
  - Adhered to hollow, bendable center channel
  - 2 angulation wires threaded through disks
    - Up-down **or** left-right
    - Connected by chain around accessible dial

- Rotational end of stationary section
  - Rotates entire bending section
  - Prevents wires from twisting

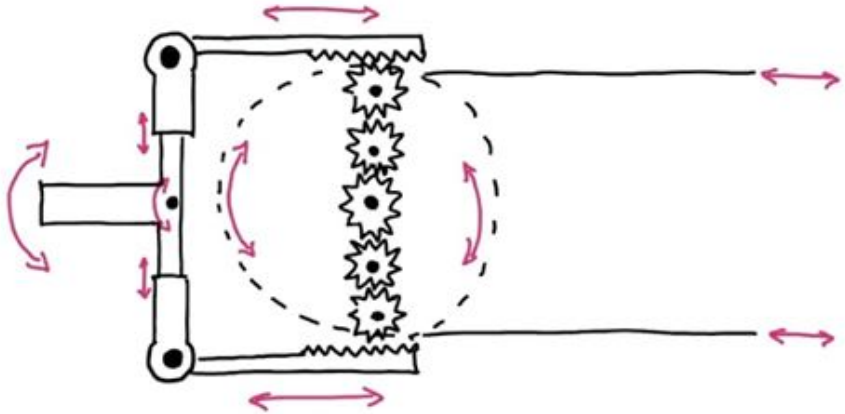


- Simplistic design
- Easy to manufacture
- Potentially difficult to operate
  - Dial #1 rotates with end

Mechanical Design - Option 2

- Bending section consists of plastic disks
  - Adhered to hollow, bendable center channel
  - 4 angulation wires threaded through disks
    - Full 2-axis angulation with 1 control stick
    - 1-axis mechanism shown below

- More complicated design
- More difficult to manufacture
- Easy to learn operation
- Decreased wire mobility



Short-Term Goal: Functional Prototyping

- Control system and handle
  - Modeled and created using Legos
- Flexible insertion channel
  - Structural disks will be CAD modeled and 3D printed
  - 16 gauge steel wire
- Electronics/optics
  - Raspberry Pi
  - Sony IMX219 image sensor add-on
- Programming
  - Basic computer vision code created using openCV packages
  - Run using Python

Future Design Path

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