



# Low-cost Motorized Microscope Stage

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## ABSTRACT

The use of microscopic serial imaging and stitching is a common practice used in laboratory settings to conduct research and contribute to academic experience. Said processes can be time consuming and tedious when done manually. Moreover, motorized microscope stages allow for a streamlining of this process and more efficient use of materials, but they are very expensive to purchase commercially. Creating a low-cost motorized microscope stage or mechatronic system for stage attachment would allow for more experimental throughput and expand on the potential of microscopy. The proposed device is a mechatronic system that will attach to the translational control knob of two UW-Madison BME Shared Lab microscopes via set screws. The design consists of a custom gear-grip system driven by two gear-reduced stepper motors. These will be mounted to the existing stage, with a control architecture implemented on an Arduino Uno. The Arduino microcontroller will interface with Micro-Manager imaging software to provide a contrived imaging experience with the microscopes of interest.

## PROBLEM STATEMENT

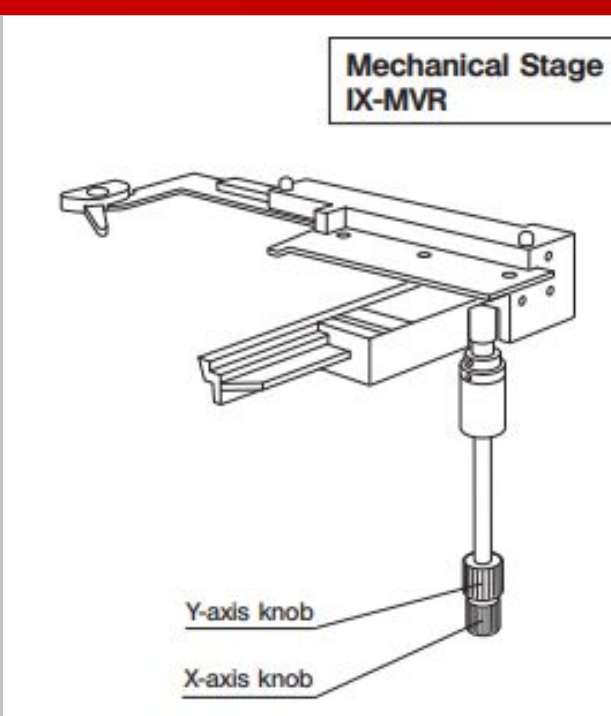
### Design Motivation:

- Motorized stages allow for increased laboratory efficiency
- Such commercialized stages are very expensive and impractical
- A less expensive stage would allow students to save time and gain image consistency without the institution's financial commitment

### Objective:

Design and fabricate a microscope stage or mechatronic system that allows for stage motorization and automation of imaging processes used in the UW-Madison BME Experimental Teaching Lab.

## BACKGROUND



[Figure 1] Drawing of current Olympus stage mechanism [1]



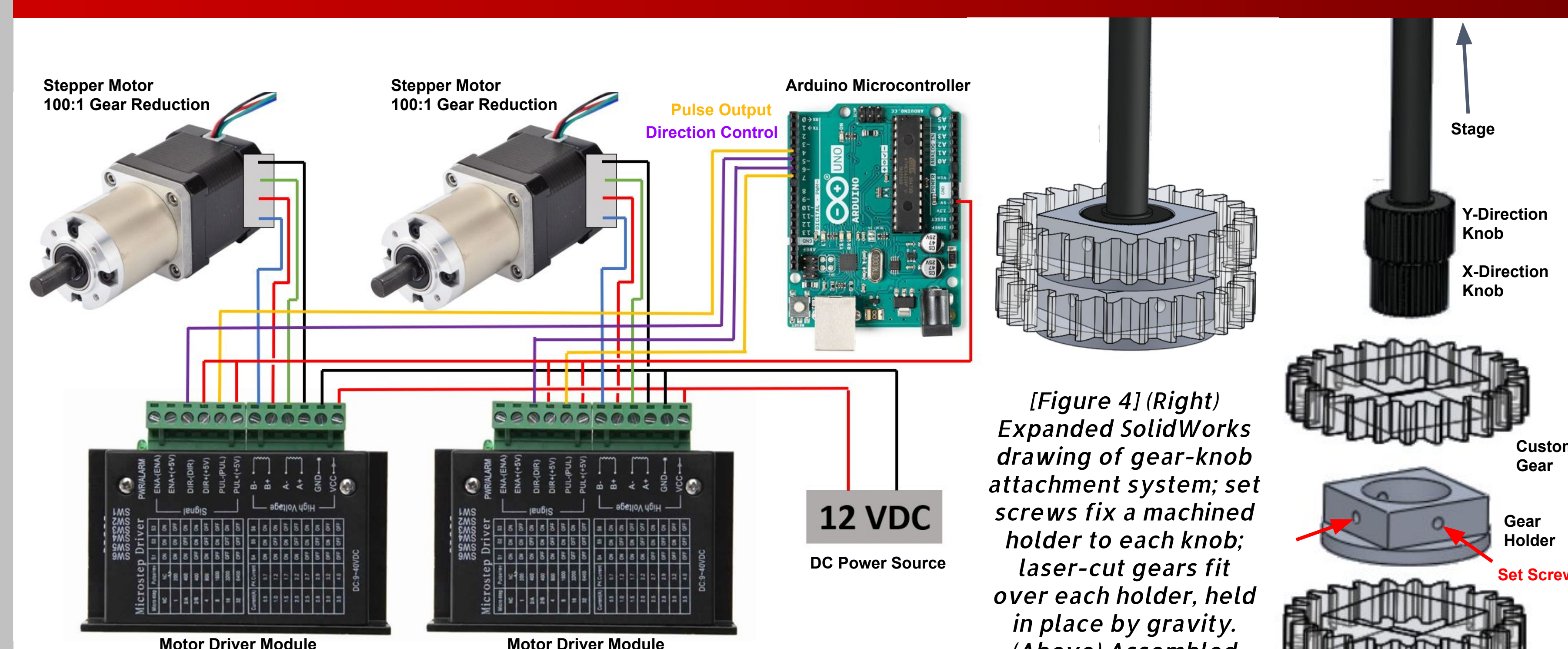
[Figure 2] Nikon TI-U Inverted Fluorescence Microscope [2]

- Serial Imaging is a process used in scientific research to capture sequential images of a specimen
- Stitching is the process of taking a series of serial images and creating a singular image using software like ImageJ
- Using a motorized microscope stage, a researcher can automate serial imaging through programming.
- Open Source MicroManager software can help with this automation [3]
- Industrial systems from Prior and ASI exist, but are expensive
- Cells span diameters of 10s of microns

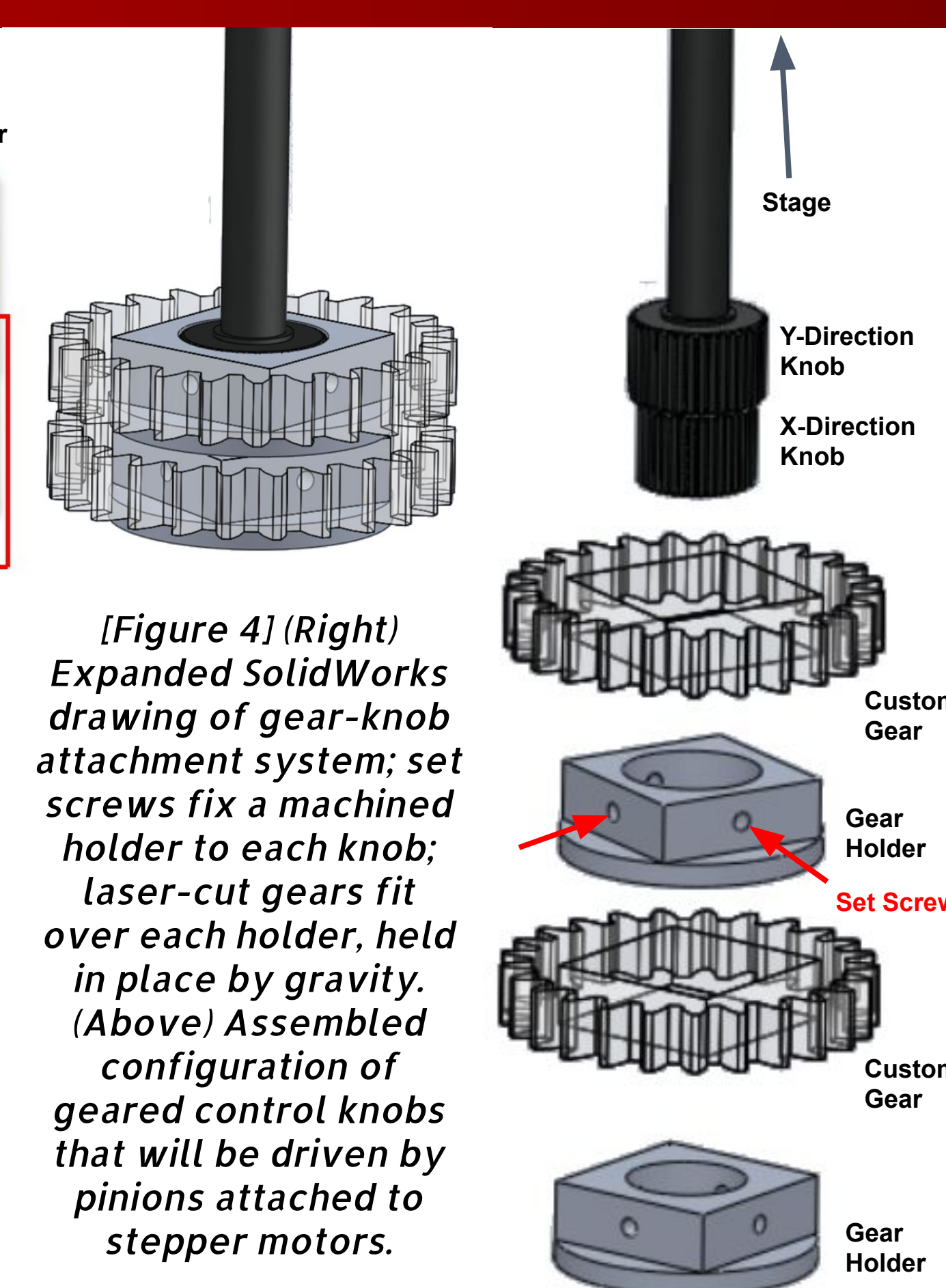
## DESIGN CRITERIA

- Motorized mechanism to move the microscope stage
- Can be adapted to either BME Teaching Lab microscope
- Controls the stage movement in the x- and y-directions
- Maintain a resolution of 1 micron and a budget of \$100

## CURRENT DESIGN



[Figure 3] (Above) Wiring diagram of mechatronic system for driving two 100:1 gear reduced stepper motors; each motor driven by a stepper motor driver modulating power from a 12V source according to pulse and direction input from an Arduino Uno.

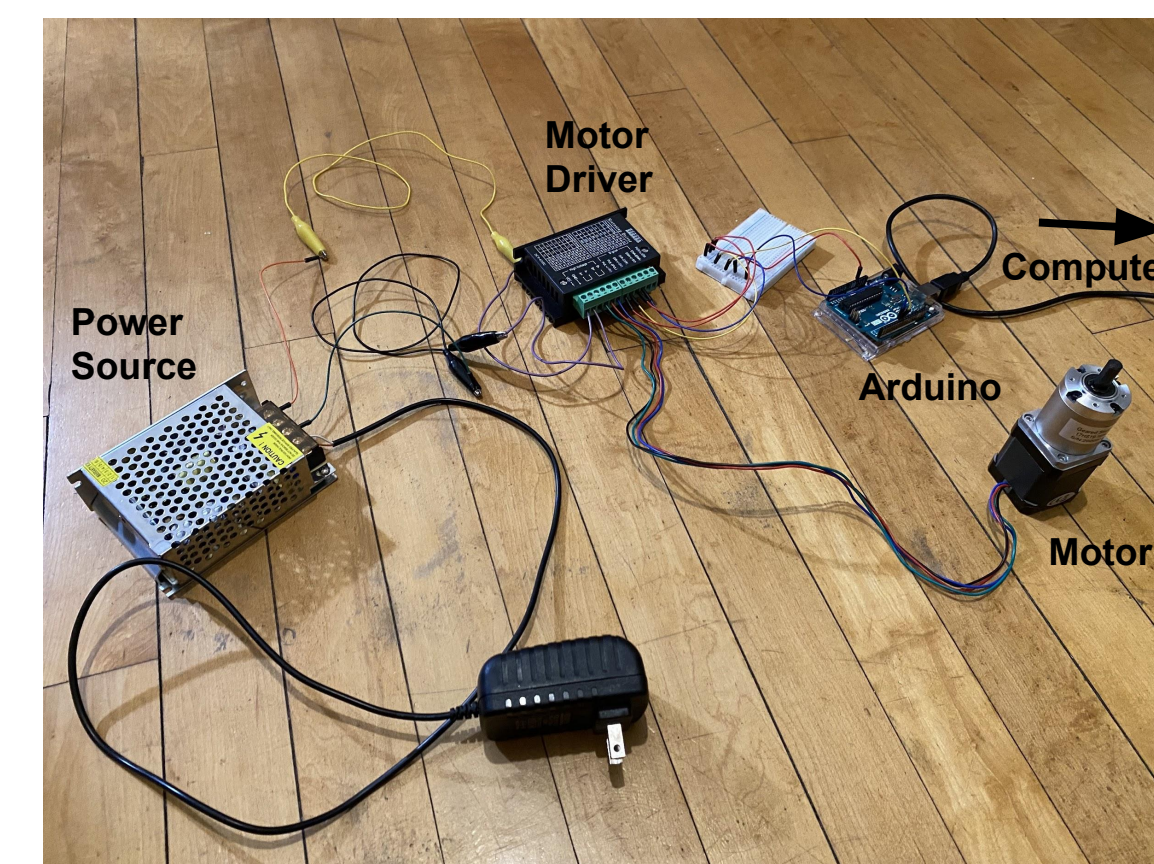


[Figure 4] (Right) Expanded SolidWorks drawing of gear-knob attachment system; set screws fix a machined holder to each knob; laser-cut gears fit over each holder, held in place by gravity. (Above) Assembled configuration of geared control knobs that will be driven by pinions attached to stepper motors.

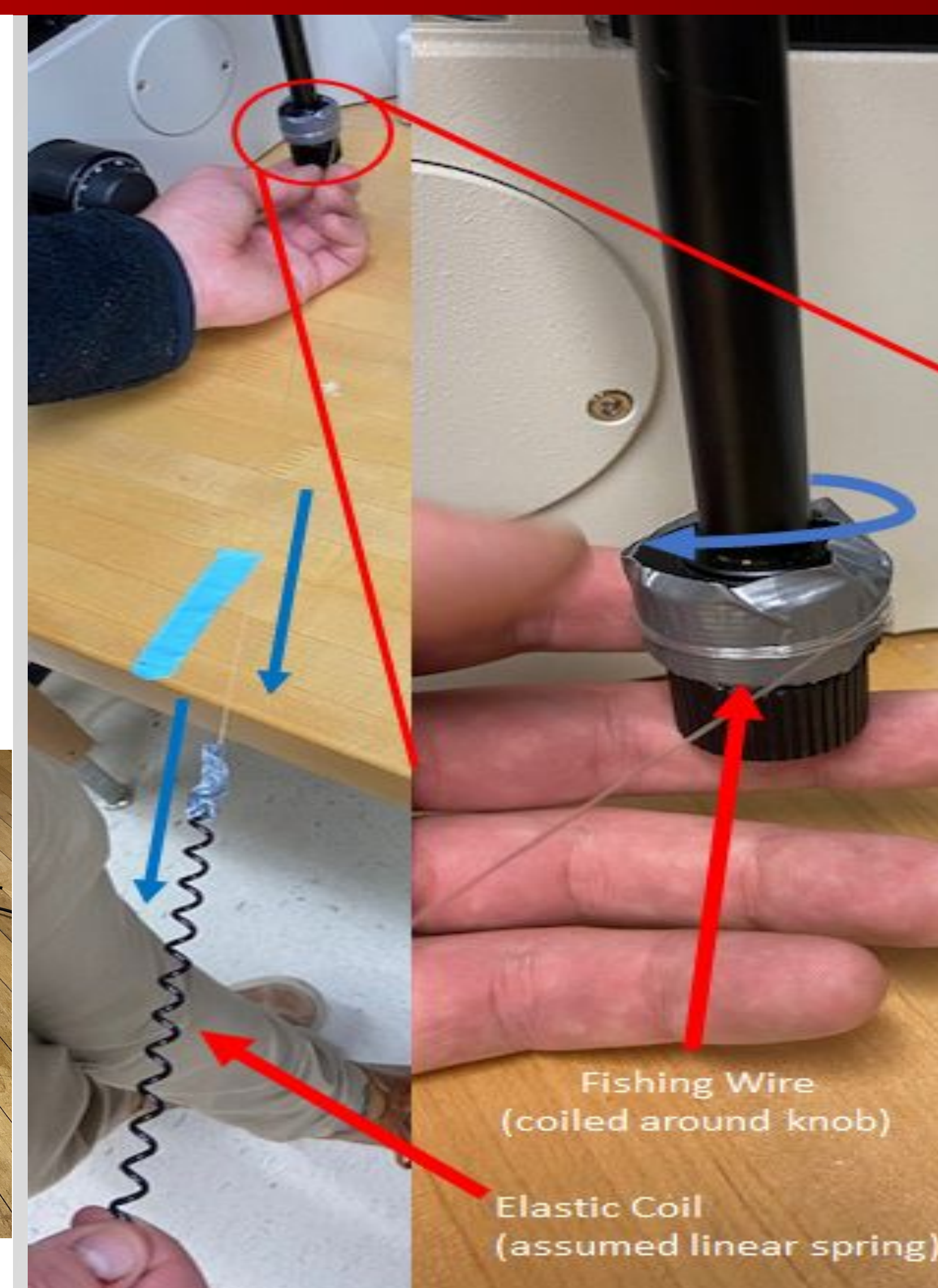
## TESTING

- Thus far we have run a test to determine the amount of torque required to rotate the microscope knob which is 1.97 N
- Additionally we tested the ratio of rotations to translation to determine the motor step resolution needed
  - x dir: 18 mm/rev, 0.02 degrees/ $\mu$ m
  - y dir: 32 mm/rev, 0.011 degrees/ $\mu$ m
- We used rudimentary code to determine the range of speeds our motor could output

[Figure 6] Physical mechatronic system used to drive one stepping motor; system implemented with basic microcontroller code to evaluate various motor driver settings and maximum speed of the motor.



- Future Testing will include
  - Confirmation of resolution and speed
  - Consecutive accuracy with serial imaging code



[Figure 5] Testing performed to determine the torque required to turn the knob of the microscope stage; fishing wire coiled around the knob was pulled by an elastic coil assumed to act as a linear spring with known spring constant; force to unwind wire estimated knob torque.

## ACKNOWLEDGMENTS

- Dr. John Puccinelli, Department of Biomedical Engineering
- Dr. Paul Campagnola, Department of Biomedical Engineering

## DISCUSSION

- Physical prototype not yet fully developed due to remote instruction and time constraints
- Our maximum motor speed translates to roughly .6 and 1 mm/sec in the x and y-directions respectively
- Torque produced by the motor exceeds the determined torque needed to turn the microscope knobs
  - Torque testing was conducted using linear spring constant approximations
  - Ensure high torque capability of the motor does not damage the existing microscope stage system

## FUTURE WORK

### Mounting:

- Mechatronic apparatus will be mounted on microscope
  - Mounting will take place on the underbelly of the stage (Figure 6)
  - Contact/Mounting points will translate with the control knob along racks



[Figure 7] View from underneath the microscope stage

### Programming:

- Part of the team will work with software development
  - Interface an Arduino and Micro-Manager software
  - Micro-Manager is an open source imaging software that provides hardware compatibility modules and Arduino compatible source code for said application
  - Basic Arduino code that already operates the current mechatronics system will be further developed for manual joystick implementation/operation [4]
  - Software development is anticipated to be experimental, and coincide with the designed mechatronic system operation as well as microscope functionality throughout the serial imaging process

## REFERENCES

- [1] Olympus IX81 Motorized Inverted Research Microscope Instructions Manual. Olympus.
- [2] Nikon.com. 2020. Nikon | Healthcare Products & Solutions (Microscope Solutions) | Inverted Microscopes. [online]
- [3] Micro-manager.org. 2020. Micro-Manager. [online]
- [4] DroneBot Workshop. (2019, May 25). Using BIG stepper motors with Arduino. Retrieved December 3, 2020, from Dronebotworkshop.com website: <https://dronebotworkshop.com/big-stepper-motors/>