The use of microscopic serial imaging and stitching is a common practice used in laboratory settings to conduct research and contribute to the academic experience. Serial imaging involves taking consecutive images to gather a larger field of view and is necessary to image larger sections of cells or tissue. These processes can be time consuming and tedious when done manually; motorized microscope stages streamline this process and utilize materials more efficiently, but they are expensive to purchase. Companies such as Zeiss, Nikon, Olympus and Leica sell these for a price of $7,000 to $25,000 which exceeds the practical value they bring to teaching laboratories, yet experience with motorized microscopes remains a valuable asset for young scientists.

The goals of this design were specifically to control the movement of the Nikon TI-U stage. The target accuracy for the system is to a degree of 1μm and demonstrates precision between measurements. The stage translation only travels in the X and Y directions, with the zoom and focus maintaining manual control. Finally, the design does not permanently attach to the microscope and can be removed if the user desires to operate the microscope manually.

In order to automate the existing manual microscope stage, which is driven by translation control knobs, a novel gear system driven by stepper motors through logic from an Arduino Uno microcontroller was developed. It allows for the reversible fixation of spur gears to the stage control knobs while making use of cost-effective and accessible fabrication methods. This gear system incorporates a gear holder component that fixes to each control knob (for the x- and y-direction) via tightening of lateral set screws. The custom gear that matches the gear holder is an involute spur gear with a square cutout in its center that matches the profile of the gear holder. The gear holders can be easily machined on a mill and lathe from cylindrical aluminum stock while the gears can be laser cut from a sheet of acrylic. Mechatronic control of the existing translating stage knobs is implemented via two gear-reduced stepper motors, each controlling an independent direction of translation, corresponding to one of the two manual knobs. To allow for a resolution of up to 1 micron of translation in either direction, these stepper motors are gear reduced to a ratio of 100:1. These motors are driven according to pulse commands sent from an Arduino Uno which are converted into phase-specific current modulations in each motor by corresponding stepper motor driver modules.

Arduino code controls two stepper motors which will then turn gears in order to turn the knobs of the microscope. The Arduino serves as a shutter for Micro-Manager to determine the succession of images of a specimen. The Micro-Manager website provides an open-source version of this code which the team can utilize to our specifications. With both of these software elements combined, the user should have complete control of translational movement of the microscope as well as the imaging process from the computer. The goal of the cross-platform software integration is to aid the user in autonomous imaging upon specified set up.

To test the accuracy of movement for the system, fluorescent beads will be employed to mark distances. Input measurements will be compared to those distances to verify accuracy. Additionally, consecutive accuracy in the serial imaging procedure will be tested by statistical analysis - comparing manual serial imaging procedures to autonomous procedures, holding appropriate variables like culture size and image stitching protocol constant. Autonomous procedures will also be analyzed in a context of reliability and consistency.

In the near future, the team plans on submitting a report of the design and fabrication of the system to an academic engineering journal, hoping for other universities to follow the protocol and implement motorized stages in teaching labs. Code used for the project will be uploaded on GitHub for people to use with the mechatronic system.