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An Educational Model of Atomic Force Microscope

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Abstract

An Atomic Force Microscope (AFM) is an important tool in modern nanoscience. The AFM is capable of producing surface maps at resolutions below 1 nm, which is impossible for other methods. The goal of this project is to create a macro scale model, which will serve as an educational tool to introduce the principles behind AFM to undergraduate and high school students. Currently a fully automatic microprocessor-controlled surface scanning block has been built and successfully tested with a scan area of one square foot. Continued work includes designing and building of a topography measurement block that will work on the same principle as a real AFM does at nano-level. We expect that macro AFM building an image using AFM techniques will empower instructors to show the concepts, and to spark interest of potential students in Bioengineering. Sponsors for this project have been the Creative Inquiry Program and the Bioengineering Department.

Introduction

In atomic force microscopy, a cantilever with a Nano scale tip is moved in a raster pattern across a sample while a photo diode tracks its position with the help of a laser as seen in **Figure 1**. The sample is moved with the cantilever with the help of a piezoelectric stage that changes its length in response to electric current. The position of the cantilever is then recorded and translated into an image with the help of a computer.[2] Our goal is to move this process which take place in the scale of angstroms, and magnify it to the visible world. In doing that, our team hopes to make the principles easier to learn and make the learning more enjoyable.

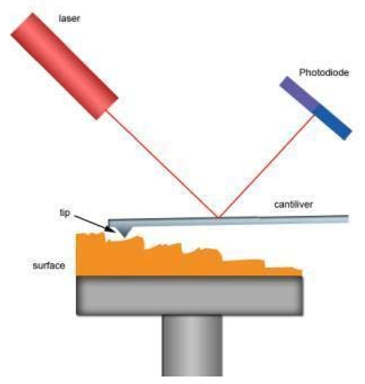


Figure 1: An depiction of the basic AFM principles that our project seeks to explain[1]

Project

Automated Macro AFM

Our current project builds on our previous Lego model and keeps the idea of a hands-on learning tool but on a bigger scale with more robust components. With the use of stepper motors, sensors, and an Arduino microcontroller, students will be able to manipulate samples in real time and observe the operations that take place that would normally not be visible inside a real AFM. This project will enable instructors to teach the principles of AFM in an interactive and intuitive way.

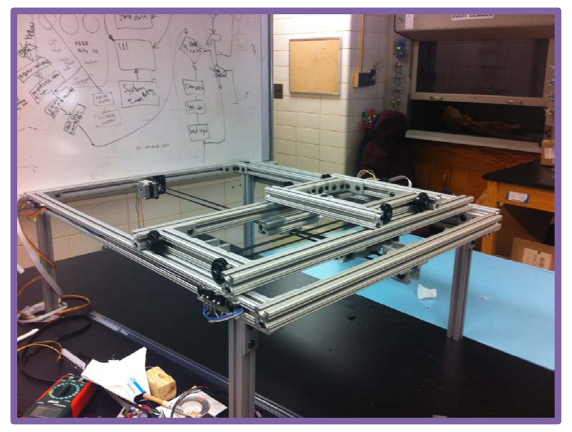


Figure 2: The new Macro AFM project currently without cantilever probe.

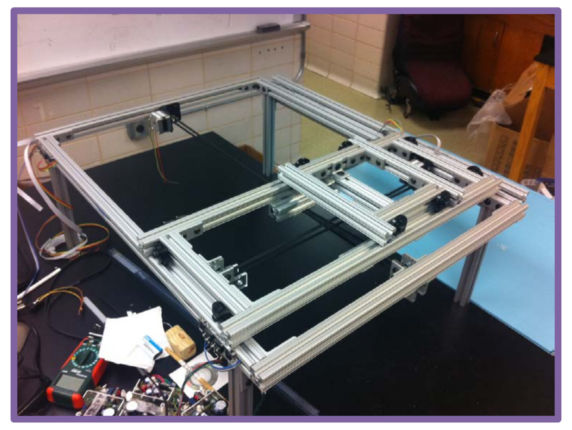


Figure 3: The new Macro AFM project currently without cantilever probe. (Birdseye view)

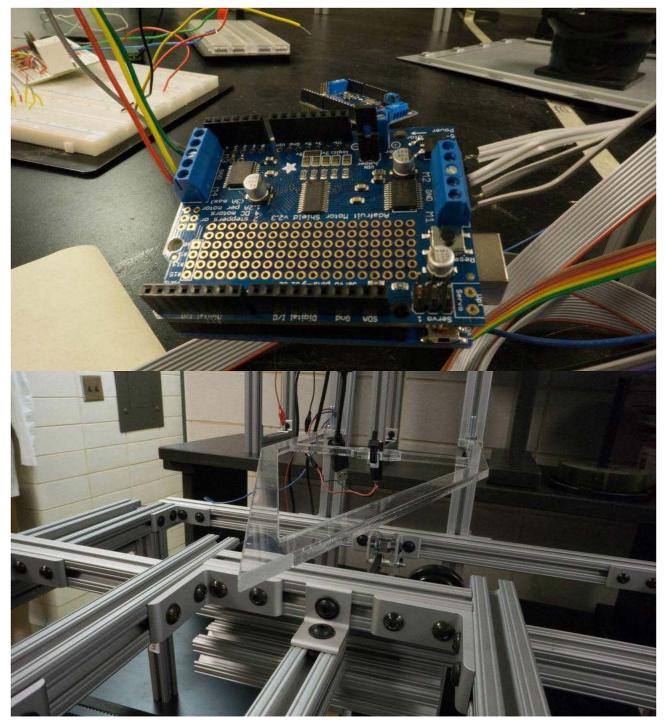


Figure 4: Arduino and Stepper Motor used to drive the X and Y axis stepper motors.

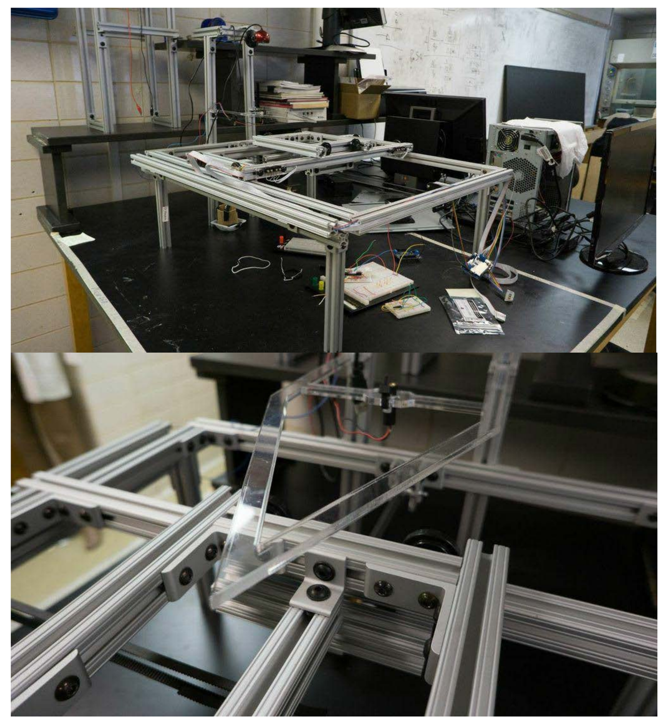


Figure 5: Acrylic cantilever shown above sample stage.

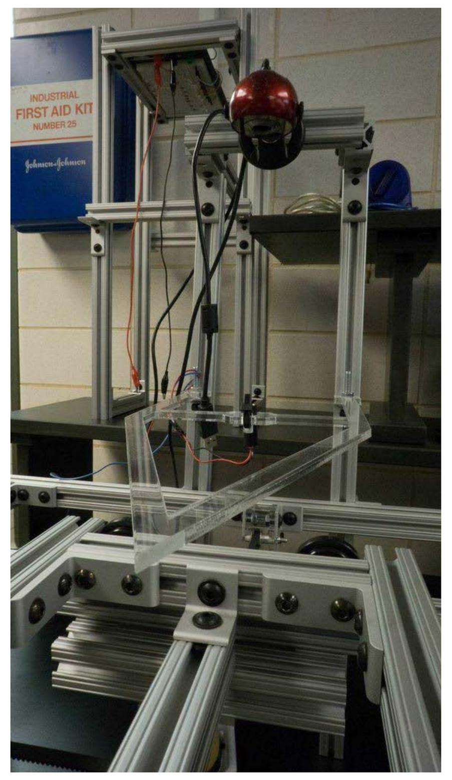
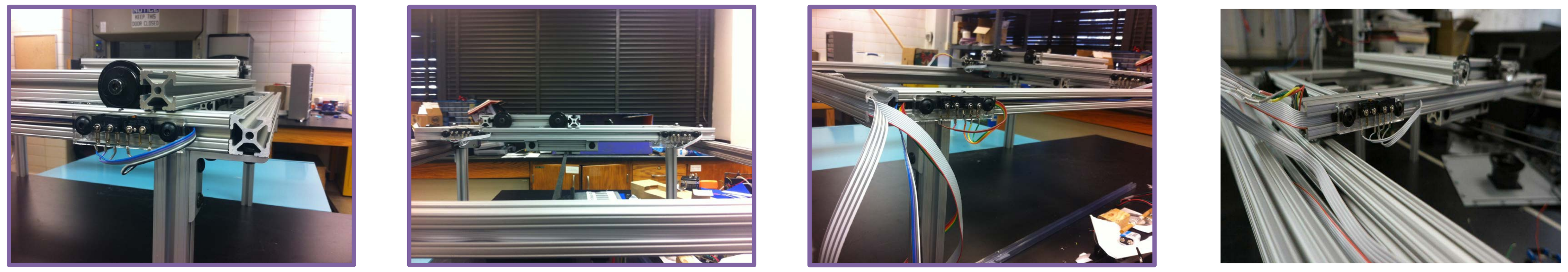


Figure 5: Camera mounted above acrylic cantilever to detect cantilever movement.

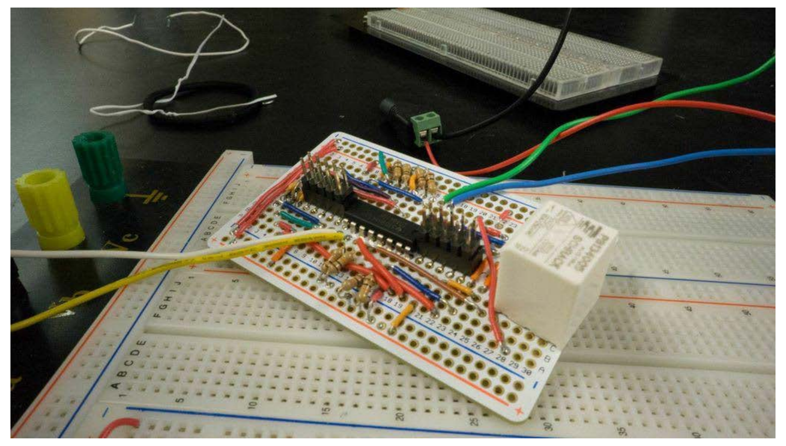


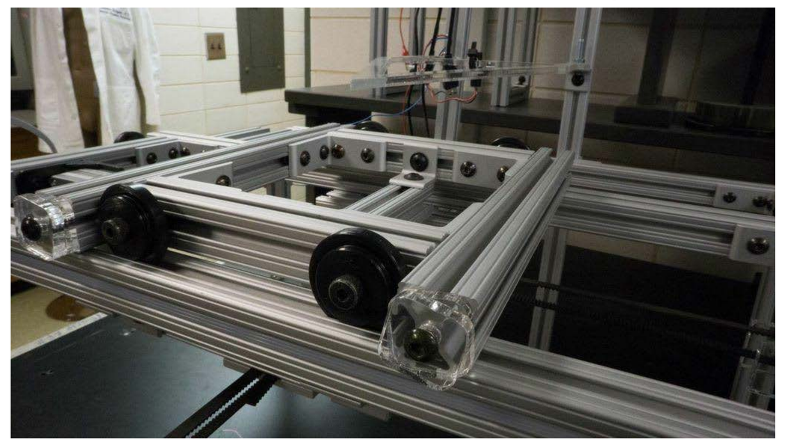
7(a) 7(b) 7(c) 7(d)

Figure 7: (a) Close up view of Y axis limit switches, **(b)** side view of X axis limit switches and sample stage, **(c)** view of other Y axis limit switches and wires tucked inside of track structure, **(d)** close up view of X axis limit switches.

Detailed view of Horizontal axis

At the current state of our project, we completed the X-Y moving table simulating the piezo-motor-driven horizontal scanner of a real AFM. The table we assembled uses two stepper motors, one for the X axis and one for the Y axis, and an Arduino micro controller to operate the motors. The table (Arduino microcontroller) can be connected to a computer and is capable of fully-automatic operations following user's instructions sent remotely from the computer – including moving to a desired position and scanning in a desired pattern with user-defined speed, precisely mimicking the real AFM at macro scale. This table is an essential part of the whole Macro-AFM project.





Future Work

Our team hopes to continue construction of the Macro AFM to ultimately build a device that scans macro samples and displays the surface profile in real time. To accomplish this, the z-axis and a cantilever will be built to the specifications necessary to have an adequate contact between the sample and the cantilever. After the physical system is finished, the team will then focus on the software and programming aspect of the project. An Arduino micro controller will be used to control the motion of the Macro AFM in the X, Y, and Z stages and record the position of the probe tip. This data can then be sent to a computer to graph the data and produce an image of the sample scanned. The goal for this project is to eventually be a user-friendly standalone automated system where users can change the sample being scanned and watch the monitor image change accordingly. It is our hope that the macro AFM will serve a pit stop on future bioengineering tours as a means to demonstrate some of the more complex principles of imaging that are learned in the Bioengineering department.

References

[1] http://comp.uark.edu/~jchakhal/AFM%20scans.htm
[2] http://virtual.itg.uiuc.edu/training/AFM_tutorial/

Acknowledgements

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