CALIBRATION OF A FORCE FEEDBACK JOYSTICK

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Abstract

The objective of this project was to calibrate a commercially available force feedback joystick that could be used for the control of a laser beam optical tweezers testbed. A calibration box was built to hold the joystick and the loadcell. The joystick handle was restrained by springs under tension and the handle force was measured by a single axis loadcell.
The calibration is done by measuring the forces generated by the joystick handle in the X and Y axes in response to controller command signals.

Key words: force, joystick, calibration

Introduction

The Manufacturing Engineering Laboratory of the National Institute of Standards and Technology is building an optical tweezers testbed to experiment with metrology, sensors, calibration and control issues related to nano-manufacturing. The controller of this testbed will use joysticks for manual control experiments. A force feedback joystick will provide the operator with a better feeling of the forces generated by the laser beams when they interact with various nano-particles. This work describes the calibration of a Logitech[1] [1] Wing Man Force 3D Force Feedback, joystick.

LoadCell Calibration

To calibrate the loadcell I fixed its front plate on a metal plate and attached one end to different amounts of weight. I used a fishing line to connect the weights to the sensitive end of the loadcell. Before the application of the weights, I leveled the front supporting plate of the loadcell so that the fishing line is approximately aligned with the sensitive axis of the loadcell. Then, I connected the output cable of the loadcell signal conditioning amplifier to an oscilloscope and measured the voltage in millivolts (mV).

[1] Certain commercial products are identified in this paper to specify experimental procedures adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the products identified are necessarily the best available for the purpose.

Figure 1 displays the loadcell calibration results. The horizontal axis represents the input force (weight) in newtons (N) and the vertical axis the output voltage in millivolts (mV).

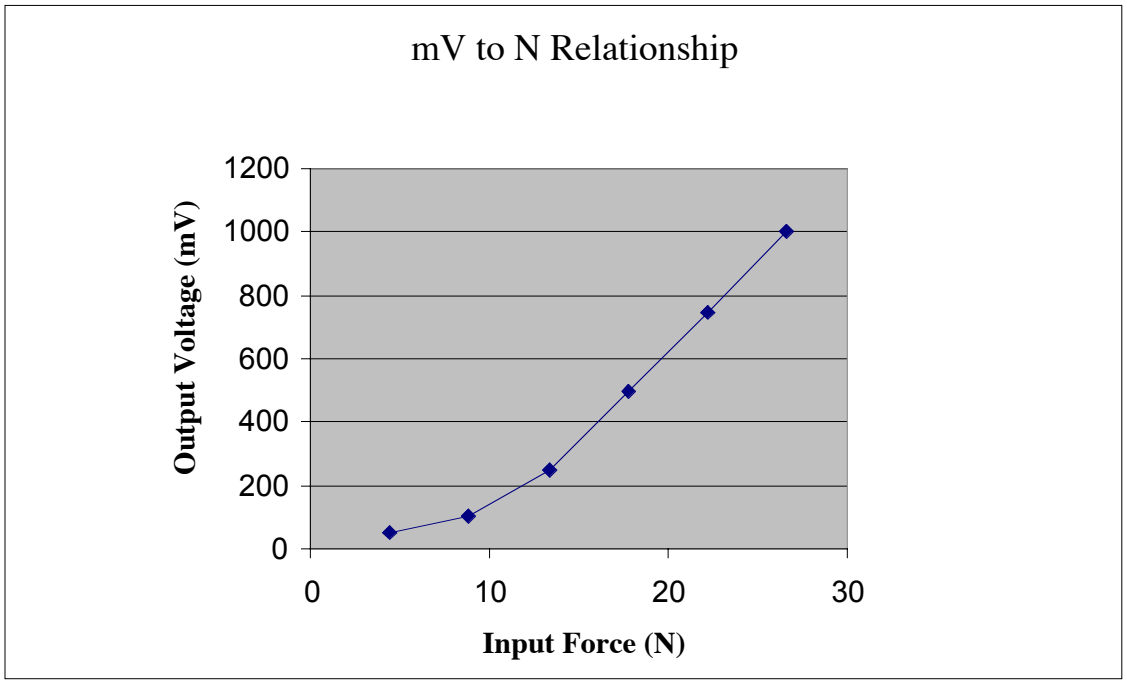

Figure 1. Loadcell calibration results

Joystick Controller Interface

The joystick controller commands software was developed by the Immersion Corporation[1] [2], and was written in Java-Script. This company provides a library of functions that can be downloaded from the web network. For example some very useful functions are the following:

- document.ImmWeb.MakeConstant("hi"); This function commands the joystick controller to generate a constant handle force.
- document.ImmWeb.ChangeDirection("hi", -1, 1, 0); This function provides the joystick controller the desired direction vector (-1, 1, 0) of this force.
- document.ImmWeb.ChangeMagnitude("hi", 1, 5000, 0); This function provides the joystick controller the desired magnitude (5000) of this force. According to a technical support programmer the acceptable range of this magnitude is 0 to 10,000. The main objective of our calibration work was to determine the relationship between this magnitude setting and the force generated at the handle of the joystick.
- document.ImmWeb.ChangeDuration("hi", -1, 5000); This function provides the joystick controller the desired duration (5000ms) of the force application.

I combined these functions to create my own calibration functions. These functions initialize the joystick controller and generate forces of desirable magnitude along the positive and negative directions of the X and Y axes of the joystick handle. My interface program is divided into two parts. The first part is a Java-Script code that defines the previously mentioned functions. The second part is an HTML code that includes the Java-Script code section, initializes the controller and calls the proper functions that generate the desired joystick handle forces.

Joystick Calibration Experimental Setup

Figure 2 shows the experimental setup built for the joystick calibration experiments.

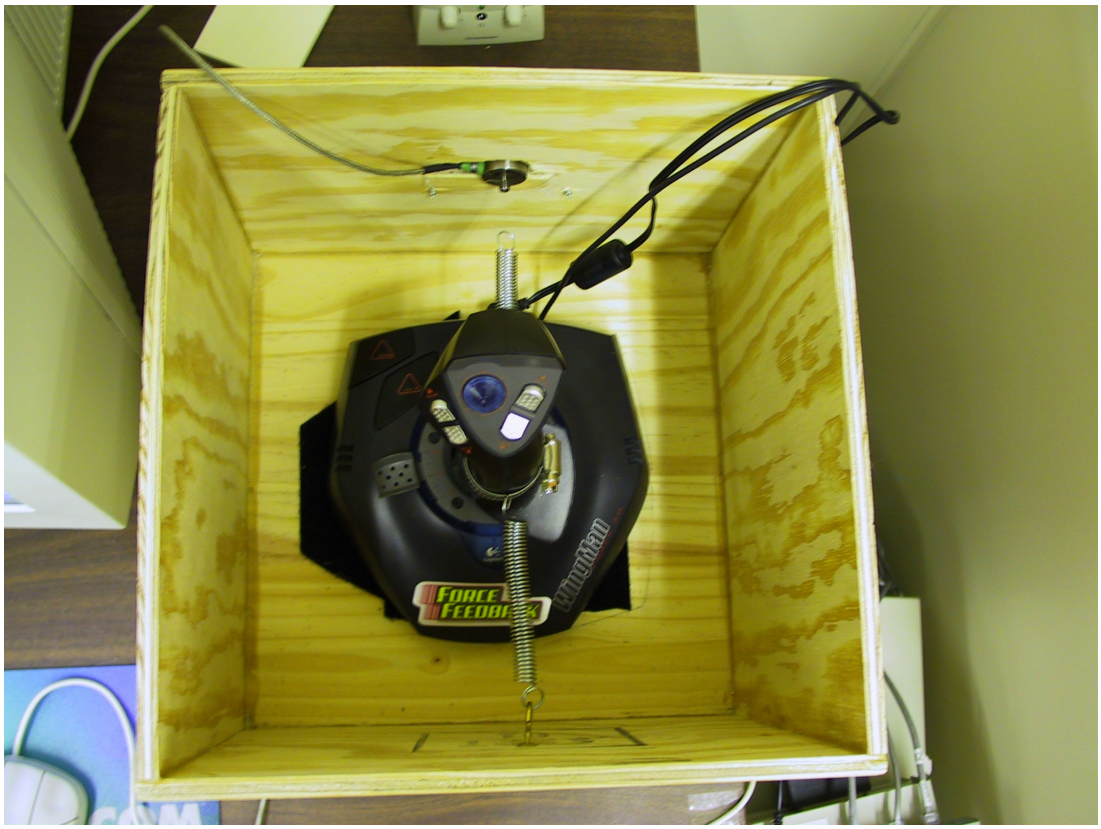

Figure 2. Top view of the joystick calibration experimental setup

It consists of an open-top rectangular wood box with provisions for the mounting of the joystick and the loadcell. The base of the joystick is mounted on Dacron[1] tape attached to the center of the bottom plate of the box. A strap is attached to the handle, which is connected to two springs. One spring is connected to the loadcell, which is mounted on one of the vertical sides of the box. The other spring is attached to a hook mounted on the opposite side of the box. The axis of the loadcell and the hook are approximately collinear. The springs are always in tension and the tension force is monitored by the

loadcell. When the joystick generates a force it modulates the spring tension force. It is this modulating tension force that is recorded as the calibration test generated force.

Calibration Test Results

Using the interface program, I applied forces from 1,000 to 10,000, in steps of 1,000, in 4 directions: +X, -X, +Y and -Y. The joystick exerted a force on the loadcell, which was read by the oscilloscope. The results were then plotted on 4 separate graphs for each axis direction. These graphs are displayed in Figures 3 to 6.

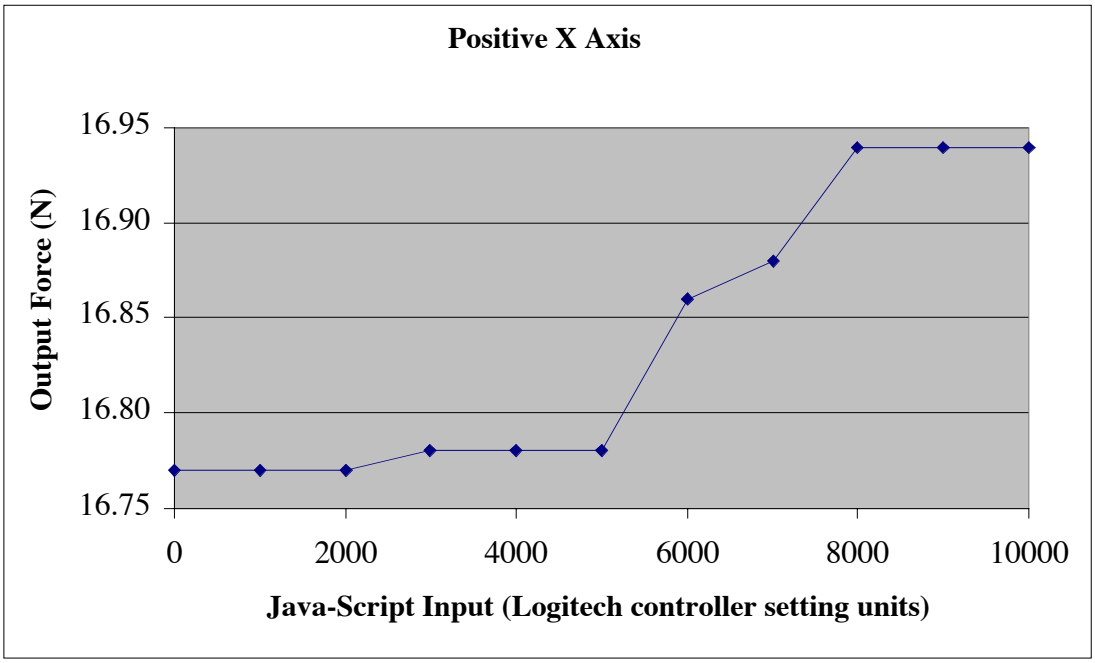

Figure 3. This curve represents the data that was collected when the test was run in the +X direction with inputs 0 to10,000.

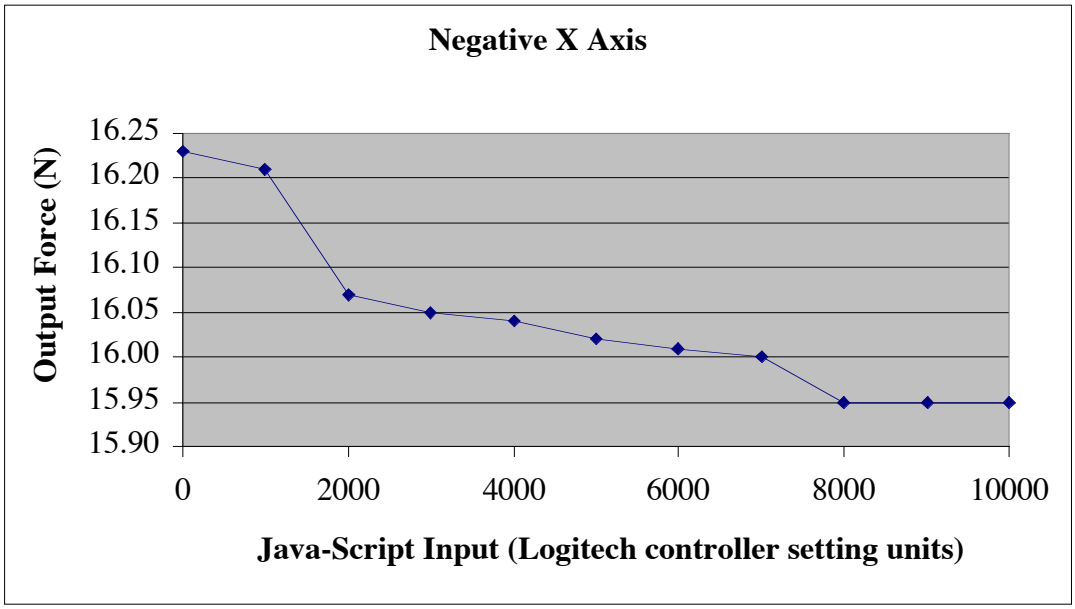

Figure 4. This curve represents the data that was collected when the test was run in the -X direction with inputs 0 to10,000.

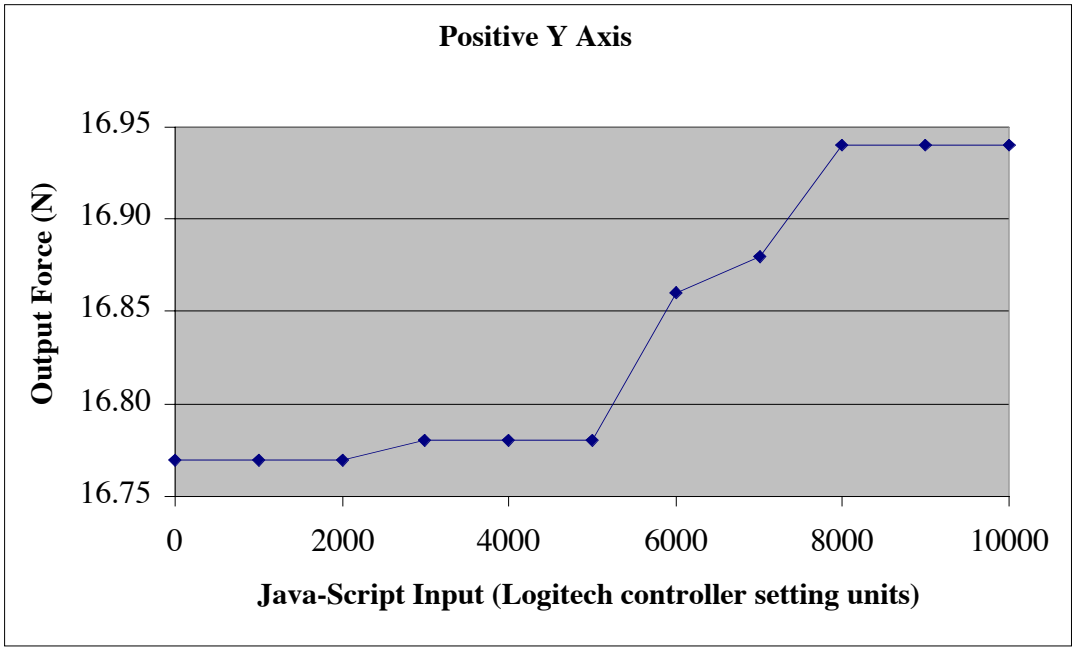

Figure 5. This curve represents the data that was collected when the test was run in the +Y direction with inputs 0 to10,000.

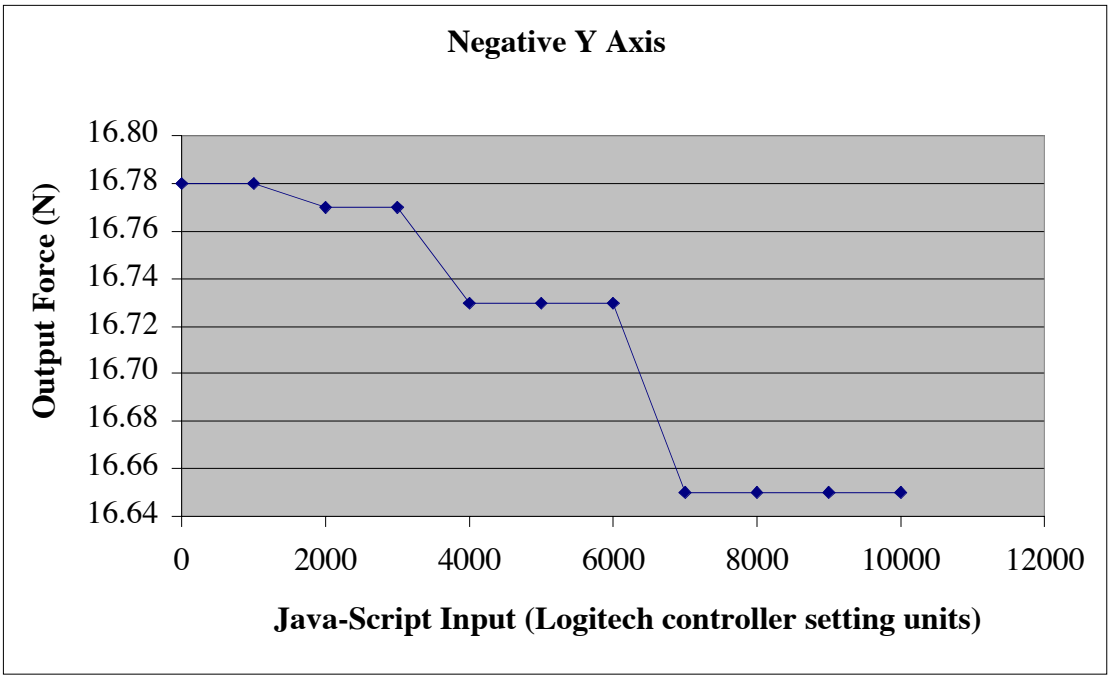

Figure 6. This curve represents the data that was collected when the test was run in the -Y direction with inputs 0 to10,000.

Conclusions

We have accomplished all of the goals of the experiment. An interface that can control the joystick has been programmed using JavaScript. We have found a joystick that is appropriate for our needs and built housing where it can be controlled. Finally, the graphs of the final results show the relationship between the input command signals and the output force.

References

1. Logitech company, < http://www.logitech.com/cf/index.cfm>.
2. Immersion Corporation, < http://www.immersion.com/>.