Lab 1: Error Analysis and Orientation

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Abstract
This lab explores propagating uncertainties and gaining familiarity with the tracking camera. The tracking camera was utilized by measuring the length and width of the sides of a square to calculate the total area, average lengths and widths, and the uncertainties associated with each by using error propagation.

Keywords: *error propagation, uncertainty, tracking camera, area*

Introduction

An important concept our team is utilizing is that no tool or instrument gives an exact reading. As a result, inconsistencies in measurements were taken into account and uncertainties had to be calculated. In addition, our team is using our previous knowledge of coding with Python to handle and operate the tools connected to the data acquisition machine. These tools include the tracking camera, the air table, and the CNC robotic arm.

The goal for this first lab is to calculate the error propagation of uncertainty based on values obtained from the data observed by the tracking camera. The tracking camera was used to record the positions of three colored stickers on the corners of a wooden square. The square was slowly spun on the DAQ (data acquisition) table while the camera simultaneously recorded the locations of the stickers. The theory that is being upheld is that although the shape of the square does not change, the camera is used to measure it produces data with a slight margin of error. The camera measures the positions of each sticker in pixels, each value with an uncertainty of ± 0.5 pixels. To avoid inaccurate results, the side lengths and area of the square will be calculated by using each individual data point within the list of data acquisitions.

Experimental Procedure

Our experiment began with downloading the recommended mobaxterm, which was to be used for operating the tracking camera and interacting with the DAQ table. The next step we took was connecting our computer to the DAQ table via an ethernet cord. Once this was complete, we practiced with the commonly used commands in mobaxterm. Familiarized with the coding commands, we proceeded with the experiment. This involved creating a file for the data we would collect and initializing a connection with the tracking camera. Once the tracking camera and computer were properly connected, three different colored dots, hot pink, green, and orange, were stuck in the corners of the square. These dots would be the points the camera would track. The square was then placed in the middle of the air table and the camera identified each of the colors. The square was moved and spun around in order to obtain a large number of data points that were exported to a .csv file.

The next step in our experimental process was to analyze that data. Our group data analyst processed the gathered information. Due to technical errors in the camera, our data collected only came from the diagonals of the square. The identity of a 45°-45°-90° was used to calculate the side lengths of the square. The uncertainty of the camera, ±0.5 pixels, was taken into consideration when calculating the side lengths. Following this approximation, the standard deviation for all the side lengths was found. With that data, we were able to approximate the area of the square.

Results

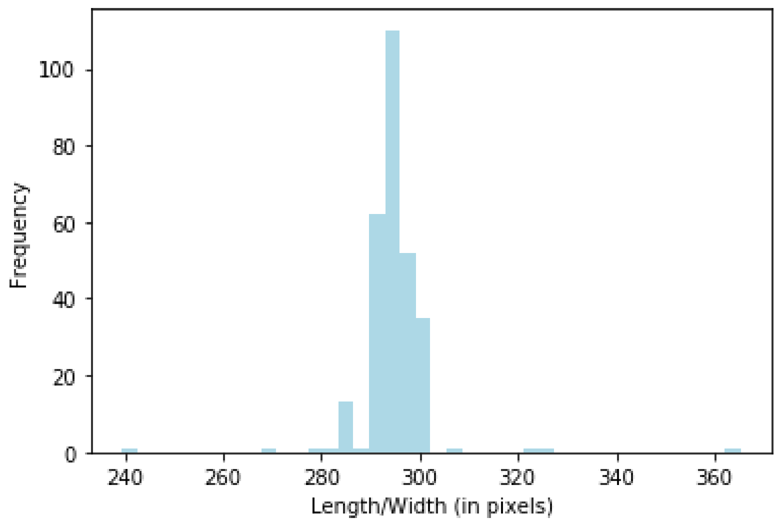

Figure 1: *A histogram of the frequency of different lengths/widths in pixels*

Figure 1 is a representation of our data in a histogram. The x-axis is the length/width in pixels and the y-axis is the frequency. In the x-axis, the data that was collected is divided into 40 bins, each bin containing 3 possible data points or rather in intervals of 3. The data collected consisted of a few outliers, which the group decided to not extract from the data set and rather create a visual representation consisting of the outliers. The majority of the data points approximately lie between 280 pixels and 305 pixels. The histogram was made through the use of python, through jupyter notebook. To develop the histogram on python, it required a few libraries such as matplotlib, and pandas, to be able to read the excel file and output graph based on the data. Then utilizing matplotlib, we were able to plot the histogram and customize it based on data points (number of bins and by interval) and presentation, such as color, size, etc.

Calculations:

With x and y data for two stickers on opposite corners of the square, the distance formula was used to find the length of the squares diagonal in pixels. Then, using the Pythagorean theorem, the length of the square was calculated as the diagonal divided by the square root of two. Using the calculated lengths, the area was calculated in two ways. First, by averaging the calculated side lengths, then squaring that average length to find the area. Uncertainty was determined as the standard deviation of the side lengths, then undergoing a simple power-rule uncertainty calculation, the area with the uncertainty was found to be 86958 +- 4243 pixels to the nearest pixel. Second, the average area was calculated by finding the area for each individual side length, then averaging the calculated areas. The uncertainty for that calculation can be defined as the standard deviation of the area values, with a result of 87010 +- 4356 pixels.

Conclusions

Based on the data that was collected, the calculated standard deviations, and the area, it was found that as the number of data points increases, the uncertainty of the final calculation decreased and the final answer became more accurate.