Motion Paths for Biomechanical Wear Testing

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1.Introduction

At the Human Mobility Research Centre, wear testing is performed with the AMTI Ortho-Pod (Figure 1). This wear testing machine can have a user-specified wear motion path that will teach the system by positioning a pin at several points along the track.

However, because motion paths are defined by rotations of both the plate and the pins, there is no simple method to produce the coordinates of a motion path. The current results are therefore inaccurate and not reproducible.

2.Objective

The goal of this project was to design and implement an application that allows an accurate and reproducible simulation of friction and wear of natural and artificial joints through different motion paths.

3.Procedure

Mathematical theory to find plate and pin rotary angles:

- (x, y) was the point requiring transformation
- Plate rotated (α) with chip to meet the arc of pin (Figure 2)
- Pin rotated (β) to meet chip at desired point (Figure 3)

Computational method with graphical user interface:

- Defined line, square or polygon, circle and figure-eight
- Accuracy settings set by number of points on curve
- Output .txt file

Experimental lab testing:

- Pressure-sensitive film (Fujifilm) placed on test chip
- Converted output file to .wfg form
- Plotted curves

Figure 1. The AMTI Ortho-Pod machine is a six-station pin-on-plate type wear testing machine. The machine has three independently controlled variables, which are the plate rotary motion, the pins rotary motion and the normal load on the pins.

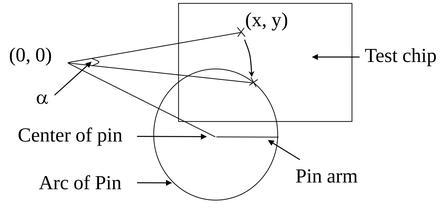

Figure 2. Diagram to display the plate rotary angle. Diagram is not to scale.

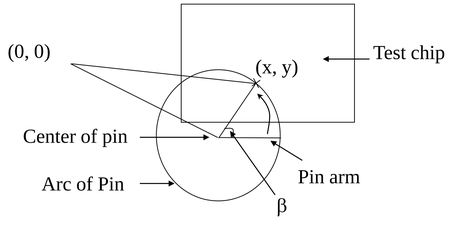

Figure 3. Diagram to display the pin rotary angle. Diagram is not to scale.

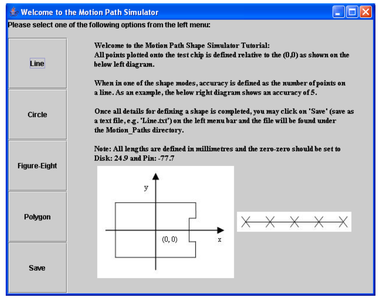

Figure 4. Screenshot to display the GUI front page.

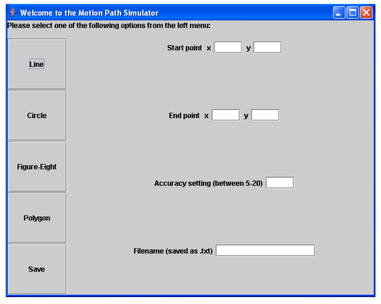

Figure 5. Screenshot to display the GUI for one of the shapes – the line.

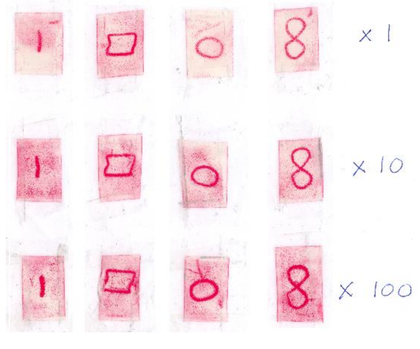

Figure 6. Experimental results for the four different shapes (the line, square, circle and figure-eight) on the Fujifilm. Each was plotted by the Ortho-Pod machine with a repetition of 1, 10, and 100 times.

4. Results

The GUI application as implemented was easy to use with menu buttons, appropriate text, fields, etc (Figures 4 & 5).

Experimental results showed that the shapes were repeatable and did not deviate from its motion path (Figure 6). The shapes correctly described the desired curves. As repetitions increased, there was more thickening of the curve. Between 1 to 10 repetitions, there was a more significant thickening of the curve in comparison to 10 to 100 repetitions (Table 1 & 2).

Repetitions	Line	Square	Circle	Figure-eight
1	10	6	5	6.5
10	12.5	9	8	8.5
100	12.5	9	9	9

Table 1. Table to show the thickness (mm) of line, square, circle and figure-eight on a zoomed scale of 600% on scanned image

Repetitions	Line	Square	Circle	Figure-eight
1 to 10	25.0	50.0	60.0	30.8
10 to 100	0	0	12.5	5.88

Table 2. Table to show the percent change (%) on the line, square, circle and figure-eight based on the results from Table 1

5. Discussion

The results showed that the software correctly described the shapes.

Sources of error included:

- Calibration of the machine by manual measurements,
- Acceleration and deceleration of the machine caused the square to be slightly wavy and the circle to be warped
- Machine limitation to prevent pin overshoot led to shorter vertical lines
- Movement of Fujifilm, although this was acceptable

The machine was not an extremely accurate plotter but was capable of producing many kinds of shapes. For the purposes of wear testing with different motion paths, we have achieved our goal.

Presented as an undergraduate thesis in April 2008. This work was supported in part by the Canada Foundation for Innovation.