2 Axis Motion Test Rig

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Abstract

Evaluating software and the components it runs it on can be a complicated task. In the case of an accelerometer repeatable movements are needed to ascertain what the threshold for a reading is. This project sought to design and program a test rig that can produce repeatable movements for two axis.

Introduction

We developed a two-axis test rig using stepper motors and an Arduino to produce repeatable movements for evaluating accelerometers and software. By employing off-the-shelf components, we minimized manufacturing time while ensuring precise calibration and movement in pitch and roll axes. The rig demonstrates effective performance with potential for future enhancements, such as integrating printed circuit boards for more compact electrical component mounting.

Hardware

Stepper motors were chosen to control the test rig as they provide a reliable way of angle control without the need for constant feedback. During the design of the test rig emphasis was placed on selecting a design that incorporates primarily of the shelf parts. This is done to avoid the time-consuming task of manufacturing. Four components however had to be manufactured. Three were 3D printed because of the speed and adaptability this provides. The axle that the bigger motor drives and which the smaller motor is attached to has a welded plate for mounting the smaller motor. The metal plate also has drilled holes for attaching the smaller motor. This was done because 3D printed parts didn't have the necessary load bearing characteristics.

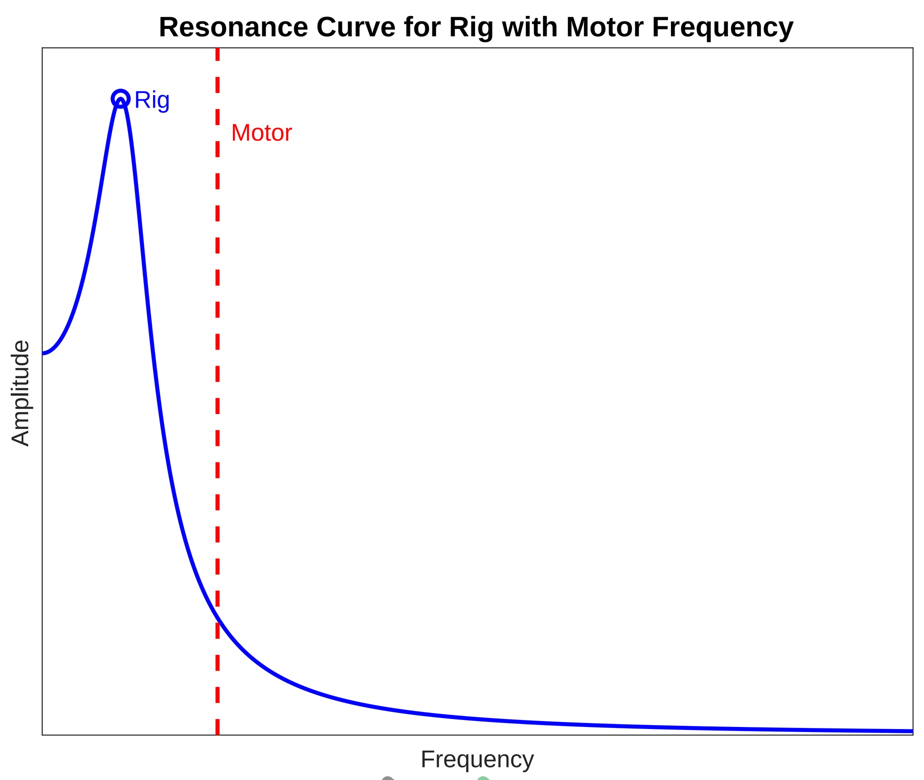
Software

The Arduino receives instructions via I2C containing the angles it should produce with the motors and if it needs to calibrate. Calibration involves the inertial measurement unit (IMU) reporting the gradient of the test rig in both pitch and roll. Inside the Arduino calculations are done to get the number of steps between the current angle and the goal. The angle is calculated using the accelerometer values for all three axles and then via trigonometry calculating the angle that the test rig is at.

$$\theta_x = \arctan\left(\frac{a_y}{a_z}\right) \quad (1)$$

$$\theta_y = \arctan\left(\frac{a_x}{a_z}\right) \quad (2)$$

$$\theta_y^\circ = \begin{cases} 180^\circ - \theta_y^\circ, & \text{if } a_z > 0 \text{ and } \theta_y^\circ > 0 \\ -\theta_y^\circ, & \text{if } a_z < 0 \\ \theta_y^\circ, & \text{otherwise} \end{cases} \quad (3)$$



Challenges

During the testing of the motor we observed that the rig resonated when the pitch motor stepped at specific frequencies this created excessive vibrations which could impact the quality of measurements. To solve this we changed the frequency of the steps for the motor so a to not match the resonance frequency of the rig. This was done with qualitative observations of sound and movement.

Result

The test rig can calibrate and move precisely in both the pitch and roll axis. The construction is solid and has minimal play. Further work can be done to order printable circuit boards (PCB) to mount the electrical components in a more compact way as now they are soldered to prototype boards. Additional work can also be done on the control software for the rig as the feedback from the IMU is only used intermittently. Using the IMU constantly would enable a more precise control. The project taught us how to create a product in a short amount of time.

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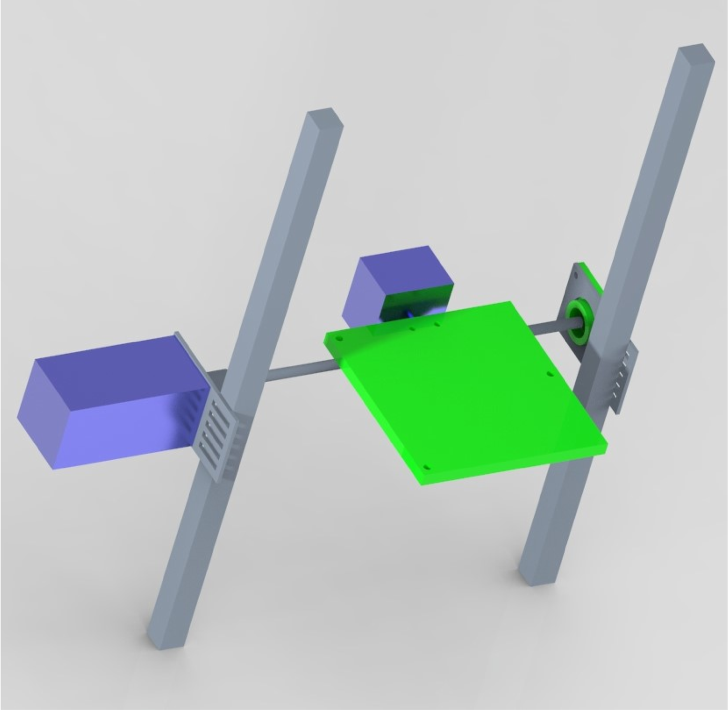

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