Animal Bed Positioning System

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Abstract

An animal bed positioning system was designed for an open source micro CT, PET, and RT system. This positioning system currently has four degrees of freedom including translation and rotation about the x and y-axis. However, translation along the z-axis can be easily incorporated. This system is very precise with accuracy up to 200 microns for translation using Firgelli L12 Linear Actuators and .067 degrees for rotation using Phidgets Inc. Planetary Gearbox Stepper Motors.

Background

- Our client is designing a micro CT, PET, and RT imaging system
- Combining CT and PET allows for two images while the subject is anesthetized once
- Small animals require scaled down versions of the imaging systems used by humans
- These systems function analogously to those used on humans, but with finer resolution imaging and treatment
- Precise patient positioning is required in imaging and even more so in treatment
- Open-Source Project so the device must be simple to build, have specific parts and be inexpensive
- Other products on the market can cost upwards of a million dollars
  - Siemens Inveon System, $1.4 million

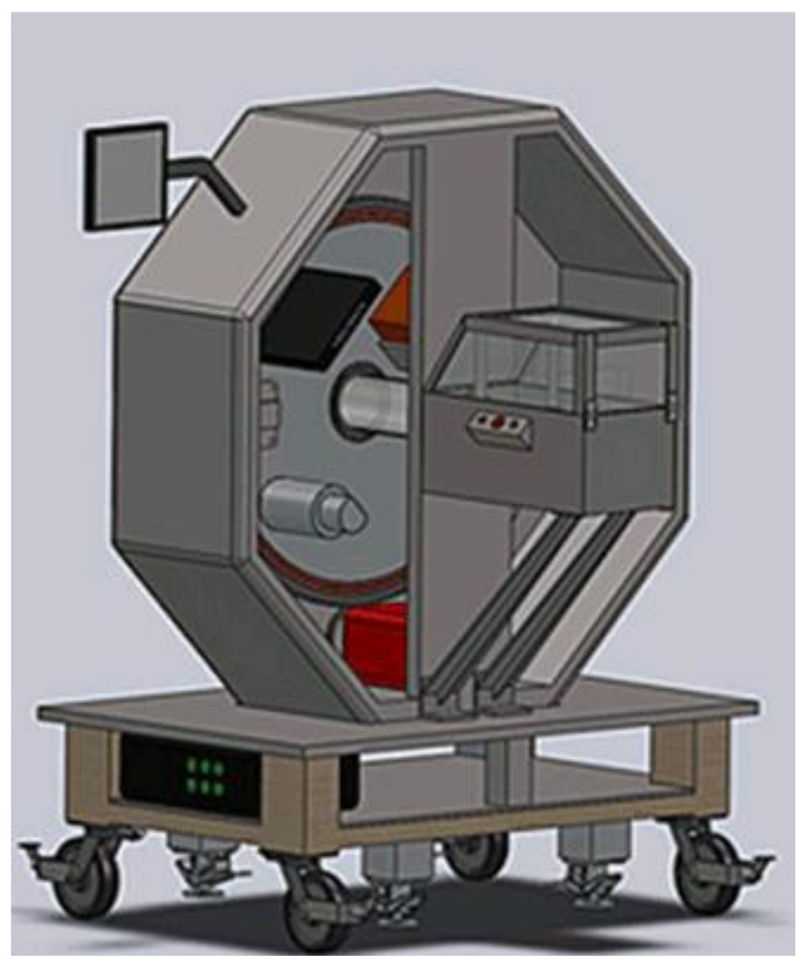


Figure 1 – Solidworks design of small animal imaging and radiotherapy system (http://discovery.wisc.edu/osmd).

Design Requirements

- Fit into 12 cm bore hole
- Four degrees of freedom: translation and rotation about x, y axis
- Translation: Movement up to 1 cm in both directions with 200 micron precision
- Rotation: Movement up to 5 degrees in both directions with .1 degree precision
- Must not exceed $500

Final Design

- 2 Geared stepper motors bracketed together
  - Control pitch & yaw
  - Arduino controlled interface
  - Before linear actuators due to weight
- 2 Linear actuators bracketed together connected to stepper motors
  - LAC board controls X & Y
- Less deflection achieved by building support under first stepper motor

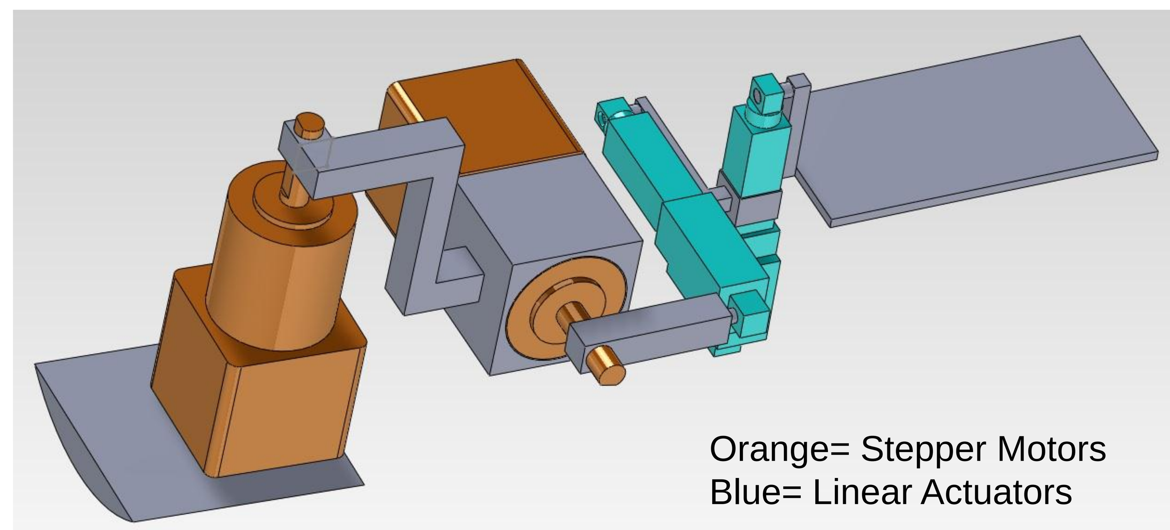


Figure 2 – Solidworks drawing of final design.

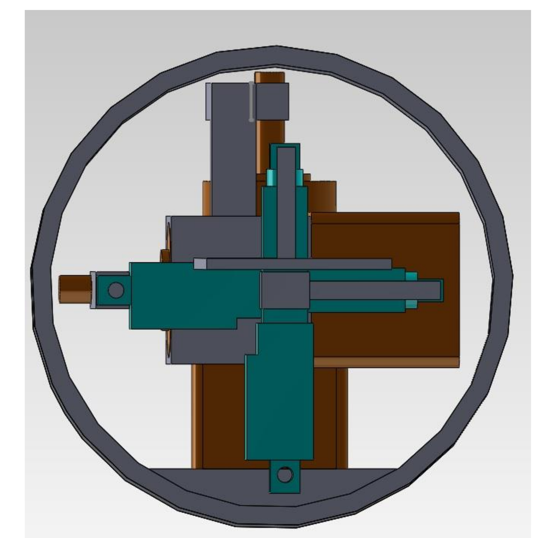


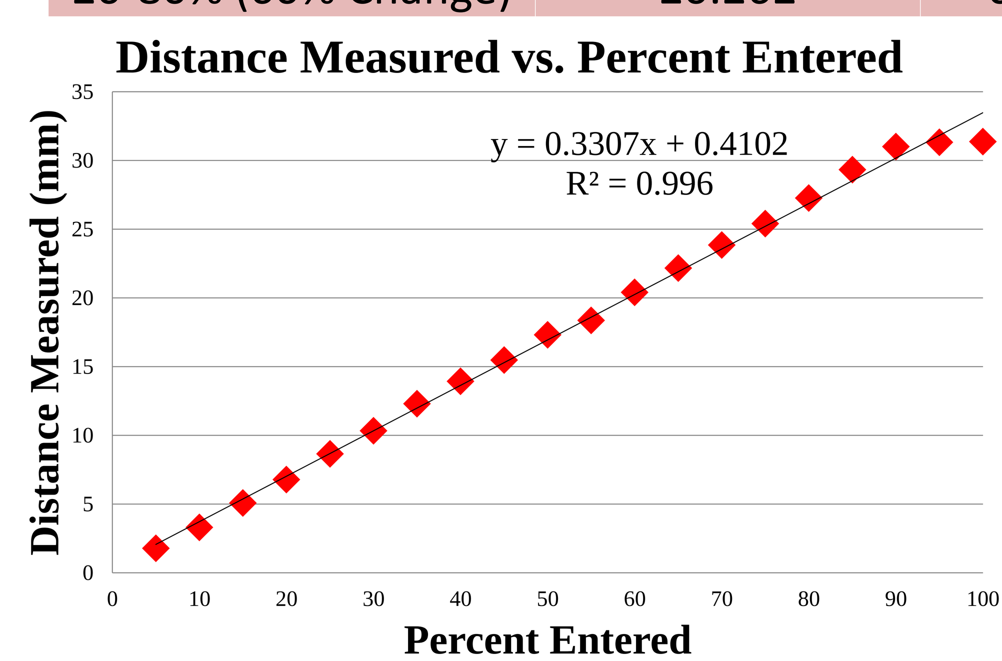
Figure 3- Design shown inside the bore hole, the bed is in front.

Precision Testing

- Measured accuracy and precision of linear actuator
- Used digital caliper to measure distance between start point and end point
  - 20% extended to 35%, 50%, and 80%
  - Used Firgelli LAC board and software to control position
  - 10 measurements each, calculated average & standard deviation
- Calibration curve created, measuring at 5% increment

Figure 4 – Testing measurement

Linear Actuator Position	Average	Standard Deviation	95% Confidence Interval
20-35% (15% Change)	9.989	0.091098238	9.923832 - 10.054168
20-50% (30% Change)	5.083	0.18754555	4.902828 - 5.172162
20-80% (60% Change)	20.262	0.110433489	20.183 - 20.341



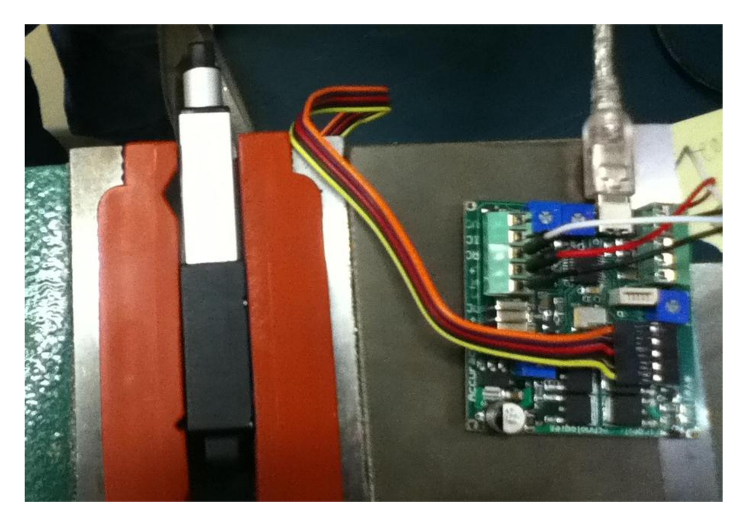


Figure 5 – View of testing set up in vice grip

Testing Analysis

- Relatively precise, small standard deviation and fit of calibration curve
- Accuracy not directly correlated to position given by LAC program
  - Could be caused by measurement error
  - Solution: more accurate measuring methods, calibration curve

Cost Analysis

- Two Linear Actuators:
  - Firgelli L12, model P= $90
  - Firgelli linear actuator control board = $40
- Two Stepper Motors
  - Phidgets Inc. NEMA 17 Bipolar Planetary Gearbox Stepper = $40
- Two Arduino Uno = $40
- **Total=$420**

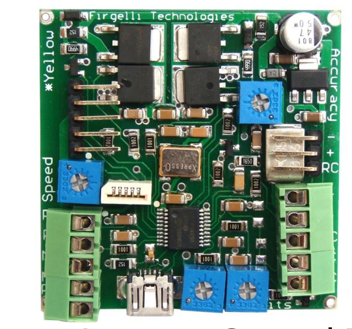


Figure 6 – Linear Actuator Control Board (www.store.firgelli.com).

Figure 7 – 30mm L12-P linear actuator (www.store.firgelli.com).

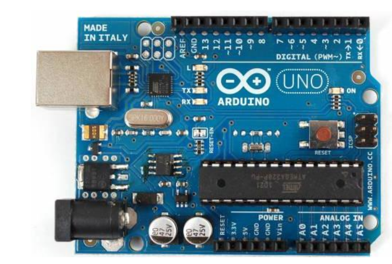


Figure 8 – Arduino Uno Microcontroller (www.arduino.cc).

Figure 9 – Phidgets Biopolar geared stepper (www.phidgets.com).

Future Work

- Building carbon fiber animal bed that connects to the positioning system
- Design a connection to allow for movement in the z-direction with a linear actuator
- Design of a copper coil heating bed to keep the animal warm during testing
- Design of filtration system to allow for a mix of oxygen and isofluorine to keep animal asleep and alive
- Completing the code that allows for movement of all four positioning systems both independently or as a whole
- Additional circuitry to allow arduino to control current instead of voltage required
- Assembling the system from the SolidWorks design

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