Project Design Specification Report

Bed Controller
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Problem Statement:

To develop and design an animal bed system that will be able to translate in the X and Y directions, as well as angular motion. This bed system must be capable to work in micro CT, micro PET, and micro RT systems. Must design a platform for small animals that can move in the treatment area, a borehole with a diameter of 12 cm. The bed must have at least four degrees of freedom: translation on the X and Y-axes, and rotation around the X and Y-axes. The bed system should also be made to incorporate oxygen and isoflourine ducts to keep the subject unconscious. As well as a design should integrate a possible heat pad and other vital readings during the treatment like: heart rate, blood pressure, temperature, etc. In addition, shielding of the animal bed system may be required to attenuate the treatment X-rays. Our positioning system must be made with a low-density material and made so that it does interfere with the imaging systems. The specimen bed should be designed so that the specimen is positioned in the same way each time for imaging or therapy.

Client Requirements:

- Should have 4 DOF, 5 if possible: rotation about the X-axis, Y-axis, and movement in the X and Y direction, Z movement if possible
- Should have movement with 0.2mm precision up to 1 cm in X and Y
- Should have rotational movement up to 5 degree with 0.1 degree precision on both sides
- Total cost should be less than $500

Design Requirements:

1. Physical and Operational Characteristics

a. Performance Requirements: A mouse or similar sized animal will be lowered onto the device from above and then will be moved into the machine, along the z-axis, by a linear actuator. Our positioning system must be very precise after being put into place so the animal lies in the same position as the last test.

b. Safety: The client's device will include an x-ray system, so we may have to come up with a shielding method.

c. Accuracy and Reliability: Our animal positioning system must have precision in the x and y-direction of 200 microns up to 1 cm on both sides. Rotational accuracy should be .1-degree precision up to 5 degrees on both sides.

d. Shelf Life: Will be incorporated into the client's imaging system so it will need to work many times.

e. Operating Environment: The holding device will undergo both CT and PET scans, but the motor system will remain outside. Our device will be housed inside the client's device.

f. Ergonomics: Qualified technicians should be using the machine with animals similar in size to a large rat or a small, skinny bunny.

g. Size: The hole in which our bed will be inserted has a diameter of 12 cm, so our bed will be a maximum of10 cm wide to incorporate a cm of movement along the x-axis but will be more likely 5 or 6 cm wide.

h. Materials: We need to use a low-density but sturdy material, such as carbon fiber, for the bed as to not interfere with x-rays and stay rigid even with large loads.

2. Production Characteristics
a. Quantity: Only one device will be needed
b. Target Product Cost: $500
3. Miscellaneous
a. Standards and Specifications: The device is an animal positioning system which holds specimen (mostly rats for this project) in an imaging and radiotherapy system for CT micro, PET and micro RT scanning. This positioning system has four degrees of freedom in X and Y-axes translation and angular motion about the X and Y-axes in the imaging and radiotherapy system. General specifications on the functional aspect of this device include:
-Positioning specimen in a particular way every time on the animal bed.
-Enabling the bed to translate and rotate in X and Y direction inside the imaging and radiotherapy system with specified distance (1 cm), angle (5 degrees) and precision (0.2 mm and 0.1 degree)
b. Customer: The customer mentioned that this animal positioning system is preferred to be in rectangular shape, which would fit better for a rat specimen's physical shape. In addition, the customer pointed out that among the six degrees of freedom for translation and rotation, the function of translational and rotational motion on z- axis would be the least significant and can be neglected if they causes tremendous work or delays on the whole project.
c. Patient-related concerns: The patient for our design will be a mouse or other small animal. The most important element of our design for the patient will be the oxygen, isoflourine ducts, and heating pad which will allow the patient to breathe, keep it unconscious, and keep it warm as a mouse's internal body temperature decreases when it is put under anesthesia. In addition, the patient will need to be fully supported during the scanning and treatment procedures by the stage.
d. Competition: The goal of the project is to make this technology accessible by making this small animal imaging and therapy system design open source and freely available. To do this our design must be simple to build and with precise parts; it should be less expensive than existing systems (both the entire product and our bed controller design). Examples of existing systems, which include small animal positioning systems, include:
-Siemens Inveon PET and CT scanner: commercially available product, our group will be able to see week of 9/18
-GE Triumph: commercially available PET/SPECT/CT imaging product
-SARRP (Small Animal Radiation Research Platform): Developed at Johns Hopkins and commercialized by Xstrahl, it has a robotic animal positioning system with 4 degrees of freedom (X, Y, Z, and Θ)
-X-Rad 225Cx by Precision X-Ray Inc.: has 3D computer controlled stage, makes automated stage corrections