

Product Design Specifications - V2.0

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Project Title: An open-source imaging platform for small animals

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Client:

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Problem Statement:

The overall aim of this project is to develop an open source small animal imaging and therapy platform that integrates imaging (e.g., Computed Tomography (CT), Positron Emission Tomography (PET)) and therapy (e.g., radiotherapy (RT)) together. This system will be designed on a flexible platform, enabling researchers to build their own system according to the available resources and needs. The specific aim for the design project is to provide initial design of such an open source imaging/therapy platform and potentially start prototyping the system at the fast prototyping system at the Morgridge Institute for Research (MIR).

Client Requirements:

- Complete list of specifications necessary for the design of a small animal imaging system
- System should be able to perform PET, CT, and radiation therapy
- Each type of imaging or therapy modality should be independent (e.g., an example device could only incorporate CT or only CT/RT)
- The development should be open source (i.e., all intellectual property is publicly available)
- The final product should have software and hardware completely ready to go in a "plug and play" format

Physical and Operational Characteristics:

- The device is to be used on small animals (e.g., rats and mice)
- The system should be able to incorporate any combination of PET, CT, and RT.
- Couch positioning, data acquisition, and data storage should be independent of any imaging/therapy modality.
- Each imaging/therapy modality will have its own level of specification

Miscellaneous:

Initial specifications for the imaging/therapy modalities and the overall device systems can be found in the tables below.

Specifications for the Radiation Therapy (RT) System

Components	Specifications
X-ray production - orthovoltage tube	2 focal spots, size: 2 mm for RT, 250 kVp max

X-ray filter	0.5 mm Cu, 2 mm Al
Source treatment dose	200 cGy per min
Dose monitoring system	0.1 cGy accuracy with ion chamber, Radiochromic films
Primary collimation material	Mainly Pb, hardened with Ca
Jaw system	Brass sliding
Secondary & tertiary collimation system	Max FS = 60 mm x 60 mm
MLC leaves: W or Pb	Thickness - 1 mm, min. FS < 0.5 mm x 0.5 mm
Beam control system	Charge and time measurement
Target cooling system	Either Oil to water or oil to air
Motor for positioning	Absolute encoded DC motor
Animal positioning system - table	0.125 mm accuracy, 0.05° rotational
Animal support fixture system	Gas anesthesia, temperature control, stereotactic frames
Laser alignment system	0.5 mm accuracy for positioning
Physical platform and support	Made with plastics as practicable

Specifications for the Computed Tomography (CT) System

Components	Specifications
CT system	Cone beam CT or Fan beam CT (FOV = 10 cm x 10 cm)
Bore diameter	120 mm
X-ray source - orthovoltage tube	2 focal spots, size: 0.2 mm for CT
Source imaging dose (whole body scan)	1 cGy
X-ray filters	0.5 mm Cu, 1 mm Al

Flat-panel CCD detector	512 x 512 pixel array, 0.25 mm ³ voxel resolution
Detector frame rate	7 Hz
Image reconstruction system	Feldkamp or filtered backprojection
Motor	Encoded DC motor (same as for RT system)
Three dimensional digitizer	MicroScribe3DX
Animal positioning system - table	0.125 mm accuracy, 0.05° rotational
Detector Scintillator Crystal	CsI(Th)

Specifications for the Positron Emission tomography (PET) System

Components	Specifications
LSO detector crystals size	2 mm x 2 mm x 10 mm, 64 channel, 20 x 20 array
Hamamatsu H8500 PS PMT	8 x 8 anodes, pixel = 5.8 mm x 5.8 mm, pitch = 6.08 mm
Photocathode	Bialkali, 300-650 nm spectral response, λ (peak) = 420 nm
Crystal array	64 (8 X 8 crystal/PMT)
Number of detectors	32
Number of crystals	2,048
Number of rings	4
Ring diameter	14.8 cm
Time resolution	3 ns
Transmission source	Co-57 or X-ray CT
Image reconstruction system	Filtered backprojection

Combined modular sub-systems and other sub-systems

Software/Hardware	Management
Image guided treatment planning	Data acquisition/management
PET and CT image reconstruction	Quality assurance
Fail-safe	Report and Verify
Power control	Picture archiving and communications
Power/Battery Backup	Data base management
Shielding and structural support	Electronic recording and patient scheduling