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Physics of Medical Imaging and Radiotherapy, self-study projects 2025

Project code	Project supervisor	Title	Short description
UO01	Uwe Oelfke	Quantifying radiation damage for tumour cells	Group of students visit CCI in Sutton once (3 hours) to irradiate tumour cells with various doses, we will plate the irradiated cells and will send pictures of the clonogenic assays to the students after one week, students will be asked to count the surviving cell colonies, draw the respective survival curves and fit parameters for a linear quadratic model. This can be compared to data from the literature. The remaining task will be describing the details of the experiment and the methods and analysis and interpretation of their own results.
UO02	Uwe Oelfke	Why MRI guided Radiotherapy with MR-Linacs	We can provide a live stream of an on-line adapted RT treatment at the MR-Linac into a seminar room at ICL. Students should record the clinical workflow and describe the potential advantages and challenges of this new technology for each step of the treatment they observe. This can start from the challenges in dosimetry (electron return effect) and online treatment planning to the problem of extended treatment time and lower patient throughput. In case students would be willing to come to Sutton, we may be able to let them participate in MR-Linac QA – however I cannot confirm this yet.
NHP01	Neva Patel	PET: The Centilloid Scale in patients with Alzheimer's Disease **– Implementation in clinical practice and limitations**	Amyloid are protein deposits that accumulate between nerve cells, and their presence is indicative of Alzheimer's disease. The Centilloid scale is a standardized method (universal scale), introduced to quantify the amount of amyloid (or the amyloid load) in the brain across different tracers, scanners and analysis techniques. The scale uses a 100-point scale to measure the average amyloid load in a patient's brain, with 0 representing no amyloid load or a high certainty of amyloid negativity and 100 representing the average load in a patient with mild to moderate Alzheimer's disease (AD). A higher Centilloid number is indicative of a greater amount of amyloid load. In Clinical practice, the Centilloid scale can be a useful tool in assessing and following up patients with Alzheimer's disease. However, there are limitations in using a scale like this. This literature search discusses how the Centilloid scale can be used in Clinical practice and the limitations that need to be considered.

JH01	James Hubber	Actinium-225: Targeted Alpha Therapy in cancer treatment.	Unsealed radionuclide therapy is a rapidly growing area in the treatment of a variety of cancers. In the UK, between 2007 and 2021 there was an 87% increase in the number of cancer patients treated, and a 231% increase in treatments given. In addition to increased patient and treatment numbers, the number of radiopharmaceuticals available, and the number of cancers treatable are also increasing. Alpha emitting radionuclides, in particular, are a big area of development, with the global market for alpha emitters predicted to increase from $672.3 million in 2020, to $5.2 billion by 2027. There are currently dozens of different therapeutic radiopharmaceuticals in development and clinical trials. One such alpha-emitting therapeutic radionuclide is Ac-225. The students should perform a literature review on the practical considerations of implementing an Ac-225 therapy service in the clinical setting. They should consider the production of Ac-225, physical characteristics of the emitted radiation (shielding, radiation doses to staff etc.), the possible methods of administration, post-therapy radiation protection issues, and post-therapy imaging.
AS01	Andrew Scott	MRI along non-Cartesian trajectories	MRI acquisitions usually collect data along rectilinear Cartesian trajectories in k-space. However, other k-space trajectories can be more efficient for some applications. One such efficient trajectory that has been extensively used in research studies is a centre-out spiral. The study of such trajectories is not only an active research topic, but provides useful insights into the relationship between image space and k-space. In this project students will investigate the use of spiral trajectories in MRI by: - Reviewing the advantages and disadvantages of non-Cartesian k-space trajectories in comparison to more standard Cartesian trajectories, and the current and potential future applications of non-Cartesian trajectories in routine clinical use. - Using a “gridding” algorithm to interpolate k-space data sampled along a spiral trajectory (provided) onto a Cartesian matrix allowing a straightforward Fourier transform reconstruction. - Performing simulations to compare the effects of motion between the acquisition of k-space data along both spiral and Cartesian trajectories.

RT01	Clare Antoine, Olivia Channon, Laurence Hill	SRS Margins	Stereotactic Radiosurgery (SRS) is a high dose radiotherapy treatment for metastases within the brain. The treatment is carried out with a high level of precision. MRI images are acquired for accurate delineation of lesions with the brain; the patient is immobilised within a reinforced mask, pre-treatment imaging and small shifts are used to place patient in the correct position before the radiation beam is delivered. Linac-based SRS is typically carried out with a 1mm margin; other treatment modalities such as Cyber-knife and Gamma-knife may treat patients with a 0mm margin Research the literature for best practice SRS treatment. The final report should present how linac-based SRS treatment compares against CyberKnife and Gamma-Knife deliveries. You should describe what the uncertainties in the treatment process are and evaluate the highest levels of accuracy that can be achieved. Make recommendations on the margin size that should be applied for SRS treatment and situations where a change to this standard practice might be justified A visit to the clinical Department of Radiation Physics and Radiobiology and Department of Radiotherapy at Imperial College Healthcare NHS Trust will allow the students to observe the methods currently in use to deliver linac-based SRS in the clinic, and discuss the issues faced with radiotherapy professionals including radiotherapy physicists.

RT02	Olivia Channon, Ruth McLauchlan	Plan Robustness	In Radiotherapy, patients have their treatment planned individually to ensure that they receive the required dose to their tumour while minimising dose to surrounding normal tissues. Ideally, the patient's position and anatomy remain consistent throughout the course of treatment to maintain accuracy. However, as treatment plans become increasingly complex in their delivery, they may become more sensitive to changes in the patient's anatomy, such as breast swelling or small variations in patient positioning. Plan robustness evaluation provides a way to assess how changes in patient anatomy or positioning can affect the delivered dose, allowing clinicians to determine whether the plan remains clinically acceptable under different scenarios. This project will involve a literature review to explore and compare current methods for evaluating plan robustness in radiotherapy. A visit to the clinical Department of Radiation Physics and Radiobiology and Department of Radiotherapy at Imperial College Healthcare NHS Trust will allow students to observe current practices for addressing plan robustness and to discuss challenges with radiotherapy professionals, including physicists. The final report should include a review of plan robustness evaluation methods and recommendations for clinically applicable techniques that could be implemented in practice.
RQ01	Rebecca Quest, Mary Finnegan	Image Distortion in MRI	MRI is subject to many possible artefacts, one of which is image distortion. In this project you will investigate the potential sources of distortion and consider what their impact may be in various clinical applications, such as MRI for radiotherapy treatment planning. You will review what spatial uniformity tolerances should be expected in commercial scanners, based on manufacturers' specifications and design a phantom which could be used to test these limits. In designing the phantom, cost and user experience should be considered. Finally, you will design a simple program to analyse simulated data from your phantom.
RQ02	Rebecca Quest, Mary Finnegan	AI in Image Reconstruction	AI in image reconstruction: This project will explore the current status of AI image reconstruction in clinical MRI systems. You will review the concepts of deep learning based algorithms compared with conventional reconstruction methods, and compare approaches by different manufacturers. You will explore the strengths and weaknesses of the techniques and its impact in healthcare.

RQ03	Rebecca Quest, Mary Finnegan	Using zero echo time (ZTE) MRI for tissue segmentation	This project will investigate how ZTE MRI can be used for segmentation of different tissue types, such as bone, cartilage, and soft tissue. In this project you will compare ZTE with other ultrashort echo time (UTE) and conventional MRI methods. You will choose one clinical application to focus on for which you will design methods of technique optimisation and validation, and investigate the potential clinical benefits.
CD01	Chris Dunsby	Super-resolution ultrasound imaging using microbubble contrast agents	Microbubble contrast agents are small gas-filled bubbles that are commonly used as contrast agents in clinical US imaging. US imaging systems have the sensitivity to localise individual microbubbles if the concentration of microbubbles is sufficiently low. By localising individual microbubbles as they flow through the vasculature, it is possible to beat the conventional diffraction limit of spatial resolution. This project would review the state-of-the-art of super-resolution ultrasound imaging and the underlying physical principles governing its operation.
CD02	Chris Dunsby	State-of-the-art SPECT imaging systems	This project will involve a review of state-of-the-art commercially available SPECT imaging systems and a comparison of their performance relative to the theoretical limits. This will include consideration of detector technologies, event detection rates, system electronics and image reconstruction algorithms.
JM01	James McGinty	Phase contrast X-ray imaging	Traditional X-ray imaging and computed tomography can suffer from low signal contrast when imaging low atomic number samples, such as biological soft tissues. Phase contrast techniques offer the potential for increased contrast in such samples without the need for additional chemical contrast agents. In this project you will research the experimental approaches and accompanying data processing to generate phase contrast X-ray images, where the techniques are currently applied and discuss the prospects for clinical deployment.
KL01	Ken Long	Simulation of image generation and deconvolution	The raw RF signal generated in an MRI scan is recorded into "k-space" and processed using a two-dimensional Fourier transform to deliver the coordinate-space representation of the image. This process is subtle and is prone to a variety of artefacts. In this project you will develop an object-oriented model of the encoding of the image in k-space and the reconstruction of the image. You will then use your model to investigate a variety of artefacts. The objective of the project is to deepen your understanding and, ideally, to deliver a pedagical tool that can be used to demonstrate the impact of various instrumental effects on the image.

KL02	Ken Long	Integration of MRI in radiation therapy	This project will review the issues related to the integration of MRI in the radiotherapy, the state-of-the-art in integrated systems and the possible exploitation of MRI techniques to determine the profile of dose delivered.