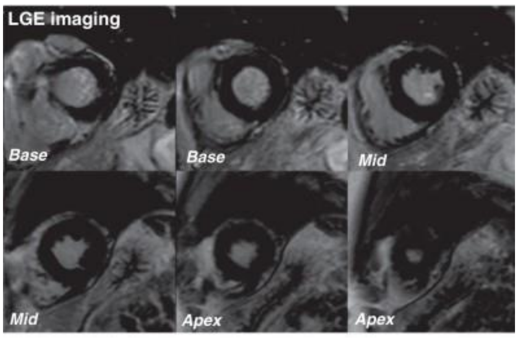
Synthesis of LGE cardiac MR for optimal integration of scar and perfusion images

Background: Quantification of myocardial perfusion cardiac MRI can accurately identify areas of reduced myocardial perfusion, which is of significant clinical importance. One of the, as yet, unsolved issues is that it does not allow the immediate decision of whether this reduced perfusion is an area of inducible ischaemia (i.e the tissue is still alive) or the result of a previous myocardial infarction (and the tissue is scarred). However, late gadolinium enhancement (LGE) images can also be acquired to identify regions of scar and our group has shown the utility of overlaying the two types of images to assess both ischaemia and scar together (both types of images shown in Figure 1).

Figure 1:



One of the challenges of overlaying the two types of images is that there are a different number of slices acquired at different locations and at different cardiac phases (time moments) so their positions do not match exactly. However, our group have recently shown that it is possible to generate new synthetic images for a patient at new slice locations using GAN models. In this project, we aim to use this to generate new LGE images for the patient, in slice locations that match exactly with the perfusion images in order to more easily combine the pixelwise information.

One approach for generating new slice locations of a patient is to train a Variational Autoencoder (VAE), which is a class of deep generative models, and encode all available slices to the latent space using the encoder part of the VAE. The latent space can be understood as a compressed hidden representation of the training data, which in this case includes the anatomical features of patient's heart shape as well as its image appearance. We previously demonstrated that anatomical features can be learned by a VAE model trained on the segmentation mask of cardiac MR images. As shown in Figure 2, we can perform interpolation between two latent codes (which correspond to two different shapes) to reconstruct intermediate shapes using the decoder part of the VAE. The labels for intermediate shapes are subsequently used for generating realistic cine images using a conditional GAN model. A similar approach could be used to match the slices for LGE and perfusion images to better integrate the outcome of the two analysis.

Aims: To develop and train VAE and GAN models that will be used to create LGE images from corresponding slice locations of perfusion images in order to better combine pixelwise information.

Outcomes: The outcome of this project may result in a scientific conference or journal paper, co-authored by the student.

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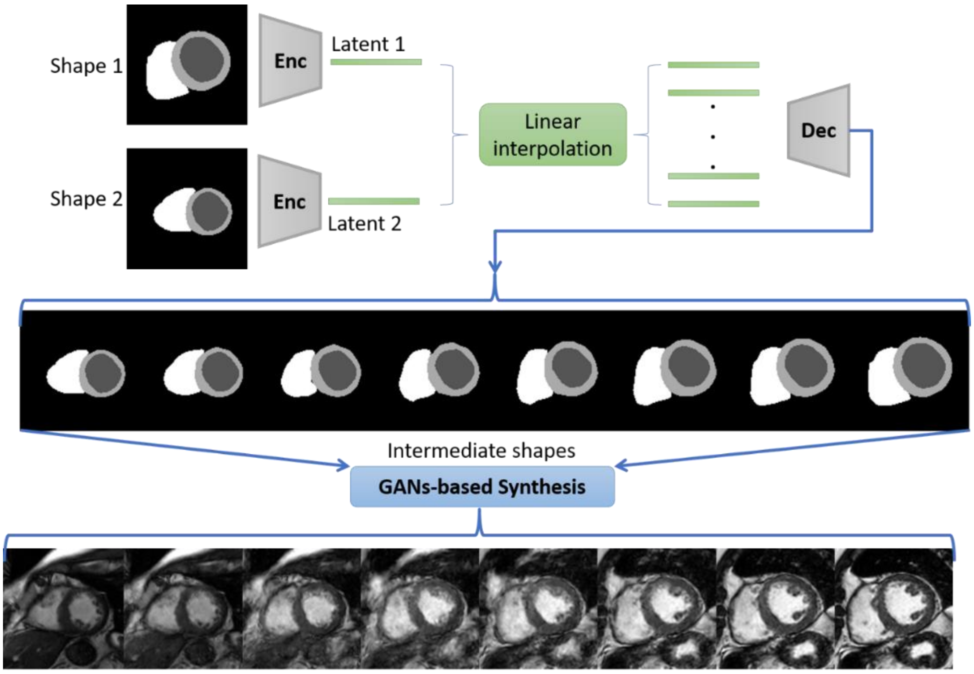
Further information: This project will be conducted with our clinical collaborators at King's College London and, if interested, the student could arrange to visit their hospital as part of the project.

Figure 2:



Expected skills and experience

- Programming in Python, other languages (e.g. course BMB502417)
- Machine learning / deep learning (e.g. courses 8DM40, 8DM00, 8DM20)
- Medical image analysis (e.g. courses 8DC00, 2DMM10)
- Experimental study design (course 8DM20)
- Written and oral communication in English