# Abstract

In this paper, a model is presented for deformable image registration using an approach based on the VoxelMorph algorithm. This model is trained on the MNIST dataset as a lightweight demonstration of the convolutional approach to image registration.

# Introduction

Image registration is an important step in many medical imaging applications. Deformable image registration, where the shape of the image is allowed to be warped to achieve congruence between the initial and target images, is particularly useful in applications such as neuroimaging and organ segmentation, where images may represent cross-sections of volumes that shift in a 3-dimensional space. By mapping a deformation field from one image to another, annotated boundaries in one image can be mapped to their corresponding boundaries in different layers of a scanned volume, allowing for important clinical and research processes such as the 3-dimensional mapping of different organ systems, or the aggregation of multi-modal data into one aligned space.

Previous deterministic algorithms for deformable image registration have been slow and computationally intensive, limiting their practical clinical application. By training a convolutional neural network to approximate the deformation field between pairs of images, this field can be generated significantly faster by the VoxelMorph algorithm than older methods. Efficiency improvements not only provide for more convenient application for the user, but also allow models to be applied practically on much larger datasets, and in use cases where long runtimes present a barrier to deployment.

In this paper, this approach is demonstrated using the MNIST dataset. This dataset, which is made up of grayscale images of handwritten integers from 0 to 9, is both freely available and relatively lightweight, making it ideal for training on consumer-grade hardware.

# Methods

## Algorithm

The approach taken in this project was based on the VoxelMorph algorithm.

## Dataset

* Based on VoxelMorph
* Applied to MNIST dataset
  + Image pairs were matched randomly within the training dataset
* Loss function:
  + MSE reconstruction error
  + Field smoothing error
* Architecture
  + Convolutional neural net
* Trained for 20 epochs
* Hyperparameter tuning

# Results

* Best hyperparameters

# Discussion