NODEO: A Neural Ordinary Differential Equation Based Optimization Framework for Deformable Image Registration

REPRODUCIBILITY PROJECT | REPRODUCED | NEW ALGORITHM VARIANT | NEW CODE VARIANT

CS4240 Deep Learning | 2022/23 Q3

INTRODUCTION

The reproduced paper 'NODEO' introduces a novel framework for **Deformable Image Registration (DIR)** that uses neural ordinary differential equations (NODEs) to optimize for a dynamical system between the image pairs and corresponding transformation. DIR is a technique used to align two or more images by deforming one of them to match the other. A **warped** image is created by applying a deformation field to the **moving** image, such that it aligns with the **fixed** image. The experiments in the paper are conducted on the OASIS and CANDI dataset and compared to benchmarks from other relevant literature.

REPRODUCTION PROJECT

1. Reproduction

We reproduced the provided code on GitHub for 3D deformable image registration on the OASIS dataset.

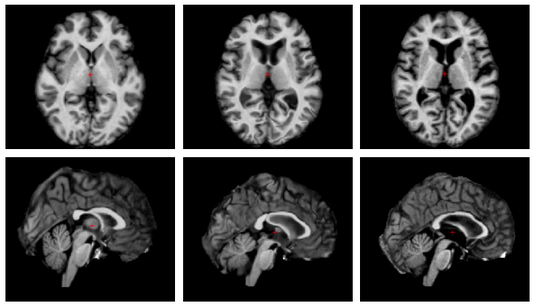
2. New Algorithm Variant

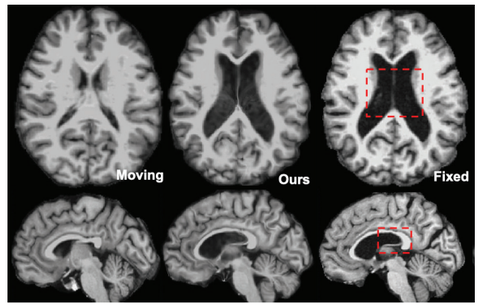
Since the existing code only functions for 3D images, we modified the code for compatibility with 2D brain images. Additionally, we implemented a variant that supports PNG images, enabling us to assess the model with a self-created toy dataset based on the one provided in the paper.

3. New Code Variant

We refactored certain hard-coded snippets to make the code more generalisable and implemented a loop structure allowing to iterate over multiple image pairs and compute the average dice scores.

3D OASIS DATASET

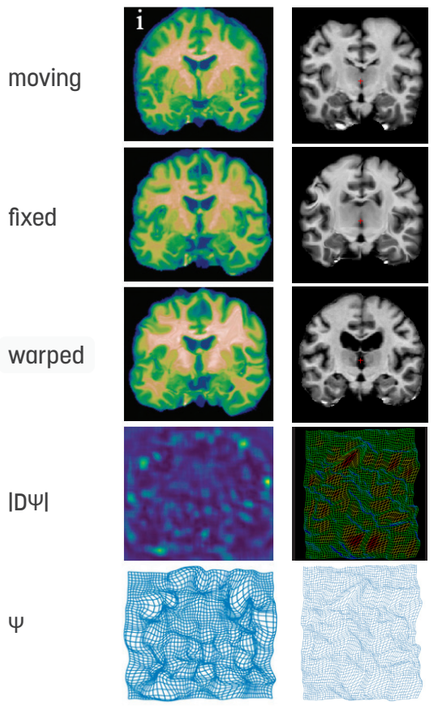




Snippet of Figure 5 from NODEO paper

Example of a registration image pair with OASIS ID001 (fixed) and OASIS ID002 (moving). Our reproduced result is displayed on the left, next to the example from the NODEO paper on the right.

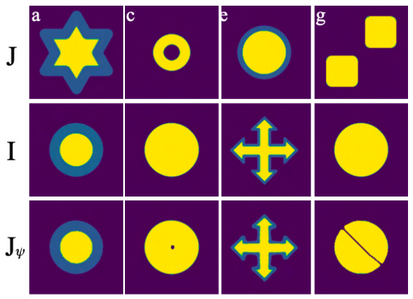
2D OASIS DATASET



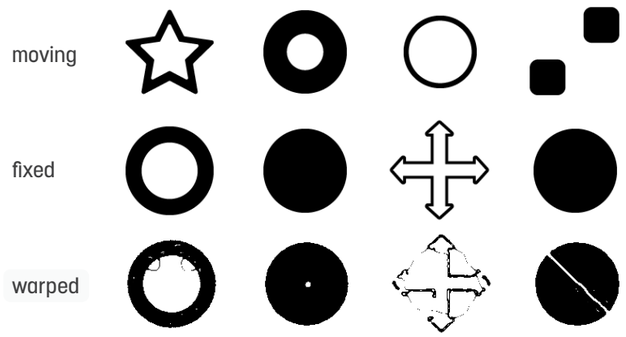
NODEO *reproduced*

Algorithm variant for 2D image pair with OASIS ID001 (fixed) and OASIS ID002 (moving). Snippet from NODEO paper in the left column, our reproduction in the right column.

2D TOY DATASET



Toy dataset from NODEO paper



Variation of the 2D algorithm, adjusted for PNGs and applied to self-created toy image pairs, similar to the ones used in the paper (left).

Wu, Y., Jiahao, T. Z., Wang, J., Yushkevich, P. A., Hsieh, M. A., & Gee, J. C. (2022). NODEO: A Neural Ordinary Differential Equation Based Optimization Framework for Deformable Image Registration. In 2022 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR). https://doi.org/10.1109/cvpr52688.2022.02014

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