Artificial MRI brain images creation with Variational Autoencoders

Miguel Tablado

November 2022

Contents

FICHA DEL TRABAJO FINAL

Título del trabajo:	Artificial MRI brain images creation with Variational Autoencoders
Nombre del autor:	Miguel Tablado León
Nombre del Tutor/a de TF:	Baris Kanber
Nombre del/de la PRA:	Baris Kanber
Fecha de entrega:	02/2023
Titulación o programa:	Máster en Ciencia de Datos
Área del Trabajo Final:	Area Medicina (TFM-Med)
Language:	English
Keywords	Deep Learning, Brain MRI, Variational Autoencoder

Abstract

Artificial Intelligence is set to be key technology at medicine projects in where models will help doctors at diagnostics with image processing. Magnetic Resonance Images allow doctors to scan brains and create a images that can be used for training models. However, it is too expensive and slow to be able to create large dataset required for models to work at highest accuracy and this project aims to create artificial brain MR images that would enlarge the base dataset combining with real images.

A potential use case in where AI-generated images could be used are anomaly detection by comparing an input image with healthy images to detect if it presents any anomaly to be analyzed by a doctor.

During this project Variational Autoencoders will be used in order to create new images where different existing network architectures will be analyzed before working on the performance tuning with the one which brings better results at initial analysis.

The duration of the project implementation will start on October 24th and will end up by December 25th with one Data Scientist working on the project with a budget of 300 hours that will be distributed during that frame and that will require GPU computation for processing the different training and testing networks.

This project aims to be a Proof of Concept and the resulting images will be visually analyzed and compared to real images to check if the network is able to generate images that could be used as valid images.

Chapter 1

Introduction

1.1 Context and project justification

Artificial Intelligence has arrived to change the world in almost (if not all) any field. Today, we are surrounded by (and we are using many) AI products like smartphones' face recognition capabilities, home cleaning robots or cars with autopilot options.

From the different AI fields, computer vision is maybe the most popular one and the one which is usually used for explaining AI capabilities to general public. Identifying a cat in a picture could perfectly be the example used in every AI presentation to welcome people to AI.

Image processing is intuitively matched with medical diagnosis by anyone having or not any expertise on the field. Every single citizen will have heard of magnetic resonance imaging, and anyone easily transposes 'cat detection' to 'anomaly detection', being the anomaly a tumor or anything else.

There are different techniques to scan people and create images for clinical diagnosis like X-Ray or Magnetic Resonance Imaging. In this project, we will work with Magnetic Resonance Images (MRI) which are images created by a machine with a large bore that scans people lying inside it. The MR technique is non-invasive, it produces no radiation, and is used to scan almost any part of the body from which we will focus on brain images.

Combining AI diagnosis capabilities on image processing and MRI images, we can think of helping doctors to identify the presence of anomalies or looking for concrete diagnosis for a specific disease.

Obviously, these projects are not easy at all and they face a lot of challenges. One of the first challenges that such AI project faces is the difficulty to obtain a large set of brain images that are needed to train an accurate AI model. Scanning people is too costly and requires a lot of time. and the challenge of having a large dataset gets harder once we understand that brain images may differ depending on age or gender.

Today, there is a clear limitation on how to reproduce or obtain healthy

brain images for AI-based diagnosis projects while the appearance of new AI techniques known as Autoencoders and Variational Autoencoders introduces a new area of investigation to mitigate the gap.

This project aims to be a proof of concept to create AI-created images with new variational autoencoders that would serve to augment any existing MRI dataset and that will help to improve the accuracy of brain anomaly detection projects, including those which could be used for overall anomaly detection to others more specific which would help on concrete disease diagnosis.

Personal motivation comes from various angles:

- One is to prove myself that I can work with new AI architectures demonstrating that I have acquired the knowledge needed (deep enough) to be productive and to be able to innovate in the health sector.
- Deep Learning has been the subject which I enjoyed the most, hence continuing with Autoencoders seems natural to me as the next step on AI adoption
- At no doubts, if I can contribute to help on brain issue detection or diagnosis, I will feel my life been completely fulfilled

1.2 Aim of the project

The aim of this project is to serve as a Proof of Concept on how MRI brain images can be artificially generated with Variational Autoencoders which ultimately would serve to enhance existing or new datasets to improve model accuracy by having bigger samples of data

Foreseen projects objectives are:

- Obtain basic knowledge about MRI images and the NIFTI file format
- Obtain and visualise 2-D images from 3-D images in the dataset
- Select what range of slices (2-D images) from brain to be created
- Test different existing networks and choose the one to be used
- Tune network parameters
- Compare generated brain images against real ones, qualitatively

1.3 Project Plan

1.3.1 Resources

1. 1 Data Scientist: Miguel Tablado will be playing this role and will dedicate 300h

2. 1 Coach/Tutor: Baris Kanber will be assisting Miguel Tablado during the project
3. MRI images and demographic information from IXI Dataset
4. GPU resources are needed to train and test the network

1.3.2 High Level Plan

The plan will be executed in 3 different phases with the listed tasks:

1. Phase 1: Analysis
   (a) Gain knowledge on MRI and NIFTI protocol
   (b) Describe images and dataset
   (c) Extract 2D images
   (d) Pre-processing images
2. Phase 2: MR Images creation
   (a) Test different Network architectures
   (b) Tune-up architectural network
3. Phase 3: Project documentation
   (a) Write conclusions
   (b) Create project documentation
   (c) Create project presentation

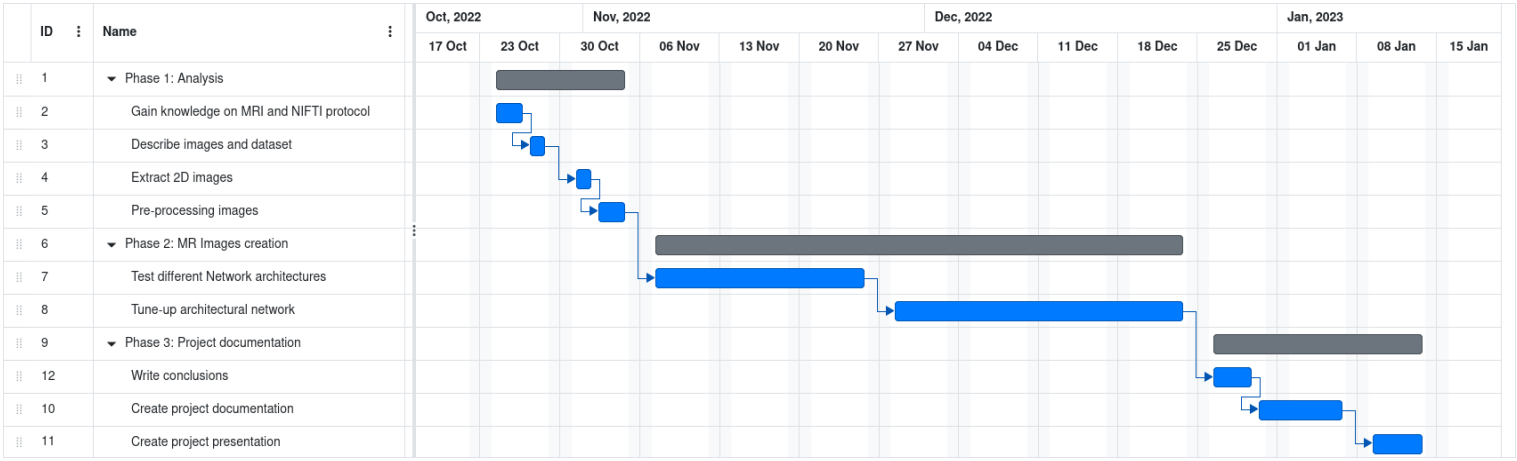

Figure 1.1: Project Plan. source: https://www.onlinegantt.com