Purbanchal University

College of Biomedical Engineering and Applied Sciences

Application of Machine Learning Algorithms for the detection of brain tumours in images acquired through Magnetic Resonance Imaging

Proposed By:
Lucky Chaudhary [A27]
Namrata Tamang [B3]
Nikin Baidar [B4]
Nilima Sangachchhe [B5]
Shashwot Khadka [B18]
Sneha Khadka [B22]
Suhana Chand [B23]

June 2021.

Abstract

The absence of biological markers makes it exceptionally difficult for neurologists to diagnose a person with a mental disorder. Currently, diagnosis of mental disorders is based on behavioral observations and patient-reported symptoms and the Diagnostic and Statistical Manual of Mental Disorders (DSM) classification.

Although there have been thousands of studies revolving around implementation of various imaging modalities for deciphering the etiology and the physical cause of several mental disorders, the findings from these studies do not appear amongst the diagnostic criteria. Meaning that the findings from these studies are not used for diagnosis purposes. A critical barrier to the clinical translation of many findings is the reverse inference fallacy.

Reverse inference is a kind of reasoning that is applied to infer the involvement of a specific cognitive process from observed brain activation during a task. It attempts to uncover specific cognitive processes or behaviours that may be associated with specific structural or functional brain alterations. However, reasoning backwards from brain activity is problematic because neurological disorders are multifaceted and are influenced by several factors such as concurrent diseases, disease history and artifacts.

For this reason alone, neuroimaging is not "widely accepted" in the process of psychiatric diagnosis. Despite, the reverse inference fallacy, neuroimaging for diagnosis of mental disorders seems promising in the future and as a matter of fact, a bold (choose correct word here) minority have already started to implement neuroimaging techniques such as fMRI, SPECT, PET for the diagnosis psychiatric disorders. Nevertheless, there are no solid molecular or imaging basis that are widely accepted for the assessment of mental disorders.

Here in the proposed research we will be *assessing* MR images of 35 subjects who, are suffering or have suffered, from one major depressive disorder and *making an attempt* at arriving to a comprehensive conclusion about how the "limbic brain network" of patients suffering from Major Depressive Disorder compare to that of healthy individuals who share similar socio-demographic parameters as the subjects.

1 Introduction

1.1 Major Depressive Disorder

Major Depressive Disorder, generally abbreviated as MDD, is one of the most common and a serious mental disorder. MDD is also referred to as clinical depression, or just depression as well.

MDD can be characterized by an array of distinct symptoms. Persistent felling of sadness, feelings of low self-worth and guilt, and an overall reduced ability to take pleasure from activities that previously were enjoyable are a few symptoms prevalent in MDD. Although, the exact symptoms of depression may vary from person to person, depending on their upbringing and various socio-demographic variables such as age, sex, religious affiliations, employment, income etc; for an individual to be classified as "suffering from Major Depressive Disorder", 5 out of 10 symptoms, one from a set of two and at least four additional symptoms from another set of 5, must have to have been present as a bare minimum during span of 2 weeks. WHO reference here

Fortunately, depression is also one the most treatable mental disorder. Before treatment for depression is begun, a health care professional conducts a diagnosis based on specific patterns of behaviour and in some cases, a physical examination may also be conducted to rule out some other medical condition that may cause depression like symptoms, such as thyroid problems, a brain tumor or vitamin deficiency. For example, a blood test might be done to ensure the symptoms are not due to thyroid related conditions. The treatment overall may include medications (antidepressants), psychotherapy and electroconvulsive therapy. Depending on the severity of the depression, treatment can take a few weeks or much longer.

1.2 Brain Networks

A brain network, on a large scale, can be defined as a collection of brain regions working together to produce a specific function.

Brain networks can be identified at various different resolutions, therefore there is no universal atlas of brain networks that fits all circumstances. However, on the basis of converging evidences from related studies, there are six large-scale, core brain networks that are most widely accepted due to their stability:

1. Default Mode Network
2. Salience Network
3. Dorsal Attention Network
4. Frontoparietal Network
5. Sensorimotor Network
6. Visual Cortex

There are more subsets of these six networks such as the limbic, auditory, right/left executive, cerebellar, spatial attention, language, lateral visual, temporal and visual perception/imagery.

An emerging paradigm in neuroscience is that cognitive tasks are performed not by individual brain regions working in isolation but rather by brain networks consisting of several discrete brain regions that are said to be "functionally connected".

The functional connectivity of brain networks can be acknowledged (or understood) through statistical analysis of images acquired through a variety of techniques such as the fMRI BOLD signals, or other signals acquired through techniques such as the EEG, PET or SPECT.

It is suspected that the default mode network is the epicenter of depression.

Such statistical approach to image analysis makes it possible to discover, spatial and temporal patterns that correspond to performance of specific tasks and specific diagnoses. Statistical methods have only been begun to be applied to clinical disorders but show promise for increasing the "specificity" of brain imaging markers for mental illness such as the MDD.

The functional connectivity of these brain networks can may be found using several different techniques. The ICA and the SCA are more common amongst the others.

1.3 Resting State Connectivity

Resting state connectivity

Resting-state connectivity (RSC) may be defined as significant correlated signal between functionally related brain regions in the absence of any stimulus or task. Resting-state functional connectivity measures **temporal correlation** of spontaneous BOLD signal among spatially distributed brain regions, with the assumption that regions with correlated activity form functional networks. There are two broad methods used to examine functional connectivity: seed-based approaches and independent components analysis (ICA). In seed-based approaches, activity is extracted from a defined brain region and correlated with the rest of the brain. In contrast, ICA does not begin with pre-defined brain regions. It is a multivariate, data-driven approach that deconstructs fMRI time-series data throughout the brain into separate spatially independent components. The components are usually then sorted into nuisance components (i.e. noise, motion related) and components of interest that correspond to well-known networks, such as the default mode network.

In addition to producing reliable and reproducible results, there are several features of resting- state fMRI that it makes it a particularly attractive method for investigating the neural correlates of psychiatric and neurological disorders. First, compared to the modular representations of traditional fMRI, functional connectivity provides a broader network representation of the functional architecture of the brain. Second, the absence of an explicit task eases the cognitive demand of the fMRI environment, thereby eliminating the problem of whether or not to match groups on task performance and allowing researchers to investigate under-studied populations, including infants and cognitively impaired individuals. Finally, the relatively standard manner in which resting-state fMRI data are acquired makes it ideal for multi-site investigations and data sharing.

1.4 Neuroimaging

Neuroimaging

Neuroimaging or brain imaging is the use of various techniques to either directly or indirectly image the structure, function, or pharmacology of the nervous system. Current neuroimaging techniques reveal both form and function. They reveal the brain's anatomy, including the integrity of brain structures and their interconnections. Neuroimaging falls into two broad categories:

Structural imaging, which deals with the structure of the nervous system and the diagnosis of gross (large scale) intracranial disease (such as a tumor) and injury.

Functional imaging, which is used to diagnose metabolic diseases and lesions on a finer scale (such as Alzheimer's disease) and also for neurological and cognitive psychology research and building brain-computer interfaces.

Magnetic resonance imaging (MRI) and functional magnetic resonance imaging (fMRI) scans are the form of neural imaging most directly useful to the field of psychology.

2 Objectives

The objectives of the proposed project are as follows:

2.1 General Objectives

- Deploy computational tools , and develop image processing strategies for the exploration of MR image datasets of brain using AFNI.
- Explore data visualization tools, with emphasis on displaying functional brain networks.
- To perform Seed-based Analysis (SCA) to explore functional connectivity within the brain based on the time series of a seed voxel or Region of Interest (ROI).

2.2 Specific Objectives

- Perform analysis of the functional and structural connectivity of the hippocampal network of patients suffering from Major Depressive Disorder and acquire a comprehensive idea about how it compares to that of normal individuals from the same socio-demographic background.

3 Problem Statement

3.1 Need For An Imaging Basis

The diagnosis procedures that are the gold standard for diagnosis of psychiatric disorders are wholly based on behavioral observations and patient reported symptoms. There are two most widely established symptoms that are used to classify these manifestations, one is the Diagnostic and Statistical Manual of Mental Disorders (DSM) and the other is International Classification for Diseases (ICD).

Despite each being as widely used as the other, both of these diagnosis manuals are more like frameworks provide a way of classifying a psychiatric disorder depending on patterns of behaviour rather than interpreting the etiology and the physical cause of those disorders.

This statement alone raises an argument that "although reliable, current diagnostic procedures in psychiatry are not entirely valid".

Let us take an example of the diagnostic procedure involved in the diagnosis of Major Depressive Disorder. The DSM-V, published in 2013, is the most up-to-date manual and is based upon the work of expert study groups and makes use of large sets of data. According to the DSM-V, for a person to be classified as "suffering from Major Depressive Disorder", *he/she must report with either depressed mood or anhedonia (inability to feel pleasure in normally pleasurable activities) along with four out of eight additional symptoms.*

This makes it totally possible for 2 distinct individuals who do not share a single symptom in common and yet receive treatment (or medication) for MDD.

Furthermore, the current diagnostic procedures such as the DSM-V are not entirely bulletproof. For example, impulsivity, emotional lability (the property of changing rapidly), and difficulty with concentration each occurs in more than one disorder.

Now, the fact that,

1. Different exemplars of the same category can share no symptoms and that
2. The exemplars of two different categories may share common symptoms

raises questions about the validity of the current diagnostic procedures in psychiatry. Therefore, an imaging basis is necessary for the diagnosis of mental disorders.

WHY IMAGING WON'T WORK?

There exists thousands of published research studies using functional neuroimaging methods such as SPECT, PET, and fMRI.

Findings from brain imaging do not appear amongst the diagnostic criteria. aside from its use to rule out potential physical causes of a patient's condition, for example a brain tumor, neuroimaging is not used in the process of psychiatric diagnosis.

Why has diagnostic neuroimaging not yet found a place in psychiatric practice? Sensitivity, specificity and standardization in psychiatric brain imaging.

- Diagnosis must be made for individuals and not groups - meta-analyses of neuroimaging studies has yet to reveal patterns of neural activity that are unique to specific mental disorder

Sensitivity

Imaging studies are generally not highly sensitive to the difference between illness and health

Specificity:

Most psychiatric imaging studies involve subjects from only two categories- patients from a single diagnostic category and people without any psychiatric diagnosis (healthy individuals), the most that can be learned from such a study is how brain activation in those with a particular disorder differs from brain activation in those without a disorder.

This raises a dilemma for the diagnosing clinician, as the question is not "does this person have disorder X or is she healthy? " but "does this patient have disorder X,Y,Z or is she healthy?" because the pattern of images that distinguishes patients with disorder X from healthy people may not be unique to X but shared with a whole alphabet of other disorders.

For example, Amygdala ko example

- (more sophisticated) methods of image analysis may hold promise discerning the underlying differences among the many disorders that feature similar regional abnormalities !??

- “statistical approach” to image analysis makes it possible to discover, spatial and temporal patterns that correspond to performance of specific tasks and specific diagnoses. Such statistical methods have only been begun to be applied to clinical disorders but show promise for increasing the “specificity” of brain imaging markers for mental illness.

near-term and long-term prospects of neuroimaging? and what obstacles block the use of such methods? Answer to the 2nd: The nature of imaging studies and of psychiatric diagnosis.

Standardization

Standardization is relevant in the sense that protocols for imaging studies differ from study to study, particularly amongst functional imaging studies.

The results of psychiatric imaging research are often summarized by stating that certain regions are under or over active or more or less functionally connected.

Findings on the patterns of activation acquired in studies of psychiatric patients depends strongly on the task being performed by the subjects and the statistical comparisons made by the researcher afterwards. Such findings are pretty much incomplete unless they include the information about what task evoked the activation in question: whether the patient wa resting, processing an emotional stimuli, resisting emotional stimuli or engaged in some other task?

Therefore the fact that imaging study’s conclusions are relative to the tasks performed adds further complexity to the problem of consistently discriminating patterns of activation of healthy and ill subjects.

4 Review of Literature

Implementation of fMR-imaging techniques to research the core aspects of structural and functional brain alterations in patients suffering from MDD.

Past work seems like structural MRI and fMRI look promising for providing excellent and reliable indexes for the aid in the diagnosis and ultimately treatment of MDD

tara ahile samma figure out bhako kura haru lai chai actual practice ma lyauna sakeko chaina

5 Feasibility Study

6 Methodology

7 Cost Estimations

8 Time Frame & Proposed Work Flow

9 Conclusion