

# Utilization of Neuroimaging for Diagnosing Disease and Assessing Brain Health in the Modern Era

Sugasri Sureshkumar<sup>1\*</sup>, K. Yogarajan<sup>2</sup>

<sup>1</sup> Head of the Department of Neurology, Faculty of Physiotherapy,

Meenakshi Academy of Higher Education and Research, Chennai, Tamil Nadu, India

<sup>2</sup> Associate Professor, National institute for Empowerment of Persons with Multiple Disabilities (Divyangjan), Kovalam, India

---

## Abstract

*This article has described the neuroimaging process that helps to provide a clear picture of the brain that can help medical practitioners to detect disease and also helps to detect the health of the brain. This study focusses on the neuroimaging process and its connections with the disease. This study has shed light on the practical applications of neuroimaging techniques such as CT scans that can create an image of the brain, MRI is one of the processes that also helps to provide and detect the blood clot and effects of stroke on the brain. On the other hand, there are various kinds of techniques that help to identify the blood flow and oxygen flow in the brain. This study has also shed light on the significance of neuroimaging and its benefits. It has been seen that these techniques are one kind of decision-making tool that helps to provide the proper treatment. As per patients' requirements, medical professionals can also provide suggestions for treatment. accordingly, Neuroimaging process gives the opportunities to enhance their knowledge and create a pre-surgical brain map. In the modern era, hospitals use advanced technologies to detect disease. It provides real-time data that helps to provide accurate suggestions to the sufferer. Accordingly, neuroimaging process also has some technical difficulties that may provide accurate data all the time. This research uses a simple method to do the research and get an effective outcome from it.*

## Keywords

*3D detailed image, brain, central nervous system, Computed Tomography Scans, magnetic nuclei, Magnetic Resonance Imaging, Neuroimaging technique, PET-based technique, positron emission tomography.*

---

## INTRODUCTION

Neuroimaging is one of the conceptual techniques that are based on the function and structures of the central nervous system. These techniques assist in studying the health of the human brain in an effective and non-invasive manner. Neuroimaging processes are also used to detect psychiatric illnesses and brain diseases. In the modern era, neuroimaging is one of the multidisciplinary research projects. This study will focus on the concept of neuroimaging and its connections with the detection process of disease and assessing brain health. The brain is a crucial and essential part of the body and it helps to maintain physical balance and also helps to learn new skills and activities. It can be said that the brain is one kind of networking system that is able to communicate with the body through nerves. On the other hand, all nerves are connected with the spinal cord and brain and neurons play a major role in the body's function. Any kind of issue in the brain can make a big impact on the individual and it is essential to detect the issues and recover the issues as soon as possible. Nowadays, neuroimaging is one of the innovative advances that can detect brain activity and also assist to find issues. It can be said that neuroimaging is one of the branches of medical imaging that is highly focused on the human brain. This process also detects the ways the brain works and the different impacts of activities in the brain. Accordingly, neuroimaging techniques are able to reveal the anatomy of the brain including the integrity of the

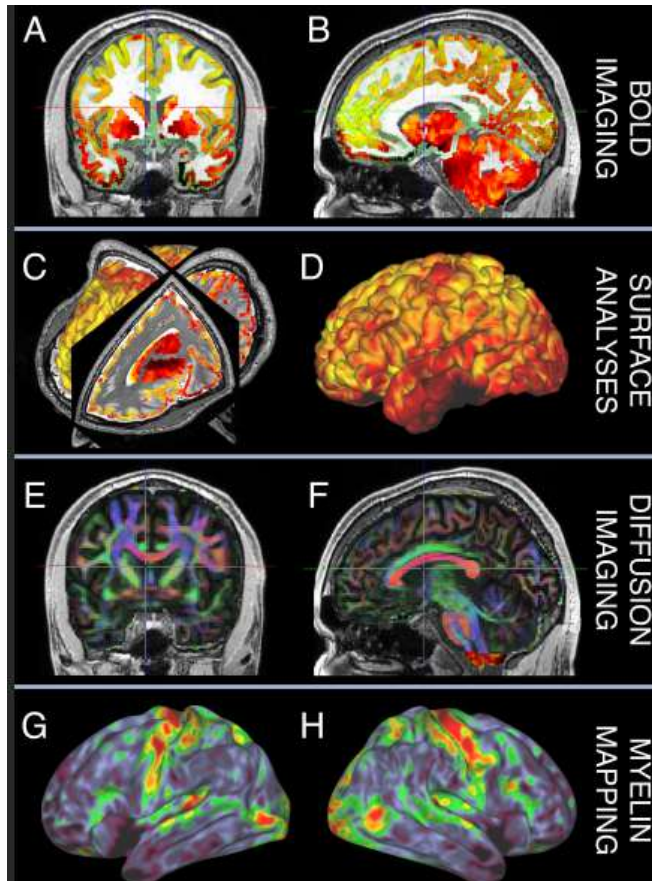
brain structures and connections. This study will further discuss the significance of neuroimaging and its benefits. Neuroimaging techniques have various application processes and all processes have their own significance. This paper also will shed light on the limitation of technological advancement that prevents the detection of the disease and the analysis of the outcomes properly. Computed Tomography Scans (CT), Positron Emission Tomography scans (PET), and Magnetic Resonance Imaging (MRI) are different kinds of practical applications of Neuroimaging technologies that create a renaissance in the modern medical world.

## LITERATURE REVIEW

### Concept of neuroimaging and utilization of neuroimaging to detection of disease and brain health

Neuroimaging uses different kinds of edge-cutting technologies that can bale to produce brain images and CNS also. Neuroimaging techniques are also known as MRS or magnetic resonance spectroscopy and it allows to obtain of biomedical information. Neuroimaging is a technique that assists to detect the pharmacology and function of the central nervous system. This technique is generally focused brain and captures the position and condition of the brain in non-invasive structures. Neuroimaging technologies provide a clear visual presentation. It can also give the essential qualitative analysis of blood flow, anatomy, electrical

activity, blood volume oxygen consumption, metabolism, and other kinds of physiological functions function that is connected with the CNS [1]. neuroimaging technologies also have two categories such as functional and structural neuroimaging. Functional neuroimaging is generally used to measure the function of the brain. structural neuroimaging is used for quantifying and visualizing the structure of the brain.



**Figure 1.** Neuroimaging of the brain  
(Source: 1)

The brain imaging method allows practitioners to see the view of the living brain. It helps to understand the function of the brain and also measures the connection between the brain and nerves. All the function has certain position and boundaries that are generally considered normal parameters. Neuroimaging process helps to detect the difficulties and it also explains the root causes of symptoms [2]. The neurological disorder can easily affect a particular portion of the brain and it is easily recognized by the imaging process. This process can be performed easily and it does not require any invasive steps. On the other hand, brain imaging techniques allow medical professionals to map out the actual function and region of the brain and CNS in an effective non-invasive way.

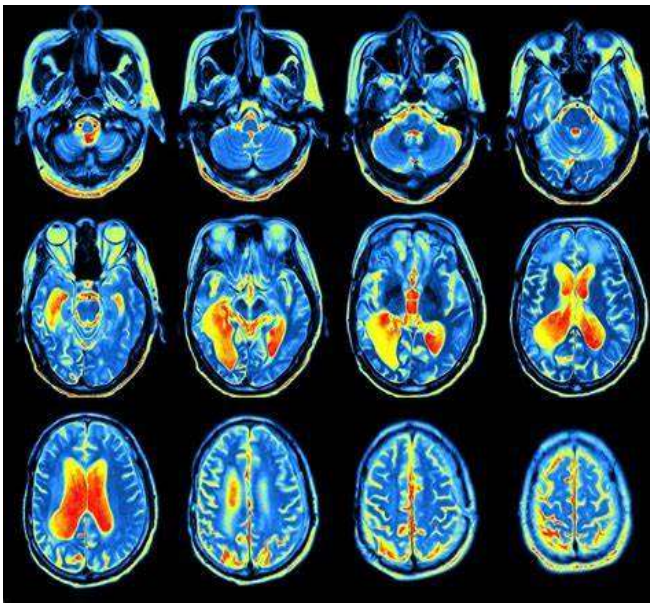
This process usually uses for finding bleeding and swelling and also identifying the impacts of stroke. Neuroimaging process also locates tumours and cysts and it helps to get the proper treatment to the individuals. Neuroimaging process can also identify some mental health issues and also able to

detect the anxiety level as well. fMRI or Functional magnetic resonance imaging can detect the flow of blood and the level of oxygen. It uses the magnetic field to give affect the *“magnetic nuclei”* of the hydrogen atoms [3]. This process is able to access the activities of the brain, also able to find the abnormalities brain, and allows to create the presurgical map of the brain.

Accordingly, neuroimaging enables understanding of the process of the function of the brain and also detects the connectivity process with the central nervous system. A brain scan is a process that helps to provide the details of the brain and it is also able to detect the abnormalities between nerves. This process is also attached to the clinical presentation that makes an impact on the medical condition of the individuals. It can be said that neuroimaging techniques provide a clear view that makes an impact on psychological treatment, medication as well as neuroscience research. On the other hand, it also allows medical professionals to begin the treatment earlier.

#### Significance of neuroimaging and its benefits

The anatomy of the brain is understood with neuroimaging, and the integrity of brain structure and interconnections can be developed with this process. Studies of the brain are helping to detect and properly diagnose the issues of tumours, stroke, or vascular dementia. The understanding of different developments is seen by neuroscientists inside of a living brain. Neurological disorders are helping to develop a relationship between the functions and specific areas of the brain. The neuroimaging technique is developed as a decision-making tool for neuro-oncology, stroke, and neurotrauma [4]. Enhancement of clinical assessment can be done with neuroimaging by understanding the issues of neuromuscular and movement disorders in a person. The technicians are using this technology to find out the details of disturbing functions of the brain that are crucial for ensuring growth in neurology. Neuroimaging can be divided into three types: structural imaging, functional neuroimaging, and molecular imaging. In the process of structural imaging visualization of the brain’s anatomy and pathology are helping to measure the volume and characteristics of the tissue. Functional neuroimaging is helping to measure brain activities, blood flow, and glucose metabolism. Molecular imaging is beneficial for gaining information from biological processes, and protein aggregations.



**Figure 2.** PET Image of brain  
(Source: 4)

Positron emission tomography (PET) is helping to find out the characterization of the effect on the brain. The disease-modifying treatment is identified with neuroimaging techniques. The imaging modality in neurology is identified through proper interpreting scans of a person. The proper understanding of the effects of brain injury, diseases developed in the brain systems, and rehabilitation changes in the brain system are ensured with the help of neuroimaging. Gaining the details about structural or disease-related changes can be found with the help of neuroimaging technology [5]. The electronically stored images with neuroimaging are beneficial for easy accessing impressions. Less time-consuming for processing the images gained from neuroimaging techniques.



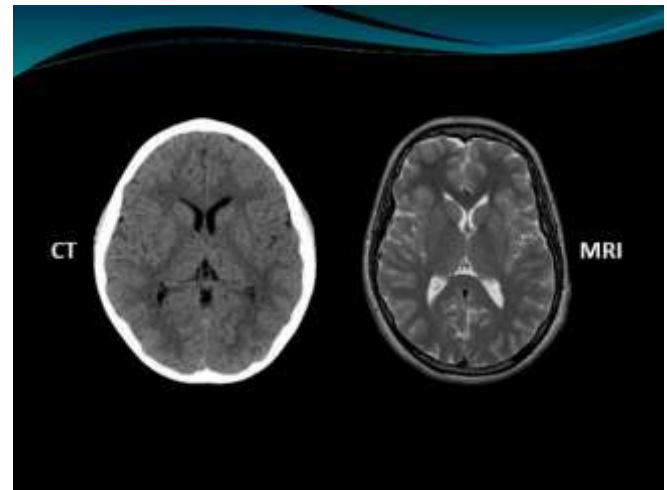
**Figure 3.** MRI image of Brain  
(Source: 5)

MRIs are helping to take imaging of any part of the body. The abnormalities in the brain are identified with neuroimaging techniques that are helping to understand in-depth study about the brain. The fMRI is used for scanning the brain without using radiation such as X-rays or computerized tomography (CT) and positron emission

tomography (PET) scans. To evaluate the brain functions noninvasively, effectively, and safely are ensured with this scanning. Imaging the structure and functions of nervous systems is developed with neuroimaging techniques [6]. Neuroimaging techniques are correlated with different cognitive tasks or projects.

### Practical application of neuroimaging

Brain imaging is beneficial for understanding the issues of effects of stroke, locating the issues of cysts and tumours in the patients, and understanding swelling and bleeding helping to gain details from analysing the brain. Neuroimaging is helping to ensure an in-depth study of the brain that is helping patients to get the proper help from surviving diseases. Performing fat suppression, developing magnetic resonance venography, and diffusion of weighted imaging techniques are used for developing neuroimaging [7].

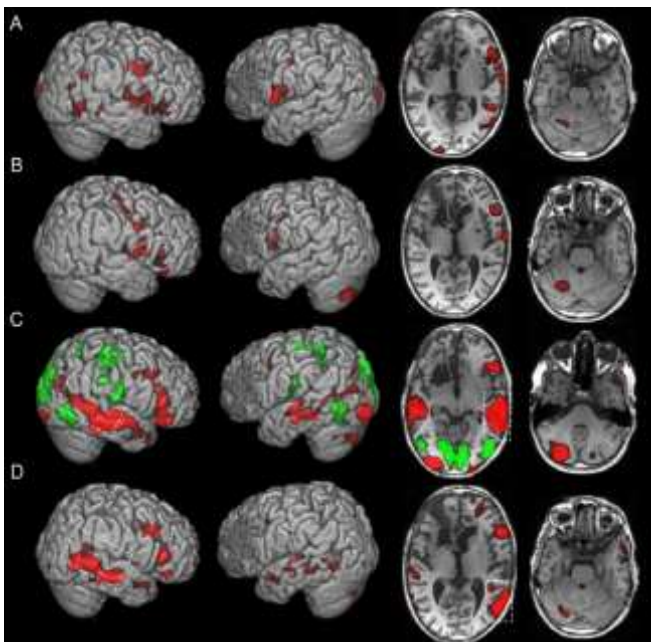


**Figure 4.** The Difference between CT and MRI  
(Source: 7)

MRI and CT scanners are used in various hospitals which are located in rural areas of India. The identification of brain disturbance is easily developed with neuroimaging. This is beneficial for understanding the mental health conditions of a person or brain disorders. Doctors are able to diagnose easily and identify tumours and other abnormalities in the brain. These are done with the help of imaging technologies of the brain. Magnetic resonance imaging (MRI) is a kind of imaging technique that is beneficial for gaining a 3D detailed image of the brain and also of our body. This is done with the help of non-invasive imaging technology which is painless. PET-based techniques are used for gaining better live visualization that are helping to monitor brain activities in real-time. This process is done at the molecular level which is helping to develop progress in different scientific and medical applications.

Different processes of the brain are understood with neuroimaging techniques that are helping to gain a proper understanding of brain development. The working memories of a normal person are understood with the help of

neuroimaging. It is also beneficial for gaining knowledge about language, happy and sad emotional stages of the mind, spatial attention, arousal, and much more. Sleeping disorders are easily treated with neuroimaging techniques such as electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) [ 8]. These are helping to understand and identify the sleeping disorders mechanisms for a person. Intracranial infections are easily identified with the help of neuroimaging techniques that are helping to develop differential diagnoses between toxoplasmosis and lymphoma.



**Figure 5.** The fMRI image of the brain  
(Source: 9)

Any haemorrhage is easily understood with the help of neuroimaging techniques for understanding the cavernous sinus thrombosis of a person. Acute ischemic changes are identified with neuroimaging techniques for evaluating the intracranial vessels of a person. This is helping to identify the issues of stroke for a person. Observation of any haemorrhagic transformation also can be found with neuroimaging are beneficial for lifesaving development. Postcontrast isotropic 3D T1W imaging gained from the neuroimaging techniques is able to identify the growth of tumours that are closely related to vascular structures [9]. Different neuro infections are identified with the help of neuroimaging technologies that are beneficial for neuraxins-producing characteristic imaging features. Bacterial meningitis is easily diagnosed with neuroimaging techniques that are created with the inflammatory breakdown of the blood-brain barrier. Inborn errors of metabolism are understood with the help of neuroimaging techniques. Grey matter degenerative disorders, Demyelinating disorders can find out in neuroimaging techniques that are effective to understand the issues of the brain.

### Difficulties of neuroimaging techniques

The increase in financial and physical stress can be developed with neuroimaging techniques. The repetition of the high-quality test is increasing the mental stress on a person due to not finding any details from neuroimaging techniques. All neuro-ophthalmic disorders of intracranial and intra- orbital ethology are not able to detect with the help of neuroimaging techniques. This is the biggest limitation of neuroimaging techniques. Difficulties to identify the changes in electrical activities and deep brain structures are not able to gain with the help of neuroimaging technologies [10]. Neuroimaging techniques are expensive for using by a normal person. Patients using any metallic devices such as pacemakers are not able to use neuroimaging. The claustrophobic patients are also feeling difficulty using the neuroimaging techniques due to going inside the machine for a long period of time. The challenges developed in fatal neuroimaging are the small size of the brain, the huge quantity of water, motion of the patient [11]. The ear of patients can be affected by loud noises that are created in the MRI machines if proper protection is not used. The heating of the body can be found in MRI scanning which is creating a major issue for people. The lack of spatial precision is the main weakness that is not possible to find the deep locations in the brain and asymmetrically distributed neurons are also not helpful for gaining from the potential methods of the brain.

### METHODOLOGY

Research methodology can be considered as a process or procedure that is followed for research work. As per the requirements of this study, the research approach, design, and philosophy data collection analysis method are discussed. Researchers used all of the things as per their requirement which is also based on the topic assumption. This research has chosen the secondary qualitative method that helps to understand the research-related subject matter and also helps to understand the entire topic also. On the other hand, this process also can provide effective outcomes from the work by delivering different kinds of knowledge and experiences [12]. This research technique also gives a large sample size and helps to recognize the suitable outcomes and information for the project work.

This study has selected a positivist research philosophy and inductive research approach to finding the actual and relevant conclusion from the discussion. Maximum researchers use this approach to create a significant conclusion for the research work. In this context data, collection method helps to get different types of information and provides the raw data for further research work. The data collection process under the deductive approach helps to test the research hypotheses [13]. This study has not used the hypotheses and that is why this study has considered the inductive way to explore the research background. As mentioned previously this study has used the secondary

qualitative method and the qualitative method has four kinds of research design process such as grounded history, case study, ethnography, and phenomenology [14]. The case study design process is one of the suitable processes for this research study. This process helps to provide a large amount of data that is able to increase the value of the research work. The secondary qualitative method gives the opportunity to analyse various kinds of data and gather knowledge from it.

On the other hand, researchers consider this method due to it provides the world bases data, and researcher can explore their experiences with these data. Online articles, websites, journals, and magazines are the basic source of secondary qualitative methods and these sources are always available on google scholar, google, and other search engines [15]. Accordingly, those have easy accessibility that assists to extract the data easily. on the other hand, this method does not need high technical knowledge to extract the data from the source. Minimum knowledge can acquire a large amount of data for research. Moreover, the secondary qualitative process is effortless and time-saving which helps to concentrate the researcher on their work. Furthermore, less time consumption decreases the research budgets and that is why this process is much more budget-friendly and anyone can do their research work through this process. It helps to provide economic support to research work and assist with the research work. This process provides opportunities to get relevant and accurate data for the research.

The secondary qualitative process also helps to gather the data from authentic sources such as PUBMED, AMED, MEDLINE, and other internet sources with maintaining a proper ethical manner. In this method of research, human participation is not necessary and it is also responsible for increasing the budget as well [16]. Those factors are more justified to apply this process in this research work. Accordingly, one of the biggest advantages of this study is, the collected data are previously gathered by someone that helps to identify the contrast between the information. On the other hand, this process of research also provides a structural set of data by maintaining its patterns and values. It can be said that this methodology helps to gain essential knowledge on the neuroimaging process and its impact on the disease and assessing the health of the brain.

## DISCUSSION

From the above mention study, it can be observed that neuroimaging is one of the multidisciplinary approaches, and in current days neuroimaging is one of the research materials. Generally, it focused on the brain and central nervous system. This process also can detect mental diseases and other difficulties in the brain. From this study, it has been seen that there are several techniques that make a positive impact on the patient's health and they can be used as a decision-making tool [17]. The brain is one of the essential parts of the body and it controls the entire function of the body. These organs are also connected with the central nervous system which is based on the neurons. Neuroimaging techniques have some

different kinds of application processes that can able to detects abnormalities in the brain. On the other hand, it can provide opportunities to see the living brain and extract real-time data by using advanced technologies [18]. neuroimaging techniques are able to reveal the anatomy of the brain including the integrity of the brain structures and connections. In this context, neurological disorders can affect a particular portion of the brain, and neuroimaging techniques can easily recognize all the factors. Medical professionals prefer this technology due to its easy-performing process. This technology has a connection with clinical assessment and medical professionals can also provide appropriate and useful suggestions to individuals. It helps to introduce people to modernization and make a positive impact on their well-being and quality of life.

The studies of neuroimaging are helpful to detect understanding about proper imaging development that is essential for gaining overall growth. The study is also beneficial for understanding the exact issue developed in the brain and other parts of the body with the help of imaging techniques. Neuroimaging is helping to understand the overall status of the brain which is also benefitting the patients in getting the right treatment within a short period of time. Diagnosis of the disease and understanding the health of the brain are easily understood with the help of neuroimaging techniques. Different activities impacting brain functions are easily identified with the help of neuroimaging techniques [19]. Computed Tomography Scan (CT), Magnetic Resonance Imaging (MRI), Positron Emission Tomography Scan (PET), Functional Magnetic Resonance Imaging (fMRI) T1-Weighted MRI, T2-Weighted MRI, Diffusion-Weighted MRI (DWI), and Diffusion Tensor Imaging (DTI) are different examples of neuroimaging techniques that are useful for detecting different abnormalities in brain functions. The production of images from the brain and other parts of the nervous system can be developed with the help of neuroimaging techniques. CT scans are the most common neuroimaging method that is used for understanding the brain functions of a person. The damage in the brain is easily identified with the help of CT scanning techniques that are used commonly by doctors to identify the issues of skull fracture and bleeding in the brain. Scanning of the brain cannot able to detect illnesses like autism, anxiety, depression, and schizophrenia in a person. Magnetic resonance imaging (MRI) is helping to identify any brain tumours in a person. Brain scanning is also beneficial for identifying the issues of the blood vessel, injuries, abnormal brain development, malformations, stroke, and haemorrhage development in the brain [20]. Double vision, vision loss, abnormal reflexes, confusion, and swelling in the optic nerve are the main reason a person is advised for brain scanning. A detailed image of the brain, spinal cord, and nerve tissue found from the MRI scanning is beneficial for understanding any issues or monitoring any injuries. Ultrasound is identified as the best imaging technique that is beneficial for gaining the image through the skin. This is the

least risky imaging technique that can be used for new-born babies. The functions of a living brain can be easily identified with the help of neuroimaging techniques effects developed with neurological disorders can be found in the brain with the help of these scanning techniques. Demonstrations of brain activities are developed with neuroimaging techniques that are able to find out the repairment of the functions of the brain of a person. Neuropsychology and neuroimaging are helping to find out the relationship between brain functions and structures that are useful for achieving converging results in the brain. Beck Depression Inventory (BDI), Dissociative Experiences Scale, Schizophrenia Test and Early Psychosis Indicator (STEP), Goldberg Bipolar Spectrum Screening Questionnaire, and Hamilton Anxiety Scale (HAM-A) are the common physiological tests that are beneficial to find out the mental illness in a person. Modern neuroscience is helping to understand the issues of the nervous system and its growth. The impact on cognitive functions is understood by neuroscientists as the behaviour of a person. Modern imaging methods such as functional MRI (Magnetic Resonance Imaging) scan is helping to use strong magnetic fields and radio waves to study the function of the brain.

### CONCLUSION

From this above study, it has been seen that neuroimaging process is one of the multidisciplinary approaches and a branch of the medical imaging process that assist to detect the issues of the brain and also identifies the health of the brain. Neuroimaging techniques have the ability to reveal the anatomy and structure of the brain and also has the capability to detect the connections of the brain. There are various kinds of practical application processes that make an outstanding impact on the world medical platform. This study also highlights the neuroimaging process and its significance in medical science and disease detection. With help of neuroimaging techniques, it is beneficial for understanding the proper growth of brains and is important for people to identify easily the issues in the brain. Real-time data find out from the neuroimaging techniques that are helping in gaining overall growth to identify the issues in the brain. Secondary qualitative methods are used to identify the issues of the brain that are important to gain and overall growth in the research in a quick and cost-effective manner. Pharmacological functions are detected by neuroimaging technologies helpful for understanding any major disturbance in brain functions. Neuroimaging techniques are helpful to ensure any minor difficulties in nerve and other brain disorders that are creating damage for a person. MRI scanning, CT scanning, Positron Emission Tomography scans (PET), and fMRI are useful ways of understanding the issues of disturbance in a person. The use of neuroimaging is helping to elevate the results for a person facing the disturbance of brain injuries.

### REFERENCES

- [1] Ahmed, M.R., Zhang, Y., Feng, Z., Lo, B., Inan, O.T. and Liao, H., 2018. Neuroimaging and machine learning for dementia diagnosis: recent advancements and future prospects. *IEEE reviews in biomedical engineering*, 12, pp.19-33.
- [2] Cole, J.H., 2020. Multimodality neuroimaging brain-age in UK biobank: relationship to biomedical, lifestyle, and cognitive factors. *Neurobiology of aging*, 92, pp.34-42.
- [3] Sui, J., Jiang, R., Bustillo, J. and Calhoun, V., 2020. Neuroimaging-based individualized prediction of cognition and behavior for mental disorders and health: methods and promises. *Biological psychiatry*, 88(11), pp.818-828.
- [4] Panesar, S.S., Kliot, M., Parrish, R., Fernandez-Miranda, J., Cagle, Y. and Britz, G.W., 2020. Promises and perils of artificial intelligence in neurosurgery. *Neurosurgery*, 87(1), pp.33-44.
- [5] Huang, J., Wang, M., Xu, X., Jie, B. and Zhang, D., 2020. A novel node-level structure embedding and alignment representation of structural networks for brain disease analysis. *Medical Image Analysis*, 65, p.101755.
- [6] Martucci, K.T. and Mackey, S.C., 2018. Neuroimaging of pain: human evidence and clinical relevance of central nervous system processes and modulation. *Anesthesiology*, 128(6), pp.1241-1254.
- [7] Handa, A., Xu, L., Machado-Rivas, F., Cortes-Albornoz, M.C., Ruggiero, M., Bedoya, M.A., Yang, E., Gee, M.S. and Jaimes, C., 2022. Magnetic resonance imaging in neonates: a practical approach to optimize image quality and increase diagnostic yield. *Pediatric Radiology*, pp.1-14.
- [8] Khosla, A., Khandnor, P. and Chand, T., 2020. A comparative analysis of signal processing and classification methods for different applications based on EEG signals. *Biocybernetics and Biomedical Engineering*, 40(2), pp.649-690.
- [9] Vamvakas, A., Williams, S.C., Theodorou, K., Kapsalaki, E., Fountas, K., Kappas, C., Vassiou, K. and Tsougos, I., 2019. Imaging biomarker analysis of advanced multiparametric MRI for glioma grading. *Physica Medica*, 60, pp.188-198.
- [10] Krauss, J.K., Lipsman, N., Aziz, T., Boutet, A., Brown, P., Chang, J.W., Davidson, B., Grill, W.M., Hariz, M.I., Horn, A. and Schulder, M., 2021. Technology of deep brain stimulation: current status and future directions. *Nature Reviews Neurology*, 17(2), pp.75-87.
- [11] Schulz, M., Malherbe, C., Cheng, B., Thomalla, G. and Schlemm, E., 2021. Functional connectivity changes in cerebral small vessel disease-a systematic review of the resting-state MRI literature. *BMC medicine*, 19(1), pp.1-29.
- [12] Ruggiano, N. and Perry, T.E., 2019. Conducting secondary analysis of qualitative data: Should we, can we, and how?. *Qualitative Social Work*, 18(1), pp.81-97.
- [13] Sherif, V., 2018, May. Evaluating preexisting qualitative research data for secondary analysis. In *Forum: qualitative social research* (Vol. 19, No. 2, pp. 26-42). Freie Universität Berlin.
- [14] Ballantyne, A., Moore, A., Bartholomew, K. and Aagaard, N., 2020. Points of contention: Qualitative research identifying where researchers and research ethics committees disagree about consent waivers for secondary research with tissue and data. *PloS one*, 15(8), p.e0235618.
- [15] Chauvette, A., Schick-Makaroff, K. and Molzahn, A.E., 2019. Open data in qualitative research. *International Journal of Qualitative Methods*, 18, p.1609406918823863.

- 
- [16] Powell, J. and van Velthoven, M.H., 2020. Digital data and online qualitative research. *Qualitative research in health care*, pp.97-109.
- [17] Tulay, E.E., Metin, B., Tarhan, N. and Arıkan, M.K., 2019. Multimodal neuroimaging: basic concepts and classification of neuropsychiatric diseases. *Clinical EEG and neuroscience*, 50(1), pp.20-33.
- [18] Vasung, L., Turk, E.A., Ferradal, S.L., Sutin, J., Stout, J.N., Ahtam, B., Lin, P.Y. and Grant, P.E., 2019. Exploring early human brain development with structural and physiological neuroimaging. *Neuroimage*, 187, pp.226-254.
- [19] Zhao, J.L., Jiang, W.T., Wang, X., Cai, Z.D., Liu, Z.H. and Liu, G.R., 2020. Exercise, brain plasticity, and depression. *CNS Neuroscience & Therapeutics*, 26(9), pp.885-895.
- [20] Sheth, K.N., Anderson, C.D., Biffi, A., Dlamini, N., Falcone, G.J., Fox, C.K., Fullerton, H.J., Greenberg, S.M., Hemphill, J.C., Kim, A. and Kim, H., 2022. Maximizing Brain Health After Hemorrhagic Stroke: Bugher Foundation Centers of Excellence. *Stroke*, 29(2), pp.1020-1029.