Example of history of neuroimaging technology essay

Technology, Development

Introduction

There are many techniques that are being used today to examine the functionality of the human brain. Most of the current technologies emerged in early 1990s. Some of the technologies that are used for brain imaging include; computed tomography (CT), positron emission tomography (PET), Magnetic resonance imaging (MRI), event-related potentials (ERPs) and magnetoncephalography (MEG). This paper will look at the history of these techniques used for brain imaging(Katz & Alexander 1994).

1895 – 1900 Early uses of brain imaging

The process of imaging human dieses started in 1895 following the discovery of Wilhelm Roentagen. He was a physicist that illustrated the first radiograph which gave way for new methods of medical diagnosis. There were many early scientists who contributed to the development of neuroimaging. Ventriculography and pneumoencephalagraphy were the first medical diagnosis performed in 1918 and 1919 respectively by Walter Dandy a neurosurgeon. The first cerebral arteriogram was done in 1927 by Moniz a neurologist. There was further development in the mid-1970s when magnetic resonance imaging MRI was developed(Ewing-Cobbs et al. 1998).

1927 – 1960 Computerized tomography

The first image of computed tomography was produced in 1960s by Sir Godfrey Hounsfield. Computed tomography was the first brain imaging technique that showed neuroanatomical structure in a three dimensional manner. Neurosurgeons used ventriculogrpahy and pneumoencephalography technique in visualizing the brain functionally which was in two dimension or plain- film technologies. The two techniques

were performed by draining cerebrospinal fluid in and around the brain replacing with either air or oxygen. This was done in order to get a clear picture of the brain. This method was not only painful to the patient but it also posed many risks. CT gave neuropsychiatry an opportunity to have clear, accurate and reliable brain structure using a noninvasive technique. The discovery of this technique is believed to have been a revolutionary of neuroscience field(Shorvon 2009).

1963-1975 Radioactive neuroimaging

X-ray computed tomography CT was introduced in 1973 by Godfrey Hounsfield which was based on Alan Cormack's technique. This was an eye opener into the way scientists looked at the brain. There was another technology that was initiated by researchers right after CT which enabled them to map the functionality of human brain. This technology enabled researchers to come up with another tomography called positron emission tomography PET which created autoradiogram of brain function. The blood flow and glucose metabolism in the brain was measured using autoradiographic technique(Listernick et al. 1994).

The X-ray images taken several times at different angles were used to produce a brain image of unprecedented clarity. Since the first X-ray image of the brain in 1972, many brain imaging techniques are still based on x-ray technique. CT produces high quality images in a safe manner without exposing the patient to pain and risks. Getting a 3D structure of the brain demanded additional of mathematical component into the CT program. This was done by the geometrical formulas that enable 3D image structure

visualization.

1968 – 1973 Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) as mentioned earlier is also a neuroimaging technique. It was discovery during the same period CT was discovered. This technique is based on nuclear magnetic resonance (NMR) root. Felix Block (1946) described the concept of hydrogen atoms or protons moving in a magnetic field which is the fundamental principal of MRI. This concept was demonstrated by Paul Lauterbur in1973 when he created an image of an object in two-dimension. The variation of protons frequency depends on the strength of the magnetic field. The difference between the energy emitted at a given spatial location actually determines how much space it occupies(Cabeza & Kingstone 2001).

This concept of Lauterbur was modified or improved by Peter Mansfield's echo-planner imaging in 1976. The entire object could be mapped by complex signals coming from the object concurrently could be used to image it. Through the effort of the two scientists, MRI was successful technique in imaging. The year 1982 marked the start of commercially available general electric human-body 1. 5T scanner based on MRI technique. This technology has been treated as the standard scanner for clinical use which was approved in 1985.

1978 - 1983 Functional magnetic resonance imagings

Functional magnetic resonance imaging (fMRI) is another method of brain structure imaging. This technique unlike MRI puts into consideration the fact that neuronal activities change based on the level of oxygen in the blood. The disturbance of the magnetic field as a result of hemoglobin changes with

the amount of oxygen in the blood (Ogawa and Lee, 1990). This method does not use radioactive tracers or other compounds hence non-invasive. This method has proved very successful in the neuroscience field.

There was more need to have three dimensional images in order to have direct assessment of the brain activity. This quest led to more technological advancement and in 1982 positron emission tomography (PET) was developed. This method created brain images of metabolic functions using autoradiographic technique. It measured glucose metabolism. This was based on the concept that glucose provides energy for electrical activities of neurons in the brain. Understanding how glucose is used in the brain could give clear picture of the neural activity in the brain. PET is based on the principle of information processing theory.

1985 – 1990 Metabolite scanning technologies

1995 – 2000 The rise of multimodal neuroimaging

This is a technology that was introduced in the late 90s and combines the existing brain imaging techniques in synergistic ways to have an enhanced data interpretation. With this technology, it was not possible to use older techniques of imaging to have one map of the brain. This is commonly seen with MRI and EEG scanning techniques. The electrical diagrammatic representation of EEG gives timing which is considered to be split-second while that of MRI gives high spatial levels of accuracy.

After these techniques, there was another development of anatomically – constrained magnetoencephalography (aMEG). This is a technology which was developed in the year 2000. This technique brings together the spatial resolution of the structural MRI scanning technique with the scanning

technique of MEG, which is known to be temporal. It is common to eradicate the lack of uniqueness in MEG source estimation by integrating it with other information from other imaging techniques in a priori constraint manner. in this technique, aMEG makes use of anatomical MRI data in the form of geographical location constraint and also as a means to visualize results from MEG. The MEG technique does not have a way of providing structural or anatomical information. For this reason, it is often common to combine MEG data with that of MR so that a composite image is achieved. The two composites produces activation map.

Recent breakthroughs

The recent discoveries in brain imaging that is considered to be non-invasive have not been that successful because of the fact that most of them have not been novel. This is because most of the discoveries have been refining the techniques that have existed before. There are not new discoveries in imaging. One example of such technologies is the fMRI which was popular in the 1990s. It is still the most popular brain imaging technique that is found today(Cabeza & Kingstone 2001).

Many of the developments in brain imaging can be associated with the developments in computer use in interpreting data. One example where this technology was used is in the growth of the human brain from three months to fifteen years. This has been made possible with the use of high brain maps which have high resolution to analyze the maps from different times of developments. This is one common breakthrough that was realized in the world of neuroscience. With the use of fMRI technology, most of the current

effort is dedicated to the interpretation of the brain maps rather than probing into new imaging technologies. This is seen in the way neoroinformatics is becoming an important aspect of brain discovery. There are thousands of brains that are being analyzed and assessed. The archives of neuroimaging are becoming a center of interest to most of the researchers and they are no longer being interested with new technologies that are used in imaging. The archives are also being standardized and universalized so that the searching process will be easier for everyone. In past few years, there has been availability of data and information sharing is now possible with many people(Cummings 1997).

2000 and beyond

In the recent years, there has been the discovery of transcranial magnetic simulation (TMS), which is a new brain imaging technology. With this technology, a coil is placed near the head of the person undergoing imaging. The coil will then generate magnetic impulses that will cause the cells beneath to make the patient do something. With this and together with MRI technology, the researcher is in a position to get the maps of the brain when it is doing a specific action. With this, the researcher can generate brain maps which will be used to get more information regarding the brain. With this technology, the TMS coil will tell the brain to do a specific action like tapping finger, closing the eye. This technology has eliminated the false positives that have been received and also the traditional MRI and fMRI testing. With this technology, the images that are received are slightly different from the ones received in traditional MRI and fMRI. The results can

be used in any types of brain mapping and can generate up to 120 simulations(Cabeza & Kingstone 2001).

References

Cabeza, R. & Kingstone, A., 2001. Handbook of functional neuroimaging of cognition,

Cummings, J., 1997. The Neuropsychiatric Inventory Assessing psychopathology in dementia patients. Neurology.

Ewing-Cobbs, L., Kramer, L. & Prasad, M., 1998. Neuroimaging, physical, and developmental findings after inflicted and noninflicted traumatic brain injury in young children. .

Katz, D. & Alexander, M., 1994. Traumatic brain injury: predicting course of recovery and outcome for patients admitted to rehabilitation. Archives of neurology.

Listernick, R. et al., 1994. Natural history of optic pathway tumors in children with neurofibromatosis type 1: a longitudinal study. The Journal of pediatrics.

Shorvon, S., 2009. A history of neuroimaging in epilepsy 1909–2009. Epilepsia.