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Brain Mapping Disease Identification System

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Abstract: This paper introduces concepts and principles of how computer assisted diagnosis (CAD) systems work and addresses the challenges of processing large amounts of medical data for diagnosis. It also provides an overview of CAD methods developed in the field of diagnosing neurological diseases and which existing technologies provide what big data for analyzing which diseases. Although there is extensive work on the development of CAD systems for automated screening of diseases, experts still cannot use them regularly in their decision-making processes due to the lack of easily available online methods. This study may help professionals gain insight and understand how CAD systems can help solve diagnosis problems and may help computer designers to be inspired to create more accessible CAD systems in the future from existing medical big data rarely used in CAD at present.
Keywords: Medical big data analysis, Computer-aided diagnosis system, Neurological diseases diagnosis etc.

I. INTRODUCTION

Visual analysis of these data is not a generally accepted method for reliable and accurate diagnosis as patients may experience fatigue. This can also be a mistake and is time consuming. Therefore, there is a need for a system that can provide neurologists with the support they need. Systems must make timely and accurate diagnoses to improve patient health. Therefore, medical analytics uses computer intelligence to develop automated decision-making systems for fast, accurate, and efficient diagnosis and prediction [1][2]. This can improve diagnostic consistency, improve treatment efficiency, save lives, and reduce cost and time. Signal processing, medical image analysis, and physiological data integration solve the same problems from a variety of big data sources. It has been observed that examiners need an online computer-aided design (CAD) system for real-time assessments rather than an offline CAD system.

To create a more accurate diagnostic system, it is necessary to develop a common feature extraction method, a robust classification method, and an efficient online CAD system. It is also necessary to find a compromise between accuracy and efficiency [3]. Diagnosis of neurological diseases is of growing interest and is one of the most challenging tasks in modern medicine. According to a recent World Health Organization (WHO) report, neurological disorders such as epilepsy, Alzheimer's disease and headaches affect up to 1 billion people worldwide.

It is estimated that 6.8 million people die each year from neurological disorders. Modern diagnostic technologies (e.g. magnetic resonance imaging, electroencephalogram) produce a huge amount of data (in size and dimensions) for the detection, monitoring and treatment of neurological diseases. In general, the analysis of this big medical data is done manually by experts to identify and understand anomalies. It is indeed a difficult task for a human being to accumulate, manage, analyze and assimilate such large amounts of data through visual inspection[4]. As a result, experts have called for computerized diagnostic systems called “computer aided diagnosis (CAD)” that can automatically detect neurological abnormalities using big medical data. This system improves consistency of diagnosis and increases the success of treatment, save lives and reduces cost and time. Recently, CAD development research for managing big medical data for diagnostic evaluation is being conducted.

II. LITERATURE REVIEW

In the medical world, neurological diseases are the most difficult diseases to diagnose, treat and monitor due to complexities of human nervous systems as well as due to the fact that mental problems are hardly always caused by biological factors and can be psychologically or even sociologically caused in an interactive way with human biology. Diagnosis and treatment of neurological diseases require high accuracy, dedication and experience. Today's modern technologies and systems enable neurologists to provide appropriate neurological care. Neurological disorders are diseases of the nervous system of the body. Structural, biochemical, or electrical abnormalities in the brain, spinal cord, or other nerves can result in a range of symptoms. There are more than 600 nervous system diseases such as epilepsy, dementia, Alzheimer's disease and cerebrovascular diseases, including stroke, multiple sclerosis, Parkinson's disease, migraine, neuroinfections, brain tumors and traumatic disorders of the nervous system such as brain trauma and autism .

According to the World Health Organization (WHO) report, more than 50 million people suffer from epilepsy [1]. Recently, a cutting-edge idea for an automated CAD system to detect neurological abnormalities in medical big data was presented to specialists/neurologists. Since the algorithms of large CAD systems are developed using methods and theories in the field of pattern recognition, CAD participates as one of the areas of pattern recognition [6].
It is estimated that 35.6 million people suffer from dementia, with 7.7 million new cases each year; Alzheimer's disease is the most common cause of dementia and may contribute to 60-70% of cases [2].
These disorders affect people in all countries, regardless of age, gender, education or income. Neurological disorders have a devastating impact on affected patients and their families and often reduce the patient's quality of life. Prompt and timely diagnosis of these diseases can save a patient's life and significantly improve it by performing appropriate procedures. Recently, various advanced diagnostic technologies such as electroencephalography (EEG), computed tomography (CT), magnetic resonance imaging (MRI), electromyography (EMG) and arteriography have been used to detect, manage and treat neurological diseases. (also called angiography), positron emission tomography (PET scan or PET image)
These technologies are vital tools that help doctors confirm or rule out the presence of a neurological disorder or other medical conditions. The large amount of medical data generated from these technologies is an important resource for diagnosis, treatment evaluation and planning. In general, medical image data ranges from a few megabytes for a single study to hundreds of megabytes per study (for example, fine-bit CT studies consist of 2500+ scans per study) [3,4].
Such data requires large storage capacities if stored for long periods of time. Due to the high volume, speed and complexity of medical data, it is really difficult for specialists to collect, manage, analyze and assimilate large volumes of data for diagnosis, treatment evaluation and planning. The integration of large amounts of physiological data is the biggest challenge for experts in making clinical recommendations. Supporting medical professionals or neurologists in the process of finding a timely correct diagnosis to a hypothesis is highly desirable to improve a patient's outcome. Generally, the analysis of this large amount of information is performed manually by neurologists/experts through visual inspection to identify and understand abnormalities arising from medical imaging and signal data [5].
Visual inspection of such large data is time-consuming, error-prone, and fatigue-prone, making it not a satisfactory procedure for precise and reliable diagnosis. Therefore, medical analytics demands to develop automated decision systems using computational intelligence for fast, accurate and efficient diagnosis, prognosis and treatment processes.

III. CURRENT MEDICAL TECHNOLOGIES FOR MEDICAL DATA, COLLECTIONS AND CHALLENGES IN MEDICAL BIG DATA ANALYSIS

Today, neurological diseases are diagnosed using various medical techniques such as electroencephalography (EEG), computed tomography (CT scan or CAT scan), magnetic resonance imaging (MRI scan), electromyography (EMG), positron emission tomography (PET scan or PET image).), arteriogram (also called angiogram), and single photon emission computed tomography (SPECT). These diagnostic tests help doctors confirm or rule out the presence of a neurological disorder or other medical conditions. EEG is used to record brain cell activity through the skull to diagnose brain-related diseases such as epilepsy, certain seizure disorders, degenerative disorders, sleep disorders, autism, brain tumors, and migraines, and to study functional states of the brain. assists physicians to detect and monitor brain abnormalities [7].
Variations or abnormalities in brain waves suggest different types of neurological disorders. To diagnose neurological conditions such as tumors, blood clots, degenerative diseases and the location of strokes. To identify brain abnormalities, a CT or CAT scan is used to view cross-sectional images of the body using X-rays and a computer [8].
Such tests are mainly used for swelling and lesions in certain areas, broken bones, heart disease and internal bleeding. In finding brain and spinal cord abnormalities, MRI tests are valuable for looking for detailed images of body structures, including tissues, organs, bones, and nerves [9-11].
MRI tests help doctors diagnose torn ligaments, tumors, circulation (blood flow) problems, eye disease, inflammation (for example, arthritis) and infection. MRI scans are also used to detect and monitor degenerative disorders such as multiple sclerosis and can document brain damage from trauma. fMRI is an appropriate diagnostic test if doctors need to examine the brain in motion (for example, speaking or moving) and identify areas of the brain that become active and note how long they remain active. fMRI testing measures small changes in blood flow as a person completes tasks while in the MRI scanner [12].
The fMRI imaging process is used to evaluate brain damage from head injury or degenerative disorders such as Alzheimer's disease, and to identify and monitor other neurological disorders, including multiple sclerosis, stroke, and brain tumors.

A PET test may be used to follow up with a CT or MRI scan to give the doctor a better understanding of certain areas of the brain, including two- and three-dimensional pictures of brain activity. SPECT tests are also ordered as an MRI follow-up to diagnose tumors, infections, degenerative spine disease, and stress fractures. It is used to record the electrical activity of the muscles to detect abnormal electrical activity of the muscle, which can occur in many diseases and conditions such as amyotrophic lateral sclerosis (ALS, Lou Gehrig's disease), carpal tunnel syndrome, muscular dystrophy, neuropathy, sciatic nerve dysfunction, muscle inflammation, EMG scan [13].

ECG is used to record the electrical activity of the heart to understand how the heart is working to detect different heart problems such as heart attack, coronary heart diseases and stroke [14]. An arteriogram is used to take an X-ray of the arteries and veins to detect occlusion or narrowing of the arteries. Myelograms are used to look for spinal nerve injury, herniated discs, fractures, back or leg pain, and spinal tumors. Ultrasounds are used to evaluate blood flow through various vessels, and transcranial doppler ultrasounds are used to view arteries and blood vessels in the neck and determine blood flow and stroke risk. These medical technologies generate large amounts of complex and high-dimensional data that are an important resource for the diagnosis, treatment, and treatment planning of neurological diseases. Medical big data analytics has the potential to be a valuable tool, but implementation can be a challenge. It requires careful data analysis that can provide authentic, accurate and reliable information for good decision making in disease diagnosis. In practice, most case interpretations of this data are performed visually by specialists/neurologists [15].

Due to the limitations of the human eye-brain system, limitations in education and experience, and factors such as fatigue and distraction, it is natural that clinicians are not always making the best use of the data obtained. Human interpretation of medical data is limited due to the unsystematic search patterns of humans, the presence of structure noise, and the large amount of data. For complex processing of high volumes of data, the use of digital technologies to support medical data analysis is essential. Therefore, there are ever-increasing requirements to develop such CAD systems for specialists/neurologists who can automatically make an accurate assessment for the detection of different neurological problems.

IV. COMPUTER-AIDED DIAGNOSIS SYSTEMS FOR AUTOMATIC DIAGNOSIS OF NEUROLOGICAL DISEASES

Recently, CAD is becoming very popular in medical and diagnostic imaging to automatically detect anomalies from medical big data sources. The basic concept of CAD was proposed in the mid-1980s by the University of Chicago, whose idea was to provide a computer output to assist professionals in interpreting medical data, thereby ensuring accuracy and consistency of diagnosis. can be improved and also the analysis time can be reduced [16-18].

The CAD system consists of three main steps such as preprocessing, feature extraction and classification as shown in Figure 1 [6]. In the preprocessing section, the acquired medical data (eg medical image data or medical signal data) is processed. To remove noise, which reduces the complexity and computation time of CAD algorithms.

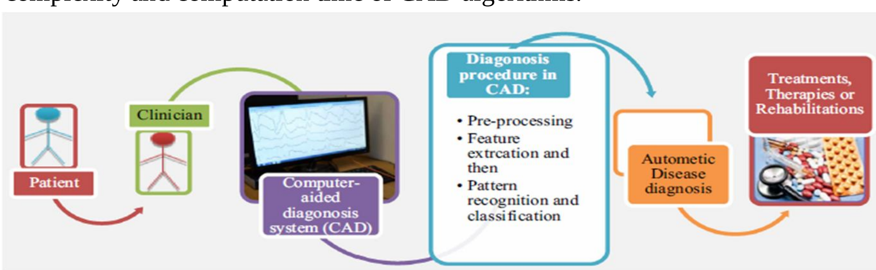

Fig. 1 Diagram of CAD system for automatic detecting abnormities from the medical big data

The feature extraction part of the CAD system is one of the most important parts in which the biomarkers of disease identification are extracted from the original source data. In the classification process for CAD systems, the feature vector extracted in the classifier model is used as input to assign the candidate to one of the possible categories (for example, healthy or normal) based on the output of a classifier. In general, a CAD system can be of two types. If the CAD system involves dividing all candidates into two categories such as abnormal and normal candidates, it is called a two-class categorization system.

On the other hand, if a CAD system can classify unknown cases according to various types of anomalies, more than two, it is called a multiclass categorization system. Many researchers are trying to develop CAD diagrams for the detection and classification of various abnormalities from medical data. Like pattern recognition, the performance of CAD systems can also be affected by k-fold cross validation testing, bootstrapping method, one-on-one exclusion [19].

Free response receiver operating characteristic (FROC) and ROC curves are used to evaluate the overall performance of CAD systems for various operating points. The FROC curve shows the relationship between sensitivity and the number of false positives, which can be obtained by thresholding a particular parameter of the CAD system or the output of the classifier [20].
Recently, a lot of research has been done on the development of CAD systems for the detection of neurological problems such as epileptic seizures, dementia, Alzheimer's disease, autism, stroke, brain tumors, alcoholism-related neurological disorders and sleep disorders [19][20].

V. CONCLUDING REMARKS

The dramatic impact of neurological disease pathologies on quality of life is a growing concern. Modern technologies for the diagnosis of neurological diseases generate enormous amounts of medical data, such as medical images or electrical signals data. Interpreting these images or signals is the ultimate "big data" challenge. The integration of medical image analysis, signal processing and physiological data faces similar challenges when dealing with different big data sources. This article provides an insight into how medical big data can be managed by computational smart system in diagnosis of neurological diseases.

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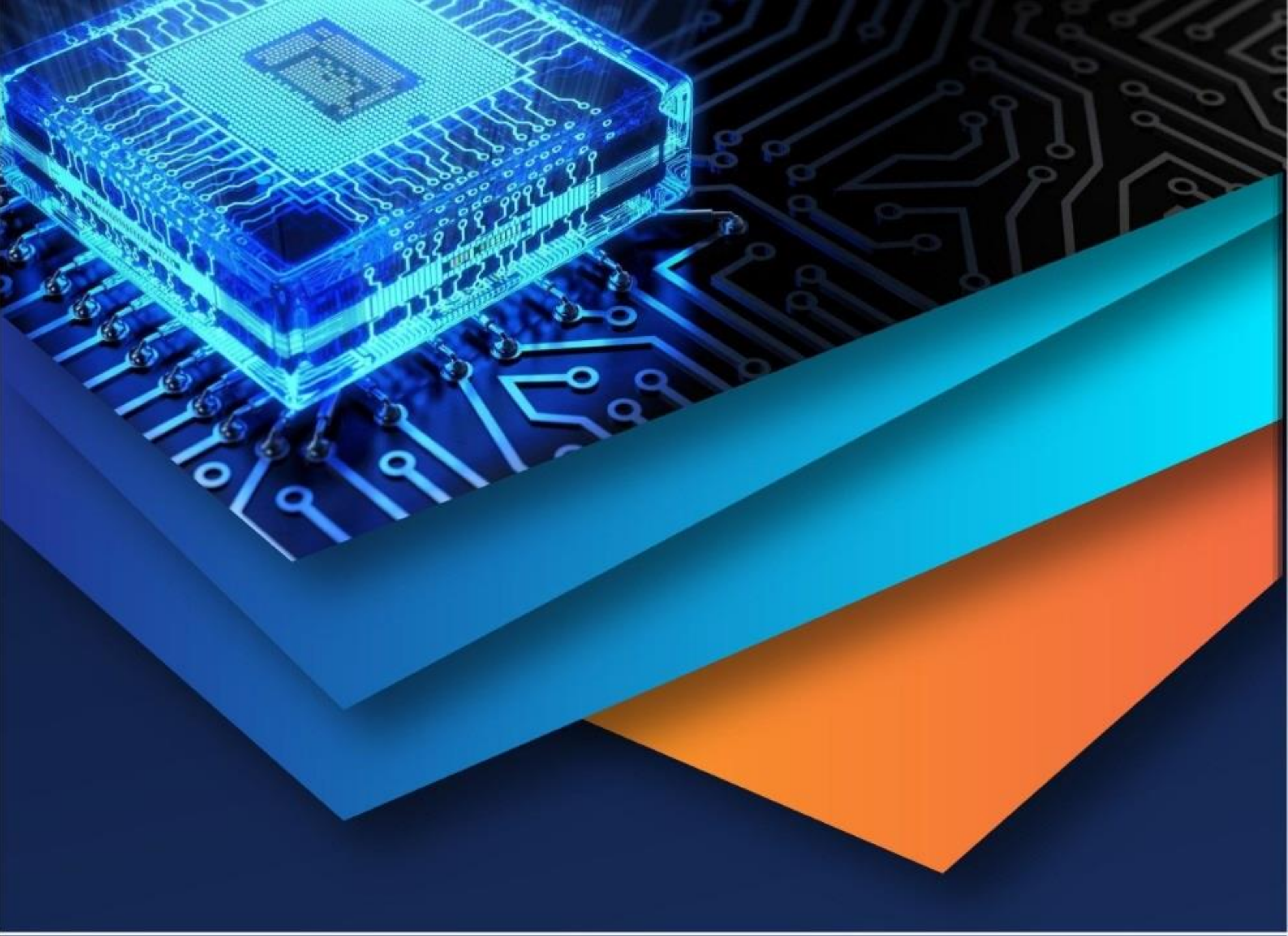

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