NEURAL NETWORK TOWARDS DIAGNOSIS OF BRAIN TUMOR

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ABSTRACT

It is proposed to have a study on the diagnosis of Brain Tumors using Neural Networks. The Neural Networks are best at identifying patterns or trends in data and they are well suited for predicting or forecasting. Hence Neural Networks are extensively applied to biomedical systems. A special work is carried out on Neural Networks effort on diagnosis of Brain Tumors. This paper focuses on the importance and applications of neural networks in the medical world, particularly in the diagnosis of Brain Tumors. The detailed study on Primary and Secondary Brain Tumor are taken here. A new development framework for Neural Networks helps for diagnosing Brain Tumors more efficiently and accurately. The UIMS are applied for decision support system.

Keywords: Neural Networks – ANN – Primary Brain Tumors – Secondary Brain Tumors – Neural Networks Diagnosing Strategy – UIMS – KB-UIMS – NKB-UIMS.

I. INTRODUCTION

An Artificial Neural Network (ANN) is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons.

Neural networks, with their remarkable ability to derive meaning from complicated or imprecise data, can be used to extract patterns and detect trends that are too complex to be noticed by either humans or other computer techniques. A Neural

Network is an interconnected assembly of simple processing elements, units or nodes, whose functionality is loosely based on the animal neuron. The processing ability of the network is stored in the inter-unit connection strengths, or weights, obtained by a process of adaptation to, or learning from, a set of training patterns.

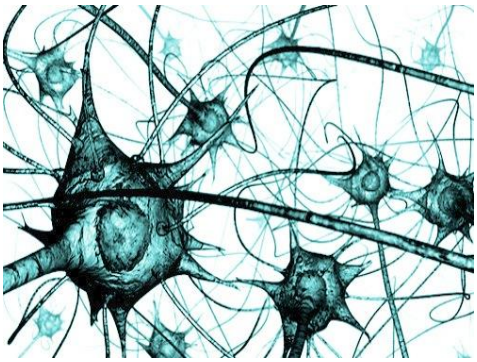


Fig1. Neural Network

Learning Processes in Neural Networks

An important property of neural networks is their ability to learn from input data with or without a teacher. Learning has long been a central issue for researchers developing neural networks. It is a process by which the free parameters of a neural network are adapted through a process of stimulation by the environment in which the network is embedded.

II. ARCHITECTURE OF NEURAL NETWORKS

Neural networks are not only different in their learning processes but also different in their structures or topology. Bose (1996) has broadly classified neural networks into recurrent (involving feedback) and nonrecurrent (without feedback) ones.

1. Feed forward and Back-Propagation

The feed forward, back-propagation architecture was developed in the early 1970.s by several independent sources (Werbor; Parker; Rumelhart, Hinton and Williams). This independent co-development was the result of a proliferation of articles and talks at various conferences which stimulated the entire industry. Currently, this synergistically developed back-propagation architecture is the most popular, effective, and easy to earn model for complex, multi-layered networks. This network is used more than all other combined. It is used in many different types of applications. This architecture has spawned a large class of network types with many different topologies and training methods. Its greatest strength is in non-linear solutions to ill-defined problems.

The typical back-propagation network has an input layer, an output layer, and at least one hidden layer. There is no theoretical limit on the number of hidden layers but typically there is just one or two. Some work has been done which indicates that a

minimum of four layers (three hidden layers plus an output layer) are required to solve problems of any complexity. Each layer is fully connected to the succeeding layer, as shown in Figure 1.

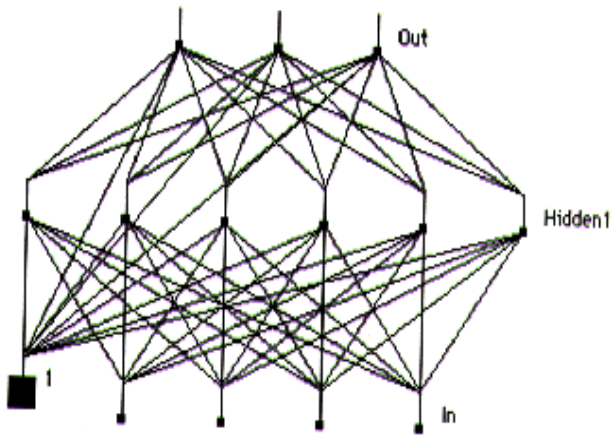


Figure 1

1. Feed-forward networks:

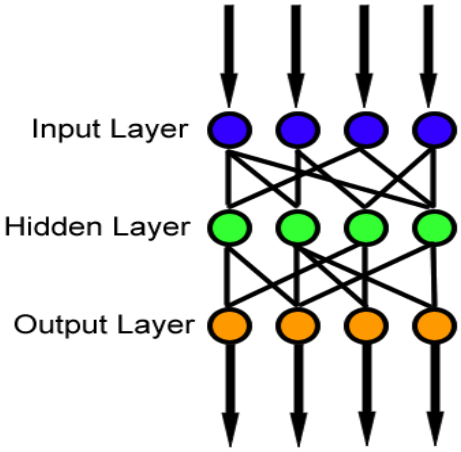


Fig.2 Feed-Forward Networks

2. Recurrent networks

In the neural network literature, neural networks with one or more feedback loops are referred to as recurrent networks. A recurrent network distinguishes itself from a feed forward neural network in that it has at least one feedback loop. Such a system has very rich temporal and spatial behaviors, such as stable and unstable fixed points and limit cycles, and chaotic behaviors. These behaviors can be utilized to model certain cognitive functions, such as associative memory, unsupervised learning, self-organizing maps, and temporal reasoning.

Feedback plays a major role in the study of recurrent networks. There are two ways for feedback: local feedback at the level of a single neuron inside the network and global feedback encompassing the whole network.

Input Hidden Output

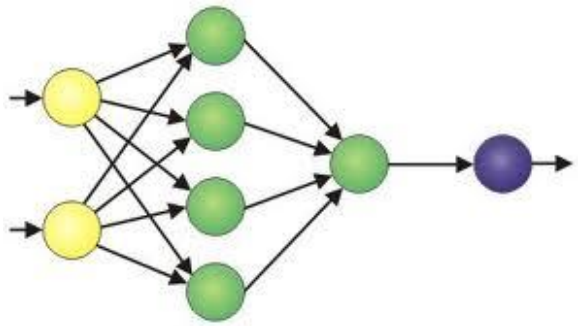


Fig.3 Feedback Networks

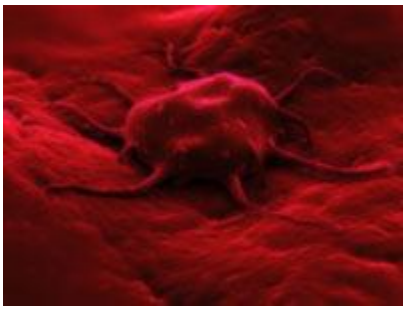
III. NEURAL NETWORKS LAYER

The common type of artificial neural network consists of three groups, or layers, of units: a layer of "**input**" units is connected to a layer of "**hidden**" units, which is connected to a layer of "**output**" units. The activity of the input units represents the raw information that is fed into the network. The activity of each hidden unit is determined by the activities of the input units and the weights on the connections between the input and the hidden units. The behavior of the output units depends on the activity of the hidden units and the weights between the hidden and output units.

IV. CANCER

Cancer is a class of diseases characterized by out-of-control cell growth. There are over 100 different types of cancer, and each is classified by the type of cell that is initially affected.

Cancer harms the body when damaged cells divide uncontrollably to form lumps or masses of tissue called tumors (except in the case of leukemia where cancer prohibits normal blood function by abnormal cell division in the blood stream). Tumors can grow and interfere with the digestive, nervous, and circulatory systems, and they can release hormones that alter body function. Tumors that stay in one spot and demonstrate limited growth are generally considered to be benign.



More dangerous, or malignant, tumors form when two things occur:

1. a cancerous cell manages to move throughout the body using the blood or lymph systems, destroying healthy tissue in a process called invasion
2. that cell manages to divide and grow, making new blood vessels to feed itself in a process called angiogenesis.

When a tumor successfully spreads to other parts of the body and grows, invading and destroying other healthy tissues, it is said to have metastasized. This process itself is called metastasis, and the result is a serious condition that is very difficult to treat.

In 2007, cancer claimed the lives of about 7.6 million people in the world. Physicians and researchers who specialize in the study, diagnosis, treatment, and prevention of cancer are called oncologists.

What causes cancer?

Cancer is ultimately the result of cells that uncontrollably grow and do not die. Normal cells in the body follow an orderly path of growth, division, and death. Programmed cell death is called apoptosis, and when this process breaks down, cancer begins to form. Unlike regular cells, cancer cells do not experience programmatic death and instead continue to grow and divide. This leads to a mass of abnormal cells that grows out of control.

Genes - the DNA type

Cells can experience uncontrolled growth if there are damages or mutations to DNA, and therefore, damage to the genes involved in cell division. Four key types of gene are responsible for the cell division process: oncogenes tell cells when to divide, tumor suppressor genes tell cells when not to divide, suicide genes control apoptosis and tell the cell to kill itself if something goes wrong, and DNA-repair genes instruct a cell to repair damaged DNA.

Cancer occurs when a cell's gene mutations make the cell unable to correct DNA damage and unable to commit suicide. Similarly, cancer is a result of mutations that inhibit oncogene and tumor suppressor gene function, leading to uncontrollable cell growth.

Carcinogens

Carcinogens are a class of substances that are directly responsible for damaging DNA, promoting or aiding cancer. Tobacco, asbestos, arsenic, radiation such as gamma and x-rays, the sun, and compounds in car exhaust fumes are all examples of carcinogens. When our bodies are exposed to carcinogens, free radicals are formed that try to steal electrons from other molecules in the body. Theses free radicals damage cells and affect their ability to function normally.

Genes - the family type

Cancer can be the result of a genetic predisposition that is inherited from family members. It is possible to be born with certain genetic mutations or a fault in a gene that makes one statistically more likely to develop cancer later in life.

V. HUMAN BRAIN

The Brain is a soft, spongy mass of tissue. It is protected by the bones of the skull and three thin membranes called meninges. Watery fluid called cerebrospinal fluid cushions the brain. This fluid flows through spaces between the meninges and through spaces within the brain called ventricles. The three major parts of the brain control activities:

1. Cerebrum - The cerebrum is the largest part of the brain. It is at the top of the brain.

It uses information from our senses to tell us what is going on around us and tells our body how to respond. It controls reading, thinking, learning, speech, and emotions. The cerebrum is divided into the left and right cerebral hemispheres, which control separate activities. The right hemisphere controls the muscles on the left side of the body. The left hemisphere controls the muscles on the right side of the body.

2. Cerebellum - The cerebellum is under the cerebrum at the back of the brain. The cerebellum controls balance and complex actions like walking and talking.

3. Brain Stem - The brain stem connects the brain with the spinal cord. It controls hunger and thirst. It also controls breathing, body temperature, blood pressure, and other basic body functions.

VI. BENIGN AND MALIGNANT BRAIN TUMOR

1. Benign - Brain tumors do not contain cancer cells:

Usually, benign tumors can be removed, and they seldom grow back. The border or edge of a benign brain tumor can be clearly seen. Cells from benign tumors do not invade tissues around them or spread to other parts of the body. However, benign tumors can press on sensitive areas of the brain and cause serious health problems. Unlike benign tumors in most other parts of the body, benign brain tumors are sometimes life threatening. Very rarely, a benign brain tumor may become malignant.

2. Malignant - Brain tumors contain cancer cells:

Malignant brain tumors are generally more serious and often is life threatening. They are likely to grow rapidly and crowd or invade the surrounding healthy brain tissue. Very rarely, cancer cells may break away from a malignant brain tumor and spread to other parts of the brain, to the spinal cord, or even to other parts of the body. The spread of cancer is called metastasis. Sometimes, a malignant tumor does not extend into healthy tissue. The tumor may be contained within a layer of tissue or the bones of the skull or another structure in the head may confine it. This kind of tumor is called encapsulated.

VII. PRIMARY BRAIN TUMORS

Tumors that begin in brain tissue are known as primary tumors of the brain. Primary brain tumors are named according to the type of cells or the part of the brain in which they begin. The most common primary brain tumors are gliomas. They begin in glial cells. There are many types of gliomas:

1. Astrocytoma - The tumor arises from star-shaped glial cells called astrocytes. In adults, astrocytomas most often arise in the cerebrum. In children, they occur in the brain stem, the cerebrum, and the cerebellum. A grade III astrocytoma is sometimes called an anaplastic astrocytoma. A grade IV astrocytoma is usually called aglioblastoma multiforme.

2. Brain stem glioma - The tumor occurs in the lowest part of the brain. Brain stem gliomas most often are diagnosed in young children and middle-aged adults.

3. Ependymoma - The tumor arises from cells that line the ventricles or the central canal of the spinal cord. They are most commonly found in children and young adults.

4. Oligodendroglioma - This rare tumor arises from cells that make the fatty substance that covers and protects nerves. These tumors usually occur in the cerebrum. They grow slowly and usually do not spread into surrounding brain tissue. They are most common in middle-aged adults.

VIII. SECONDARY BRAIN TUMORS

When cancer spreads from its original place to another part of the body, the new tumor has the same kind of abnormal cells and the same name as the primary tumor. Cancer that spreads to the brain from another part of the body is different from a primary brain tumor. When cancer cells spread to the brain from another organ (such as the lung or breast), doctors may call the tumor in the brain a secondary tumor or metastatic tumor. Secondary tumors in the brain are far more common than primary brain tumors.

IX. SYMPTOMS OF BRAIN TUMORS

The symptoms of brain tumors depend on tumor size, type, and location. Symptoms may be caused when a tumor presses on a nerve or damages a certain area of the brain. They also may be caused when the brain swells or fluid builds up within the skull. These are the most common symptoms of brain tumors:

1. Headaches (usually worse in the morning)

2. Nausea or vomiting

3. Changes in speech, vision, or hearing

4. Problem in balancing or walking

4. Changes in mood, personality, or ability to concentrate

5. Problems with memory

6. Muscle jerking or twitching (seizures or convulsions)

7. Numbness or tingling in the arms or legs

X. DIAGNOSING BRAIN TUMORS

1. Neurologic exam: The vision, hearing, alertness, muscle strength, coordination, and reflexes are checked medically. The patient's eyes are examined to look for swelling caused by a tumor pressing on the nerve that connects the eye and the brain.

2. MRI: A large machine with a strong magnet linked to a computer is used to make detailed pictures of areas inside patients head. Sometimes a special dye (contrast material) is injected into a blood vessel in your arm or hand to help show differences in the tissues of the brain. The pictures can show abnormal areas, such as a tumor.

3. CT Scan: An x-ray machine linked to a computer takes a series of detailed pictures of your head. The patients may receiv contrast material by injection into a blood vessel in your arm or hand. The contrast material makes abnormal areas easier to see.

4. Angiogram: Dye injected into the bloodstream makes blood vessels in the brain show up on an x-ray. If a tumor is present, the x-ray may show the tumor or blood vessels that are feeding into the tumor.

5. Spinal tap: The doctor may remove a sample of cerebrospinal fluid (the fluid that fills the spaces in and around the brain and spinal cord). This procedure is performed with local anesthesia. The doctor uses a long, thin needle to remove fluid from the lower part of the spinal column. A spinal tap takes about 30 minutes. The patients must lie flat for several hours afterward to keep from getting a headache. A laboratory checks the fluid for cancer cells or other signs of problems.

6. Biopsy: The removal of tissue to look for tumor cells is called a biopsy. A pathologist looks at the cells under a microscope to check for abnormal cells. A biopsy can show cancer, tissue changes that may lead to cancer, and other conditions. A biopsy is the only sure way to diagnose a brain tumor.

XI. DIAGNOSING BRAIN TUMOR USING NEURAL NETWORKS

Artificial Neural Network model could perform "intelligent" tasks similar to those performed by the human brain. Artificial neural network models offer a completely different approach to problem solving and they are sometimes called the sixth generation of computing. In the network the input neuron values are the demographic data which concerns information such as patient's age, sex etc. The hidden neuron values are based on heuristic diagnostic knowledge and represent experience accumulated through years and concerns the way an expert uses the patient data to make diagnoses. The

heuristic knowledge has been acquired interviewing experts in the field and constructed a diagnostic tree based on criteria. The output layer produces the outputs.

1. Training the model:

Once a network has been structured for a particular application, that network is ready to be trained. To start this process the initial weights are chosen randomly. Then, the training or learning begins. The ANN has been trained by exposing it to sets of existing data (based on the follow up history of cancer patients) where the outcome is known.

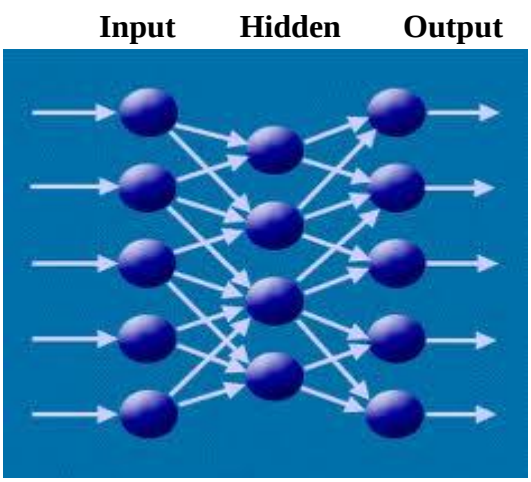


Fig.5 Neural Networks Layer

Multi-layer networks use a variety of learning techniques; the most popular is back – propagation algorithm. It is one of the most effective approaches to machine learning algorithm Information flows from the direction of the input layer towards the output layer. A network is trained rather than programmed. Learning in ANN's is typically accomplished using examples. This is also called 'training' in ANN's because the learning is achieved by adjusting the connection weights in ANN's iteratively The number of iterations of the training algorithm and the convergence time will vary depending on the weight initialization. After repeating this process for a sufficiently large number of training cycles the network will usually converge to some state where the error of the calculations is small. In this case one says that the network has learned a certain target function. Learning techniques are often divided into supervised, unsupervised and reinforcement learning.

It is well known that the performance of learning systems on the training data often does not reflect the performance on unknown data. This is due to the fact that the system often adapts well on training to the particularities of the training data. Therefore, the training data should be randomly chosen from all available data. It should represent the typical data properties. If we have initially a bias in the training data you will encounter performance problems for the test data later. In order to test the real generalization

abilities of a network to unknown data, it must be tested by classified, but yet unknown data, the test data that should not contain samples coming from patients of the training data. We have to face the fact that patient data is very individual and it is difficult to generalize from one patient to another. Ignoring this fact would pretend better results than a real system could practically achiev2. Method of study:

2.1 Cell culture and Tumor samples:

The source and other information for the cell lines and tumor samples used in this study are described for the training set and for the test set. All the original histological diagnoses were made at tertiary hospitals, which have reference diagnostic laboratories with extensive experience in the diagnosis of pediatric cancers.

2.2 Microarray experiments:

Improve knowledge for gene function. Focus basic research. Focus design of therapeutic strategies, Disease diagnosis, and sequencing & mutation detection.

XII. USER INTERFACE MEDICAL SERVICES:

UIMS is an interactive decision support system (DSS) Computer Software, which is designed to assist physicians and other health professionals with decision making tasks, as determining diagnosis of patient data. An User Interface Medical Services has been coined as an active knowledge system, which use two or more items of patient data to generate case-specific advice. This implies that a UIMS is simply a DSS that is focused on using knowledge management in such a way to achieve clinical advice for patient care based on some number of items of patient data. There are two types of UIMS, Knowledge-Based and Non Knowledge-Based.

1. Features of a Knowledge-Based UIMS:

Most UIMS consist of three parts, the knowledge base, interface engine, and mechanism to communicate. The knowledge base contains the rules and associations of compiled data which most often take the form of IF-THEN rules. If this was a system for determining drug interactions, then a rule might be that IF drug X is taken AND drug Y is taken THEN alert user. Using another interface, an advanced user could edit the knowledge base to keep it up to date with new drugs. The inference engine combines the rules from the knowledge base with the patient's data. The communication mechanism will allow the system to show the results to the user as well as have input into the system.

2. Features of a non-Knowledge-Based UIMS:

UIMS's that do not use a knowledge base use a form of artificial intelligence called machine learning, which allow computers to learn from past experiences . and/or find patterns in clinical data. Two types of non-knowledge-based systems are artificial neural networks and genetic algorithms.

Artificial neural networks use nodes and weighted connections between them to analyze the patterns found in the patient data to derive the associations between the symptoms and a diagnosis. This eliminates the need for writing rules and for expert input. However since the system cannot explain the reason it uses the data the way it does, most clinicians don't use them for reliability and accountability reasons.

Genetic Algorithms are based on simplified evolutionary processes using directed selection to achieve optimal UIMS results. The selection algorithms evaluate components of random sets of solutions to a problem. The solutions that come out on top are then recombined and mutated and run through the process again. This happens over and over till the proper solution is discovered. They are the same as neural networks in that they derive their knowledge from patient data. Non-knowledge based networks often focus on a narrow list of symptoms like ones for a single disease as opposed to the knowledge based approach which cover many different diseases to diagnosis.

CONCLUSION AND FURTHER ENHANCEMENT:

1. Neural Networks are effectively used in diagnosis of Brain Tumors
2. The applications of Neural Networks enhances the efficiency of the diagnosis
3. The diagnosing strategy of Neural Networks brings better enhancement in the Medical fields.
4. UIMS is applied for decision support
5. Features of knowledge-based and non-knowledge based brings effectiveness

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