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OPTICAL PROBE SYSTEM FOR DIFFERENTIATING TISSUES USING THE OPTICAL CHARACTERSTICS OF DRS

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ABSTRACT

Optical spectroscopy for cancer diagnosis has been a hot research area over the past two decades. Several promising optical spectroscopy techniques such as diffuse reflectance spectroscopy, fluorescence spectroscopy, Raman spectroscopy, light scattering spectroscopy, coherent backscattering spectroscopy, and low coherence spectroscopy are being considered as an excellent and cost effective tool for tissue characterization.

The study is conducted to evaluate the clinical utility and usability of a single fibre probe system (PROBIO), based on the optical characteristics of diffuse reflectance spectroscopy (DRS) and Autofluroscence (AF), for the purpose of differentiating normal from tumorous or cirrhotic tissues of the Liver. Real-time data of the normal and abnormal tissues of the liver are obtained in graphical form which represents their optical characteristics. MATLAB and neural network tool in MATLAB is used to plot, classify, analyze and find out specific statistical data using specially generated codes and is used to differentiate between the optical characteristics of normal and abnormal liver tissues.

Keywords: Optical Spectroscopy, PROBIO, Diffuse reflectance spectroscopy, Autofluroscence.

INTRODUCTION

Cancer: It is also known as a malignant tumor or malignant neoplasm, is a group of diseases involving abnormal cell growth with the potential to invade or spread to other parts of the body. Not all tumors are cancerous; benign tumors do not spread to other parts of the body. Possible signs and symptoms include: a new lump, abnormal bleeding, a prolonged cough, unexplained weight loss, and a change in bowel movements, among others. While these symptoms may indicate cancer, they may also occur due to other issues. There are over 100 different known cancers that affect humans.

Hepatocellular Carcinoma: HCC also called (malignant hepatoma) is the most common type of liver cancer. Most cases of HCC are secondary to either a viral hepatitis infection (hepatitis B or C) or cirrhosis (alcoholism being the most common cause of hepatic cirrhosis). Treatment options of HCC and prognosis are dependent on many factors but especially on tumor size and staging. Tumor grade is also important. High-grade tumor will have a poor prognosis, while low-grade tumors may go unnoticed for many years, as is the case in many other organs.

Signs and symptoms: Hepatocellular carcinoma may present with yellow skin, bloating from fluid in the abdomen, easy bruising from blood clotting abnormalities, loss of appetite, unintentional weight loss, abdominal pain especially in the right upper quadrant, nausea, vomiting, or feeling tired.

Risk factors: The main risk factors for hepatocellular carcinoma are Alcoholism, Hepatitis B, Hepatitis C, Aflatoxin, Cirrhosis of the liver, Hemochromatosis, Wilson's disease , Type 2 diabetes ,Hemophilia.

Pathgenesis: Hepatocellular carcinoma, like any other cancer, develops when there is a mutation to the cellular machinery that causes the cell to replicate at a higher rate and/or results in the cell avoiding apoptosis. In particular, chronic infections of hepatitis B and/or C can aid the development of hepatocellular carcinoma by repeatedly causing the body's own immune system to attack the liver cells, some of which are infected by the virus, others merely bystanders. While this constant cycle of damage followed by repair can lead to mistakes during repair which in turn lead to carcinogenesis, this hypothesis is more applicable, at present, to hepatitis C. Chronic hepatitis C causes HCC through the stage of cirrhosis. In chronic hepatitis B, however, the integration of the viral genome into infected cells can directly induce a non-cirrhotic liver to develop HCC. Alternatively, repeated consumption of large amounts of ethanol can have a similar effect.

Biopsy: A biopsy is a medical test commonly performed by a surgeon, interventional radiologist, or an interventional cardiologist involving sampling of cells or tissues for examination. It is the medical removal of tissue from a living subject to determine the presence or extent of a disease. When intact removal is not indicated for a variety of reasons, a wedge of tissue may be taken in an incision biopsy. In some cases, a sample can be collected by devices that "bite" a sample. A variety of sizes of needle can collect tissue in the lumen (core biopsy). Smaller diameter needles collect cells and cell clusters, fine needle aspiration biopsy. The tissue is generally examined under a microscope by a pathologist, and can also be analyzed chemically. When an entire lump or suspicious area is removed, the procedure is called an excisional biopsy. When only a sample of tissue is removed with preservation of the histological architecture of the tissue's cells, the procedure is called an incisional biopsy or core biopsy. When a sample of tissue or fluid is removed with a needle in such a way that cells are removed without preserving the histological architecture of the tissue cells, the procedure is called a needle aspiration biopsy. Biopsies are most commonly performed for insight into possible cancerous and inflammatory conditions.

This work aims at developing a software tool to anlayse the charecterstics of a tissue using three different light sources by a method of spectroscopy and using the mathematical tool process the data and finally classify the tissue as normal or abnormal using artificial neural network.

MATERIALS AND METHODS

This section describes the hardware and software components used to characterize a tissue. The main components used in this paper are as follows:-

- Spectrophotometer
- Light sources- 365, 385, THL
- Filter holder-442nm- band pass
- Optical probe
- Optical cable
- Medical graded transformer

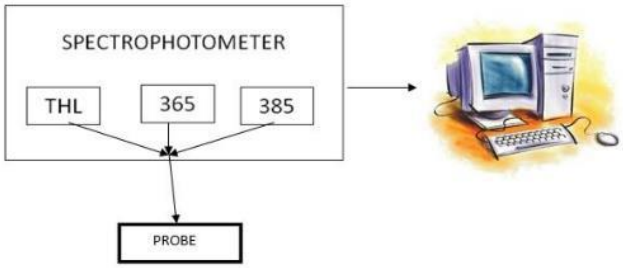

Fig.1. Block Diagram Representation

Spectrophotometer: Spectrophotometry is the quantity based study of electromagnetic spectra. A spectrophotometer measures either the amount of light reflected from a sample object or the amount of light that is absorbed by the sample object. The sequence of events in a modern spectrophotometer is as follows: The light source shines on the sample.

1. A fraction of the light is transmitted or reflected from the sample.
2. The light from the sample is directed to the entrance slit of the monochromator.
3. The monochromator separates the wavelengths of light and focuses each of them onto the photodetector sequentially.

Light Sources: There are three light sources of wavelengths 365nm and 385nm and the third light source is Tungsten Halogen Lamp (THL). 365nm wavelengths give out violet colour and 385nm wavelength is outside the visible spectrum. THL-A halogen lamp, also known as a tungsten halogen, quartz-halogen or quartz iodine lamp, is an incandescent lamp that has a small amount of a halogen such as iodine or bromine added. The combination of the halogen gas and the tungsten filament produces a halogen cycle chemical reaction which redeposits evaporated tungsten back onto the filament, increasing its life and maintaining the clarity of the envelope.

Filter: The filter used is a band pass filter and is of 442nm.A band-pass filter is a device that passes frequencies within a certain range and rejects (attenuates) frequencies outside that range.

Optical Probe: Optical fiber probes offer a compact and convenient solution for many measurements of absorbance, reflection, color, and fluorescence in a wide variety of sample media. Well-suited to process and on-line monitoring applications, they often combine light routing and sample interface in one easy sampling accessory. Fibre optic probe are a key element for biomedical spectroscopic sensing.

Optical cable: An optical fiber cable is a cable containing one or more optical fibers that are used to carry light. The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed.

Medical Graded Transformer: Medical grade isolation transformers are installed in medical devices used in hospitals, medical research facilities, and biomedical companies throughout the world. Design, testing, and construction of medical grade transformers are strictly monitored under safety rules, guidelines and governing laws.

Working: Biochemical changes are measured by optical Auto fluroscence spectra change. Structural changes are measured by Optical reflectance spectra change.

The probe is minimally invasive of size 600um diameter which is inserted into the liver tissue in real time and indicates the presence of tumor cells at tissue sites during pre-ablation and post ablation of the surgery. The single fibre optical probe system, consists of a light source unit, an optical fibre embedded needle, a spectroscopy subsystem, signal collection and display software and a screen user-interface. The light source unit consist of high power LEDs of wavelength 365nm, 385nm and Tungsten halogen light source. The light energy is transmitted through the optical fibre in the core of the needle and is then absorbed by the target tissue. In turn, reflected light is

returned through the same optical fibre, and is displayed on the UI screen. The codings are generated based on Feedforward Backpropagation Algorithm of Artificial Neural Networks tool. The data sets can be analyzed using the codings in Matlab.The optical characteristics of liver tissues can be studied. Normal & abnormal tissues can be differentiated using their optical characteristics.

Feed forward back propagation Algorithm: Each iteration of training involves the following steps:

1) A particular case of training data is fed through the network in a forward direction, producing results at the output layer.

2) Error is calculated at the output nodes based on known target information, and the necessary changes to the weights that lead into the output layer are determined based upon this error calculation.

3) Weight changes are calculated, layer by layer, as a function of the errors determined for all subsequent layers, working backward toward the input layer, until all necessary weight changes are calculated for the entire network.

4) The calculated weight changes are then implemented throughout the network, the next iteration begins, and the entire procedure is repeated using the next training pattern.

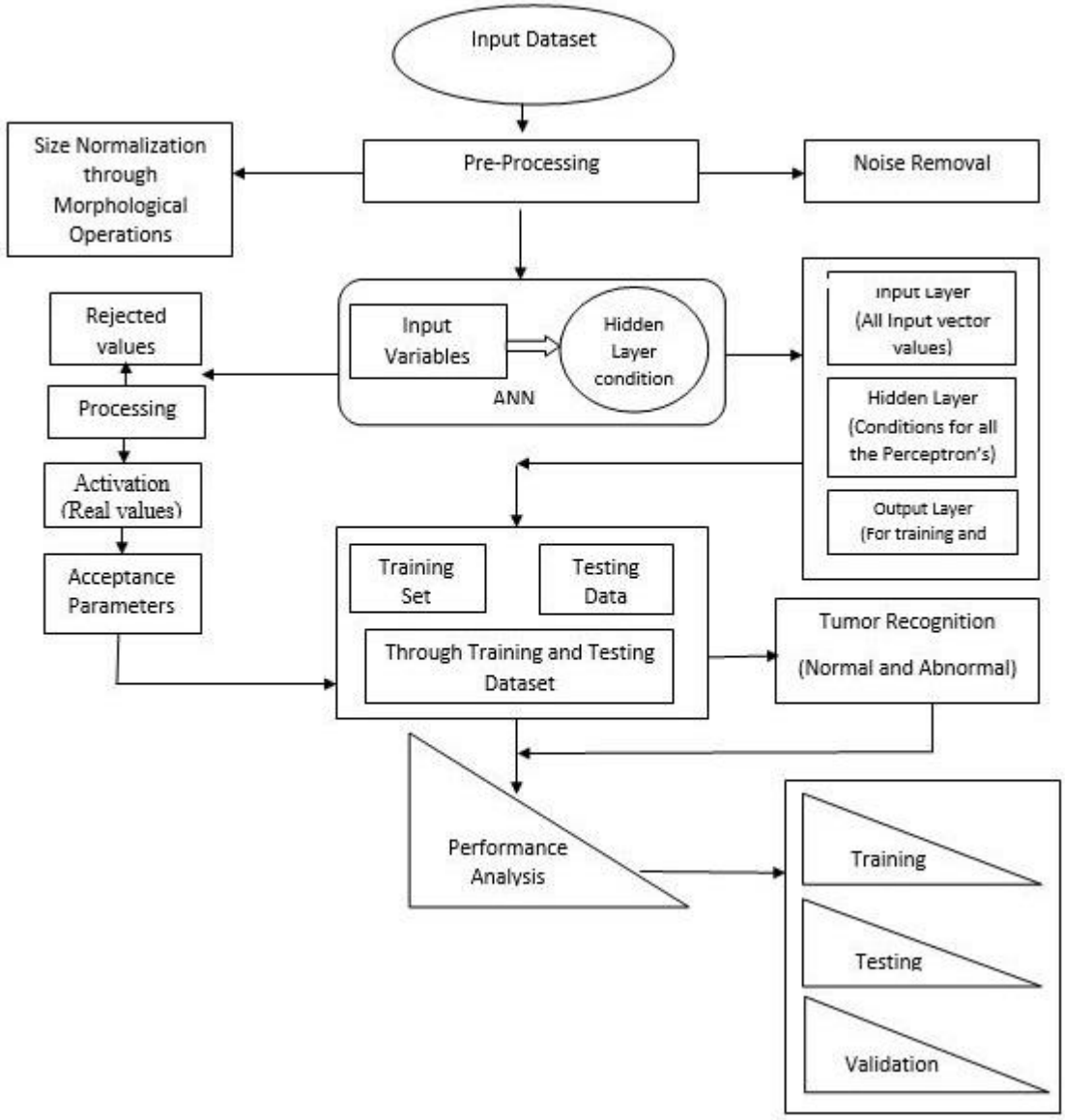

Fig.2.Flow Diagram of Neural Network Mode

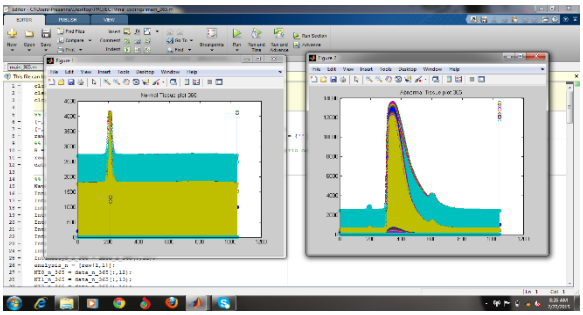

Fig.3.Plot for normal and abnormal liver tissue for 365 light source

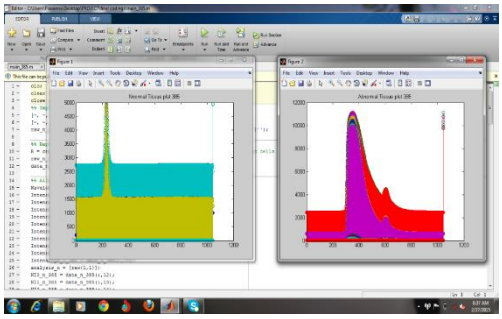

Fig.4 Plot for normal and abnormal liver tissue for 385 light source

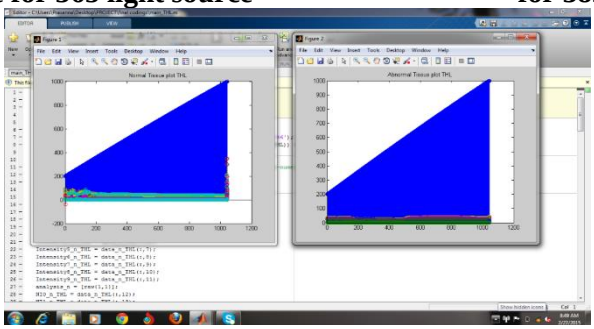

Fig. 5 Plot for normal and abnormal liver tissue for THL light source

RESULTS

Wavelength 365-27 iterations: Here, light of wavelength 365nm is used. The data of the excel are plotted as shown below. The graph is plotted in such a way that the wavelength lies in the x axis and intensity in the y axis. Figure.3 shows the plot for normal and abnormal liver tissue.

Wavelength 385-27 iterations: Here, light of wavelength 385nm is used. The data of the excel are plotted as shown. The graph is plotted in such a way that the wavelength lies in the x axis and intensity in the y axis. Figure 4 below shows the plot for normal and abnormal liver tissue.

Thl-27 iterations: Here, THL light source is used. The data of the excel are plotted as shown. The graph is plotted in such a way that the wavelength lies in the x axis and intensity in the y axis. Figure 5 shows the plot for normal and abnormal liver tissue.

DISCUSSIONS

This paper deals with the detection of liver tumor using an optical fiber by using the optical properties of the liver tissues. The real time data from normal and abnormal liver tissues were taken and the output was obtained in the form of a graph which represented the optical characteristics of these tissues. These data are plotted using MATLAB. Artificial neural network is used to train the system using feed forward back propagation algorithm to train the system and analyze the normal and abnormal data and plot it and further find out a couple of statistical data's which can differentiate between the normal and abnormal liver tissues based on their optical properties. The intensity values obtained from each sources are preprocessed and trained in a Neural Network using Feed Forward Back Propagation Algorithm. The data sets are first trained and then tested for mean values and then classification is done for 27 Iterations. The performance analysis for each light source is tabulated and shown below

Table.1.Mean Values of Normal and Abnormal Liver Tissues

	MEAN IN 365	MEAN IN 385	MEAN IN THL
NORMAL	1812.048	1811.1402	13.3121
ABNORMAL	1994.343	1868.4479	21.6646

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