

An Approach for Detection of Brain Tumor using MRI Images Using LABVIEW

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Abstract: - Brain tumors are a typical growth of cells in the brain. It is important to diagnose these tumors as malignant or benign as early as possible after detection. This paper presents a non-invasive method to differentiate between malignant and benign tumors using NI Lab view software. A script in NI Vision Assistant software is developed that identifies tumors based on the amount of edema, fluids and necrosis in the brain which is reflected in the MRI Scans. Edemas and other fluids present in the brain have a different color and texture compared to the rest of the cerebral tissue. The method used describes a strategy for detection and extraction of tumor from patient's MRI scan images of brain. It incorporates few noise removal functions, segmentation and morphological operations which are the basic concepts of image processing. The algorithm used in this work involves two stages; first is preprocessing of given MRI image, performing segmentation and applying morphological operations. The method was applied on 19 MRI scans and the results obtained reveal that the VI script developed has achieved 86.36% success rate.

Keywords - Brain tumor, MRI Scan, segmentation, morphological operation, LABVIEW

I. INTRODUCTION

The brain is the centre of the nervous system. It is the most complex organ of the body. Physiologically, the function of the brain is to exert centralized control over other organs of the body. The brain acts on the body both by generating patterns of muscle activity and by driving secretion of chemicals called hormones. This centralized control allows rapid and coordinated responses to changes in the environment[1]. Some basic types of responses such as reflexes can be mediated by the spinal cord or peripheral ganglia. This sophisticated purposeful control of behavior based on complex sensory input requires the information-integrating capabilities of centralized brain. The figure 1 depicts the human brain.

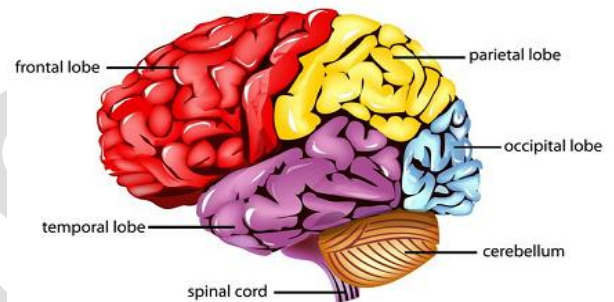
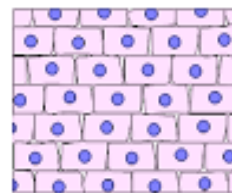


Fig. 1 Parts of human brain

1.1 Tumor

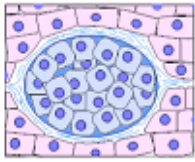
Tumor is an abnormal growth of tissue resulting from uncontrolled, progressive multiplication of cells and serving no physiological function; a neoplasm. A tumor can be benign, pre-malignant or malignant or can represent a lesion without any cancerous potential.

Benign neoplasms are typically composed of cells which bear strong resemblance to normal cell type whereas malignant tumors are cancerous growths which expand quickly and can metastasize or spread to other areas of the body. These tumors grow by invading nearby cells and spread to other parts of the body through a process called metastasis. The cell breaks off and tumor enters the bloodstream or lymphatic system, spreads to another area, infecting additional tissue[2]. The figures 2, 3, and 4 below show the structure of normal, benign and malignant tumors



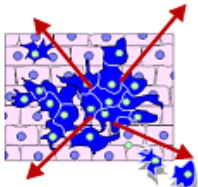
Normal Tissue

Fig. 2 Normal tissue



**Benign
(or non-cancerous)**
Not cancer
the cells that make up the growth are similar to other normal cells, grow relatively slowly, and are confined to one location.

Fig. 3 Benign tumor



**Malignant
(or cancerous)**
Cancer
the cells are very different from normal cells, grow relatively quickly, and can spread easily to other locations.

Fig. 4 Malignant tumor

The cells in malignant tumors are different from normal cells in number of ways. Normal cells are uniform in shape with a nucleus containing chromatin and a nucleolus which contains RNA and DNA, whereas the malignant tumors non-uniform cells with large irregular nucleoli and chromatin.

Treatment for this tumor can be done only after doing biopsy. These cells do not stick together like normal cells and stain differently under microscope. Malignant tumors are likely to cause death if left untreated.

Imaging tests detect whether the cancer has spread to other areas and experts can identify the malignant tumors dependent on markers or antigens found in the cancer cells. Signs and symptoms of cancer are:

- Unexplained weight loss
- Abnormal bleeding
- Unexplained tiredness or fatigue
- Unknown pain
- Skin changes such as rashes or unusual texture
- Presence of unusual lumps in the body
- Coughing and breathlessness

Few general complications that can occur with both cancer and its treatment protocols are listed below:

- Loss of appetite
- Insomnia
- Anemia
- Hair loss
- Nausea
- Immune system depression

This work focuses on detection of brain tumors by observing the MRI scans. A VI (Virtual Instrumentation) is designed using LabVIEW to detect the type of tumor whether benign or malignant.

II. BRAIN TUMORS

Brain tumor shown in figure 5 is abnormal growth in

brain that can either be cancerous(malignant) or non-cancerous(benign). The effects of malignant and benign tumors of brain are very similar and can cause the same types of problems depending on type of tumor and its location in the brain.



Fig. 5 Brain tumor

It can be defined as any intracranial tumor created by abnormal and uncontrolled cell division, either in brain itself or in the cranial nerves or in brain envelopes or skull or pituitary or pineal gland or can spread from the cancers that are primarily located in other organs (metastatic tumors).

Any brain tumor is inherently serious and life-threatening because of its invasive and infiltrative character in the limited place of the intracranial cavity[3]. As brain is well protected by skull, the early detection of brain tumor is possible only when the diagnostic tools are directed at the intracranial cavity. Usually detection can take place, when the presence of tumor causes unexplained symptoms.

2.1 Primary (true) brain tumor

Primary brain tumors are shown in figure 6 are commonly located in the posterior cranial fossa in children and in anterior two-thirds of cerebral hemispheres in adults although can affect any part of the brain.

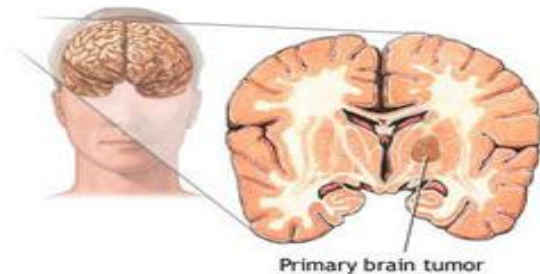


Fig. 6 primary brain tumor

Benign brain tumors usually have an obvious border or edge. Cells. Benign tumors rarely invade tissues around them and do not spread to other parts of body[4]. However these tumors can press on sensitive areas of brain and cause serious health problems. Benign tumors can become malignant. Malignant tumors have an irregular border that invades normal tissue with finger-like projections making surgical removal more difficult. Figure. 7 below shows benign and malignant brain tumors.

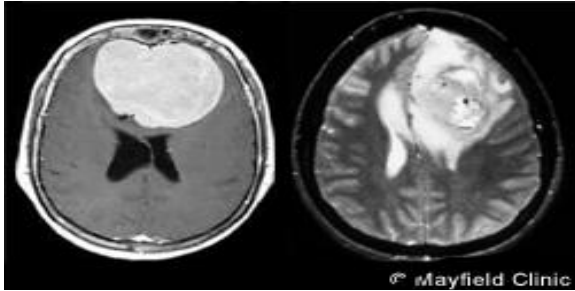


Fig. 7 MRI scans of a benign and malignant brain tumor.

2.1.1. Tumor grades

The grade of tumor refers to the way the cells are viewed under microscope.

Grade I: The tissue is benign. The cells look like normal brain cells and grow slowly.

Grade II: The tissue is malignant. The cells look less like normal cells than grade I tumor.

Grade III: The malignant tissue has cells that look very different from normal cells. These cells are actively growing (anaplastic).

Grade IV: The malignant tissue has cells that look most abnormal and tend to grow quickly.

2.2 Types of primary brain Tumors

The most common primary brain tumors

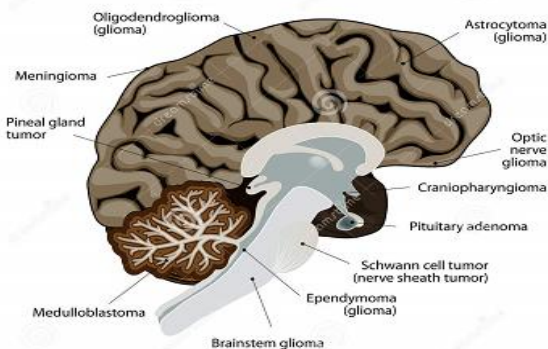


Fig. 8 types of primary brain tumors

Primary brain tumors are named according to the type of cells or the part of the brain in which they begin. The most common types are:

2.2.1 Astrocytoma

This tumor arises from star-shaped glial cells called astrocytes and can be of any grade. In adults, an astrocytoma most often arises in the cerebrum.

2.2.2 Meningioma

This develops in meninges. It can be grade I, II and III. It is usually benign and grows slowly.

2.2.3 Oligodendroglioma

This arises from cells that make the fatty substance that covers and protects nerves. It usually occurs in cerebrum. It is mostly common in middle-aged adults. It can be grade II or III.

2.2.4 Medulloblastoma

This type is commonly seen in children and arises in cerebrum. It is sometimes called a primitive neuroectodermal tumor and is of grade IV type.

2.2.5 Ependynoma

The tumor arises from cells that line the ventricles or central canal of spinal cord. Its commonly found in children and young adults. It can be grade I, II or III.

2.2.6 Brain stem glioma

This tumor occurs in the lowest part of the brain. It can be a low-grade or high-grade tumor. It diffuses intrinsic pontine glioma.

2.3 Symptoms of Brain tumor

The symptoms of brain tumor depend on tumor size, type and location. Symptoms are caused when a tumor presses on nerve or harms a part of brain or when a tumor blocks the fluid that flows through and around the brain or brain swells because of the buildup of fluid[5]. Symptoms can be divided in three main categories.

- **Intracranial hypertension-** Extensive perifocal swelling (edema) inevitably leads to elevated intracranial pressure which translates clinically into headaches, vomiting, altered state of consciousness, dilation of the pupil on the side of the lesion, papilledema, etc.
- **Dysfunction-** focal neurologic symptoms such as cognitive behavioral impairment, personality or emotional changes, hemiparesis, impaired sense of hearing or smell, facial paralysis, double vision, dizziness, etc.
- **Irritation-** Abnormal fatigue, weariness, absences and tremors and also epileptic seizures.

The people with brain tumors have several treatment options. It can be surgery, radiation therapy and chemotherapy or combination of treatments can also be used.

The choice of treatment depends on following:

- Type and grade of tumor
- Its location in brain
- Its size
- Age and general health of the person

2.4 Medical Imaging

Medical imaging is process used to create the images of the human body or parts or function thereof for clinical purposes. It refers to several different technologies that are

used to diagnose, monitor or treat medical conditions that noninvasively produce images of the internal aspect of the body. The types of medical imaging are:

- X-ray imaging and computed tomography
- Magnetic resonance imaging (MRI)
- Single photon emission computed tomography
- Positron emission tomography

This work makes use of MRI scans.

III. THE PROPOSED DESIGN

So far in clinical practice, only pathology tests have been used to diagnose tumors. This paper presents a step towards non-invasive identification of malignant and benign tumors. A script has been developed in NI Vision Assistant software which identifies tumors based on the amount of edema, fluids and necrosis in the brain which is reflected in MRI Scans.

The approach has been formed based on observations that malignant tumors cause lot more edema in the brain compared to benign tumors with some exceptions. Benign tumors are contained by the membrane and do not cause much necrosis and grow in controlled way. On the other hand, malignant tumors are not encapsulated and their growth is not restricted. As a result, they affect the surrounding tissues thereby making the tissues watery and ultimately leading to necrosis and subsequent edema.

Edemas can be clearly seen in the MRI scans along with the tumors present[7]. Therefore by processing the MRI scan in the vision assistant software, the amount of edema, fluids and necrosis that are present in the brain are compared. In this method, edema, fluids and necrosis are considered as fluids and based on amount of fluids, the tumors are detected.

3.1 Software tool requirements

LabView is the software proposed in this paper that is used to develop a VI(Virtual Instrument) to detect the tumors. LabView refers to Laboratory Virtual Instrumentation Engineering Workbench. It is a platform and development environment for visual programming from National Instruments.

3.2 LabVIEW:

It is a graphical language and is commonly used for data acquisition, instrument control and industrial automation on variety of platforms including Microsoft windows, various flavors of Linux and Mac OS X. The code files have extension “.vi”, abbreviation for virtual Instrument. The programming language used in LabView also referred as G, is a dataflow programming language. Execution is determined by the structure of a logical block diagram (the LV- source code) on which the programmer connects different function nodes by drawing wires. These wires propagate variables and

any node can execute as soon as all its input data becomes available. G is inherently capable of parallel execution, multi-processing and multi-threading hardware is automatically exploited by the built-in scheduler, which multiplexes multiple OS threads over the nodes ready for execution[8].

LabView creates user interfaces into the development cycle. The programs or subroutines in Lab View are called Virtual Instruments(VI's). Each VI has three components: a block diagram, a front panel and a connector panel. The virtual Instrument can be either run as a program, with the front panel serving as user interface or when dropped as node onto block diagram, the front panel defines the inputs and outputs for a given node through the connector panel. This implies each VI can be easily tested before being embedded as a subroutine into larger program.

Different kinds of Vision software can be used depending on the application. Those are:

- NI Vision Acquisition software
- NI Vision Development module
- NI Vision Builder for automated inspections

The Vision development module contains many image processing functions such as pattern matching, texture recognition, image filters etc. Vision Assistant is the tool for prototyping and testing image processing applications.

Components of vision Assistant

- *Script window* - Records a series of image processing steps and settings. Scripts can be run as single images or in batch to analyze collection of images. They can be modified or saved.
- *Image browser* – contains all the images currently loaded in vision assistant. An image can be selected or processed by double clicking on it.
- *Processing window* – updates the image as you change in parameters in the parameter window until the desired result is obtained and the changes can be reflected on images.
- *Functions or parameter window*- displays a list of image processing functions that are used to develop algorithms or displays parameters that can be set for an image processing function.

IV. IMPLEMENTATION

The algorithm used in this work involves two stages; first is preprocessing of given MRI image, performing segmentation and applying morphological operations.. Sequences of steps involved are explained below.

- Give MRI image of brain input
- Convert it to gray scale image
- Apply high pass filter for noise removal
- Compute threshold segmentation
- Compute morphological operation

The output is the tumor region.

4.1 Image Acquisition:

MRI Images to be processed are loaded into the Vision Assistant. New or existing scan images can be captured by camera and collected images are saved in JPEG format. There are three types of image acquisitions possible; snap, grab and sequence.

4.2 Processing of Image

The image is to be processed in the image browser. Acquired image is shown in figure.9

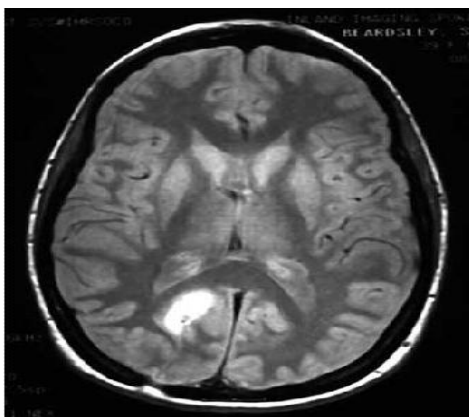


Fig 9. Acquired image

The image acquisition is done by applying a designed script to the image. Script is written to identify the texture of tumors and comparing them with the whole image. Applying a grayscale(RGB) function converts RGB images into grayscale by eliminating the hue and saturation information while retaining the luminance.

When the amount of fluids is more, the result of comparison match will be high. A specified threshold value is set below which will differentiate between malignant and benign tumors. The MRI scan that is loaded is a 32-bit image. Gray scaled image is shown in figure 10 as shown below

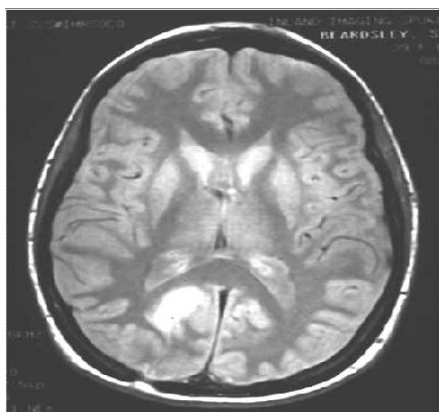


Fig.10 gray scaled image

Its brightness, contrast and gamma values are adjusted such that the tumor and edema are highlighted where as the rest of the brain matter is darkened. The enhanced image i.e., the thresholded image is as shown in figure 11 below



Fig.11 Thresholded image

Image enhancement is done by color thresholding. The color threshold is performed by color based watershed segmentation in MatLab using color thresholder app[9]. Image enhancement techniques in Image Processing Toolbox enable to increase the signal-to-noise ratio and accentuate image features by modifying the colors or intensities of image. A template is created by selecting the existing tumors as shown in figure 12 below.

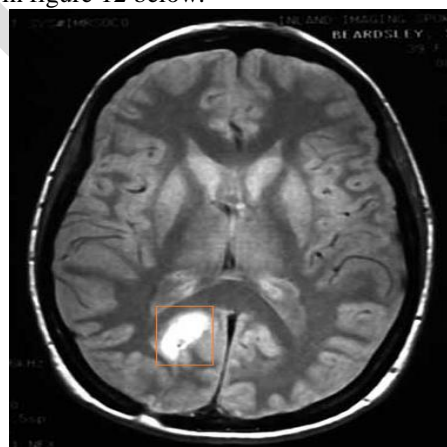


Fig. 12 Creation of tumor template

Advanced Morphological operations are applied on the matched image with that of template[10]. Morphological operation performed on the binary images is separation function, which breaks narrow isthmuses and separates touching particles with respect to a user-specified filter size. This operation uses erosions, labeling, and conditional dilations after running through the connected components algorithm. Detected tumour image is shown in figure 13. below.

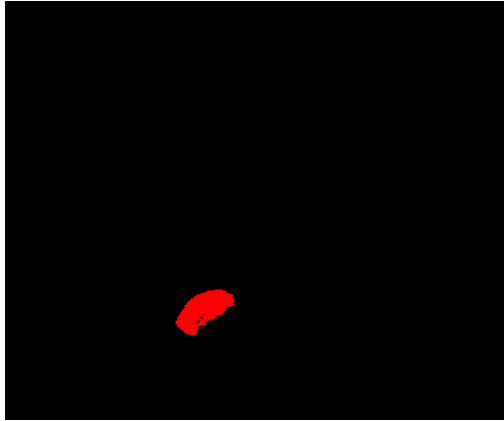


Fig. 13 image with morphological operation applied

Particle analysis is a function that is available to determine the area of tumour with its dimensions.

The radiologist who is adept at identifying tumors, edema and contents of the brain, it is not necessary to select the tumors exactly to the boundaries[11]. Thus rectangles selecting the most part of it are sufficient to generate an approximate reference. The created template is automatically loaded into the script. The entire image is selected and compared it with the template. Parameter settings are made as;

- Saturation threshold - 90°c
- Color sensitivity – high
- Minimum match score – 750

If the match score is below the minimum value, a result fail will be displayed which implies tumor is malignant. A score above the specified minimum match score would yield a pass which implies that tumor is benign as shown in figure 13. above.

A performance meter displays the time to execute the whole script. The script is generally written in vision assistant and its corresponding VI in Lab VIEW designed is shown in figure 15 below.

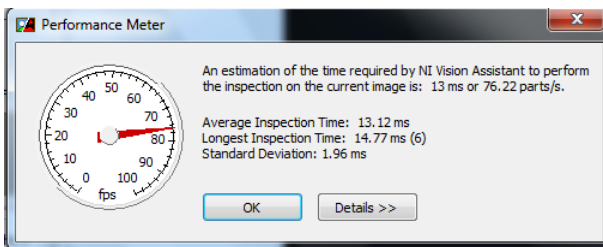


Fig 15. Performance meter

The VI created to implement the above operations is depicted figure 16.

V. EXPERIMENTAL RESULTS

The VI program has been applied on 22 images of tumors of various kinds. The experimental results show that the script developed on MRI scans of tumor was clearly identifying whether tumor is malignant or benign. Successful results were obtained where in the radiologist could diagnose the nature of tumor just by using the scans without a pathology test.

Table 1 below shows the results of images that were diagnosed and Table 2 give the statistics of the method.

S.no	Image Name	Score	Pass/fail	Diagnosis	Status
1	1b	970	Pass	Benign	Confirmed
2	2b	995	Pass	Benign	Confirmed
3	3b	980	Pass	Benign	Confirmed
4	4b	998	Pass	Benign	Confirmed
5	5b	994	Pass	Benign	Confirmed
6	6b	969	Pass	Benign	Confirmed
7	1m	279	Fail	Malignant	Confirmed
8	2m	171	Fail	Malignant	Confirmed
9	Sec00	906	Pass	Benign	Confirmed
10	Sec00	451	Fail	Malignant	Confirmed
11	Sec05	419	Fail	Malignant	Confirmed
12	Sec30(2)	968	Pass	Benign	Confirmed
13	Sec41	342	Fail	Malignant	Confirmed
14	Sec45	999	Pass	Benign	Confirmed
15	Sec47	439	Fail	Malignant	Confirmed
16	Sec55	836	Pass	Benign	Confirmed
17	Sec59	720	Fail	Malignant	Confirmed
18	Sec07	867	Pass	Benign	Misdiagnosed
19	Sec19	429	Fail	Malignant	Confirmed
20	Sec39	557	Fail	Malignant	Confirmed
21	Sec48	916	Pass	Benign	Misdiagnosed
22	Sec50	548	Fail	Malignant	Misdiagnosed
		Maximum match score : 750 Sensitivity : High Saturation threshold : 90			

Table 1: Results

NO OF IDENTIFIED TUMOURS	Correctly identified	Misdiagnosed
Number	19	3
Percentage (%)	86.36	13.64

Table 2: Success rate

Acquired image, gray scale converted images, threshold image are shown in figures above and segmented output image are shown in figure 18.

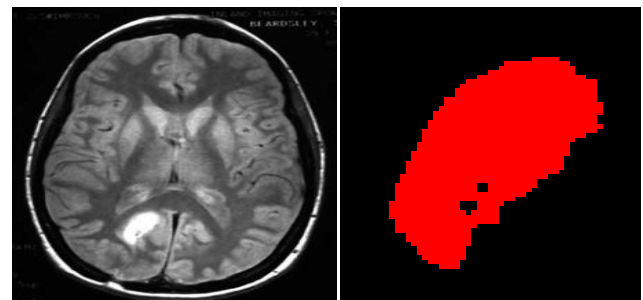


Fig. 17 segmented output image

VI. CONCLUSION

The work mainly concentrates on developing dedicated VI was developed to detect the tumors of malignant or benign[12]. It is observed that script has 86.36% success rate. Script is successful for the tumors whose bodies are clearly visible in the scans with the exception of certain meningiomata, which are benign tumors but cause edema and certain low grade malignant tumors or metastasized tumors which do not produce much edema. With improvement of the software and an understanding of scans that are suitable for this analysis, the success rate of the method can be improved by a good measure.

As the initial script is successful, it can be improved to device a method to boost the success rate to higher percentage to the best possible by taking the technical limitations into consideration.

The advantage of implementing this method reduces the manual labor involved in performing a biopsy to obtain the tumor sample and analyzing it in pathology lab.

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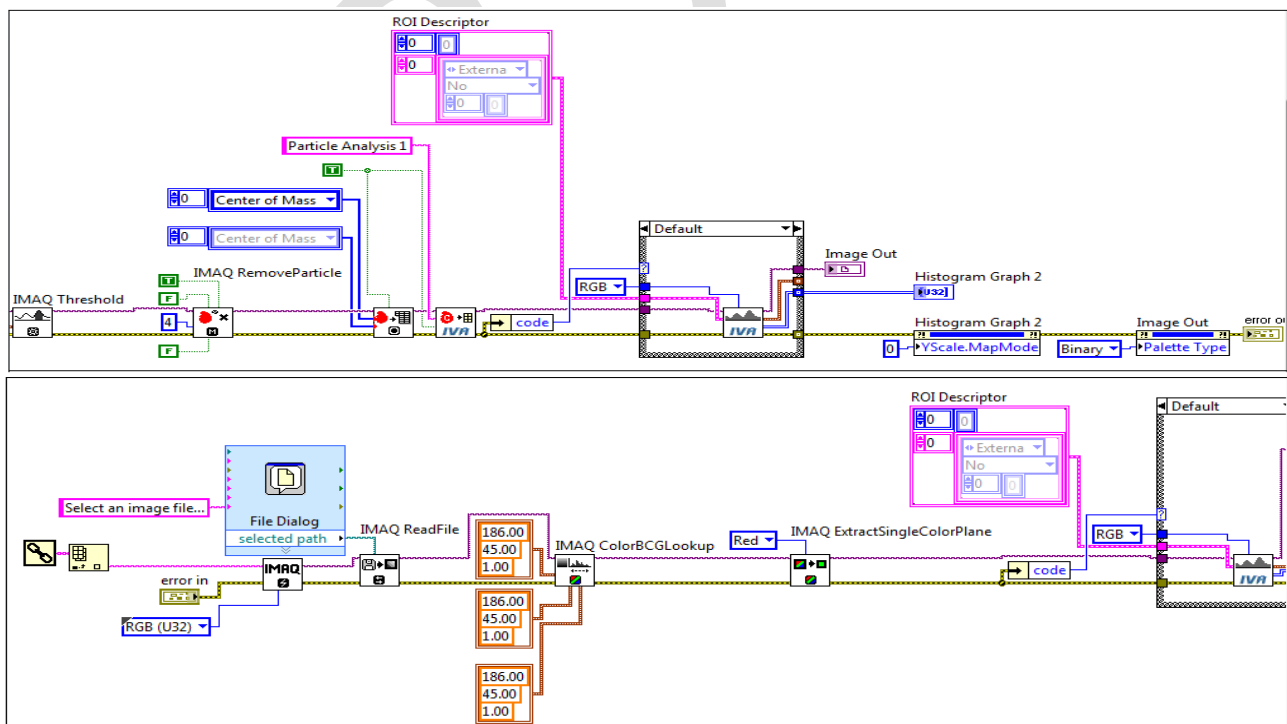


Fig 16. Virtual instrumentation created for tumor detection