EAST WEST UNIVERSITY

Developing a GUI using MATLAB in detecting brain stroke from ultrasonic data.

A Project Submitted
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DECLARATION

This is to certify that this Project is our original work. No part of this work has been submitted elsewhere partially or fully for the award of any other degree or diploma. Any material reproduced in this project has been properly acknowledged.

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Acceptance

We hereby declare that this thesis is from the student's own work and best effort of us, and all other source of information used have been acknowledge. This thesis has been submitted with our approval.

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TABLE OF CONTENTS

Chapter 4: Brain stroke risk assessment

Chapter 5: GUI design and implementation

Chapter 6: Discussion & Conclusion

LIST OF FIGURES

ABSTRACT

Brain is the main part of our body and brain stroke is severe in this day. In this research, we have implemented a method and design a graphical user interface (GUI) using MATLAB in detecting brain stroke from ultrasonic data. The ultrasonic data is chosen as it is not harmful as Magnetic Resonance Imaging (MRI). As it is known to us that carotid artery is the main path to flow the blood from heart to brain in our body. So the shrink of the wall of carotid artery through fat, cholesterol etc. is cause to change the normal level of ultrasonic velocity. In determining brain stroke through ultrasound knowledge, it is compulsory to acquire Doppler ultrasonic data from carotid artery. First, the ultrasonic displacement data obtained from the carotid artery is converted to velocity, and then the velocity data of several patients is loaded in the GUI which is developed through MATLAB. The loaded data will be accumulated in a folder. The standard velocity for the normal, abnormal and serious patients is then compared with the obtained patient ultrasonic velocity data through the GUI designed for this research. From the comparison it is possible to determine the patient's condition whether he/she has the probability of brain stroke or not. The results show better than other methods and it is less harmful for the body.

Chapter 1
INTRODUCTION

1.1 Introduction:

Medical ultrasound (also known as diagnostic sonography or ultrasonography) is a diagnostic imaging technique based on the application of ultrasound. It is used to see internal body structures such as tendons, muscles, joints, vessels and internal organs. Its aim is often to find a source of a disease or to exclude any pathology. The practice of examining pregnant women using ultrasound is called obstetric ultrasound, and is widely used. The use of ultrasound in medicine began during and shortly after the 2nd World War in various centers around the world. The work of Dr. Karl Theodore Dussik in Austria in 1942 on transmission ultrasound investigation of the brain provides the first published work on medical ultrasonic. Another use of ultrasound is blood flow measurement in Internal Carotid Artery (ICA), Common Carotid Artery (CCA), blood flow in atrium & ventricle of heart.

1.2 Introduction of the project

Our goal was to make a Graphical User Interfacing to give precise value for any user to assess the brain stroke condition for any patient. We made the GUI on the basis of comparing the blood flow measurement by using Doppler Ultrasound data with the standard blood flow in a healthy human body.

1.3 Project Management:

Chapter 1:
In this chapter we give a brief about this project.
Chapter 2:
In this chapter there is brief information about the medical ultrasound.
Chapter 3:
In this chapter there is brief information about the cause of brain stoke, syndrome and complication after brain stroke.
Chapter 4:
This chapter explain about the blood flow measurement by Doppler ultrasound & assessment by comparing with the
Chapter 5: GUI designing & data handling.

Chapter 2
ULTRASOUND

2.1 Introduction:

Ultrasound is sound waves with frequencies higher than the upper audible limit of human hearing. Ultrasound is no different from 'normal' (audible) sound in its physical properties, except in that humans cannot hear it. This limit varies from person to person and is approximately 20 kilohertz (20,000 hertz) in healthy, young adults.

2.2 Ultrasound operation:

Ultrasound devices operate with frequencies from 20 kHz up to several gigahertz. Ultrasound is used in many different fields. Ultrasonic devices are used to detect objects and measure distances. Ultrasound imaging or sonography is often used in medicine. In the nondestructive testing of products and structures, ultrasound is used to detect invisible flaws. Industrially, ultrasound is used for cleaning, mixing, and to accelerate chemical processes. Animals such as bats and porpoises use ultrasound for locating prey and obstacles. Scientists are also studying ultrasound using graphic diaphragms as a method of communication. [1]

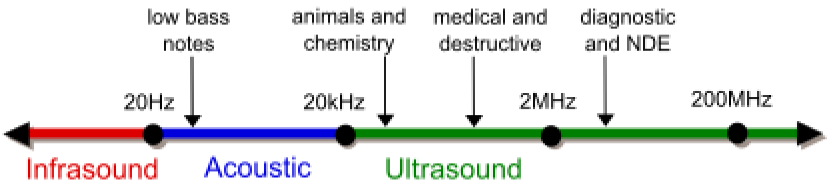

Figure 2.1: Range of Ultrasound.

Many different types of images can be formed using sonographic instruments. The most well-known type is a B-mode image, which displays the acoustic impedance of a two-dimensional cross-section of tissue. Other types of image can display blood flow, motion of tissue over time, the location of blood, the presence of specific molecules, the stiffness of tissue, or the anatomy of a three-dimensional region.

2.3 Detection and Imaging:

2.3.1 Non-contact sensor:

An ultrasonic level or sensing system requires no contact with the target. For many processes in the medical, pharmaceutical, military and general industries this is an advantage over inline sensors that may contaminate the liquids inside a vessel or tube or that may be clogged by the product. Both continuous wave and pulsed systems are used. The principle behind a pulsed-ultrasonic technology is that the transmit signal consists of short bursts of ultrasonic energy. After each burst, the electronics looks for a return signal within a small window of time corresponding to the time it takes for the energy to pass through the vessel. Only a signal received during this window will qualify for additional signal processing. A popular consumer application of ultrasonic ranging was the Polaroid SX-70 camera which included a light-weight transducer system to focus the camera automatically. Polaroid later licensed this ultrasound technology and it became the basis of a variety of ultrasonic products.[1]

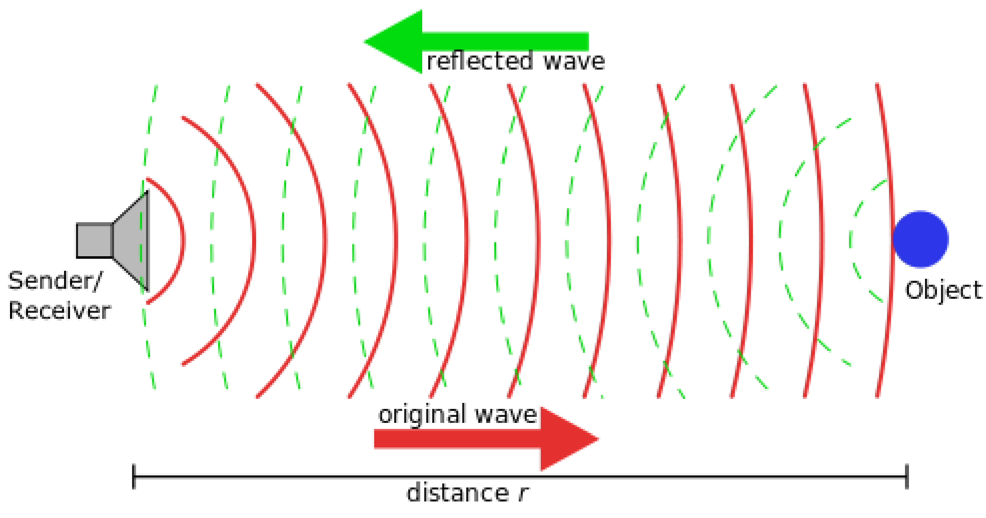

Figure 2.2: Signal path for non-contact sensor:

2.3.2 Motion sensors and flow measurement:

A common ultrasound application is an automatic door opener, where an ultrasonic sensor detects a person's approach and opens the door. Ultrasonic sensors are also used to detect intruders; the ultrasound can cover a wide area from a single point. The flow in pipes or open channels can be measured by ultrasonic flowmeters, which measure the average velocity of flowing liquid. In rheology, an acoustic rheometer relies on the principle of ultrasound. In fluid mechanics, fluid flow can be measured using an ultrasonic flow meter.[2]

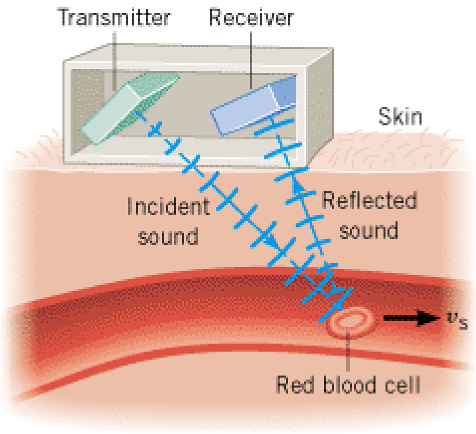

Figure 2.3: Blood flow measurement using ultrasound.

2.3.3 Imaging:

The potential for ultrasonic imaging of objects, with a 3 GHZ sound wave producing resolution comparable to an optical image, was recognized by Sokolov in 1939 but techniques of the time produced relatively low-contrast images with poor sensitivity. Ultrasonic imaging uses frequencies of 2 megahertz and higher; the shorter wavelength allows resolution of small internal details in structures and tissues. The power density is generally less than 1 watt per square centimeter, to avoid heating and cavitation effects in the object under examination. High and ultra high ultrasound waves are used in acoustic microscopy, with frequencies up to 4 gigahertz. Ultrasonic imaging applications include industrial non-destructive testing, quality control and medical uses.

Medical sonography (ultrasonography) is an ultrasound-based diagnostic medical imaging technique used to visualize muscles, tendons, and many internal organs, to capture their size, structure and any pathological lesions with real time tomographic images. Many different types of images can be formed using sonographic instruments. The most well-known type is a B-mode image, which displays the acoustic impedance of a two-dimensional cross-section of tissue. Other types of image can display blood flow, motion of tissue over time, the location of blood, the presence of specific molecules, the stiffness of tissue, or the anatomy of a three-dimensional region. Ultrasound has been used by radiologists and sonographers to image the human body for at least 50 years and has become a widely used diagnostic tool. The technology is relatively inexpensive and portable, especially when compared with other techniques, such as magnetic resonance imaging (MRI) and computed tomography (CT). Ultrasound is also used to visualize fetuses during routine and emergency prenatal care. Such diagnostic applications used during pregnancy are referred to as obstetric sonography. As currently applied in the medical field, properly performed ultrasound poses no known risks to the patient. Sonography does not use ionizing radiation, and the power levels used for imaging are too low to cause adverse heating or pressure effects in tissue. Although the long-term effects due to ultrasound exposure at diagnostic intensity are still unknown, currently most doctors feel that the benefits to patients outweigh the risks. The ALARA (As Low as Reasonably Achievable) principle has been advocated for an ultrasound examination – that is, keeping the scanning time and power settings as low as possible but consistent with diagnostic imaging – and that by that principle non-medical uses, which by definition are not necessary, are actively discouraged. Ultrasound is also increasingly being used in trauma and first aid cases, with emergency ultrasound becoming a staple of most EMT response teams. Furthermore, ultrasound is used in remote diagnosis cases where teleconsultation is required, such as scientific experiments in space or mobile sports team diagnosis. According to RadiologyInfo, ultrasounds are useful in the detection of pelvic abnormalities and can involve techniques known as abdominal (transabdominal) ultrasound, vaginal (transvaginal or endovaginal) ultrasound in women, and also rectal (transrectal) ultrasound in men. [3]

Figure 2.4: Obstetric sonogram of a fetus

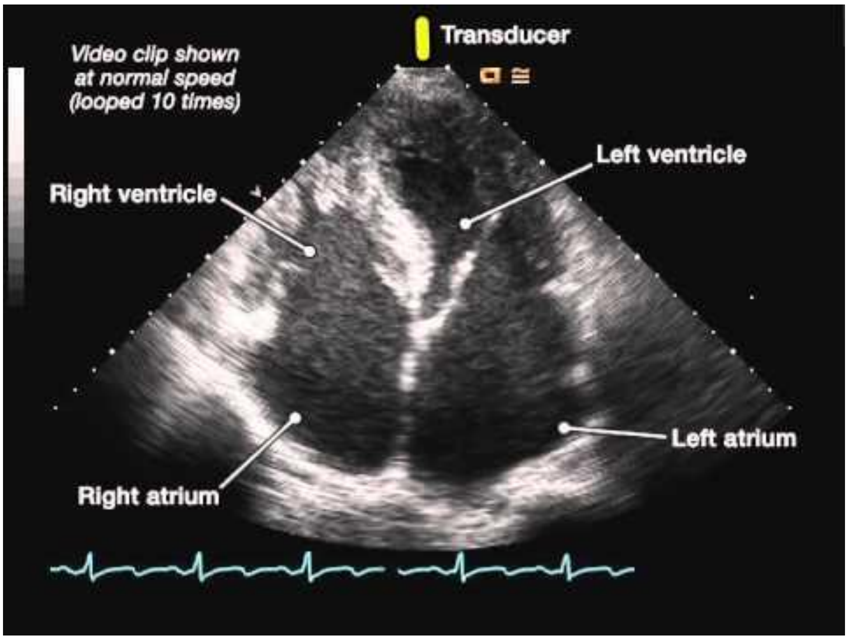

Figure 2.5: Echocardiogram

Chapter 3

Brain Stroke

3.1 Introduction:

A brain stroke occurs when the blood supply to the brain is interrupted or reduced. This deprives the brain of oxygen and nutrients, which can cause the brain cells to die. The way a stroke affects the brain depends on which part of the brain suffers damage, and to what degree.[4]

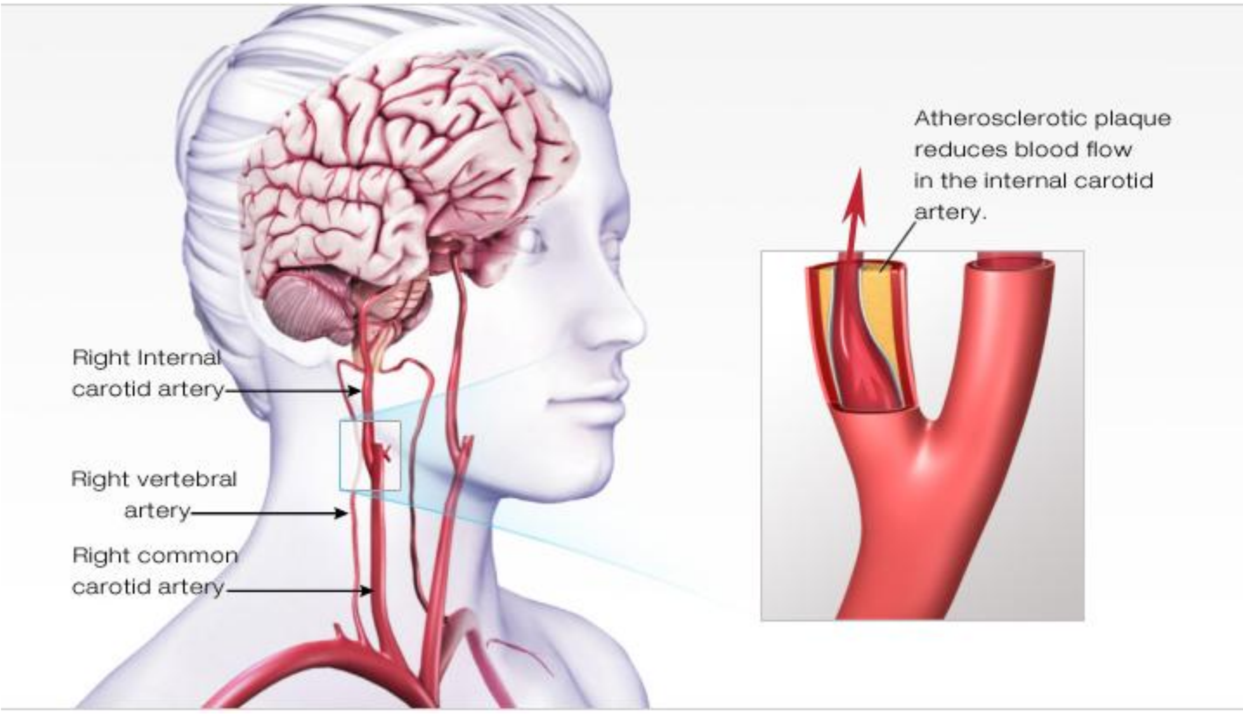

Figure 3.1: Brain Stroke

3.2 Classification of Brain Stroke:

A stroke may be caused by a blocked artery (ischemic stroke) or the leaking or bursting of a blood vessel (hemorrhagic stroke). Some people may experience only a temporary disruption of blood flow to their brain (transient ischemic attack, or TIA). [4]

3.3 Ischemic stroke:

About 85 percent of strokes are ischemic strokes. Ischemic strokes occur when the arteries to the brain become narrowed or blocked, causing severely reduced blood flow (ischemia). The most common ischemic strokes include:

- **3.3.1 Thrombotic stroke:** A thrombotic stroke occurs when a blood clot (thrombus) forms in one of the arteries that supply blood to the brain. A clot may be caused by fatty deposits (plaque) that build up in arteries and cause reduced blood flow (atherosclerosis) or other artery conditions.
- **3.3.2 Embolic stroke:** An embolic stroke occurs when a blood clot or other debris forms away from thr brain — commonly in the heart — and is swept through the bloodstream to lodge in narrower brain arteries. This type of blood clot is called an embolus.

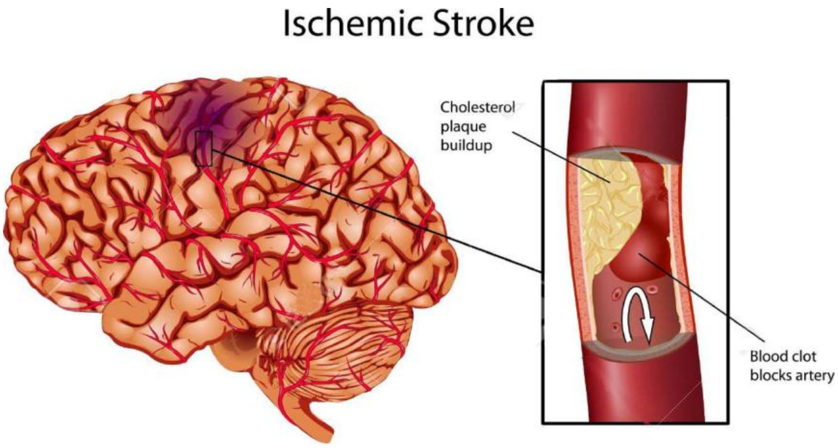

Figure 3.2: Ischemic stroke.

3.4 Hemorrhagic stroke:

Hemorrhagic stroke occurs when a blood vessel in the brain leaks or ruptures. Brain hemorrhages can result from many conditions that affect the blood vessels, including uncontrolled high blood pressure (hypertension), overtreatment with anticoagulants and weak spots in the blood vessel walls (aneurysms). [4] Types of hemorrhagic stroke include

- **3.4.1 Intracerebral hemorrhage:** In an intracerebral hemorrhage, a blood vessel in the brain bursts and spills into the surrounding brain tissue, damaging brain cells. Brain cells beyond the leak are deprived of blood and also damaged. High blood pressure, trauma, vascular malformations, use of blood-thinning medications and other conditions may cause an intracerebral hemorrhage.
- **3.4.2 Subarachnoid hemorrhage:** In a subarachnoid hemorrhage, an artery on or near the surface of the brain bursts and spills into the space between the surface of your brain and the skull. This bleeding is often signaled by a sudden, severe headache. A subarachnoid hemorrhage is commonly caused by the bursting of a small sack-shaped or berry-shaped outpunching on an artery known as an aneurysm. After the hemorrhage, the blood vessels in the brain may widen and narrow erratically (vasospasm), causing brain cell damage by further limiting blood flow.

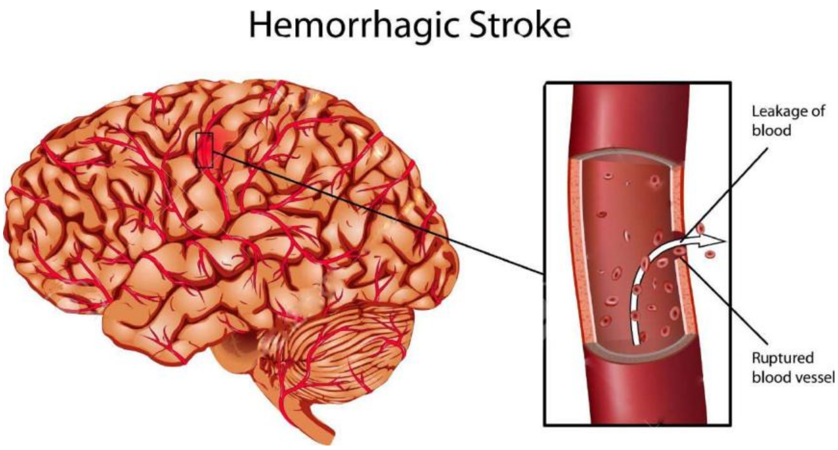

Figure 3.3: Hemorrhagic stroke.

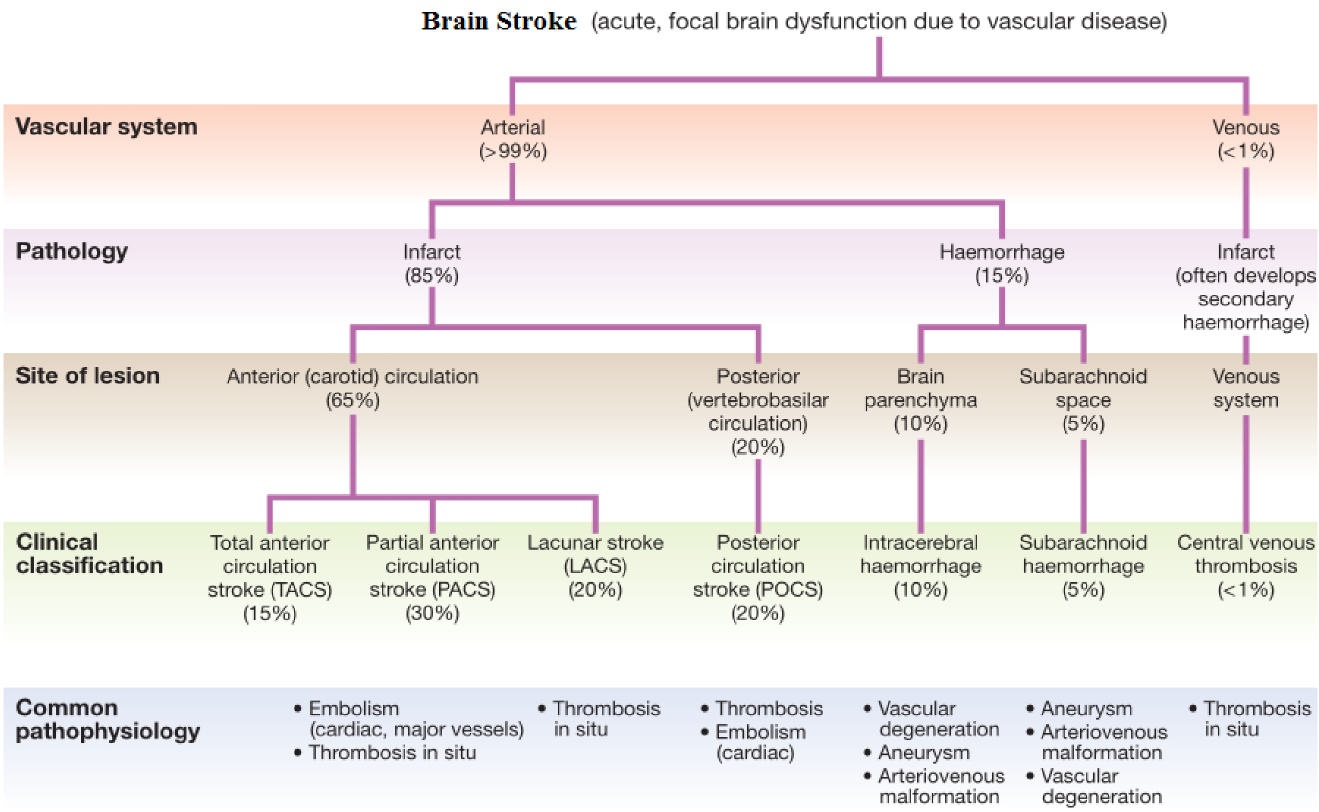

Figure 3.4: Classification of Brain Stroke.

3.5 Symptoms:

These signs and symptoms when someone else may be having a stroke. Note should be taken when the signs and symptoms begin, because the length of time they have been present may guide the treatment decisions:

- Trouble with speaking and understanding: The person may experience confusion. He/she may slur his/her words or have difficulty understanding speech.
- Paralysis or numbness of the face, arm or leg: The person may develop sudden numbness, weakness or paralysis in his/her face, arm or leg, especially on one side of his/her body. Try to raise both his/her arms over your head at the same time. If one arm begins to fall, he/she may be having a stroke. Similarly, one side of his/her mouth may droop when he/she try to smile.
- Trouble with seeing in one or both eyes: The person may suddenly have blurred or blackened vision in one or both eye, or he/she may see double.
- Headache: A sudden, severe headache, which may be accompanied by vomiting, dizziness or altered consciousness, may indicate he/she is having a stroke.
- Trouble with walking: The person may stumble or experience sudden dizziness, loss of balance or loss of coordination.[5]

3.6 Risk factors:

Many factors can increase your risk of a stroke. Some factors can also increase your chances of having a heart attack. Potentially treatable stroke risk factors include:

3.6.1 Lifestyle risk factors:

- Being overweight or obese
- Physical inactivity
- Heavy or binge drinking
- Use of illicit drugs such as cocaine and methamphetamines

3.6.2 Medical risk factors:

- High blood pressure — the risk of stroke begins to increase at blood pressure readings higher than 120/80 millimeters of mercury (mm Hg). Doctor will help to decide on a target blood pressure based on age, whether having diabetes and other factors.
- Cigarette smoking or exposure to secondhand smoke.
- High cholesterol.
- Diabetes.
- Obstructive sleep apnea — a sleep disorder in which the oxygen level intermittently drops during the night.
- Cardiovascular disease, including heart failure, heart defects, heart infection or abnormal heart rhythm.

Other factors associated with a higher risk of stroke include:

- Personal or family history of stroke, heart attack or transient ischemic attack.
- Being age 55 or older.
- Race — African-Americans have a higher risk of stroke than do people of other races.
- Gender — Men have a higher risk of stroke than women. Women are usually older when they have strokes, and they're more likely to die of strokes than are men. Also, they may have some risk from some birth control pills or hormone therapies that include estrogen, as well as from pregnancy and childbirth. .[5]

3.7 Complications:

A stroke can sometimes cause temporary or permanent disabilities, depending on how long the brain lacks blood flow and which part was affected. Complications may include:

- **Paralysis or loss of muscle movement:** You may become paralyzed on one side of the body, or lose control of certain muscles, such as those on one side of the face or one arm. Physical therapy may help to return to activities hampered by paralysis, such as walking, eating and dressing.
- **Difficulty talking or swallowing:** A stroke may cause a person to have less control over the way the muscles in your mouth and throat move, making it difficult for you to talk clearly, swallow or eat. He/she also may have difficulty with language, including speaking or understanding speech, reading or writing. Therapy with a speech and language pathologist may help.

- **Memory loss or thinking difficulties:** Many people who have had strokes experience some memory loss. Others may have difficulty thinking, making judgments, reasoning and understanding concepts.
- **Emotional problems:** People who have had strokes may have more difficulty controlling their emotions, or they may develop depression.
- **Pain:** People who have had strokes may have pain, numbness or other strange sensations in parts of their bodies affected by stroke. For example, if a stroke causes a person to lose feeling in your left arm, the person may develop an uncomfortable tingling sensation in that arm. .[5]

People also may be sensitive to temperature changes, especially extreme cold after a stroke. This complication is known as central stroke pain or central pain syndrome. This condition generally develops several weeks after a stroke, and it may improve over time. But because the pain is caused by a problem in the brain, rather than a physical injury, there are few treatments.

Changes in behavior and self-care ability. People who have had strokes may become more withdrawn and less social or more impulsive. They may need help with grooming and daily chores.

As with any brain injury, the success of treating these complications will vary from person to person.

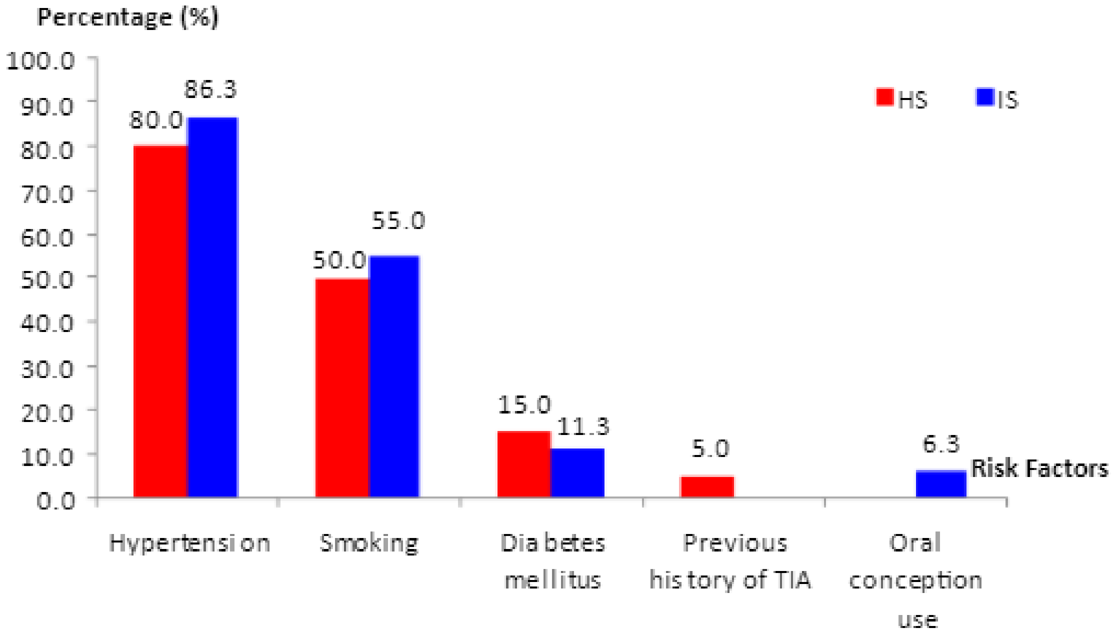

Figure 3.5: The risk factors associated with Ischemic (IS) and Hemorrhagic strokes (HS)

Chapter 4

Brain stroke risk assessment

4.1 Introduction:

We can assess the brain stroke by measuring the blood flow in Internal Carotid Artery (ICA) & Common Carotid Artery (CCA) and comparing with the standard blood flow in a healthy body. We can accurate the value by taking multiple value for each ICA & CCA.

4.2 Conventional Methods:

4.2.1 Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging (MRI) is a medical imaging technique used in radiology to form pictures of the anatomy and the physiological processes of the body in both health and disease. MRI scanners use strong magnetic fields, radio waves, and field gradients to generate images of the organs in the body. MRI does not involve x-rays, which distinguishes it from computed tomography (CT or CAT).

While the hazards of x-rays are now well-controlled in most medical contexts, MRI still may be seen as superior to CT in this regard. MRI is widely used in hospitals and clinics for medical diagnosis, staging of disease and follow-up without exposing the body to ionizing radiation. MRI often may yield different diagnostic information compared with CT. There may be risks and discomfort associated with MRI scans. Compared with CT, MRI scans typically take greater time, are louder, and usually require that the subject go into a narrow, confined tube. In addition, people with some medical implants or other non-removable metal inside the body may be unable to undergo an MRI examination safely.[6]

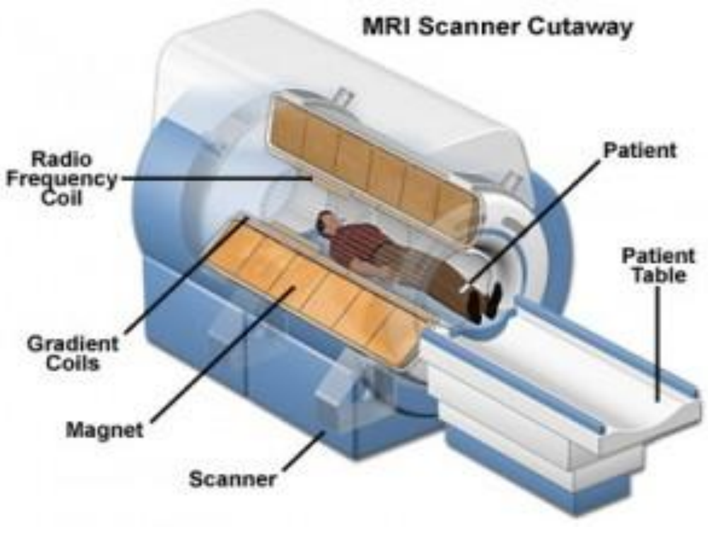

Figure 4.1: MRI

4.2.2 Computer Tomography (CT) Scan

A CT scan makes use of computer-processed combinations of many X-ray measurements taken from different angles to produce cross-sectional (tomographic) images (virtual "slices") of specific areas of a scanned object, allowing the user to see inside the object without cutting. Other terms include computed axial tomography (CAT scan) and computer aided tomography.

Digital geometry processing is used to further generate a three-dimensional volume of the inside of the object from a large series of two-dimensional radiographic images taken around a single axis of rotation.[2] Medical imaging is the most common application of X-ray CT. Its cross-sectional images are used for diagnostic and therapeutic purposes in various medical disciplines.[3] The rest of this article discusses medical-imaging X-ray CT.[6]

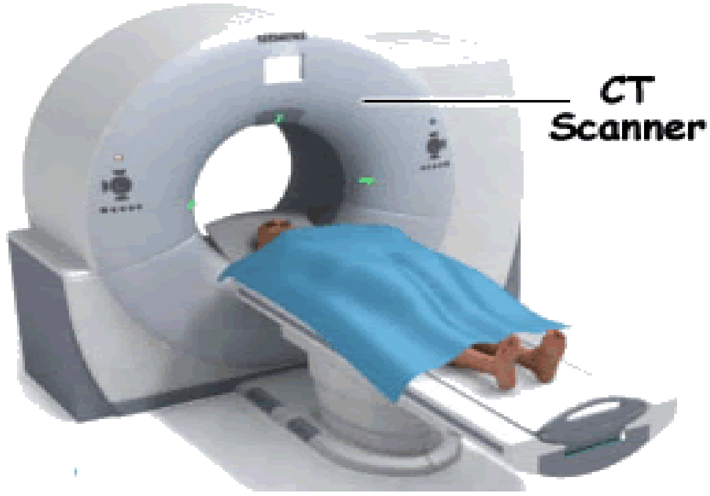

Figure 4.2: CT Scan

4.2.3 Limitations of conventional Methods:

- High Intensity Radiation (Harmful for Body)
- Causes severe disease (Soft tissue)
- Reasons of body emollition (Presence of Radioactive element)
- Multiple MRI or SPET can be effect of long run cancer
- Very costly

4.3 Doppler Ultrasound:

A Doppler ultrasound test uses reflected sound waves to see how blood flows through a blood vessel. It helps doctors assess the blood flow through major arteries and veins, such as those of the arms, legs, and neck. It can show blocked or reduced flow of blood through narrow areas in the major arteries of the neck. This problem could cause a stroke camera.gif. The test also can find blood clots in leg veins (deep vein thrombosis, or DVT) that could break loose and block blood flow camera.gif to the lungs. This problem is called a pulmonary embolism. During pregnancy, Doppler ultrasound may be used to look at blood flow in an unborn baby to check the baby's health.

During Doppler ultrasound camera.gif, a handheld device is passed lightly over the skin above a blood vessel. The device is called a transducer. It sends and receives sound waves that are amplified through a microphone. The sound waves bounce off solid objects, including blood cells. The movement of blood cells causes a change in the pitch of the reflected sound waves. This is called the Doppler effect. If there is no blood flow, the pitch does not change.[7]

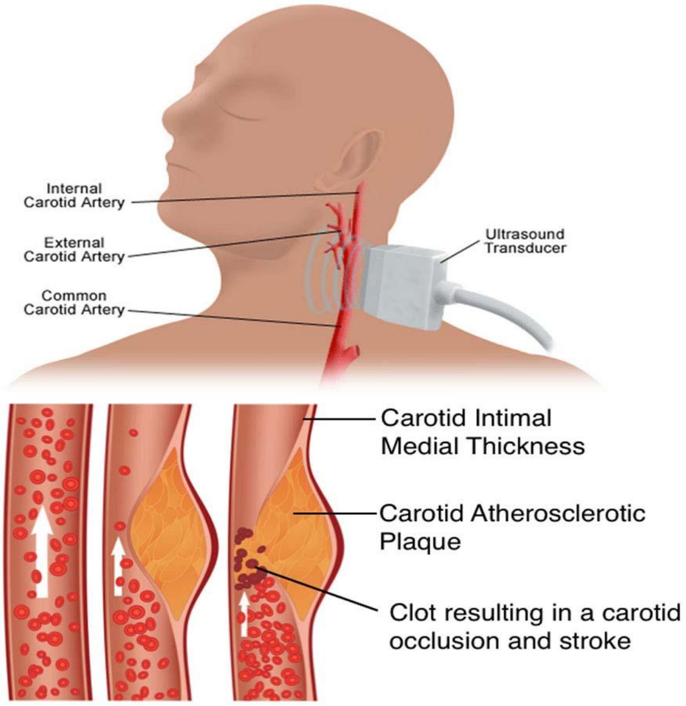

Figure 4.3: Doppler ultrasound in Carotid Artery.

4.3.1 Doppler ultrasound is done to:

- Find blood clots and blocked or narrowed blood vessels in almost any part of the body. It's most often used for the neck, arms, and legs.
- Check leg pain that may be caused by intermittent claudication. This is a condition caused by atherosclerosis of the lower limbs.
- Assess blood flow after a stroke or other condition that might be caused by a problem with blood flow. After a stroke, this can be done with a test called transcranial Doppler (TCD) ultrasound.
- Check for varicose veins or other vein problems.
- Map veins that may be used for blood vessel grafts. It also can look at the health of grafts used to bypass blockage in an arm or leg.

- Find out the amount of blood flow to a transplanted kidney or liver.
- Monitor the flow of blood after blood vessel surgery.
- Find the presence, amount, and location of arterial plaque. Plaque in the carotid arteries can reduce blood flow to the brain. This may increase the risk of stroke.
- Guide treatment such as laser or radiofrequency ablation of abnormal veins.
- Check the health of a fetus. It may check blood flow in the umbilical cord, through the placenta, or in the heart and brain of the fetus. This test can show if the fetus is getting enough oxygen and nutrients.[7]

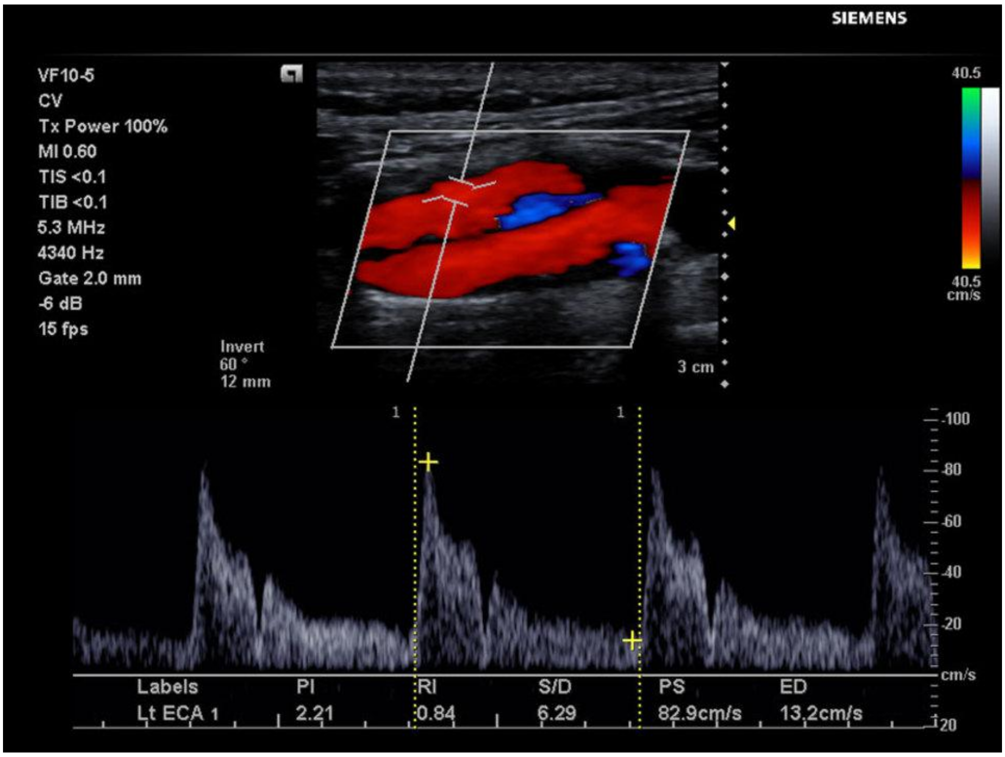

Figure 4.4: Doppler Ultrasound Imaging.

Carotid ultrasound is a test that shows the carotid arteries (vessels in the neck that provide blood flow to the brain), as well as how much blood flows and how fast it travels through them. Ultrasound waves (the same ones used in imaging the fetus in a pregnant woman) are used to make an image of the arteries. This image can be used to find out if there is an abnormality or blockage of the carotid arteries that could lead to stroke. This test can be used to investigate the carotid arteries for several reasons, but the information here applies only to stroke evaluation.

4.3.2 Why do doctors use carotid ultrasound?

Doctors often use carotid ultrasound on patients who have had a stroke or who might be at high risk for a stroke. Narrowing of the carotid arteries (often caused by cholesterol deposits) and blood clots can be detected using this procedure. These conditions can cause problems with the blood flow to the brain and lead to a stroke. The actual blood flow through the carotid arteries can also be imaged by this test. [8]

4.3.3 What happens during carotid ultrasound?

A clear gel will place on the area of the neck where the carotid artery is located. The gel is simply a lubricant that allows the transducer (a device that both puts out and detects ultrasound signals) to slide around easily on your skin. When the transducer is placed against the skin, an image of the artery is shown on a video screen. To view the arteries from many different angles, your doctor will re-position the transducer several times. Because blood is flowing through the artery, a sound similar to your heartbeat will be heard.

The procedure is repeated for the carotid artery on the other side of the neck. A carotid ultrasound usually only takes 15 to 30 minutes to complete and the results are immediately known by your doctor. [8]

4.3.4 What are the risks of carotid ultrasound?

Since the procedure is done without entering the body and does not use dyes or x-rays, there is no risk or pain involved in having a carotid ultrasound. [8]

4.3.5 How does carotid ultrasound work?

The transducer emits high-frequency, ultrasound waves that pass into the body and bounce off the carotid arteries and the red blood cells moving through them. The sound waves are reflected differently by different parts of the body. The transducer detects the different reflections of the sound waves, which are then measured and converted by a computer into live pictures of the arteries and the blood flow. [8]

4.4 Blood flow measurement:

US equipment calculates the velocity of blood flow according to the Doppler equation:

$$\Delta f = \frac{2 f_0 V \cos\theta}{C}$$

Where,
Δf = is the Doppler shift frequency,
f_0 = is the transmitted ultrasound frequency,
V =is the velocity of reflectors (red blood cells),

θ =(theta, also referred to as the Doppler angle) is the angle between the transmitted beam and the direction of blood flow within the blood vessel (the reflector path),

C= is the speed of sound in the tissue (1540 m/sec).

Since the transmitted ultrasound frequency and the speed of sound in the tissue are assumed to be constant during the Doppler sampling, the Doppler shift frequency is directly proportional to the velocity of red blood cells and the cosine of the Doppler angle.

The angle θ affects the detected Doppler frequencies. At a Doppler angle of 0°, the maximum Doppler shift will be achieved since the cosine of 0° is 1. Conversely, no Doppler shift (no flow) will be recorded if the Doppler angle is 90° since the cosine of 90° is 0. The orientation of the carotid arteries may vary from one patient to another; therefore, the operator is required to align the Doppler angle parallel to the vector of blood flow by applying the angle correction or angling the transducer.

4.5 Doppler ultrasound Result For Carotid Artery:

Normal:

The test does not show significant narrowing or other problems in any of the arteries.

Abnormal:

- There is no sign of a clot in any of the veins examined. The size and position of veins are normal.
- For continuous wave Doppler or duplex Doppler, differences in blood flow between the right and left sides of the body may be heard. At the exact spot where an artery is blocked or narrowed, the sound may be high-pitched or turbulent. Blockage (such as from a blood clot), an aneurysm, or narrowing of a blood vessel may be found. The speed of blood flow may be compared to standard values to find out how blocked or narrow the blood vessel is.
- A duplex Doppler ultrasound graph may show blood flow that isn't normal. This is a sign of a blocked or narrowed blood vessel.
- A color Doppler image may show a blocked or narrowed blood vessel or an aneurysm.
- In the veins, a blood clot may be present if blood flow does not change in response to breathing or does not increase after either a compression maneuver or Valsalva maneuver. Incomplete blockage of a vein by a blood clot may be seen on color Doppler or during a compression maneuver.[9]

4.6 Stroke measurement:

Ultrasound assessment of carotid arterial atherosclerotic disease has become the first choice for carotid artery stenosis screening, permitting the evaluation of both the macroscopic appearance of plaques as well as flow characteristics in the carotid artery.

This consensus developed recommendations for the diagnosis and stratification of ICA stenosis.

[PSV = peak systolic velocity; EDV = end diastolic velocity; ICA = internal carotid artery; CCA = common carotid artery]

- **normal:**
  - ICA PSV is <125 cm/sec and no plaque or intimal thickening is visible sonographically
  - additional criteria include ICA/CCA PSV ratio <1.0 and ICA EDV <40 cm/sec
- **<50% ICA stenosis:**
  - ICA PSV is <125 cm/sec and plaque or intimal thickening is visible sonographically
  - additional criteria include ICA/CCA PSV ratio <2.0 and ICA EDV <40 cm/sec
- **50-69% ICA stenosis:**
  - ICA PSV is 125-230 cm/sec and plaque is visible sonographically
  - additional criteria include ICA/CCA PSV ratio of 2.0-4.0 and ICA EDV of 40-100 cm/sec
- **≥70% ICA stenosis but less than near occlusion:**
  - ICA PSV is >230 cm/sec and visible plaque and luminal narrowing are seen at gray-scale and color Doppler ultrasound (the higher the Doppler parameters lie above the threshold of 230 cm/sec, the greater the likelihood of severe disease)
  - additional criteria include ICA/CCA PSV ratio >4 and ICA EDV >100 cm/sec
- **near occlusion of the ICA:**
  - velocity parameters may not apply, since velocities may be high, low, or undetectable
  - diagnosis is established primarily by demonstrating a markedly narrowed lumen at colour or power Doppler ultrasound
- **total occlusion of the ICA:**
  - no detectable patent lumen at gray-scale US and no flow with spectral, power, and colour Doppler ultrasound
  - there may be compensatory increased velocity in the contra lateral carotid

4.7 Stroke measurement parameter:

	Primary Parameter				Additional Parameter
	ICA Peak Systolic Velocity (cm/sec)	**CCA Peak Systolic Velocity (cm/sec)**	**Degree of Plaque %**	**Peak Systolic Velocity Ratio (ICA/CCA)**	**ICA End Diastolic Velocity (cm/sec)**
(Normal)	<125cm/s	81 ± 22 cm/sec	None	<1.0	<40cm/s
<50% (Mild)	<125cm/s	81 ± 22 cm/sec	<50%	<2.0	<40cm/s
50-69% (Moderate)	125-230cm/s	81 ± 22 cm/sec	50%	2.0-4.0	40-100cm/s
>70% (Severe)	>230cm/s	81 ± 22 cm/sec	>50%	>4.0	>100cm/s
80-99% (Critical)	Low or Not detectable	81 ± 22 cm/sec	Visible	Variable	>100
100% (Occlusion)	Not detectable		Visible, no lumen	N/A	N/A

Chapter 5

GUI design and implementation

5.1 Introduction:

The graphical user interface (GUI /gu:i:/), is a type of user interface that allows users to interact with electronic devices through graphical icons and visual indicators such as secondary notation, instead of text-based user interfaces, typed command labels or text navigation. GUIs were introduced in reaction to the perceived steep learning curve of command-line interfaces (CLIs) which require commands to be written. We used MATLAB to design our GUI.

5.2 Matlab:

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment. A proprietary programming language developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

5.3 Creating a MATLAB GUI with GUIDE:

GUIDE (GUI development environment) provides tools to design user interfaces for custom apps. Using the GUIDE Layout Editor, we can graphically design your User Interface (UI). GUIDE then automatically generates the MATLAB code for constructing the UI, which we can modify to program the behavior of our application.

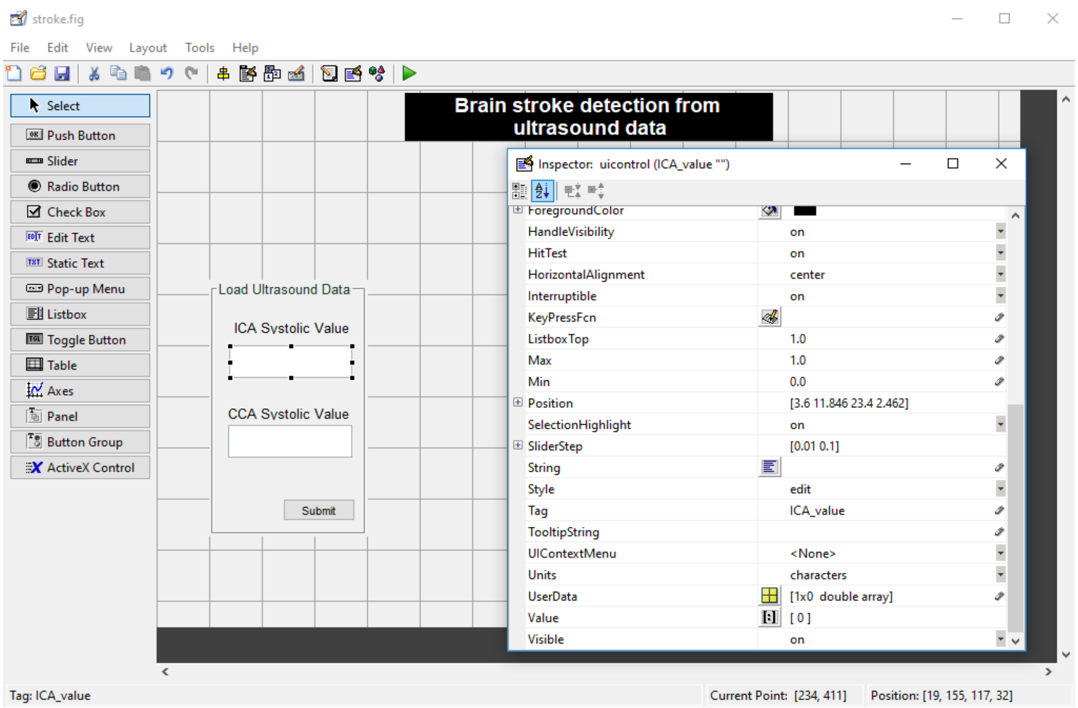

Figure 5.1: GUIDE

5.4 Designing GUI for the patient basic information:

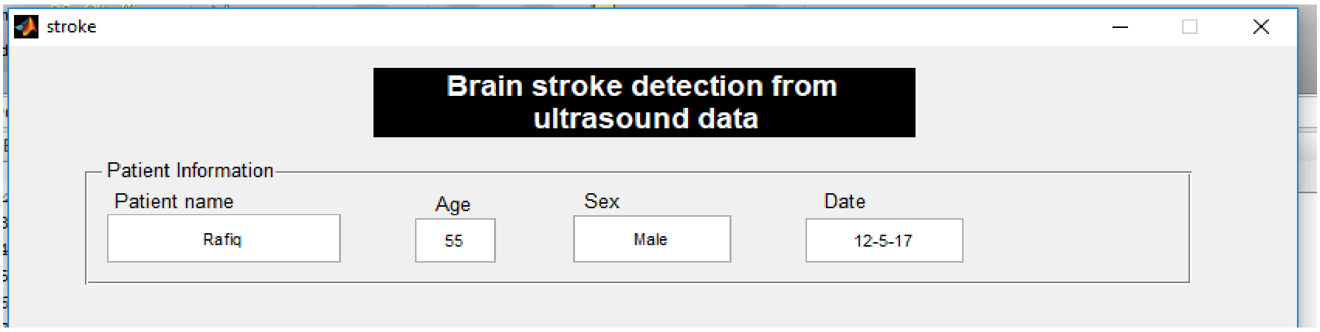

Figure 5.2: Patient Basic Information Box

5.5 Designing GUI for Loading ICA & CCA systolic velocity:

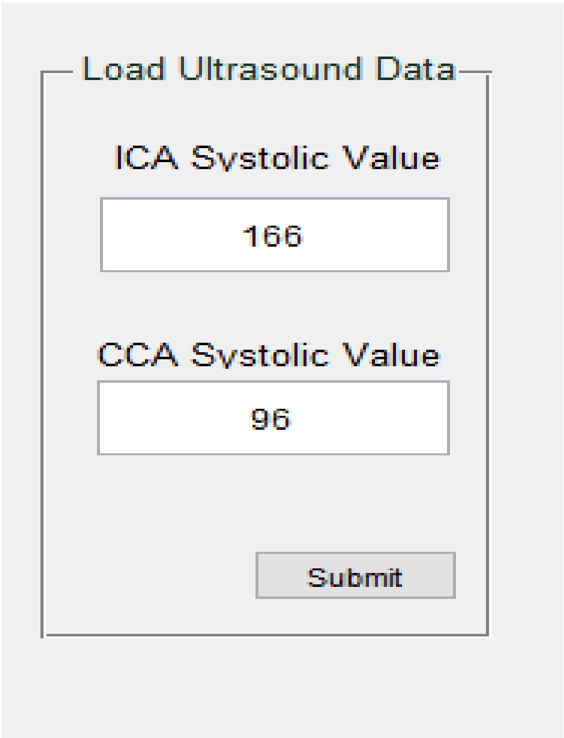

Figure 5.3: Loading ICA & CCA Systolic value

5.6 Calculating ICA/CCA value for deciding patient conditions comparing standard value using following GUI:

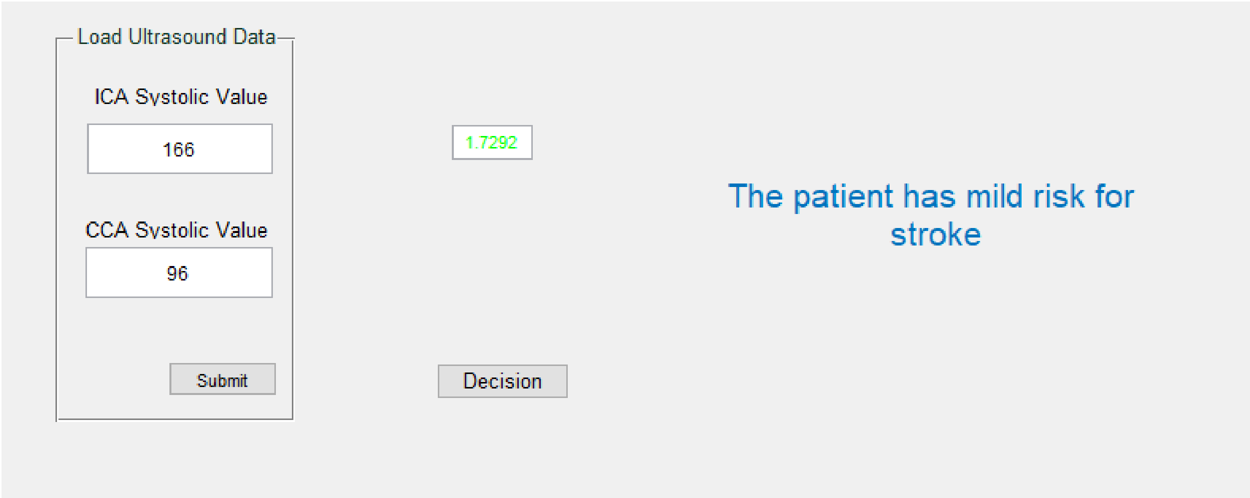

Figure 5.4: Calculating ICA/CCA ratio.

5.7 Complete scenario for detecting brain stroke using GUI

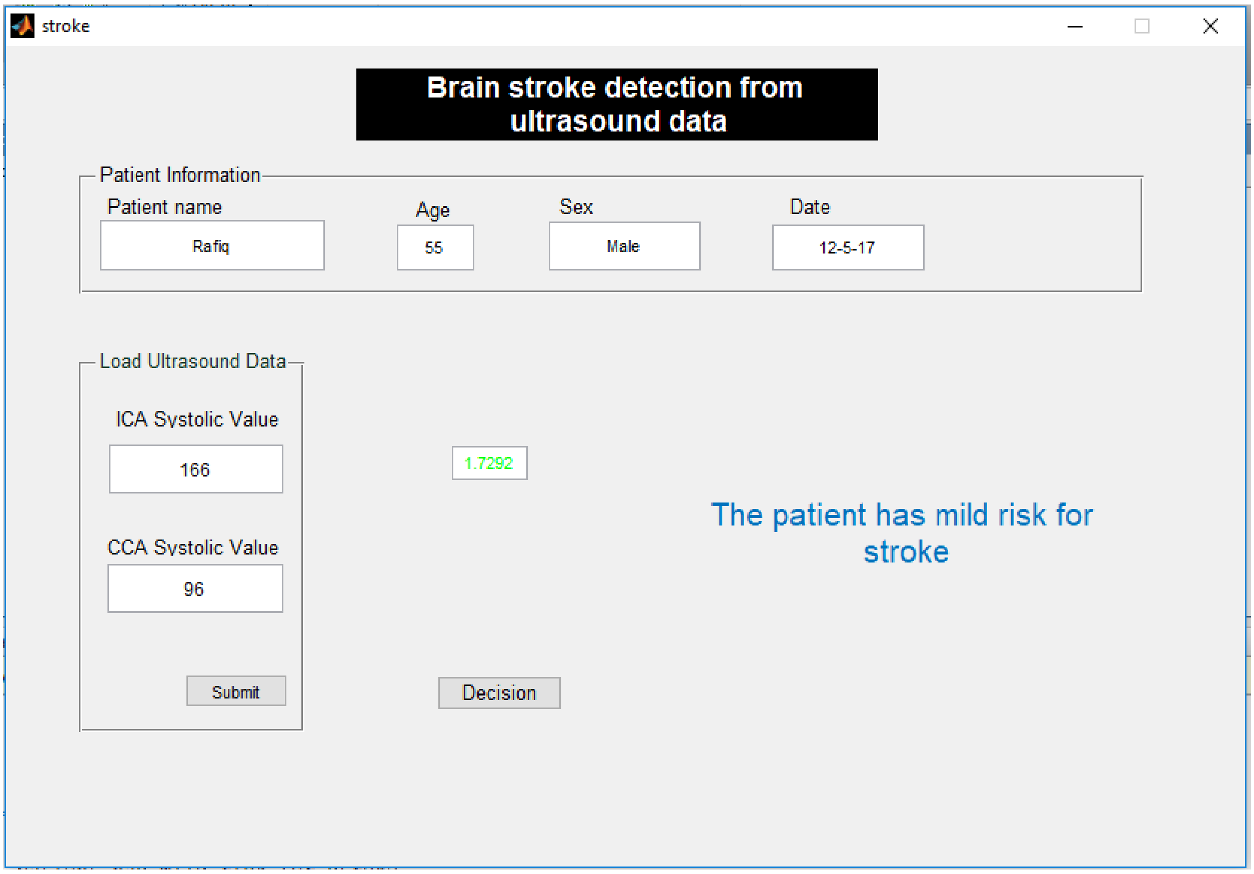

Figure 5.5: Complete GUI for brain stroke measurement.

Chapter 6

DISCUSSION & CONCLUSION

6.1 Discussion:

More than 6.2 million people dies every year from brain stroke. Stroke cases in Bangladesh have significantly increased in number over the past decades; adverse outcomes from thesecases are also rising due to the low number of neurologists and specialized hospitals in the country. Because stroke poses long-term economic impacts on individuals, families, and the country.

The use of ultrasound in biomedical sector was a revolutionary change. Doppler ultrasound is generally painless and do not require needles, injections, or incisions. Patients aren't exposed to ionizing radiation, making the procedure safer than diagnostic techniques such as X-rays and CT scans. In fact, there are no known harmful effects when used as directed by your health care provider. Ultrasound captures images of soft tissues that don't show up well on X-rays. Ultrasounds are widely accessible and less expensive than other methods.

Nowadays many doctors are using Doppler ultrasound to detect brain stroke condition. This project will give an additional advantage to such diagnostic. The GUI gives a visual inspection to the user such they could understand what the condition of the carotid artery to warn either the patient is in danger or out of danger. It could give advice what should they do for further.

6.2 Future Work:

- Creating a stroke community.
- Making a stroke patient database by the help of the stroke community.
- Create a help line for the community.

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Appendix

Code for the GUI designing in MATLAB

```
function varargout = stroke(varargin)
%STROKE M-file for stroke.fig
%      STROKE, by itself, creates a new STROKE or raises the existing
%      singleton*.
%
%      H = STROKE returns the handle to a new STROKE or the handle to
%      the existing singleton*.
%
%      STROKE('Property','Value',...) creates a new STROKE using the
%      given property value pairs. Unrecognized properties are passed via
%      varargin to stroke_OpeningFcn.  This calling syntax produces a
%      warning when there is an existing singleton*.
%
%      STROKE('CALLBACK') and STROKE('CALLBACK',hObject,...) call the
%      local function named CALLBACK in STROKE.M with the given input
%      arguments.
%
%      *See GUI Options on GUIDE's Tools menu.  Choose "GUI allows only one
%      instance to run (singleton)".
%
% See also: GUIDE, GUIDATA, GUIHANDLES

% Edit the above text to modify the response to help stroke

% Last Modified by GUIDE v2.5 21-Aug-2017 13:39:47

% Begin initialization code - DO NOT EDIT
gui_Singleton = 1;
gui_State = struct('gui_Name',       mfilename, ...
                   'gui_Singleton',  gui_Singleton, ...
                   'gui_OpeningFcn', @stroke_OpeningFcn, ...
                   'gui_OutputFcn',  @stroke_OutputFcn, ...
                   'gui_LayoutFcn',  [], ...
                   'gui_Callback',   []);
if nargin && ischar(varargin{1})
   gui_State.gui_Callback = str2func(varargin{1});
end

if nargout
    [varargout{1:nargout}] = gui_mainfcn(gui_State, varargin{:});
else
    gui_mainfcn(gui_State, varargin{:});
end
% End initialization code - DO NOT EDIT


% --- Executes just before stroke is made visible.
function stroke_OpeningFcn(hObject, eventdata, handles, varargin)
% This function has no output args, see OutputFcn.
% hObject    handle to figure
```

```
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
% varargin   unrecognized PropertyName/PropertyValue pairs from the
%            command line (see VARARGIN)

% Choose default command line output for stroke
handles.output = hObject;

% Update handles structure
guidata(hObject, handles);

% UIWAIT makes stroke wait for user response (see UIRESUME)
% uiwait(handles.figure1);


% --- Outputs from this function are returned to the command line.
function varargout = stroke_OutputFcn(hObject, eventdata, handles)
% varargout  cell array for returning output args (see VARARGOUT);
% hObject    handle to figure
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Get default command line output from handles structure
varargout{1} = handles.output;


% --- Executes on button press in Decision.
function Decision_Callback(hObject, eventdata, handles)
% hObject    handle to Decision (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hint: get(hObject,'Value') returns toggle state of Decision



function edit2_Callback(hObject, eventdata, handles)
% hObject    handle to edit2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit2 as text
%        str2double(get(hObject,'String')) returns contents of edit2 as a double


% --- Executes during object creation, after setting all properties.
function edit2_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit2 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
```

```
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function edit3_Callback(hObject, eventdata, handles)
% hObject    handle to edit3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit3 as text
%        str2double(get(hObject,'String')) returns contents of edit3 as a double


% --- Executes during object creation, after setting all properties.
function edit3_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit3 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end



function edit4_Callback(hObject, eventdata, handles)
% hObject    handle to edit4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit4 as text
%        str2double(get(hObject,'String')) returns contents of edit4 as a double


% --- Executes during object creation, after setting all properties.
function edit4_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit4 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end
```

```
function edit5_Callback(hObject, eventdata, handles)
% hObject    handle to edit5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit5 as text
%        str2double(get(hObject,'String')) returns contents of edit5 as a double


% --- Executes during object creation, after setting all properties.
function edit5_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit5 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end


% --- Executes on key press with focus on edit5 and none of its controls.
function edit5_KeyPressFcn(hObject, eventdata, handles)
% hObject    handle to edit5 (see GCBO)
% eventdata  structure with the following fields (see UICONTROL)
%   Key: name of the key that was pressed, in lower case
%   Character: character interpretation of the key(s) that was pressed
%   Modifier: name(s) of the modifier key(s) (i.e., control, shift) pressed
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in ICA_value.
function ICA_value_Callback(hObject, eventdata, handles)
% hObject    handle to ICA_value (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in CCA_value.
function CCA_value_Callback(hObject, eventdata, handles)
% hObject    handle to CCA_value (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)


% --- Executes on button press in result.
function result_Callback(hObject, eventdata, handles)
% hObject    handle to result (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
```

```
n=str2num(get(handles.ICA_value,'string'));
m=str2num(get(handles.CCA_value,'string'));
p=n/m;
set(handles.edit7,'string',num2str(p))



function edit7_Callback(hObject, eventdata, handles)
% hObject    handle to edit7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)

% Hints: get(hObject,'String') returns contents of edit7 as text
%        str2double(get(hObject,'String')) returns contents of edit7 as a double


% --- Executes during object creation, after setting all properties.
function edit7_CreateFcn(hObject, eventdata, handles)
% hObject    handle to edit7 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    empty - handles not created until after all CreateFcns called

% Hint: edit controls usually have a white background on Windows.
%       See ISPC and COMPUTER.
if ispc && isequal(get(hObject,'BackgroundColor'),
get(0,'defaultUicontrolBackgroundColor'))
    set(hObject,'BackgroundColor','white');
end


% --- Executes on button press in pushbutton8.
function pushbutton8_Callback(hObject, eventdata, handles)
% hObject    handle to pushbutton8 (see GCBO)
% eventdata  reserved - to be defined in a future version of MATLAB
% handles    structure with handles and user data (see GUIDATA)
D=str2num(get(handles.edit7,'string'))
E=str2num(get(handles.ICA_value,'string'))
if ((0<=D)&&(D<1))%&&(E>=120))
          a='The patient is normal'
elseif((1<=D)&&(D<2))%&&(E>=120))
       a= 'The patient has mild risk for stroke'
elseif((2<=D)&&(D<4))%&&(E>=120))
       a= 'The patient has moderate risk for stroke'
elseif((D>4))%&&(E>=120))
       a= 'The patient has severe risk for stroke'
elseif(E<=40)
       a= 'The patient has critical risk for stroke'
elseif(E<=20)
     a= 'The patient has Occlusion of artery'
end
set(handles.text10,'string',a)
```