Detection of Brain Tumor Using Internet of Things

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Declaration

We, hereby, declare that the work presented in this thesis is the outcome of the investi- gation performed by me under the supervision of Dr. Ahmed Wasif Reza, Associate Professor and Chairperson, Department of Computer Science and engineering, East West University. We also declare that no part of this thesis has been or is being submitted elsewhere for the award of any degree or diploma.

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Abstract

The amount of brain tumor patients are increasing indescribably in the recent years and it has become a dangerous problem. For both men and women, brain tumor placed in 10th position of the leading cause of death. If it is possible to detect any disease before it started to damage, the chance of recovery from diseases gets the increase. Previous state-of-the-art techniques based on magnetic resonance images (MRI), provide fast and robust detection of tumor on the brain. But due to use of MRI images the complexity of these techniques become high. All these existing techniques classify the MRI images and detect the brain tumor, which is computationally expensive. We have proposed a stochastic method for automatic detection of brain tumor using Internet of Things (IoT). The proficiency of the method is scrumptious, because it measures the probability of brain tumor from our daily activities. In our experiment, we have used a portable wrist wearable device and two extra sensors, which can track our daily activities. Some common symptoms of brain tumor are used here to detect the brain tumor. We have proposed some equations, which can easily measure these symptoms from our daily activities. Experimental result for brain tumor patients' group and normal persons' group show the ability of the proposed technique in automatic detection of brain tumor. In this paper, we show the effectiveness of our method in automatic detection of brain tumor is demonstrated and it produces a better accuracy with the comparison to previous state-of-the-art brain tumor detection techniques.

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As it is true for everyone, We have also arrived at this point of achieving a goal in my/our life through various interactions with and help from other people. However, written words are often elusive and harbor diverse interpretations even in one's mother language. Therefore, I/We would not like to make efforts to find best words to express my thankfulness other than simply listing those people who have contributed to this thesis itself in an essential way. This work was carried out in the Department of Computer Science and Engineering at East West University, Bangladesh.

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Chapter 1

Introduction

A brain tumor occurs when abnormal cells from within the brain. There are two main types of tumors- malignant or cancerous tumor and benign tumor. Cancerous tumors can be divided into primary tumors that start within the brain, and secondary tumors that have spread from somewhere else, known as brain metastasis tumors. All types of brain tumor may produce symptoms that vary depending on the part of the brain involved. These symptoms may include headaches, seizures, problem with vision, vomiting, and mental changes. The headache is classically worse in the morning and goes away with vomiting. More specific problems may include difficulty in walking, speaking, and with sensation. As the disease progresses unconsciousness may occure.

1.1 Overview & Motivation

The growth of abnormal cell in brain cause brain tumor [1]. Brain tumor is becoming a dangerous problem in recent years. It does not discriminate between men, women, and children. For both men and women, brain tumor placed in 10th position of the leading cause of death [2]. It is estimated that, approximately 700,000 people are living with a brain tumor in America, among them 80% are benign and 20% are malignant [4]. It is also estimated that, in this year, approximately 78,980 adults will diagnose with a brain tumor, among them 55,150 will benign and 23,830 will malignant [4]. It is also estimated that, approximately 16,700 adults will die from a brain tumor, among them 9,620 are male and 7,080 are female [3]. Also, about 4,830 children 0-19 year of age will diagnose with a brain tumor. About 34% men and 36% female survive at least

5-years with brain tumor [3,4]. However, this survival rate can vary and depends on the type of brain tumor. This 5-year survival rate is estimated from annual data in the United States. Almost about 25% of all cancer patients develop secondary brain tumor [2]. So, we can easily understand how much harmful brain tumor for us.

1.2 Problem Statement

If it is possible to detect any disease before it started to damage, the chance of recovery from diseases gets the increase. In this paper, we have proposed a methodology to detect brain tumor automatically using Internet of Things (IoT). We discuss different symptoms of brain tumor and classify them to get the internal characteristics of each symptom, which can be measured by sensors. Because, all the symptoms of brain tumor cannot measure directly by sensors (e.g., Vomiting is a symptom of a brain tumor which cannot measure directly by any sensors. So we classify vomiting and find 'increase body temperature', 'high heart rate', and 'high blood pressure' these are the common characteristics for vomiting, which can be measured by sensors). We also discuss the maximum, minimum range of symptoms for brain tumor (e.g., 'High blood pressure' is a symptom of brain tumor, the range of high blood pressure is 140 and 80).

1.3 Objectives

The aim of this study is to detect the brain tumor using IoT, which does not require any X-ray MRI images. Because X-ray is costly and low classes of people does not have the capability, so our goal is to measure and predict the brain tumor level with a low cost. Our main two objectives are-

- To measure the probability of being brain tumor of a normal person
- To create a device which can measure Systolic & Diastolic Blood pressure from heart rate
- To create a device which will detect brain tumor in a low cost

1.4 Contribution

Within this paper, we have developed a brain tumor detection technique which can take different symptoms of a person as input data (e.g., headache, vomiting, drowsiness etc.). For detection of brain tumor, we have used 7 common symptoms including- headache, vomiting or nausea, vision change, seizures, walking problem (consider normal people who can walk), drowsiness or sleeping problem, fatigue. Since there is no wearable sensor for capturing all the symptoms data correctly, we use classification in those symptoms. After classification of these symptoms we can get different sub-symptoms. Based on these sub-symptoms, we develop a model which can easily measure the probability. We also develop our own blood pressure, deep sleep, light sleep, awake time in between sleep detection techniques.

Our contribution of this paper can be summarized as follow:

1. Find out the important symptoms of brain tumor and classify them into different sub-symptoms such as these can be able to measure by sensors.
2. Develop own regression model to find out the Systolic Blood Pressure from heart rate.
3. Develop own model to find out Diastolic Blood Pressure.
4. Develop own technique to measure the Deep Sleep, Light Sleep, Awake time in between sleep from heart rate and body temperature.
5. Finally, we proposed a novel method which can detect and predict of brain tumor, in addition we have create a device based on our methodology.

1.5 Thesis Organization

We organized the rest of the paper as follows. In section 2, we discuss about different existing brain tumor detection techniques, brain tumors, types, difference, risk factors, symptoms etc, in order to introduce the brain tumor and its' effects in life. In section 3, we propose our methodology. We discuss

how we classify, measure and predict of the brain tumor. In section 4, we discuss about materials which we have used in this experiment. We also discuss about different devices, sensors, data collection and data transfer techniques. Section 5 describes about dataset collection, experiment with the dataset, result analysis and discussion, while section 6 concludes.

Chapter 2
Literature Review

In this section, we have discussed about the existing brain tumor detection techniques and brief description of brain tumor, its types, risk factors, symptoms etc.

2.1 Existing Detection Technique

Many researchers presented different methods for segmentation and detection of brain tumor. In this section we are presenting some existing techniques for segmentation and detection of brain tumor.

In [25], authors proposed a model for individualizing the texture of tumor in brain MRIs (magnetic resonance images). They used more than 300 MRIs of 14 patients to show the accuracy of their technique. They compare their automatic segmentation of brain tumor using MRIs technique to other segmentation of brain tumor works.

In [26], authors used MRIs and proposed a novel idea for efficient detection of brain tumor. They used different filtering algorithm to remove noise from MRIs. To detection of brain tumor, they used K-Means algorithm and normalized histogram segmentation technique. They used SVM and Naïve Bayes classifier for classification and show the accuracy of their proposed idea.

In [27], authors proposed a method for automatic detection and segmentation of brain tumor. They used conditional random field in MRI images for segmentation of brain tumor. They used 8 brain tumor patients and 2 normal patients to test their proposed method and got 89% accuracy on average, which is 10% more than MRF based method.

In [28], authors used MRI images and proposed a modified mean-shift based fuzzy c-mean segmentation technique for detection of brain tumor. In that paper, authors used fuzzy filter to remove noise from MRI images, and also proposed a new mean-shift based fuzzy c-mean technique, which take less time to find the segmentation results.

In [29], authors proposed a SVM and rough K-means based brain tumor detection algorithm, which classify MRI images. The authors claimed that, their proposed algorithm provide 99.05% of accuracy.

In [30], authors presented a technique to detect and classify of brain tumor, which convert MRI images to Otso Binarization followed by K-means clustering segmentation. They used discrete wavelet transform technique to extract the features and principle component analysis technique to reduce the feature. Then they used SVM for classification and they claimed, their technique achieved 99.33% of accuracy.

In [31], authors proposed a technique to detect brain tumor tissue automatically. The technique contained several steps including k-means clustering segmentation, HCSD method, extraction of features, and KNN classifier. Their proposed technique got an accuracy of 95%, which is better than ANN and SVM techniques.

2.2 Brain Tumor

When our body contains a tumor the amount of tissue is massive which is formed by a collection of abnormal cell. These cells grow in our body, died and replaced by new cells. Brain is known as one of the most common organ of human body where the brain is fixed with nerve cells, glial cells and meninges. There are three major functions; brain stem which monitors breathing activity, the cerebellum, which monitors moving muscle activity during walking and cerebrum, which monitors our memory, personality, thinking capability, different emotions etc.

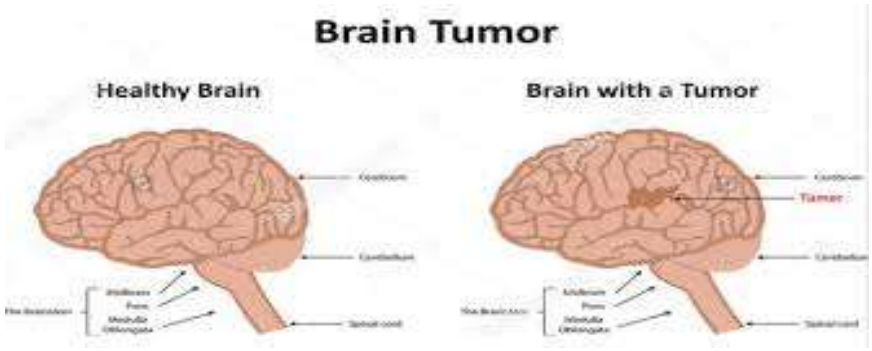

Figure 2.1: Brain Tumor

The growth of abnormal cell in the brain creates a brain tumor [5]. Brain tumor also has some variations or types [5]. Some brain tumors are benign, known as noncancerous, and some brain tumors are malignant known as cancerous. Cancerous tumors are divided into two parts. One is primary tumors and another is secondary tumors. Primary tumors start within the brain and secondary tumors have propagated from somewhere else, known as brain metastasis tumors [6]. Normally, Brain tumors can start in the brain known as primary brain tumors and cancer can start in other parts of body and generates to the brain known as secondary brain tumors.

2.2.1 Primary Brain Tumor

The tumor that is begins itself or in tissues close to the brain in known as primary brain tumor [20]. This tumor is found in the brain- such as meninges or brain covering membrane, pituitary gland, cranial nerves. When normal cells attain mutation in their DNA the cells are allowed to grow or divided at increased rate and allowed to be the reason of healthy cells die, that's how the primary brain tumor established in the brain of our body [20]. This mutation causes a mass of abnormal cells, which forms a tumor. Primary brain tumor begins in brain and secondary brain tumor begins in other parts, so they are not closely to each other.

According to the different type of cell involvement, brain tumors are categorized in different

parts. Examples include:

- **Gliomas.** These tumors start in the brain or spinal cord and include astrocytomas, ependymoma, glioblastomas, oligoastrocytomas and oligodendrogliomas.
- **Astrocytoma**: Astrocytes or star shaped of glial cells is the origin of this type of tumor. It can be also divided in several grades. An astrocytoma most often grows in the cerebrum in case of adults.
    - **Grade I or II astrocytoma**: It is known as low-grade glioma.
    - **Grade III astrocytoma**: It's an anaplastic astrocytoma or high-grade.
    - **Grade IV astrocytoma**: It is known as malignant astrocytic glioma or glioblastoma.
    - **Meningiomas.** A meningioma is a tumor. The great portion of meningioma is noncancerous and grows from the membranes that enclose your brain and spinal cord (meninges).
    - **Acoustic neuromas (schwannomas).** These types of tumors are basically the benign tumors. It is developed on the nerves. These nerves are control balance and hearing leading from your inner ear to your brain.
    - **Pituitary adenomas.** It is developed in the pituitary gland at the bottom of the brain. Pituitary hormones can be affected by this tumors and it can be effects throughout the body. These are also known to us as a benign tumor.
    - **Medulloblastomas.** Children's are the main victim of this type of brain tumor and it's the most general cancerous brain tumor. Adults can be affected by it but there is less possibility. A medulloblastoma grows in the lower part of our brain and tends to propagate through the spinal fluid.
    - **Primitive neuroectodermal tumors (PNETs)**: It is cancerous and rare. PENETs are normally grown in embryonic (fetal) cells in the brain but they can occur anywhere in the brain.
    - **Germ cell tumors (GCT).** Germ cell tumors are neoplasm. It's generally developed inside

the gonads or ovary and testis during your childhood. It can also move in the brain. Germ cell tumors can be cancerous or noncancerous.

- **Craniopharyngiomas.** These are noncancerous tumors and rare. The craniopharyngioma grows slowly. Normally it grows near the brain's pituitary gland, which secretes hormones that control many body Activities. It can affect the pituitary gland and other structures near the brain.

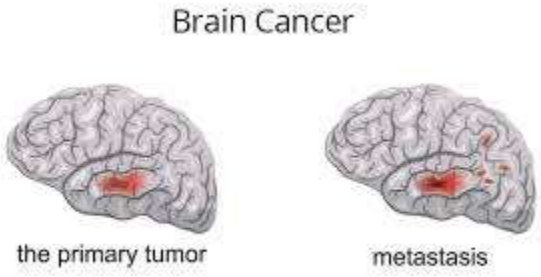

Figure 2.2: Primary and secondary Brain Tumor

2.2.2 Secondary Brain Tumor

Metastatic or the secondary tumor that has started from another part of the body and spread through the brain [21]. Brain metastasis is basically a cancer. Cancerous neoplasm is developed in another organ where the cancer cells have started from the primary brain tumor and the goes in the lymphatic system and blood vessels. Considering the brain tumor, the secondary brain tumor is more common than the primary brain tumor above the world. There are about 170,000 new cases in the United States in every year. Secondary brain tumors are the most common cause of tumors in the intracranial excavation. The structure of the skull bone can also be subject to a neoplasm that it can damage the brain and its different nature decreases the volume of the intracranial excavation [7].

Secondary brain tumors are more common than are primary brain tumors. Some types of cancer can spread to the brain as well as the other part of the body. The most common cancer that can spread to the brain and other part of body is like -

- Breast cancer
- Colon cancer
- Kidney cancer
- Lung cancer
- Melanoma

2.2.3 Difference between Benign and Malignant Brain Tumor

Noncancerous tumors are considered as a benign brain tumor and cancerous tumors are considered as malignant primary brain tumors. Malignant brain tumors originate from the brain and grow fast rather than the benign brain tumors and aggressively affect surrounding tissue. Brain cancer is harmful for our body because it can spread to the central nervous system and other parts of the brain.

Figure 2.3: Benign and Maligant Brain Tumor

Benign brain tumors are not deeply situated in brain tissue moreover they are usually clearly defined in borders [22]. That's why it's easy to remove them easier by surgery. Assuming, they are located in a safe area and easily can operate. There is possibility to recur this tumor because they can again come back, even after they have been removed from the brain [22]. Moreover

benign brain tumors are difficult to recur than malignant brain tumor.

Benign brains tumors are grow slowly and don't allow spreading in other organ. It can injure the cells by inflammation and pressure on the tissue. Overall, benign brain tumor can be a life threading issue and major health problem.

2.2.4 Risk factors of Brain Tumor

We don't know the specific factors for brain tumors but doctors have marked out some factors that may increase the possibility to have brain tumors. Risk factors include:

- **Age.** Age is the key factor to have a brain tumor. Older adults are mainly affected by brain tumors. Several types of brain tumor can occur only in children but different age of people can be attack by this type of health problem or brain tumor.
- **Exposure to radiation.** Ionizing radiation is a major issue to have a risk of brain tumor. The people who have experienced this type of radiation (ionizing radiation) is the main victim of it. Ionizing radiation contains radiation therapy and radiation exposure. Radiation therapy used to deal with brain cancer. Atomic bombs cause radiation exposure. More common radiation can also added the reason to cause a brain tumor, like- electromagnetic fields from power lines and radiofrequency radiation from cell phone and microwave ovens.
- **Chemical exposure.** Certain industrial chemicals or solvents are also the reason to increase the risk of developing a brain cancer. Although it is not crucial, there is evidence that who have work in oil refining, rubber manufacturing and drug manufacturing get the higher priority to have several types of brain tumors.
- **Family history of brain tumors.** Genetic syndromes or family history can also play a vital role to grow a brain tumors but it happens less than the other risk factor. About 5% of brain tumor are including in this risk factors.

- **Gender.** In general, men are more likely to have a brain tumor rather than women. However, women are the main victim to develop several types of brain tumor such as meningioma.
- **Head injury and seizures.** Head injury or serious head trauma is the reason of brain tumor. Besides this the risk of brain tumor can increase when the seizures are increased in human body.
- **Race.** Brain Tumors can vary from different places like the people from United States are more likely to develop glioma and less likely to develop meningioma. Caucasians. African-American people are more likely to develop meningioma's (originate in the meninges).
- **No History of Chicken Pox.** People who have history of chicken pox have a less possibility of getting tumors.

2.2.5 Symptoms of Brain Tumor

According to the different types of brain tumor and their location the symptoms of brain tumor also varied from different sides. In human body different functions are control by several areas of the brain. Some tumors are damaged directly by assail of brain tissue. Some tumors contain no symptoms but cause a serious as well as rapid fall to health when the tumors get quite large. Some tumor may have developed their symptoms slowly. Some tumors are the reason to create pressure on the neighboring brain. Symptoms of brain tumor include:

1. **Headache:** Headache is the raised intracranial pressure and it is considered early as well as prime symptoms of brain cancer [8]. However, several headaches without other symptoms are rarer, and other symptoms often arrive before headaches become common [8]. Headache provides particular warning sign which make a human body closer to have brain tumor [8]. American Academy of Neurology is defined these : "abnormal neurological examination, headache worsened by Valhalla maneuver, awakening from sleep is caused by headache, new headache in the older population, dynamically worsening headache, atypical headache features, or patients who do not fulfill the strict definition of migraine"[8].

2. **Vomiting or Nausea:** First neurological sign of brain tumor is vomiting. It is the major symptom to create a brain tumor especially for children. Normally it occurs in the morning. The sign of a tumor may include- Feeling sick in your stomach. Those symptoms are indefatigable and unexplained. Nausea and vomiting can be the side effects of various treatments like radiation, chemotherapy, medication as well as it can be the symptoms of brain tumor.
3. **Vision Changes:** Vision changes also causes brain tumor. The symptoms of vision changes may include Blurry vision, loss of vision, and double vision etc. Schwartz says. You may also see floating spots or shapes—or what's known as an "aura". Hallucinations, inability to recognize objects when we remark them, double vision, blind spots may be include as a symptoms of causing brain tumor.
4. **Seizures:** Seizures are considered one of the vital signs of brain tumor according to the type of your tumor. Schwartz says "Irritation from the tumor makes the [brain's] neurons fire uncontrollably, and you get abnormal movements," seizures have many forms as like tumors. Almost 60% people who have a brain tumor are experienced this symptom minimum one time in their whole lifetime. In case of low grade tumor you are more likely to have seizure. Feeling tired or exhausted is the common symptom after a seizure.
5. **Walking Problem:** Walking problems can raise brain tumor. The symptoms may include weakness in the whole body, certain parts of the body Awkward or stiff movements in the legs or arms [15].
6. **Drowsiness or Sleep Problem:** Patients who have solid brain tumor have a common problem which is variation in sleeping [9,10]. Night sleep disturbance resulted brain tumor problem based on daytime period [11]. There are 33%-57% with solid brain tumor and 15%-20% of the general people have faced the sleep-wake disturbances problem [12,13], including brain[14].

7. **Fatigue:** Fatigue indicates the unusual tiredness which is varied in pattern. It has a negative impact on ability to function [16]. Fatigue is one of the most serve symptoms in patients who have solid brain tumor, including those with primary brain tumors. Cross-sectional studies have reported that fatigue is the most dominant symptom, with 40%–70% of patients who have primary brain tumor are reported that to have fatigue throughout the illness trajectory [17,18]. Moreover, it is reported that fatigue is the most repellent symptom to patients [19], low level energy is reported by the high percentage of patient [18] as well as rating their fatigue as moderate to severe [17].

Brain tumor, its different types (benign, malignant, primary, secondary), risk factors, and symptoms, all these are summarized in table- 2.1.

Table 2.1: Summary of Brain Tumor

Topic	**Summary**
Brain Tumor	• Large amounts of abnormal cell combine together and causes brain tumor in our body. • It has some variation- Benign and Malignant brain tumor.
Benign Brain Tumor	• It's a part of a brain tumor and also known as Non-cancerous brain tumor.
Malignant Brain Tumor	• It's a part of a brain tumor and known as a cancerous brain tumor. • It has two parts –Primary and secondary brain tumor.
Primary Brain Tumor	• It's a part of a cancerous brain tumor. It begins in the brain. • When normal cells attain mutation in their DNA, it allow healthy cells to die and causes a mass of abnormal cells, which creates primary brain tumor • Begins in itself or in tissues close to the brain.
Secondary Brain Tumor	• It's a part of a cancerous brain tumor. It begins in the other part of the body and spread through the brain. • secondary brain tumor is more common than the primary brain tumor above the world • The most common cancer that can spread to the brain and other part of body is like- Breast cancer, Colon cancer, Kidney cancer, Lung cancer, Melanoma etc.
Risk factors of Brain Tumor	• Age, Exposure to radiation, Chemical exposure, Family history of brain tumor, Gender, Head injury and seizures, Race, No history of Chicken Pox.
Symptoms of Brain Tumor	• Headache, Vomiting or Nausea, Vision Changes, Seizures, Walking Problem, Drowsiness or Sleeping Problem, Fatigue.

Chapter 3

Proposed Methodology

For detection of brain tumor, we have used 7 common symptoms including- headache, vomiting or nausea, vision change, seizures, walking problem (consider normal people who can walk), drowsiness or sleeping problem, fatigue.

3.1 Symptoms Analysis

Since there is no wearable sensor for capturing all the symptoms data correctly, we use classification in those symptoms. The classifications of symptoms are below in the table 3.1.

Table 3.1: Classification of Brain Tumor Symptoms

Symptoms (SS)	**Classification symptoms (CS)**	**Time**
Headache (HA)	**8.** High Blood pressure **9.** Increase body temperature **10.** Accompanied by vomiting	**11.** Usually steady pain after waking in the morning **12.** Get better within a few hour
Vomiting or Nausea (VN)	• Increase body temperature • High heart rate • High blood pressure	• Maybe occur in the morning • Or when change the position
Vision changes (VC)	• Low heart rate • High blood pressure • Headache • Nausea and vomiting	• After waking from sleep • Double or triple vision in one eye • Suddenly change posture
Seizures (SZ)	• Increasing heart rate(High heart rate) • Increasing blood pressure (High blood pressure	• Any time • Around after 30 min later of seizures blood pressure and heart rate get normal
Walking problem (WP)	• Less amount of steps(compare to normal people • Lack coordination in the arms or legs	• Any time of the day, face difficulties to walk
Drowsiness or sleeping problem (DS)	• Insomnia (less sleep than normal people) • Less amount of deep sleep	• Falling asleep during the day • sometimes not sleeping until 5 or 6 am
Fatigue (FG)	• Difficulty sleeping (Insomnia) • Headache • Large amount of Awake time in between Sleep • Vision changes	• Whole day patient experience this symptoms

3.2 Classification Symptoms (CS) Measure

We use a defined value (e.g. 140/90 is for high blood pressure) for every “classification symptoms” and compare it to the observed value. For measuring CS we have proposed an mathematical equation [eqn. (1)] which is below-

$$CS\ value = \begin{cases} 1, & observe\ value \geq high\ defined\ value \\ & or, \\ & observe\ value < low\ defined\ value \\ -1, & otherwise \end{cases} \quad \text{---------- (1)}$$

Where High Blood Pressure, Increase body Temperature, and High Heart rate are high defined value(HDV) and Low Blood Pressure, Low Heart rate, Less amount of steps, Low Deep sleep, Insomnia are low defined value (LDV).

Table 3.2 shows that there are two HDV for High Blood Pressure. One is top number which is 140 and another is bottom number which is 90 [39,40]. If the observe values are greater than those HDV, we get CS value =1 using equation (1), otherwise CS value = -1.

Table 3.2: Blood Pressure Chart

Blood Pressure	**Systolic (top number)**	**Diastolic (bottom number)**
High Blood Pressure	Systolic ≥140	Diastolic ≥90
Normal Blood Pressure	90≤ systolic<140	60≤ systolic<90
Low Blood Pressure	Systolic <90	Diastolic <60

Table 3.3 shows normal body temperature for people aged 10 or above is 97.8 degree Fahrenheit. So we have considered only one HDV for Increase Body Temperature which is 98 degree Fahrenheit for age>= 10 years [41]. If we compare the observe value with HDV we can easily get the CS value.

Table 3.3: Body normal temperature

Age	**Fahrenheit**	**Celsius**
3 to 5 years	98.6 to 99.0	37.0 to 37.2
7 to 9 years	98.1 to 98.3	36.7 to 36.8
Age ≥ 10 years	97.8	36.6

Table 3.4 shows only one HDV for High Heart Rate which is 101 and also one LDV for Low Heart Rate which is 60 [42]. Compare the observe value with HDV for High Heart rate or compare the observe value with LDV for Low Heart rate.

Table 3.4: Normal Heart Rate Chart

Age	**Heart Rate**
0 to 2 months	120 to 160
3 months to 1 year	80 to 140
1 to 3 years	80 to 130
3 to 5 years	80 to 120
6 to 12 years	70 to 110
Age ≥ 13 years	60 to 110

Insomnia is a sleep disorder which means sleeplessness. During this disorder, people face difficulty to sleep [43]. During insomnia people may experienced day time sleepiness, low level of energy and always depressed [43]. People have faced difficulty for falling asleep or may have sleeplessness for a long time [44,45]. Table 3.5 shows how much average sleeps need for particular age group. During insomnia people may experienced less sleep than a normal people. So we have considered LDV for 'insomnia' is 4 hour or 240 min. If anyone sleeps less than this LDV value for a long time he/she have insomnia.

Table 3.5: Average sleep needs

Age	**Hours**
0 to 2 months	12 to 18
3 months to 1 year	14 to 15
1 to 3 years	12 to 14
3 to 5 years	11 to 13
5 to 12 years	10 to 11
12 to 18 years	8.5 to 10
Age ≥ 18 years	7 to 9

Table 3.6 shows the sleep stages for adults; we can see the amount of deep sleep is 50 min to 65 min. So for classification symptom 'Less amount of deep sleep' we have considered LDV is 40 min. Also, we can see the average awake time for adults is 25 minutes. So for classification symptom 'Large amount of Awake time in between Sleep' we have considered HDV is 35 min.

Table 3.6: Sleep Stages for Adults

Sleep Stages	**Minutes**
Light sleep	252 to 324
REM sleep	84 to 108
Deep sleep	50 to 65
Awake	25

Since a disease can not develop suddenly, also its symptoms cannot be develop suddenly. For detect the CS "Less amount of steps" we use its previous data as LDV and compare it to the present data as observe value and easily find the result.

We use an equation for find "Lack Coordination in the arm or legs". This is below-

$$Lack\ Coordination\ in\ the\ arm\ or\ legs = \frac{total\ number\ of\ steps\ per\ day}{total\ activity\ time\ in\ min.} \quad \text{---------- (2)}$$

Similar to "Less amount of steps" here we use its previous data as LDV and compare it to the current data and find the results.

We have considered around 34 min of awake time in between sleep is normal. So if anyone awake more than 34 min in between sleep for a long time, it will be considered as large amount of awake time in between sleep. Table 3.7 shows the HDV and LDV values for CS symptoms.

Table 3.7: HDV and LDV values for CS

CS	**HDV**	**LDV**
High Blood Pressure	140 & 90	
Increase Body Temperature	98	
High Heart rate	101	
Low Heart Rate		60
Insomnia		240
Less amount of Deep Sleep		40
Less amount of Steps		Previous data
Lack Coordination in the arm or legs		Previous data
Large amount of Awake time in between Sleep	35	

3.3 Symptoms (SS) Measurement

For measuring SS, the related CSs values are required. Here we have proposed an Equation [eqn. (3)], which will be very much useful to measure the SS value. The equation is given below-

$$SS\ value = \begin{cases} 1, & \sum_1^p CS\ value \geq 0 \\ -1, & otherwise \end{cases}$$ ---------- (3)

Where, p= total CS related to SS.

For example, we select a person randomly and want to measure, does the person have symptom Vomiting or Nausea (VN) right now? If the answer is greater and equal to zero then SS =1, otherwise SS =-1. At first we have to find SS related CSs values. Vomiting or Nausea (VN)

related CSs are Increase body temperature, High heart rate, and High blood Pressure. We know from equation (1), every CSs value must be either 1 or -1.

We have 3 CSs for VN. If the summation of this 3 CSs is zero or above, then we can say that, selected person have VN symptom (equation (3)). Using same approach we can measure other SSs.

3.4 Brain Tumor Prediction

All the SSs values are required for predict brain tumor. We have used the following Equations for prediction the brain tumor, which is also known as sigmoid function.

$$possibility\ of\ brain\ tumor = \frac{1}{1+e^{-L}} \quad \text{---------- (4)}$$

Where, L= sum of all SSs value (HA+VN+VC+SZ+WP+DS+FG)

In this paper, we have used 7 symptoms (SS). Our proposed equation predict correctly in terms of those SSs. This equation will show the provability of brain tumor on between 0 and 1. If we multiply 100 with this equation, we can get the provability of brain tumor in terms of percentage.

For example, we select a brain tumor patient and measure the all SSs values. We found total SSs value is 6. If we want to find the probability of brain tumor for this patient by using equation (4),

$$possibility\ of\ brain\ tumor = \frac{1}{1+e^{-L}}$$
$$= \frac{1}{1+e^{-6}}$$
$$= \frac{1}{1.002478752}$$
$$= 0.997527$$

Therefore, the provability of brain tumor is 99.7527%.

We all know headache (HA) and vomiting (VN) are common symptom for migraine. If we want to measure the provability of brain tumor for this two symptoms –

L= (HA+VN+VC+SZ+WP+DS+FG)
= (1+1-1-1-1-1-1) [using (3)]
=-3

$$possibility\ of\ brain\ tumor = \frac{1}{1+e^{-(-3)}}$$
$$= \frac{1}{1+e^{3}}$$
$$= \frac{1}{21.08553692}$$
$$= 0.047426$$

Therefore, the provability of brain tumor is 4.7426%.

In this paper, we have used 7 symptoms (SS). Our proposed equation predict correctly in terms of those SSs. This equation will show the provability of brain tumor on between 0 and 1. If we multiply 100 with this equation, we can get the provability of brain tumor in terms of percentage. We have divided these percentage probabilities of brain tumor in different class to make decision (table 3.8).

Table 3.8: Decision table of Brain Tumor

Percentage probability of brain tumor	**Decision**
70% or above	Brain Tumor
30% ≤ %age probability<70%	Brain Tumor Candidate
Below 30%	Normal

Chapter 4

Materials

We have developed our own device to measure Systolic blood pressure, Diastolic blood pressure, Deep sleep, Total sleep, Light sleep, Awake time in between sleep using heart rate sensor and body temperature sensor. Finally we proposed a method and develop a device to measure the probability of brain tumor.

4.1 Systolic & Diastolic Blood Pressure Measurement

High blood pressure known as hypertension which is increases the chance of mortality for the adults [36]. However, a recent study in china shows, peoples who have pre-high heart rate in between 80 to 90 bpm have a short life compare to who have heart rate in between 60 to 69 bpm [37]. So, there is a relationship between heart rate and blood pressure. Therefore, anything which increases the heart rate also increases the blood pressure [23]. The factors which are related to blood pressure including headache, dry eye, stress, sleep, emotion etc., also related to the heart rate. Another study from African-American teenagers shows, there is a positive relationship between heart rate and blood pressure [24].

4.1.1 Device & Components

Heart rate measuring device contains some sensors and components; the list of components is given below-

- Arduino Uno (ATmega328)
- Heart Rate Sensor (LM358)
- NRF Module (nRF24L01)
- LCD Display
- Power Supply

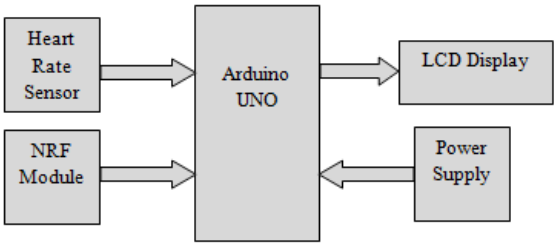

Figure 4.1: HR measure by using device

Our aim is to measure the heart rate and calculate the systolic blood pressure from the heart rate. The arduino uno (ATmega328) is working as a CPU for measuring the heart rate of a person. Figure 4.1 shows the block diagram of our device which can measure HR.

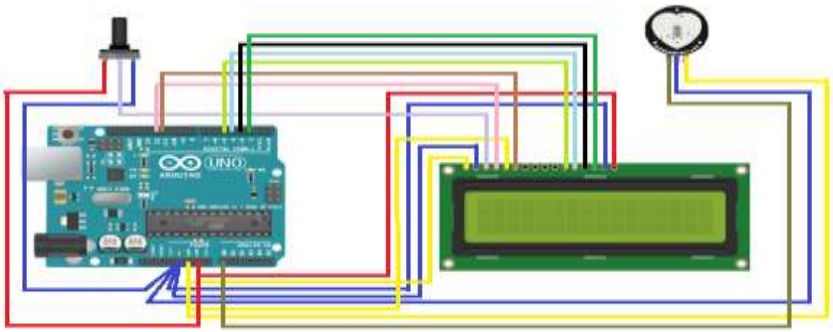

Figure 4.2: Circuit Diagram for HR, DBP and SBP Measurement

Figure 4.2 show that, when power supply block is on, it supplies power to the whole device. Heart rate sensor captures the HR data and sends it to the arduino uno, and then the transmitted information sends serially through NRF module, and finally the measured heart rate is shown on the LCD.

4.1.2 Methodology for Systolic Blood Pressure

In this experiment, we have collected more than 250 data of SBP and HR from university students aged from 20 to 28. We have collected HR through heart rate sensor via arduino uno and SBP through sphygmomanometer. Figure 4.3 shows the flow of regression model.

At first, we record HR and its corresponded SBP and divided the recorded dataset into 3 categories including high SBP, pre-high SBP, normal SBP (Table 4.1). We have considered different ranges for each category and try to find out a pattern for each category.

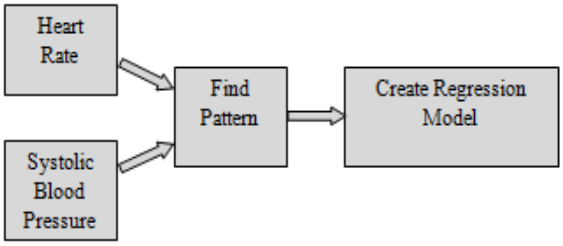

Figure 4.3 Regression Model Flow

Table 4.1: Categories & Ranges of SBP

Category	Systolic Blood Pressure	Range
Category 1	High SBP	SBP ≥140
Category 2	Pre-High SBP	120≤ SBP <140
Category 3	Normal SBP	SBP <120

Table 4.2: Regression Model for SBP using HR

Category	Regression Model
Category 1	Y= 0.383X + 108.222
Category 2	Y= 0.2411X +106.27
Category 3	Y= 0.2481X + 98.0867

Here, X= Input = HR for each individuals

Y= Output = SBP for each individual HR

Based on these patterns we develop a regression model for each category. Table 4.2 shows the regression model for each category. Finally, in our device we use these regression equations to measure systolic blood pressure from heart rate. We also have considered different status based on the original SBP and calculated SBP differences. Table 4.3 shows our considered status for the difference of original SBP and calculated SBP.

Table 4.3: Calculated SBP Considered Status

Difference of Original SBP and Calculated SBP	Status
0 —2 mmHg	Very accurate
3 —4 mmHg	Slightly inaccurate
5 —6 mmHg	Moderately inaccurate
>6 mmHg	Very inaccurate

4.1.3 Result Analysis for Systolic Blood Pressure

Table 4 shows the original SBP which is measured by sphygmomanometer and SBP measured by our proposed model for category 1 (High SBP). If we analyze the difference between all the original SBP and calculated SBP for Table 4.4, we can easily observe that, our proposed model provides very accurate result (according to Table 4.3).

Table 4.4: SBP Data for Category 1 in Our Method

HR (BPM)	Original SBP (mmHg)	SBP in our method (mmHg)	Difference (mmHg)
105	148	148.437	0.437
94	146	144.224	1.776
104	148	148.054	0.054
105	150	148.437	1.563
86	142	141.16	0.84
84	141	140.394	0.606
94	145	144.224	0.776
97	144	145.373	1.373
83	140	140.011	0.011
83	141	140.011	0.989

Thus, the difference between original SBP and our models' SBP shows the effectiveness of our proposed technique. Figure 4.4 shows the linier regression line for both original value and measured value.

Table 4.5: SBP Data for Category 2 in Our Method

HR (BPM)	Original SBP (mmHg)	SBP in our method (mmHg)	Difference (mmHg)
73	122	123.8703	1.8703
57	122	120.0127	1.9873
104	**134**	**131.3444**	**2.6556**
105	133	131.5855	1.4145
94	128	128.9334	0.9334
73	123	123.8703	0.8703
94	127	128.9334	1.9334
67	121	122.4237	1.4237
70	123	123.147	0.147
70	124	123.147	0.853

Table 4.6: SBP Data for Category 3 in Our Method

HR (BPM)	Original SBP (mmHg)	SBP in our method (mmHg)	Difference (mmHg)
67	116	114.7094	1.2906
58	111	112.4765	1.4765
61	113	113.2208	0.2208
77	119	117.1904	1.8096
88	118	119.9195	1.9195
79	117	117.6866	0.6866
81	118	118.1828	0.1828
60	114	112.9727	1.0273
74	118	116.4461	1.5539
84	**116**	**118.9271**	**2.9271**

Table 4.5 shows the original SBP which is measured by sphygmomanometer and SBP measured by our proposed model for category 2 (Pre-High SBP). The difference between original SBP and our models' SBP shows the effectiveness of our proposed technique. Among the all values of the difference of original and calculated SBP for Table 4.5, only 1 value contains slightly inaccurate result (2.6556 mmHg), and other all contains very accurate result. Fig 4.5 shows the linier regression line for both original value and measured value.

Table 4.6 shows the original SBP which is measured by sphygmomanometer and SBP measured by our proposed model for category 3 (Normal SBP). The difference between original SBP and our models' SBP shows the effectiveness of our proposed technique. Among the all values of the difference of original and calculated SBP for Table 4.6, also only 1 value contains slightly inaccurate result (2.9271 mmHg), and other all contains very accurate result. Figure 4.6 shows the linier regression line for both original value and measured value.

From the above Figure 4.4, Figure 4.5, Figure 4.6, we can observe that, the original blood pressure and our calculated blood pressure both is same at most of the time and sometimes a little bit difference between original blood pressure and calculated blood pressure. Table 4.7 shows the accuracy percentage for each proposed category.

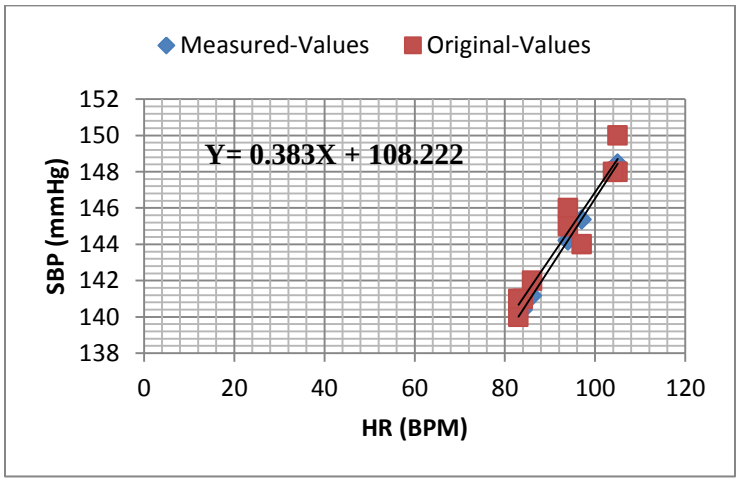

Figure 4.4: Original & New data for Category 1

Table 4.7: Accuracy table for Proposed Category (SBP & DBP)

Category	Very Accurate	Slightly Inaccurate
Category 1	100%	0
Category 2	90%	10%
Category 3	90%	10%

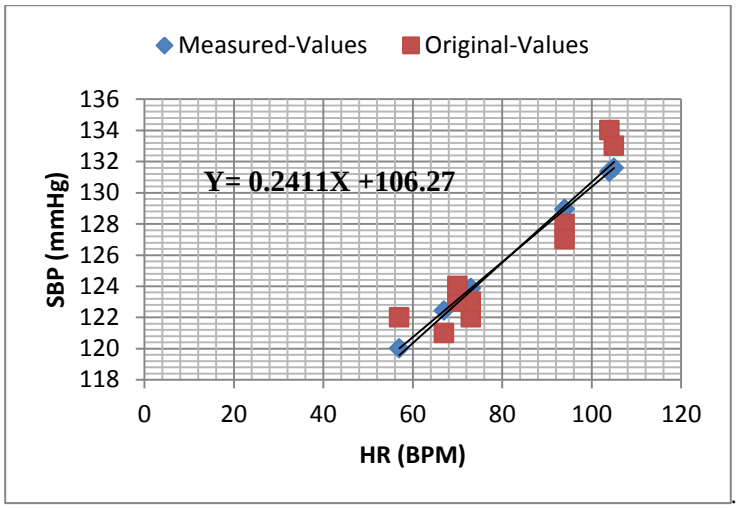

Figure 4.5: Original & New data for Category 2

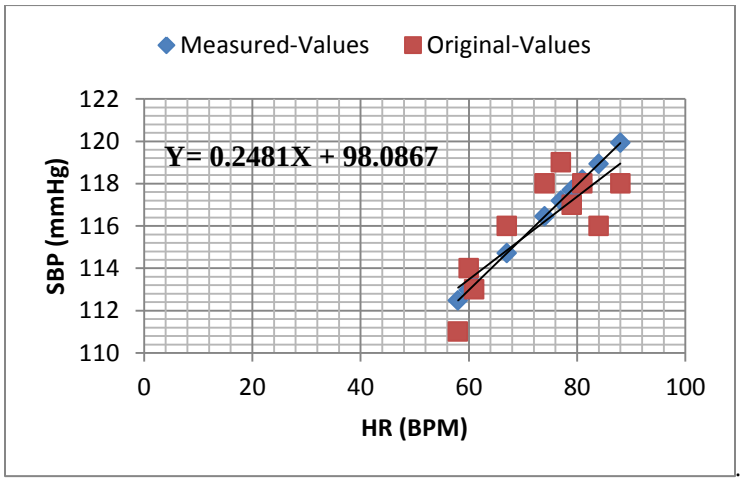

Figure 4.6: Original & New data for Category 3

4.1.4 Methodology for Diastolic Blood Pressure

In this experiment, we have collected more than 250 data of DBP and HR from university students aged from 20 to 28. We have collected HR through heart rate sensor via arduino uno and DBP through sphygmomanometer. Figure 4.7 shows the flow of regression model.

At first, we record HR and its corresponded SBP and divided the recorded dataset into 3 categories including high DBP, pre-high DBP, normal DBP (Table 4.8). We have considered different ranges for each category and try to find out a pattern for each category.

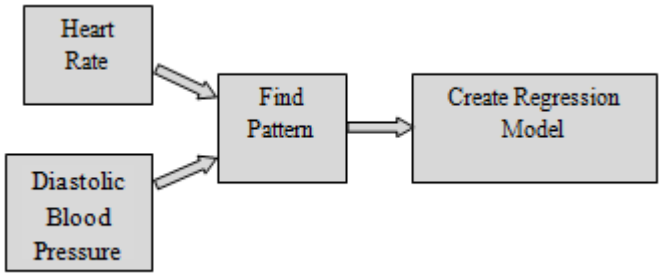

Figure 4.7 Regression Model Flow for Diastolic Blood Pressure

Table 4.8: Categories & Ranges for DBP

Category	Diastolic Blood Pressure	Range
Category 1	High DBP	DBP ≥90
Category 2	Pre-High DBP	85≤ DBP <90
Category 3	Normal DBP	DBP <85

Table 4.9: Regression Model for DBP Using HR

Category	Regression Model
Category 1	Y= 0.03021X + 89.1288
Category 2	Y= 0.0547X + 82.25
Category 3	Y= 0.1231X + 69.23

Here, X= Input = HR for each individuals

Y= Output = DBP for each individual HR

Based on these patterns we develop a regression model for each category. Table 4.9 shows the regression model for each category. Finally, in our device we use these regression equations to measure Diastolic blood pressure from heart rate. We also have considered different status based on the original DBP and calculated DBP differences. Table 4.10 shows our considered status for the difference of original DBP and calculated DBP.

Table 4.10: Calculated DBP Considered Status

Difference of Original DBP and Calculated DBP	**Status**
0 —2 mmHg	Very accurate
3 —4 mmHg	Slightly inaccurate
5 —6 mmHg	Moderately inaccurate
>6 mmHg	Very inaccurate

4.1.5 Result Analysis for Diastolic Blood Pressure

Table 4 shows the original DBP which is measured by sphygmomanometer and DBP measured by our proposed model for category 1 (High DBP). If we analyze the difference between all the original DBP and calculated DBP for Table 4.11, we can easily observe that, our proposed model provides 90% accurate result (according to Table 4.10).

Table 4.11: DBP Data for Category 1 in Our Method

HR (BPM)	Original DBP (mmHg)	DBP in our method (mmHg)	Difference (mmHg)
98	92	92.14278	0.14278
93	90	91.99173	1.99173
101	91	92.23341	1.23341
80	92	91.599	0.401
112	96	92.56572	3.43428
62	90	91.05522	1.05522
111	94	92.53551	1.46449
84	93	91.71984	1.28016
83	91	91.68963	0.68963
101	93	92.23341	0.76659

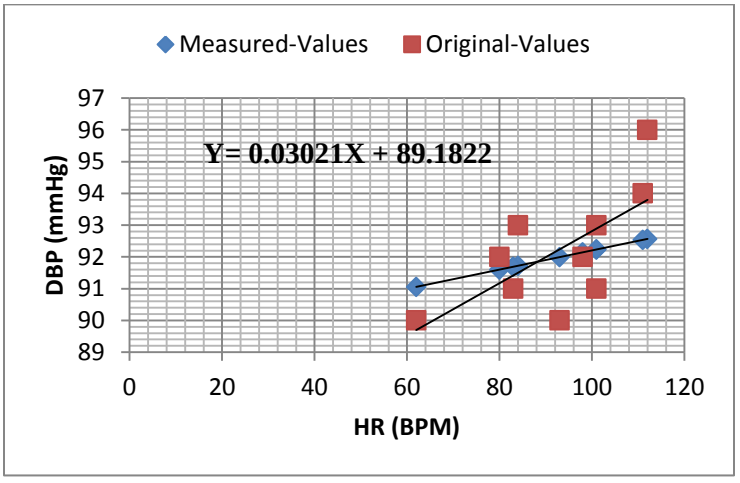

Figure 4.8: Original & New data for Category 1

Thus, the difference between original DBP and our models' DBP shows the effectiveness of our proposed technique. Figure 4.8 shows the linier regression line for both original value and measured value.

Table 4.12: DBP Data for Category 2 in Our Method

HR (BPM)	Original DBP (mmHg)	DBP in our method (mmHg)	Difference (mmHg)
83	86	86.7901	0.7901
62	87	85.6414	1.3586
100	89	87.72	1.28
101	86	87.7747	1.7747
85	87	86.8995	0.1005
67	85	85.9149	0.9149
63	85	85.6961	0.6961
87	88	87.0089	0.9911
92	86	87.2824	1.2824
87	89	87.0089	1.9911

Table 4.13: DBP Data for Category 3 in Our Method

HR (BPM)	Original DBP (mmHg)	DBP in our method (mmHg)	Difference (mmHg)
87	78	79.9397	1.9397
55	77	76.0005	0.9995
102	81	81.7862	0.7862
83	78	79.4473	1.4473
87	81	79.9397	1.0603
97	83	81.1707	1.8293
95	81	80.9245	0.0755
83	**77**	**79.4473**	**2.4473**
96	83	81.0476	1.9524
89	82	80.1859	1.8141

Table 4.12 shows the original DBP which is measured by sphygmomanometer and DBP measured by our proposed model for category 2 (Pre-High DBP). The difference between original DBP and our models' DBP shows the effectiveness of our proposed technique. If we see the values of the difference of original and calculated DBP for Table 4.12, all contains very accurate result. Figure 4.9 shows the linier regression line for both original value and measured value.

Table 4.13 shows the original DBP which is measured by sphygmomanometer and DBP measured by our proposed model for category 3 (Normal DBP). The difference between original DBP and our models' DBP shows the effectiveness of our proposed technique. Among the all values of the difference of original and calculated DBP for Table 4.13, also only 1 value contains slightly inaccurate result (2.4473 mmHg), and other all contains very accurate result. Figure 10 shows the linier regression line for both original value and measured value.

From the above Figure 4.8, Figure 4.9, Figure 4.10, we can observe that, the original blood pressure and our calculated blood pressure both is same at most of the time and sometimes a little bit difference between original blood pressure and calculated blood pressure. Table 7 shows the accuracy percentage for each proposed category.

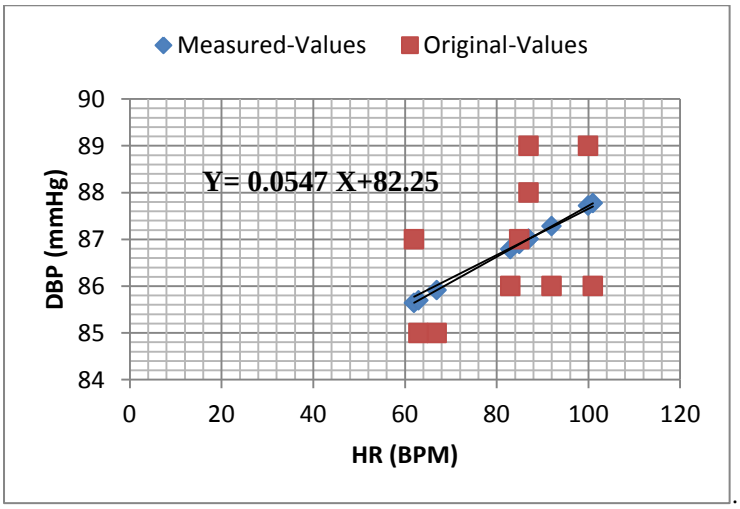

Figure 4.9 Original & New data for Category 2

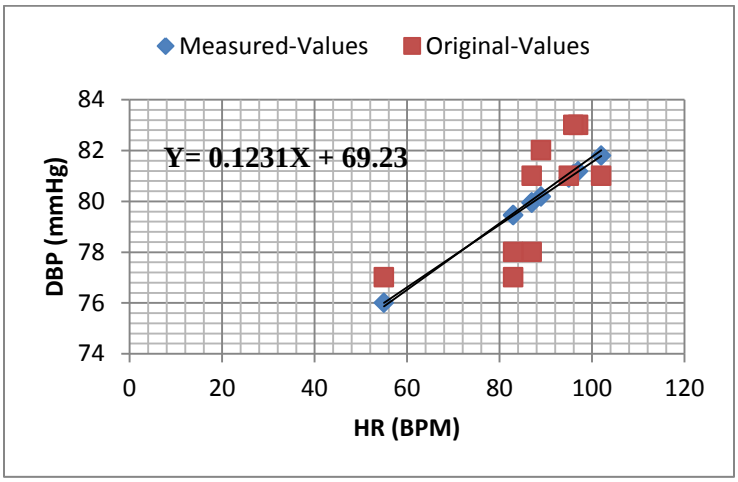

Figure 4.10 Original & New data for Category 3

4.2 Deep Sleep Measurement

Usually sleepers pass through five stages: 1, 2, 3, 4 and REM (rapid eye movement) sleep. These stages progress cyclically from 1 through REM then begin again with stage 1. A complete sleep cycle takes an average of 90 to 110 minutes, with each stage lasting between 5 to 15 minutes. The first sleep cycles each night have relatively short REM sleeps and long periods of deep sleep but later in the night, REM periods lengthen and deep sleep time decreases.

4.2.1 Stages of Sleep

Stage 1 is light sleep where you drift in and out of sleep and can be awakened easily. In this stage, the eyes move slowly and muscle activity slows. During this stage, many people experience sudden muscle contractions preceded by a sensation of falling.

In **stage 2**, eye movement stops and brain waves become slower with only an occasional burst of rapid brain waves. The body begins to prepare for deep sleep, as the body temperature begins to drop.

When a person enters **stage 3**, extremely slow brain waves called delta waves are interspersed with smaller, faster waves. This is deep sleep. It is during this stage that a person may experience sleepwalking, night terrors, talking during one's sleep, and bedwetting. These behaviors are known as parasomnias, and tend to occur during the transitions between non-REM and REM sleep.

In **stage 4**, deep sleep continues as the brain produces delta waves almost exclusively. People roused from this state feel disoriented for a few minutes.

During **REM (rapid eye movement) sleep**, brain waves mimic activity during the waking state. The eyes remain closed but move rapidly from side-to-side, perhaps related to the intense dream and brain activity that occurs during this stage.

4.2.2 Deep Sleep

Stages 3 and 4 are referred to as deep sleep, slow wave sleep, or delta sleep. It is very difficult to wake someone from them. Children are nearly impossible to wake up from this stage, and may be prone to bedwetting, sleepwalking or night terrors. In deep sleep, there is no eye movement or muscle activity.

Deep sleep reduces our sleep drive, and provides the most restorative sleep of all the sleep stages. This is why if we take a short nap during the day, we're still able to fall asleep at night. But if we take a nap long enough to fall into deep sleep, we have more difficulty falling asleep at night because we reduced our need for sleep.

During deep sleep, human growth hormone is released and restores our body and muscles from the stresses of the day. Our immune system restores itself. Much less is known about deep sleep than REM sleep. It may be during this stage that the brain also refreshes itself for new learning the following day.

4.2.3 Symptoms of Deep Sleep

After a lot of study, we have found some symptoms which happen during deep sleep. These symptoms are given below:

- Rapid drop of Body Temperature. During deep sleep, human body temperature decreases very suddenly, and it fall down to 96-degree F. So using body temperature sensor we can track these temperatures.
- Decrease in Heart Rate. When a human goes to stage 3 and stage 4 sleep (deep sleep), his heart rate decreases and after a sudden time the heart rate remain idle. For adult people heart rate falls down nearly 50 bpm to 60 bpm and remains idle as long as the people is in deep sleep.

Based on these symptoms of deep sleep we can calculate it.

Finally, our overall circuit diagram for measurement of brain tumor is given in figure 4.11.

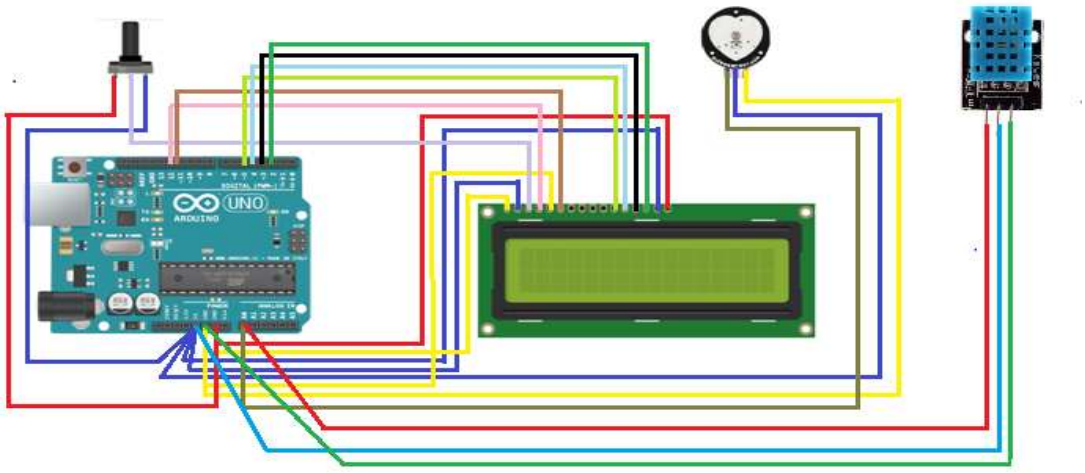

Figure 4.11 Brain Tumor Device Diagram

Chapter 5

Result & Discussion

In this section we discuss about our data collection process, experimental analysis and finally result and analysis.

5.1 Data Set Collection

We have collected our experimental data from two groups of people. One is brain tumor patients' group and another is normal person's group. Brain tumor patients' data are collected from a second class hospital in Bangladesh [38]. Form the hospital we get almost all required data except 'Walking Problem'. So we contact with the patients and take walking problem related data using clinical trial method. Normal persons' data are collected from university students, faculty, staffs and also some college level students. In our experiment, we have used five wearables device, and collected each normal person's data after observing 2 days. We collect about 150+ normal persons' data within two months. In this research paper, on each group we have used 25 person's data to detect the possibility of brain tumor. Table 5.1 shows brain tumor patients' data and table 5.2 shows normal persons' data.

Table 5.1: Brain Tumor patients' data

Sample Information		Blood Pressure		Body Tempera-ture	Heart Rate	Total Sleep	Total Deep Sleep	Total Awake Time	Total Steps	Total Activity Time of Steps	Previous Total Steps	Previous Total Activity Time of Steps
Sl. #	**Age**	**mmHg Sys**	**mmHg Dias**	**F**	**bpm**	**min**	**min**	**min**		**min**		**min**
1	60	146	98	98.5	102	198	37	46	3741	59	3645	58
2	46	141	90	98	58	196	29	63	4755	61	4982	64
3	57	153	102	98.1	101	224	42	51	3869	67	4687	74
4	52	148	94	98.6	111	214	36	49	3541	48	3543	49
5	37	140	94	99.1	51	223	26	67	6125	73	5476	69
6	62	134	107	98.6	101	234	31	32	4217	66	5136	75
7	45	151	104	99.2	103	247	46	57	6411	78	4903	63
8	51	144	112	98.8	96	195	42	68	3984	52	3911	52
9	48	161	97	98.2	107	207	35	72	2934	43	3216	46
10	46	142	96	99.3	104	220	45	56	6562	81	6671	80
11	62	156	96	99	80	237	53	31	3318	48	3453	48
12	29	142	102	99.6	67	176	21	73	6568	81	6324	79
13	38	153	101	97.9	102	212	33	57	2144	39	3143	42
14	51	141	98	98.7	102	254	34	43	3648	57	2454	41
15	67	142	90	99.2	55	207	30	59	2194	46	2203	46
16	41	162	94	100.1	51	230	38	34	5646	73	5644	75
17	47	156	90	99.1	55	249	51	66	6586	82	5739	80
18	52	140	89	98.5	101	198	31	59	5611	78	4235	56
19	56	145	96	99	108	237	42	30	4983	64	5415	71
20	49	138	110	99.2	102	241	43	53	5967	68	5613	64
21	53	133	92	97.8	101	217	36	47	4017	61	4768	66
22	44	157	101	98.5	112	234	39	32	4511	57	5241	65
23	31	152	104	99.2	57	298	31	47	3554	45	3922	47
24	42	143	96	98.7	52	211	43	64	5546	65	4132	56
25	39	148	98	98.7	96	179	29	71	4658	70	3219	63

Table-5.2: Normal Person's data

Sample Information		Blood Pressure		Body Tempera-ture	Heart Rate	Total Sleep	Total Deep Sleep	Total Awake Time	Total Steps	Total Activity Time of Steps	Previous Total Steps	Previous Total Activity Time of Steps
Sl. #	**Age**	**mmHg Sys**	**mmHg Dias**	**F**	**bpm**	**min**	**min**	**min**		**min**		**min**
1	43	123	78	97.8	87	319	53	43	3352	48	3213	47
2	26	122	77	98.1	55	365	72	3	7325	84	7193	81
3	24	126	86	98.2	83	307	57	7	6214	71	6997	77
4	39	116	75	97.8	46	363	64	85	3721	44	4366	53
5	23	121	81	97.9	102	372	61	0	4615	55	4599	57
6	24	121	76	97.9	91	342	85	14	3917	47	3878	47
7	24	111	73	98	73	326	66	32	5321	61	5629	64
8	24	126	78	97.9	83	332	70	17	3323	40	3756	43
9	23	108	72	97.8	45	291	57	12	8723	101	8313	99
10	23	138	92	98.1	98	350	105	2	5993	66	5098	59
11	57	125	87	98	47	274	33	3	9329	97	10213	109
12	23	136	90	97.9	93	475	114	5	7921	88	8111	96
13	23	126	81	97.9	77	463	108	20	11310	112	12512	117
14	51	130	89	97.9	100	363	62	12	3527	43	3409	42
15	23	121	83	97.8	97	475	119	4	3120	39	3411	41
16	24	107	72	97.9	89	393	132	2	2739	36	2711	36
17	23	123	81	97.9	95	465	127	12	1857	28	1927	31
18	25	123	77	98	83	295	60	15	7420	85	7001	79
19	17	117	76	97.9	64	377	81	2	4128	50	4077	49
20	19	121	84	98.1	56	402	93	3	3596	42	3657	43
21	19	108	77	97.9	81	352	118	0	3741	44	3464	42
22	39	131	84	97.8	66	354	78	46	4125	48	4354	5
23	31	111	72	98	80	361	103	3	5546	64	5367	63
24	42	136	87	98.6	85	311	66	37	4461	54	4751	57
25	46	118	86	97.9	101	367	97	1	4614	55	4973	56

5.2 Experimental Analysis:

In our experiment, we have shown the analysis of data and detection of brain tumor for two scenarios. We have used brain tumor patients' data (table 5.1) as Scenario-1 and normal persons' data (table 5.2) as scenario-2.

5.2.1 Scenario-1:

Scenario-1 contains brain tumor patients' data. These data are collected from hospital, so surely all the person contains brain tumor, if our experiment says the same, then the experimental result will satisfy the original result. Table 5.3, 5.4 shows the experimental analysis and brain tumor detection for scenario-1.

Since table 5.1 contains the current data and our task is to find whether the current data satisfy our required symptoms or not (e.g., blood pressure rate is a normal data, but our task is to find CS symptom like 'High Blood Pressure' by using some condition discussed earlier in section 4). In table 5.3, we measure our required CS symptoms by using our proposed equation (1). For example, CS symptoms 'High Blood Pressure' use HDV condition (table 3.7). So equation (1) will check whether the observe value satisfy the HDV or not, and show the result.

Table 5.3: Measure CS value for scenario-1

		HDV	HDV	HDV	LDV	LDV	LDV	LDV	LDV	HDV
Sample Information		High Blood Pressure	Increase Body Tempera-ture	High Heart Rate	Low Heart Rate	Insom-nia	Less Amount of Steps	Lack Coordina-tion in the arms or legs	Less Amount of Deep Sleep	More Awake time in between Sleep
Sl. #	**Age**									
1	60	1	1	1	-1	1	-1	-1	1	1
2	46	1	1	-1	1	1	1	-1	1	1
3	57	1	1	1	-1	1	1	1	-1	1
4	52	1	1	1	-1	1	1	-1	1	1
5	37	1	1	-1	1	1	-1	-1	1	1
6	62	-1	1	1	-1	1	1	1	1	-1
7	45	1	1	1	-1	-1	-1	-1	-1	1
8	51	1	1	-1	-1	1	-1	-1	-1	1
9	48	1	1	1	-1	1	1	1	1	1
10	46	1	1	1	-1	1	1	1	-1	1
11	62	1	1	-1	-1	1	1	1	-1	-1
12	29	1	1	-1	-1	1	-1	-1	1	1
13	38	1	-1	1	-1	1	1	1	1	1
14	51	1	1	1	-1	-1	-1	-1	1	1
15	67	1	1	-1	1	1	1	1	1	1
16	41	1	1	-1	1	1	-1	-1	1	-1
17	47	1	1	-1	1	-1	-1	-1	-1	1
18	52	-1	1	1	-1	1	-1	1	1	1
19	56	1	1	1	-1	1	1	-1	-1	-1
20	49	-1	1	1	-1	-1	-1	-1	-1	1
21	53	-1	-1	1	-1	1	1	1	1	1
22	44	1	1	1	-1	1	1	1	1	-1
23	31	1	1	-1	1	-1	1	1	1	1
24	42	1	1	-1	1	1	-1	-1	-1	1
25	39	1	1	-1	-1	1	-1	-1	1	1
		21	**23**	**14**	**7**	**20**	**13**	**11**	**16**	**20**

Table 5.4: SS value measure and brain tumor prediction for scenario-1

Sample Information		HA	VN	VC	SZ	WP	DS	FG	Sum of All (L)	Probabi-lity of Brain Tumor	%age Probability of Brain Tumor
Sl. #	**Age**										
1	60	1	1	1	1	-1	1	1	5	0.993307	99.33%
2	46	1	1	1	1	1	1	1	7	0.999089	99.91%
3	57	1	1	1	1	1	1	1	7	0.999089	99.91%
4	52	1	1	1	1	1	1	1	7	0.999089	99.91%
5	37	1	1	1	1	-1	1	1	5	0.993307	99.33%
6	62	1	1	1	1	1	1	1	7	0.999089	99.91%
7	45	1	1	1	1	-1	-1	1	3	0.952574	95.26%
8	51	1	1	1	1	-1	1	1	5	0.993307	99.33%
9	48	1	1	1	1	1	1	1	7	0.999089	99.91%
10	46	1	1	1	1	1	1	1	7	0.999089	99.91%
11	62	1	1	1	1	1	1	1	7	0.999089	99.91%
12	29	1	1	1	1	-1	1	1	5	0.993307	99.33%
13	38	1	1	1	1	1	1	1	7	0.999089	99.91%
14	51	1	1	1	1	-1	1	1	5	0.993307	99.33%
15	67	1	1	1	1	1	1	1	7	0.999089	99.91%
16	41	1	1	1	1	-1	1	1	5	0.993307	99.33%
17	47	1	1	1	1	-1	-1	1	3	0.952574	95.26%
18	52	1	1	1	1	1	1	1	7	0.999089	99.91%
19	56	1	1	1	1	1	1	1	7	0.999089	99.91%
20	49	1	1	1	1	-1	-1	1	3	0.952574	95.26%
21	**53**	**-1**	**-1**	**-1**	**1**	**1**	**1**	**1**	**1**	**0.731059**	**73.11%**
22	44	1	1	1	1	1	1	1	7	0.999089	99.91%
23	31	1	1	1	1	1	1	1	7	0.999089	99.91%
24	42	1	1	1	1	-1	1	1	5	0.993307	99.33%
25	39	1	1	1	1	-1	1	1	5	0.993307	99.33%
		24	**24**	**24**	**25**	**14**	**22**	**25**			

In table 5.4 we measure the SS values by using the CS values which we get earlier from table 5.3. To find the SS values, we use our proposed equation (3). This equation concludes that, if the sum of the SS related all the CS value is zero or above, the SS value will be 1 otherwise -1. Then these SS values are used in equation (4) to find the probability of brain tumor. In this table, we can see the sample number 21 has the probability of 73.11%. After consulting with the patient, we have found that, this patient developed brain tumor in the last month, so may not be experienced all this symptom.

5.2.2 Scenario-2:

Scenario-2 contains normal persons' data. These data are collected from normal people who are regularly check-up their diseases, so surely all the person does not contain any brain tumor, if our experiment says the same, then the experimental result will satisfy the original result. Table 5.5, 5.6 shows the experimental analysis and brain tumor detection for scenario-2:

Table 5.5: Measure CS value for scenario-2

		HDV	HDV	HDV	LDV	LDV	LDV	LDV	LDV	HDV
Sample Information		High Blood Pressure	Increase Body Tempera-ture	High Heart Rate	Low Heart Rate	Insom-nia	Less Amount of Steps	Lack Coordina-tion in the arms or legs	Less Amount of Deep Sleep	More Awake time in between Sleep
Sl. #	**Age**									
1	43	-1	-1	-1	-1	-1	-1	-1	-1	1
2	26	-1	1	-1	1	-1	-1	1	-1	-1
3	24	-1	1	-1	-1	-1	1	1	-1	-1
4	39	-1	-1	-1	1	-1	1	-1	-1	1
5	23	-1	-1	1	-1	-1	-1	-1	-1	-1
6	24	-1	-1	-1	-1	-1	-1	-1	-1	-1
7	24	-1	1	-1	-1	-1	1	1	-1	-1
8	24	-1	-1	-1	-1	-1	1	1	-1	-1
9	23	-1	-1	-1	1	-1	-1	-1	-1	-1
10	23	-1	1	-1	-1	-1	-1	-1	-1	-1
11	57	-1	1	-1	1	-1	1	-1	1	-1
12	23	-1	-1	-1	-1	-1	1	-1	-1	-1
13	23	-1	-1	-1	-1	-1	1	1	-1	-1
14	51	-1	-1	-1	-1	-1	-1	-1	-1	-1
15	23	-1	-1	-1	-1	-1	1	1	-1	-1
16	24	-1	-1	-1	-1	-1	-1	-1	-1	-1
17	23	-1	-1	-1	-1	-1	1	-1	-1	-1
18	25	-1	1	-1	-1	-1	-1	1	-1	-1
19	17	-1	-1	-1	-1	-1	-1	1	-1	-1
20	19	-1	1	-1	1	-1	1	-1	-1	-1
21	19	-1	-1	-1	-1	-1	-1	-1	-1	-1
22	39	-1	-1	-1	-1	-1	1	1	-1	1
23	31	-1	1	-1	-1	-1	-1	-1	-1	-1
24	42	-1	1	-1	-1	-1	1	1	-1	1
25	46	-1	-1	1	-1	-1	1	1	-1	-1
		0	**9**	**2**	**5**	**0**	**13**	**11**	**1**	**4**

Since table 5.2 contains the current data which we have captured by wearables and sensors, and our task is to find whether the current data satisfy our required symptoms or not. In table 5.5, we measure our required CS symptoms similarly as table-12 by using our proposed equation (1).

In table 5.6 we measure the SS values by using the CS values which we get earlier from table-14. We use our proposed equation (3) to find the SS values. This equation concludes that, if the sum of the SS related all the CS value is zero or above, the SS value will be 1 otherwise -1. Then these SS values are used in equation (4) to find the probability of brain tumor. In this table, we can see the sample number 11 and 25 have the probability of 4.74% each. The probability 4.74% is not good probability for decision make.

Sample number 11 is a old person, so maybe she have walking problem (WP) and drowsiness (DS), that does not mean she have brain tumor. Also for sample number 25, this person has seizures (SZ) and walking problem (WP) but that does not mean brain tumor.

Table 5.6: SS value measure and brain tumor prediction for scenario-2

Sample Information		HA	VN	VC	SZ	WP	DS	FG	Sum of All (L)	Probabi-lity of Brain Tumor	%age Probability of Brain Tumor
Sl. #	**Age**										
1	43	-1	-1	-1	-1	-1	-1	-1	-7	0.000911	0.09%
2	26	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
3	24	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
4	39	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
5	23	-1	-1	-1	1	-1	-1	-1	-5	0.006693	0.67%
6	24	-1	-1	-1	-1	-1	-1	-1	-7	0.000911	0.09%
7	24	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
8	24	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
9	23	-1	-1	-1	-1	-1	-1	-1	-7	0.000911	0.09%
10	23	-1	-1	-1	-1	-1	-1	-1	-7	0.000911	0.09%
11	**57**	**-1**	**-1**	**-1**	**-1**	**1**	**1**	**-1**	**-3**	**0.047426**	**4.74%**
12	23	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
13	23	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
14	51	-1	-1	-1	-1	-1	-1	-1	-7	0.000911	0.09%
15	23	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
16	24	-1	-1	-1	-1	-1	-1	-1	-7	0.000911	0.09%
17	23	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
18	25	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
19	17	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
20	19	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
21	19	-1	-1	-1	-1	-1	-1	-1	-7	0.000911	0.09%
22	39	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
23	31	-1	-1	-1	-1	-1	-1	-1	-7	0.000911	0.09%
24	42	-1	-1	-1	-1	1	-1	-1	-5	0.006693	0.67%
25	**46**	**-1**	**-1**	**-1**	**1**	**1**	**-1**	**-1**	**-3**	**0.047426**	**4.74%**
		0	**0**	**0**	**2**	**16**	**1**	**0**			

5.3. Result & Comparison

From experimental analysis, we can find the accuracy of our proposed method. For both scenarios, our proposed method identifies all the samples. Table 5.7 shows the result of our method.

Table-5.7: Results of the proposed method

Dataset	**# of sample**	**Identify correctly**
Scenario-1 (Brain Tumor patient's data)	25	25
Scenario-2 (Normal person's data)	25	25

Different authors proposed different techniques to detect the brain tumor. Although, most of the works used different classification techniques, we can compare our accuracy to them. Table-5.8 shows the accuracy measure of the different methods.

Table-5.8: Accuracy measure of different techniques

System	Accuracy
Naïve Bayes Classifier [26]	87.23%
Rao et al.[27]	89%
Dandil et al.[33]	90.79%
SVM classifier [26]	91.49%
Samjit [31]	95%
Devasena[34]	98.8%
El-Dahshan et al[32]	99%
Halder [29]	99.05%
Arakeri[35]	99.09%
Shil et al.[30]	99.33%
Proposed Method	100%

Chapter 6

Conclusion

In this paper, a stochastic method for automatic detection of brain tumor based on IoT is proposed. In our experiment, we have used a portable wrist wearable device and two extra sensors, which can track our daily activities. We analysis the different symptoms of brain tumor and select the most common symptoms, classify them such as it could be measure from our daily activities. We have experimentally shown, on brain tumor patient group and normal person group datasets, our proposed method estimates brain tumor more accurately. Experimental results with 50 person's including 25 brain tumor patient and 25 normal people confirm the effectiveness of our novel method for automatic detection of brain tumor using IoT. In addition, we compared our method to other state-of-the-art automatic brain tumor detection techniques and shown that our method perform excellent. Note that our proposed automatic brain tumor detection method does not require any magnetic resonance images (MRI), thus the computational complexity of our method is less as compare to other state-of-the-art techniques.

We have proposed a methodology for classification and detection of brain tumor. The sub-section 'result & comparison' shows the effectiveness of our proposed methodology for detect the brain tumor. Develop other methodology for other diseases using the same approach will be interesting. In future work, the addition of other symptoms including brain tumor detection method such as memory loss, confusing, changes in the ability to hear, taste, or small etc, would be interesting. Another future work would be detection of heart disease using the same line.

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Appendix A

List of Acronyms

SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
HR	Heart Rate
SS	Symptoms
CS	Classification Symptoms
HA	Headache
VN	Vomiting or Nausea
VC	Vision Changes
SZ	Seizures
WP	Walking Problem
DS	Drowsiness or Sleeping Problem
FG	Fatigue
HDV	High Define Value
LDV	Low Define Value
REM	Rapid Eye Movement

Appendix B

List of Notations

e	Exponential
x	Heart Rate
Y	Diastolic/Systolic Blood Pressure
$\geq$	Grater than or equal
$\leq$	Less than or equal
$<$	Less than
$>$	Grater than
$=$	Equal