Predicting the Possibility of Being Malignant Tumor based on Physical Symptoms using IoT

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***Abstract*—This paper presents a novel technique for predicting the possibility of being malignant brain tumor based on human physical symptoms using internet of things. Other state-of-the-art techniques for detecting the malignant brain tumor based on MRI images use X-ray light to detect malignant tumor, which is more expensive and harmful for health. On the other hand, the proposed device is designed in a portable way to monitor the real-time heart rate, blood pressure, body temperature and also more suitable for predicting the possibility of being malignant tumor compared to other existing techniques. This study also shows the relationship between symptoms and sub-symptoms of malignant brain tumor. The effectiveness of the proposed method for predicting the possibility of being malignant tumor from physical symptoms is testified by the result analysis.**

Keywords— Malignant Tumor, Vomiting, Vision Change, Headache, Insomnia, Deep Sleep

I. INTRODUCTION

In the addition of new technologies with various electronics devices and sensors has made Internet of Things (IoT) as a popular area for many researchers. The aim of this work is to predict the possibility of being malignant tumors based on the physical symptoms using IoT. Malignant tumors or cancerous tumors originates from the brain and grow fast and aggressively affect surrounding tissue. Malignant tumors have becoming very dangerous cause of death in recent years. According to the Cancer Statistics Center, a total of 1,762,450 new malignant cancer cases and 606,880 deaths from malignant cancer are projected to occur in the US in 2019 [1]. In recent year, approximately 23,830 adults diagnosed with malignant tumors [2]. On average 34% male and 36% female can survive at least 5-years after diagnose with malignant tumors [3]. No one can predict the future, but these survival rates show us the formidable face of malignant tumors.

Detection of any disease in early stage can increase the survival rate. Many researchers proposed various techniques for detecting the malignant tumors. In [4] author discussed a mechanism for detection of malignant tumors using photo sensitizers and their proposed mechanism is often known as photodynamic therapy (PDT). On that mechanism they used dosimetry of light delivery in the tissue to detect the malignant tumors which is responsible for damage blood cells. A study by Kobatake et al. discussed about a tumor detection technique for digital mammography [5]. They divided their proposed mechanism into two parts, one is detecting the tumors and another is extract features to ensure malignant tumors [5]. To solve the first part authors proposed an adaptive filter known as iris filter. Their system is basically based on image classification to detect the malignant tumors but that is very expensive. Another recent study by Rouhi et al. presented two automatic techniques to detect the benign and malignant tumors [6]. In the first technique, they proposed a method which is trained by artificial neural network (ANN) with automated region growing. In second technique, they used a genetic algorithm (GA) to determine the parameters segmented by cellular neural network (CNN) [6]. Their system provides a good accuracy compared to other methods but it is expensive. When someone develops some symptoms of malignant tumors and if he goes to hospital for ensure it, doctors asked him for the test which might be very costly. But our developed device works like a primary treatment which confirms the possibility of being malignant tumor.

The rest of the paper is organized as follows. Section II discusses the detailed overview of malignant brain tumor and its physical symptoms classification. The proposed methodology of this study is shown on section III, where the measurement of every symptoms and the possibility prediction technique is discussed. Section IV focuses the device and materials used in this study. The overall result analysis and discussions are described in section V where section VI provides some concluding remarks and future directions.

II. PHYSICAL SYMPTOMS OF MALIGNANT BRAIN TUMOR

A tumor formed by a group of abnormal cell which creates massive amount of tissues in our body. Brain is known as the most important organ of human body which controls all the activities. There are mainly two types of brain tumor- (i) benign or noncancerous, (ii) malignant or cancerous [7]. Malignant tumors originate from the brain and grow fast rather than the benign brain tumors and aggressively affect surrounding tissue. Malignant tumors also categorized into two parts- primary tumors and secondary tumors. Primary tumors start within the brain and secondary tumors have propagated from other parts of the body and generates to the brain [8]. Secondary brain tumors are more common than are primary brain tumors. The most common malignant tumors that can spread to the brain and other part of body are – Breast cancer, Colon cancer, Kidney cancer, Lung cancer, Melanoma etc.

The symptoms of malignant tumors varied from different sides according to the types and location of tumors. In human body different functions are control by several areas of the

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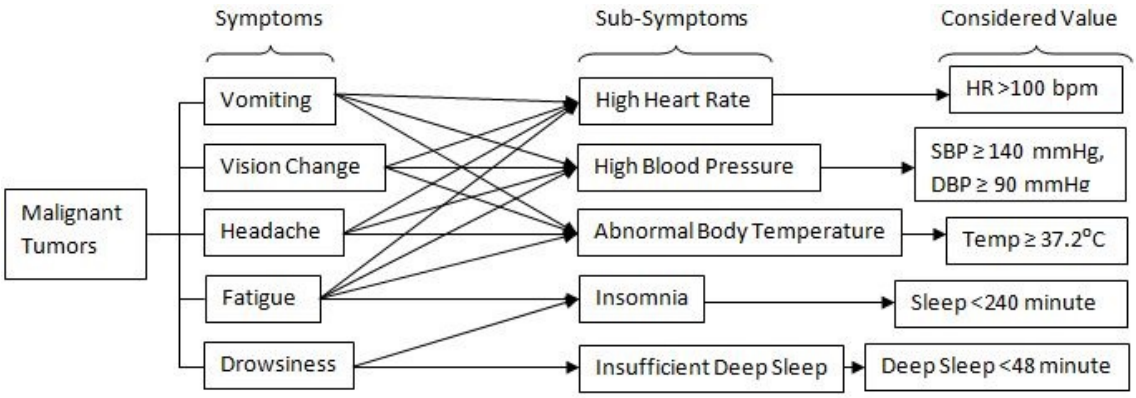

Fig. 1. Physical Symptoms Classification of Malignant Tumors

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. Fig. 1 shows the physical symptoms, sub-symptoms and corresponding considered value of malignant tumors.

A. Vomiting

Sometimes it can be occurred when a patient changes his position [9]. A patient feels fever, headache and sick to his stomach during this symptom. Also, the patient's blood pressure and heart rate become high during vomiting [9]. Vomiting is also the symptom of many conditions including-early stages of pregnancy [10], emotional stress (e.g., fear), intense pain, food poisoning, infections (e.g., stomach flu), overeating, and ulcers etc. But the main difference is malignant tumor related vomiting occurs in the morning when the patient wake from sleep. If those symptoms of vomiting are presents to someone, he could be developing a sign of brain tumor.

B. Vision Change

Vision change can be occurred from temporal lobe, brain stem, or occipital lobe of a brain [11]. Vision change includes double vision, blurry vision, and loss of the part of the vision. Patients also can see some floating spots during this symptom, which is known as 'aura' [11]. During this symptom, patient's heart rate and blood pressure becomes high, and feels vomiting. This symptom occurs when patients wake up from sleep and go to sleep.

C. Headache

Headache often occurs when patients wake up from sleep. Headache also can be caused by migraine. A recent statistic by American Brain Tumor Association shows around 700,000 people develop malignant tumor and 37,000,000 people develop migraine in US [2]. But the most important difference between malignant tumor headache and migraine headache is the change of pattern of headache [12]. Malignant tumors headache pattern changes rapidly and migraine headache pattern is not change rapidly [12]. During this symptom, patients experience high blood pressure, increase body temperature, vision change, and seizures problem.

D. Fatigue

Many several studies from malignant tumor patients show that fatigue decreases the quality of life [13]. During fatigue people usually cannot perform their daily functions. Fatigue has been considered as one of the leading signs, when a patient sends to doctor for ensure about malignant tumor diagnosis. Another study shows fatigue is caused by brain injury. About 40% to 70% of the primary brain tumor patients have fatigue as the most prevalent symptom [13]. During fatigue people often face vomiting, headache, and insomnia etc.

E. Drowsiness

Many several studies from malignant tumor patients show that fatigue decreases the quality of life [13]. During fatigue people usually cannot perform their daily functions. Fatigue has been considered as one of the leading signs, when a patient sends to doctor for ensure about malignant tumor diagnosis. Another study shows fatigue is caused by brain injury. About 40% to 70% of the primary brain tumor patients have fatigue as the most prevalent symptom [13]. During fatigue people often face vomiting, headache, and insomnia etc.

F. High Heart Rate (HHR)

The measurement of heartbeat speed per minute (bpm) is commonly known as heart rate. It can be varied quickly according to the body conditions. High heart rate is also known as tachycardia. When the heart rate is exceeded to the normal heart rate called high heart rate [15]. Generally, when heart rate exceeds 100 bpm is accepted as high heart rate in adults [15].

G. High Blood Pressure (HBP)

Blood pressure is the amount of pressure of blood flows through arteries. Blood pressure is varied between people to people. High blood pressure is also known as hypertension which is the excessive amount of pressure of blood flows through arteries. Basically, blood pressure is accepted high when systolic value (top number) is above or equal 140 mmHg and diastolic value (bottom number) is above or equal 90 mmHg [16]. High blood pressure increases the risk and causes different health problems.

H. Abnormal Body Temperature (ABT)

When the body temperature rises above the normal range of temperature set-point, usually defined as fever or abnormality in the body temperature [17]. There is not a constant lower point of body temperature which can be considered as lower limit of fever [17]. In our experiment, we have considered 37.2 °C as the lower limit of fever.

I. Insomnia (Ins)

Insomnia is a sleep disorder where people face difficulties during sleeping [18]. During insomnia people experiences less amount of sleep, and day time period sleep problem. It takes long time to falling asleep in insomnia [18]. In this study, we

have considered insomnia as poor amount of total sleep than normal people which is below 240 minutes.

J. Insufficient Deep Sleep (IDS)

When someone enter into deep sleep, it becomes difficult to wake him/her up. During deep sleep, human body temperature and blood pressure gets drop [19]. Different studies have shown that the standard deep sleep should be the 20% of overall sleep. During drowsiness people often face this symptom. In our experiment, we have considered below 48 minutes in deep sleep as insufficient deep sleep.

III. METHODOLOGY

In Fig. 1, we have divided the symptoms of malignant tumor into corresponding sub-symptoms because sub-symptoms can easily be measured by sensors. In total five sub-symptoms are used in this work. Only two sensors (heart rate sensor and body temperature sensor) are used in this research to calculate those five sub-symptoms. Heart rate sensor can directly measure the heart rate and temperature sensor can directly measure the body temperature. But these two sensors cannot measure rest of the three sub-symptoms (high blood pressure, insomnia, and insufficient deep sleep) directly.

In this research, we have used our previous work where we developed a system to calculate the systolic blood pressure using heart rate [20]. On that study, we collected more than 2500 data of heart rate and blood pressure then found out three common patterns between heart rate and systolic blood pressure [20]. Based on those common patterns we developed three regression equations. Our developed system takes heart rate as input and provides systolic blood pressure as output [20]. In this research, we have used the same concept to calculate the diastolic blood pressure.

There are five stages of sleep- stage 1, 2, 3, 4, and REM sleeps [21]. All these stages create a sleep cycle and it takes almost 90 to 110 minutes to complete one cycle. A cycle starts from stage 1 and end to REM sleep. All the stages take 15 to 20 minutes to complete. During sleep human heart rate drops and becomes 40-50 bpm. Stages 3 and 4 are called deep sleep [21]. When someone enter into deep sleep, it becomes difficult to wake him/her up. During deep sleep, human body temperature and blood pressure gets drop [21]. Using those concepts, we can easily measure the insomnia and insufficient deep sleep.

If we analyze Fig. 1, we can find out that the symptom Vomiting contains 3, Vision Change contains 3, Headache contains 3, Fatigue contains 4 and Drowsiness contains 2 sub-symptoms individually. If we add the number of sub-symptoms of all the individual symptoms, we get a total 15 sub-symptoms. Fig. 2 shows the flowchart of overall process of our system. In this flowchart-

HR = Heart Rate (unit is bpm)
BP = Systolic Blood Pressure (mmHg)
BP = Diastolic Blood Pressure (mmHg)
BT = Body Temperature (□C)
TS = Total amount of Sleep (minute)
TDS = Total amount of Deep Sleep (minute)

The system contains a temporary variable 'P' which is 0 (Zero) initially. After completing the input process, the system will check whether the HR > 100 or not. Because HR > 100 is the considered value for sub-symptom high heart rate (Fig. 1). If it is true then variable 'P' will update its value by adding 4 because high heart rate is a sub-symptom of 4 symptoms (Vomiting, Vision Change, Headache, and Fatigue). Otherwise variable 'P' contains the same value and goes to the next condition. Other sub-symptoms calculation is same as like this one. After completing all conditions, variable will 'P' contain a final value and based on that value our system will provide the result using the decision table (Table I). The result will show in a status which might be 'Positive' or 'Neutral' or 'Negative'. Positive means strong possibility of being malignant tumor, neutral means average possibility of being malignant tumor and negative means low possibility of being malignant tumor.

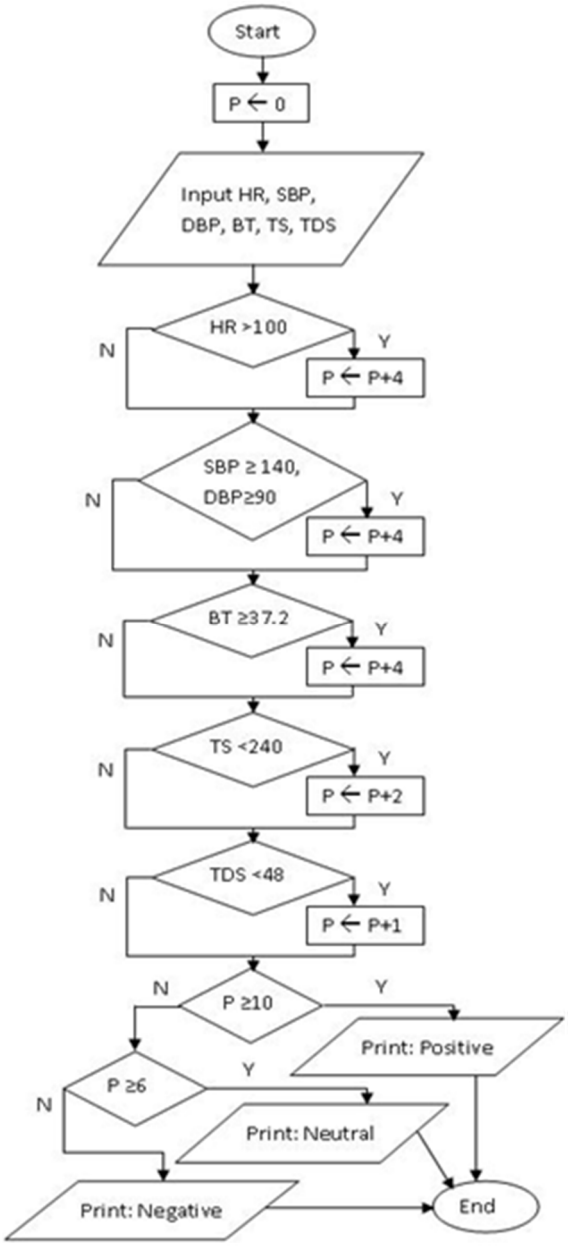

Fig. 2. Flowchart of overall Process

TABLE I. DECISION TABLE FOR MALIGNANT TUMORS

Final value of P	Result
P≥10	Positive
9≥P≥6	Neutral
P < 6	Negative

IV. DEVICE & COMPONENTS

This research aim is to measure the sub-symptoms including: heart rate, blood pressure, body temperature,

amount of sleep and calculate the approximate possibility of being malignant brain tumor. The Arduino Uno (ATmega328) is working as a CPU for measuring those sub-symptoms of a person. The list of sensors and components are given below-

- Body Temperature sensor
- Heart Rate sensor
- Arduino Uno (ATmega328)
- Power Supply
- Push Button
- LCD Display

Fig. 3 shows the overall circuit diagram of our device. In our experiment, we have used two push buttons, one is for start and another is restart. When the power supplied into the microcontroller (Arduino Uno), the device become active. After that, heart rate sensor and body temperature sensor will start to sense data when the start button is pushed. These sensors will wait until they do not get any valid data. A program is set into the microcontroller which calculates the sub-symptoms by using sensed data. Then this device calculates the possibility of being malignant brain tumor and display the output into LCD display.

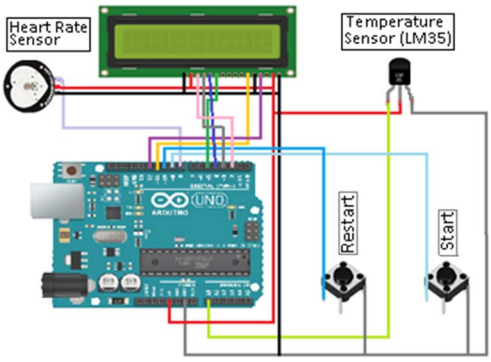

Fig. 3. Circuit Diagram for Possibility Detection of being Malignant Tumors

V. Result Analysis & Discussion

To find the efficiency of our method, we have used malignant tumors patient's data as well as normal people's data. Malignant tumors patient's data are collected from a second-class hospital in Bangladesh [22] and normal people's data are collected from university students with different age group. Table II and Table III show the experimental analysis for two groups with 20 randomly taken dataset (10 for each group). Here, '+' means patient contains sub-symptom and '-' means patient doesn't contain sub-symptom. By using the flowchart of Fig. 2 we have calculated the value of 'P'.

In Table II we can observe that, the value of 'P' for all samples are above 10. According to the decision table, all these samples contain strong possibility of being malignant tumor (Table I). In Table III we can see that, 9 out of 10 samples have the value of 'P' is less than 6 and only 1 sample contains above 6. Therefore, our system will provide a low possibility of being malignant tumor for 9 samples and an average possibility of being malignant tumor for the rest one. Finally, Table IV shows the efficiency of our proposed method.

TABLE II. Experimental Analysis of Malignant Tumors on Patients

No	HHR	HBP	ABT	Ins	IDS	P
1	+	+	+	+	-	14
2	+	+	+	-	-	12
3	-	+	+	+	+	11
4	+	+	-	+	+	11
5	+	+	+	+	+	15
6	+	-	+	+	-	10
7	+	+	+	-	-	12
8	+	+	+	-	+	13
9	-	+	+	+	-	10
10	+	+	-	+	-	10

TABLE III. Experimental Analysis on Normal Human Data

No	HHR	HBP	ABT	Ins	IDS	P
1	-	-	+	-	+	5
2	-	+	-	-	-	4
3	-	-	+	+	-	**6**
4	-	-	-	+	-	2
5	+	-	-	-	-	4
6	-	-	-	-	-	0
7	-	+	-	-	+	5
8	-	-	-	+	+	3
9	-	-	+	-	+	5
10	-	-	-	-	+	1

TABLE IV. Result Analysis of Proposed Method

Dataset	Total sample	Result		
		Positive	*Neutral*	*Negative*
Malignant Tumor patient	10	10	-	-
Normal People	10	-	1	9

VI. Conclusion

In this paper a novel method for the possibility prediction of being malignant tumor from the physical symptoms via IoT has been proposed. The experimental analysis was conducted for 20 datasets into two groups, and the proposed model provides nearly acceptable result. The result analysis of our model validates the effectiveness of the proposed low-cost design. In future, the accuracy of our system can be further improved with the addition of other parameter related to human body e.g., loss of balance, walking problem etc.

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