Brain Tumor Prediction by Utilizing Mathematical Approach and Internet of Things

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Abstract: In recent years, Brain Tumor has become one of the most dangerous disease which is increasing at an alarming rate. To put it simply, Brain Tumor is the growth of abnormal cells in the brain. They generate stress which can lead to brain damage, so detecting a Tumor before time is necessary in order to prevent the disease from entering the last stage. The common technologies devised in order to detect Brain Tumor till now involved Magnetic Resonance Imaging (MRI) or X-Ray. There are many methods to detect Brain Tumor using MRI imaging techniques but there aren't many methods to predict the occurrence of Brain Tumor before getting an MRI. This paper provides an easy and efficient procedure to estimate the possibility of Brain Tumor without much complexity. The proposed device makes use of a mathematical approach involving sub-symptoms, verifies the main symptom, predicts the possibility of a person having a malignant Tumor or not and finally keeps a record of patient's data and sends a report to the respective patients via QR Code. The sub-symptoms data is acquired through a heart rate sensor, a temperature sensor and a sphygmomanometer. This equipment can be used at home, but it is especially designed for hospitals that can't afford an MRI scanner. The proposed model demonstrates how Doctors can analyse the data generated by this equipment and give an overall feedback about the test results.

Keywords **- Systolic blood pressure, Diastolic blood pressure, Malignant Tumor, Brain Tumor Prediction, MRI.**

I. INTRODUCTION

With advancements in medical science, there is a gradual increment observed in health diseases relating to human heart, limbs, respiratory and brain related failures. Brain Tumor is one of the cause of fatalities observed in many people.
According to study of National Health Portal of India, the Brain Tumor or Central Nervous System CNS affects every 5 to 10 people in 100,000. Of these 26 % of childhood suffers from metastatic Cancers [1]. Metastatic Brain Tumor is which takes place due to transfer of Cancer from other part of the body to Brain or CNS. 40% of all Cancers spread through brain in almost all cases. Brain Tumor also occurs due to mental pressure causing strain to cells of the brain. Another study from IARC International Agency for Research on Cancer tells approximately 126,000 patients are diagnosed for Brain Tumor across the globe, of which the mortality rate of more than 97,000 [2]. It is of paramount importance to control this mortality rate. This rate can be mitigated if the Tumor can be diagnosed earlier. A patient may experience few of the symptoms if he/she is suffering through. Apparently the next step he/she can take is to diagnose it. The difficulty is that the conventional method of Brain Tumor diagnosis involves the expensive cumbersome techniques like radiotherapy, chemotherapy, or common MRI Magnetic Resonance Imaging. However, it is essential to detect the exactness of existing Tumor at first place, if the Tumor is detected latter on the type, it can be diagnosed by MRI depending upon the part of the brain affected.

This paper proposes an idea of a device which accepts body parameters and diagnoses the Tumor result with the help of algorithm developed by observing the patterns occurred in most Tumor patients. The two main Tumor types are benign (non-cancerous) and malignant which is aggressive. The malignant Tumor is so severe that it has cumulative survival rate of 2.5 years. At 2% for 10 years children and 57% for adults [3]. It is because of symptoms of Benign Tumor is subtler than malignant Tumor and can be removed without reaching other parts of the body. A person suffering with malignant Tumor can be detected as its symptoms are more pre-determined and frequent. Patients of various age group have different sets of symptoms. Out of 80,271 Tumor patients in India, 43% of men and 57% of women were affected with various malignant Tumor (2007 estimates) [4]. In this model, we divided the patients into two sets of age groups which ranges from 17 to 51 years and another from 31 to 70 years of group according to the symptoms observed. The major common symptoms suffered among them were un-explained nausea or vomiting, hearing deficiency, confusion in everyday matters, vision problem, personality or behavioral changes. Out of these symptoms we selected a few symptoms and distributed it into sub-symptoms. The sub-symptoms that shows common linearities in patterns and occurrence are then formulated to the main symptoms such that it is further used in algorithm.

The symptoms of malignant Tumor is classified from lower degree of severity to higher degree. In our study, we found that the symptoms with higher seriousness are vitally important in detecting the Tumor and widely incorporated as compared to minor symptoms which are discussed further. Whereas, walking problem, insufficient sleep time; blurriness, loss of peripheral vision, double vision problems in vision change, and lack in co-ordination are not considered since they are not severe. Compared to the symptoms mentioned earlier, there are more severe symptoms in detection that includes headache, confusion in everyday matters, cognitive problems like anxiety, déjà vu, and loss of self-awareness or behavioral personality changes. These symptoms are seen as minor parameters in in this study. As these symptoms take place under main symptoms in malignant patient, it is considered as sub symptoms in the diagnosis. The main symptoms that are used in spotting of malignancy are the heart rate, Systolic and diastolic blood pressure of the body, body temperature. These parameters of the body are widely used in this study for computing the possibility. Moreover, the less severe symptoms are totally based on the above mentioned main symptoms

II. LITERATURE SURVEY

Till now, many researchers have demonstrated different techniques to detect brain Tumor. Below are some of the existing techniques with a little description about their proposed concept.

I. Hayder Saad Abdulbaqi [5] proposed a hybrid method for detecting Brain Tumor using Hidden Markov Random Fields (HMRF) and Threshold methods. This technique obtained segmentation with high accuracy of MRI Brain Tumor and also calculates the size of the Tumor.

II. Ehab F. Badran proposed [6] a computer-based method that used neural network for classification of a healthy brain and a brain having Tumor after which it differentiated if it's benign or malignant. The major processing steps included segmentation and extraction which was tested using Matlab.

III. E. Ben George [7] proposed a technique which used a swarm-based optimization algorithm called the cuckoo Search (CS) algorithm and minimized the MAP estimate to segment the MRI images by segmentation. The Hybrid Centre Weighted Median Filter was introduced to smoothen and enhance the MRI images, also Markov Random Field was used to label the image pixels and their posterior function id calculated.

IV. Anatoly Sorokin [8] proposed a tool known as mass spectrometry to obtain brain biopsy samples. It used multi label classification technique in order to predict Brain Tumor and two classifiers on a dataset that checked the performance and stability.

V. T. M. Shahriar Sazzad [9] proposed a method which utilized greyscale MRI images for Tumor detection. It used a threshold-based OTSU segmentation over colour segmentation since it studied only greyscale. The pathology experts' acceptable accuracy rate provided a better understanding of the occurrence of Tumor.

VI. M. Usman Akram [10] proposed a model where in order to detect Brain Tumor, removal of noise and image sharpening took place after which global segmentation was run across sharpened images which therefore was processed by morphological operations and Tumor masking was done to remove the false segmented pixels.

VII. Md. Lizur Rahman [11] proposed a technique where in order to calculate systolic and diastolic blood pressure, they made use of temperature and heart rate to obtain a regression model which was further used to obtain blood pressure. This method was further used by the author in a different model to predict the possibility of Brain Tumor using these common symptoms.

III. PROPOSED SYSTEM

The main aim of this paper is to propose an idea that detects the brain tumor simply by taking observations of major symptoms as input, and detect the possibility of malignancy in brain. The symptoms that are observed in most of the malignant cases are derived into sub symptoms as discussed earlier. We have used the prominent sensors for the sub symptoms. For instance, A Fatigue has sub symptoms like high or low heart rate, high blood pressure, abnormal body temperature and Insomnia. So, the heart rate, blood pressure, body temperature are the parameters to measure fatigue. Similarly, the parameters of other main symptoms are also measured by their sub symptoms.

Heart Rate: It is observed that the heart rate for the younger age group from 3 year to 5 year child is 80 to 120; for children aged 6 to 12 years and above 13 years ranges 70 to 110 and 80 to 110 respectively. The malignant risk factors are generally prone to adults. So, the normal heart rate is considered for the children aged above 13 years as 80 to 110 bpm for this algorithm.

Blood Pressure:

1. Systolic Pressure range: When the heart pumps out the blood to the arteries and thereby to the whole body, it contracts. This is the systole pressure of the body. A normal range for systolic blood pressure is between 90 to 140 mmhg. By using sphygmomanometer, we inferred that the aggregate value for systolic pressure as 90 to 139 mmhg.
2. Diastolic Pressure range: In like manner, the diastolic pressure is the measure of blood pressure when the blood is filled in arteries of the heart, the heart expands and the blood pressure in the body goes lower. From the same work using sphygmomanometer, we used 59 to 90 mmhg as normal range of diastolic pressure. And the diastolic value below 60 as under defined value, while above 90 mmhg as higher diastolic pressure.

Body Temperature: By using the data [11], we used 97.8 F as normal defined value for an adult age above 18 or more.

Fig. 1 shows the flow diagram of the proposed methodology. We had defined a pre-determined range for every symptoms used in this algorithm. Since, there is an indirect relationship of heart rate with blood pressure, it is dependent symptom parameter. From the dataset, the symptoms are assigned such that if the recorded value exceeds the higher defined value or falls behind the lower defined value, they'll fall under different criteria. We had procured the dataset by measuring the body symptoms using sensors and equipment for more than 100 people. Parameter like blood pressure is measured externally by digital sphygmomanometer. The heart rate and body temperature is measured by their respective sensors, after which the value is sent to the Arduino. The algorithm with the mathematical model will compare the range with the normal range. For distinct composite values of under defined or higher defined values of systolic pressure, diastolic pressure, and body temperature, the heart rate is determined whether it falls under lower or above high defined value. On basis of comparison, the values are the final decision is made into two results. Either the evaluated range will be either under lower defined or above higher defined, or the normal range. The evaluation of range values is discussed further.

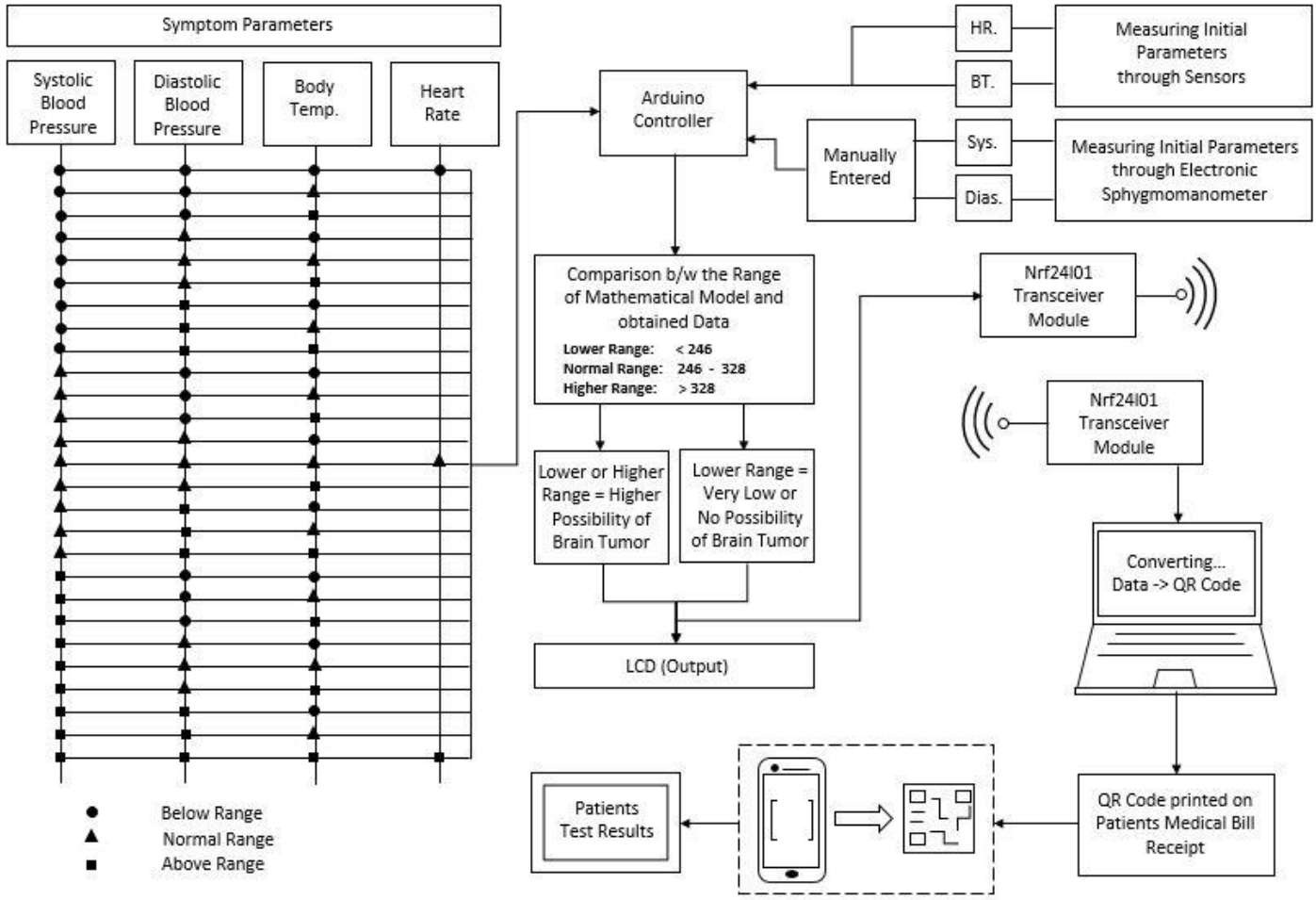

Fig. 1 Overview of the proposed model

Now, that the dataset is prepared, it is compared with the pre-determined values and assigned with the convention as shown in the fig. 1. As per our calculation of dataset, for the below under defined value, solid dot is used. For the value that comes out to be above higher defined is represented by cross convention. An evaluated value in normal range is shown by an empty circle. There are 27 possibilities of from three symptoms based on either under ranges. While the fourth symptom – heart rate is dependent on rest three symptoms. If the rest three symptoms are in normal range, the heart rate is also considered as in normal range. After our evaluation we inferred that if the maximum range for the symptoms is 328 and 246 is minimum range for an adult. We used LCD for displaying the result. The data of displayed result can be sent over by NRF Bluetooth module to personal computer of the doctor.

Another transceiver node can receive with its 2.4 GHz ISM band the results to the personal computer of the doctor. Once the data is received into the pc, the patient's report can be generated. On addition to that, QR code can be inscribed on it. The QR code may comprise of the results and any prescriptions if the doctor wants to prescribe.

IV. DEVICES & COMPONENTS

Fig. 2 shows the circuitry diagram of the proposed work. Evidently, the devices that are used for this work are Arduino Uno (ATmega328) which is as CPU to all the other components, Heart Pulse sensor, DHT humidity and temperature sensor for measuring body temperature, a 4x4 matrix keypad to enter the patient's data manually, LCD Display. For measuring the blood pressure, a digital sphygmomanometer was procured. Both of the parameters, systolic and diastolic pressure is used to measure. The Bluetooth NRF is 2.4GHz on chip transceiver also capable of audio streaming. Heart Pulse sensor which uses optical signal transmission to measure by placing finger to count the pulse rate.

Heart Pulse sensor: It is common knowledge that on every heart beat there is variation in volume of blood overall body. The heart pulse senor comprises of LED and the light detector. While measuring the heart rate, when the person being under test places its index finger on the heart rate sensor, there occurs a phenomenon called photoplethysmography. Which measure the continuous change in light intensity transmitted and reflected back. Some of the light is absorbed by the blood present in tissue. So, the detector outputs the pulse rate in the form of electrical signal. This signal is in AC is then converted into DC signal by using 2 stage HP-LP filter for the CPU [12].

DHT11 sensor: DHT11 is humidity and temperature sensor. Its composition carries the humidity sensing component and NTC temperature thermistor. Humidity sensing component with moisture holding substrate. When the person under test places the palm or finger on it, the water vapour is absorbed by the substrate in the sensor this makes releasing of ions from substrate. The amount of ions released is equivalent to higher conductivity. This gives the reading of body temperature of the person being

tested. While the thermistor is formed by sintering the semiconductor materials like polymer or ceramic, which causes large change in resistance for a small change in temperature [13].

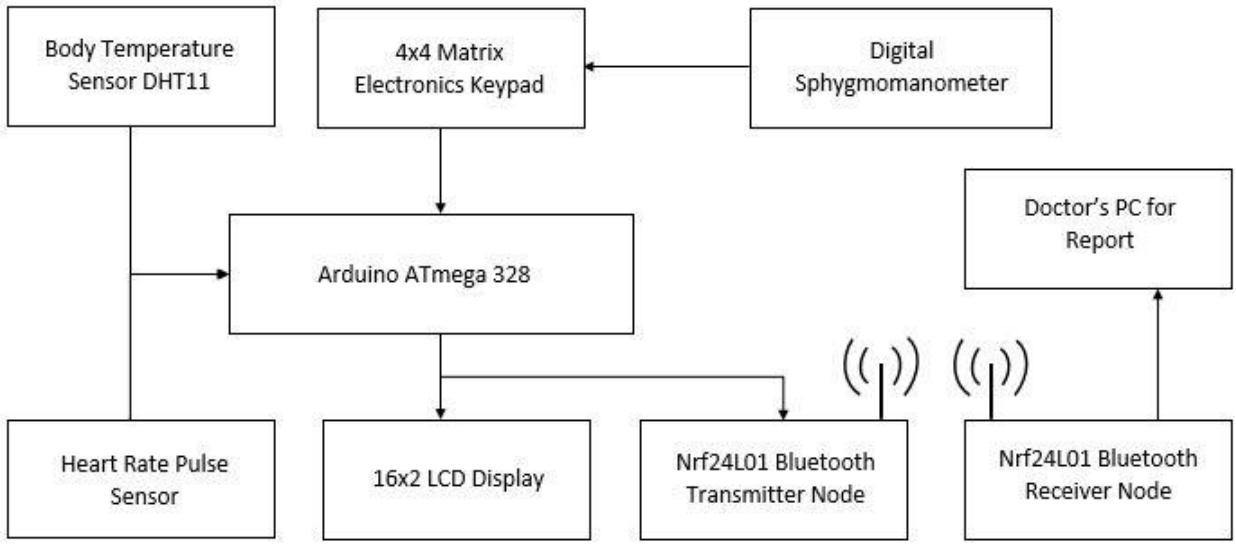

Fig. 2 Component Assembly

Digital Sphygmomanometer: The systolic and diastolic pressure can be easily obtained by using the digital sphygmomanometer. A wrist wearable digital sphygmomanometer that operates on 3V DC battery can measure the blood pressure from 20mmHg to 280 mmHg (hypertension / hypotension) with an accuracy of ±3mmHg.

4x4 Matrix keypad: A 4x4 matrix keypad is electronic component with values that are entered manually by using keypad. A keypad is the matrix like structure, designed to instruct the set of numeric. Every numeric is send according to the row and column belonging to that key. A dedicated "keypad" library can be imported which takes the value being entered manually. Each segment or button operates on 24Volts. Every row and column is provided with +5 V HIGH logic. When a key is pressed, the row and column belonging to that matrix is short circuited and the current flows for that segment. This gives the instruction to the CPU for that number [14].

NRF24L01 Bluetooth: The NRF24L01 is a Bluetooth module for communication like, data and control signals transmission, audio streaming. This module comes in two piece with one as transmitter and another as receiver node. It can work on 125 different channels and this transceiver IC operates in the 2.4GHz band. Both the transmitter as well as receiver node needs to be interfaced by a CPU. It operates on 3.3V with maximum output power of +20dBm.

V. EXPERIMENTAL RESULTS

It is quite evident from the above study, for a person to be non-Tumor in nature, the range should lie in between 246 to 328. If the heart rate is taken into consideration, the range for a healthy person should be between 306 to 438, but this possibility hasn't been considered since heart rate is indirectly related to blood pressure and including heart rate introduces discontinuity in the final output. The section including Heart Rate is considered only when all the other 3 parameters i.e. Sys, Dias & Temp are either lower, normal or higher. In our current study, the test was conducted for 10 random people. Below table first shows the range and the result for the test conducted for the 10 people of different ages, however we can envisage our work to be more accurate by adding more symptoms.

Table 1. Range of Parameters

Parameter	Systolic Blood Pressure (in mmhg)	Diastolic Blood Pressure (in mmhg)	Temperature (in ° F)	Heart Rate	Overall Summation (Including Heart Rate)	Overall Summation (Excluding Heart Rate)
High	139	90	99	110	438	328
Low	90	59	97	60	306	246

Table 2. People showing negative results for Brain Tumor

Age	Systolic		Diastolic		Temperature		Heart Rate		Result (Including HR)		Result (Excluding HR)		Final Result
30	124	0	79	0	98	0	88	0	389	0	301	0	NT
32	100	0	76	0	98.3	0	69	0	343.3	0	274.3	0	NT
40	121	0	87	0	98.4	0	84	0	390.4	0	306.4	0	NT
36	115	0	74	0	98	0	59	0	346	0	287	0	NT
42	87	-1	82	0	98.1	0	-	-	-	-	267.1	0	NT
43	120	0	92	1	98.6	0	-	-	-	-	310.6	0	NT
45	112	0	74	0	98.4	0	74	0	358.4	0	284.4	0	NT
46	125	0	58	-1	98.2	0	-	-	-	-	281.2	0	NT
51	101	0	61	0	98	0	52	-1	**312**	0	**260**	0	NT
48	117	0	91	1	98.7	0	-	-	-	-	306.7	0	NT

Table 3. People showing positive results for Brain Tumor

Age	Systolic		Diastolic		Temperature		Heart Rate		Result (Including HR)		Result (Excluding HR)		Final Result
47	136	0	103	1	99.8	1	-	-	-	-	338.8	1	T
51	151	1	103	1	99.4	1	112	1	465.4	1	353.5	1	T
63	149	1	99	1	98.9	0	-	-	-	-	346.9	1	T
52	139	0	93	1	99.3	1	-	-	-	-	331.3	1	T
45	163	1	95	1	100.3	1	76	0	**434.3**	0	**358.3**	1	T
30	142	1	95	1	98.9	0	-	-	-	-	335.9	1	T
50	158	1	100	1	98.7	0	-	-	-	-	356.7	1	T
42	155	1	90	0	99.3	1	-	-	-	-	344.3	1	T
51	139	0	109	1	99.4	1	-	-	-	-	347.4	1	T
54	147	1	98	1	99.3	1	99	0	443.3	1	443.3	1	T

Table 4. Acronyms & Notations

Notations	Meaning
-1	Below value
0	Normal
1	Above value
NT	Non-Tumor
T	Tumor

As it can be observed from Table 2 which shows negative results for Brain Tumor, a patient with an age of 51 has a result of 312 (including HR) and 260 (excluding HR). Though these two values are really close to the lowest value from the range table 1, the person still has very low chances of having a brain tumor based on the value of the other 3 parameters. Similarly in Table 3, the patient with the age of 45 has an overall sum of 434.3 (including HR) and 358.3 (excluding HR). Here, the result (including HR) does lies in the normal range but as it was mentioned earlier that due to proportionality of Heart Rate and Blood Pressure, the result including heart rate won't be considered since either way its value is too close to the higher value from range Table 1 and the result (excluding heart rate) clearly lies beyond the higher level of the range table.

VI. CONCLUSION

In this paper, we presented a simple yet useful method of malignant Brain Tumor prediction. There are numerous ways available for diagnosing the brain Tumor, but it is vain and risky unless and until the possibility of the Tumor is undetermined. Through analysis of literature, we found that there are researches on diagnosis of Tumor, however currently there is not any prediction technique. From the above model, we demonstrated that it is essentially important to identify the possibility of Tumor before going further for expensive MRI of radiotherapy diagnosis techniques.

The method proposed for detection is totally unique and gives the acceptable results in its segment. Moreover higher accuracy can be attained if more symptoms are taken under consideration. Our proposed work is easy to execute and we see this noble idea to be deployed in future in medical and household as a kit.

VII. FUTURE SCOPE

For the future work, we expect this device to be widely deployed for detecting other diseases. It is observed that almost every other disease exhibits a particular set of symptoms and their sub-symptoms. So, the idea is to study and use these patterns of symptoms and sub-symptoms to detect the disease with easy steps. The Current device is having many possibilities of improvements that can be worked upon in future depending upon the application. Diseases that occurs internally but their symptoms are evident can be detected from this technique.
The same study can also be conducted for detection of other serious chronic diseases like Corona Virus, cancerous or arthritis disease. We would also like to explore other possibilities of detection by means of physical symptoms.

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