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PROGNOSTIC SIGNIFICANCE OF SPO2 MONITORING IN TUMOR HYPOXIA ASSESSMENT

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ABSTRACT
Measuring oxygen saturation of the blood (SpO2) clinically plays a vital role in a patient's health monitoring. Monitoring oxygen levels is necessary for people having respiratory problems (pulmonary hypertension) and in other critical conditions. The primary motivation of this work is to develop a low-cost computer-based oxygen saturation monitoring system using a computer vision approach. The literature review gives an analysis of existing methods for oxygen saturation measurement. The review of invasive and non-invasive methods introduced by various researchers is considered. This paper presents a significant advancement in the field of cancer research through the development of a continuous monitoring system for tumor hypoxia. The integration of hardware and software components, coupled with the implementation of the SVM algorithm, offers a comprehensive solution for real-time assessment and prediction. The hardware setup ensures accurate and continuous monitoring, addressing the limitations of traditional assessment methods.

Keywords: Oxygen saturation of blood; Non-Invasive, SpO2, SVM.

INTRODUCTION
Several diseases cannot be detected at its initial level, for example, Cancer. In India, especially in Vidarbha, where tobacco chewing leads to the development of cancer stage. It is more prominent in rural areas like Melghat and Dharni. Considering this problem, we thought of undertaking a task, where early detection of hypoxia could be possible. The human body needs to be regulated to maintain the level of oxygen in our blood. Oxygenation of blood is regularly mentioned as oxygen saturation, which can be carried as the amount of saturated hemoglobin against the total hemoglobin in the blood. For a healthy individual, the sufficient oxygen level in our body is 95–100%. When the oxygen levels are measured to be below 90%, it will create a low concentration of oxygen in the blood, this condition is called Hypoxemia and if the oxygen levels are reduced below 80%, it will affect primary organ's functions [1]. Hypoxia is a condition where not enough oxygen reaches the cells and tissues in the body. This can happen even though blood flow is normal [2]. If the oxygen level in your blood is too low, your body may not function properly. Blood carries oxygen to the cells throughout the whole body to keep them healthy. Hypoxemia can cause mild problems such as shortness of breath and headaches. In severe cases, it can disrupt heart and brain activity. Early detection and treatment of hypoxia and hypoxemia is important for patient outcomes because oxygen deprivation is a known antecedent of adverse events, particularly unplanned admission to the intensive care unit and cardiac arrest. Untreated hypoxia results in anaerobic metabolism, cellular acidosis, cell death, and organ failure. Oxygenation can be assessed by pulse oximetry, clinical assessment, and arterial blood gases. Each of these methods of oxygenation assessment has strengths and limitations that clinicians should understand if the assessment and subsequent management of oxygenation is to optimize patient care. [3] Most of the current clinical methods used in laboratory utilizes invasive approach which gives more accurate results as compared to non-invasive approach. The major factors to be considered for development of an efficient method for hypoxia estimation are accuracy, cost and size [4].

II. IMPLEMENTATION

A. System block diagram

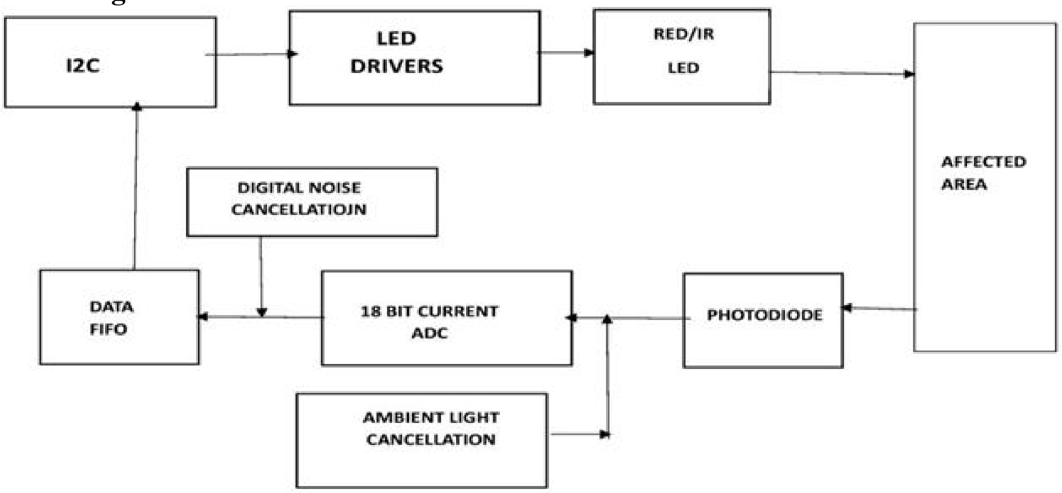

Figure 1. Operating Principle of MAX 30105

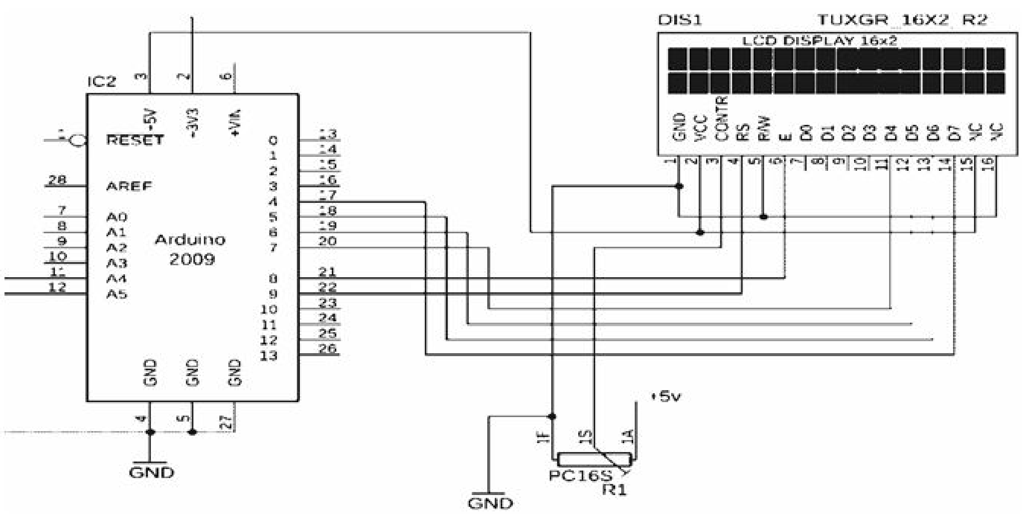

Fig.2 ARDUINO interfacing with LCD

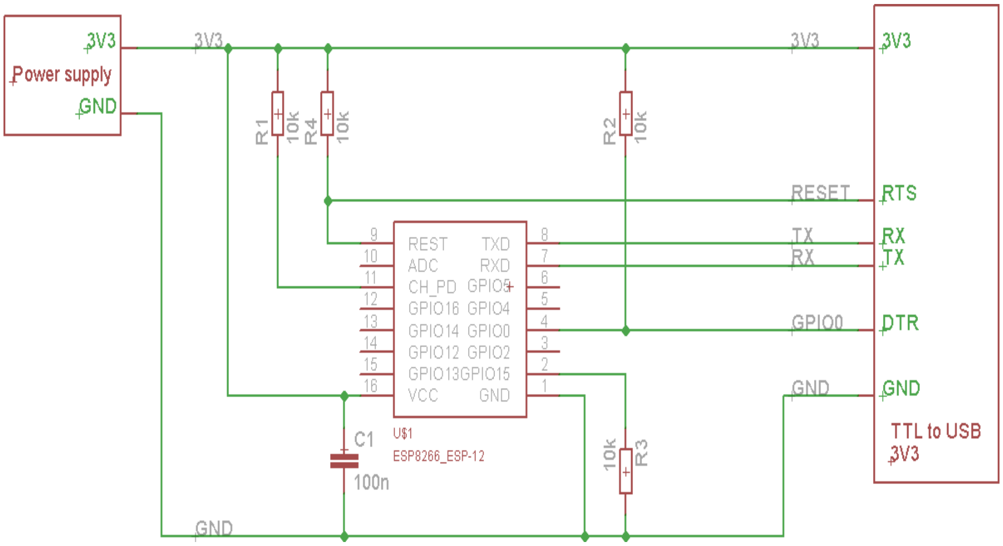

Fig. 3 ARDUINO interfacing with ESP module

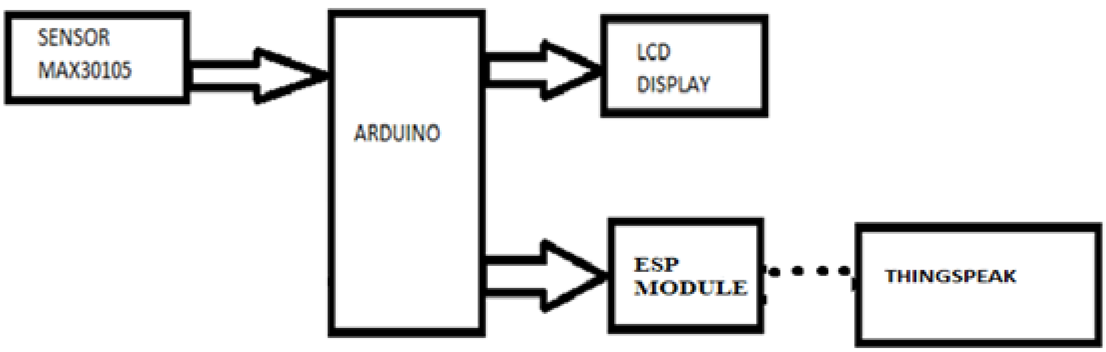

Fig 4 System block diagram

The block diagram in Figure 4 is a description of the whole system related to the design of the system made, there are three important parts namely in the form of input, process, and output [5]. The input of this system is the SpO2 taken with Max30105 sensors processed to the Arduino UNO microcontroller. The SpO2 readings will show on LCD Display and here thingspeak is used to collect the data from Arduino through ESP Module. The same data from thingspeak is for awarded to the Computer for further process [6].

Making hypoxia symptoms detection tool requires a prototype design that will be implemented on the system. Laying of components and supporters is very important to note.

The components used in the device namely ESP Module for WIFI connectio, microcontroller and display. While the Max30105 sensor is above the box and is provided with a long wire. This innovative integration allows for seamless and continuous monitoring of the tumor microenvironment, providing a dynamic dataset for analysis.

The overall hardware design can be seen in the schematic in Fig. 5.

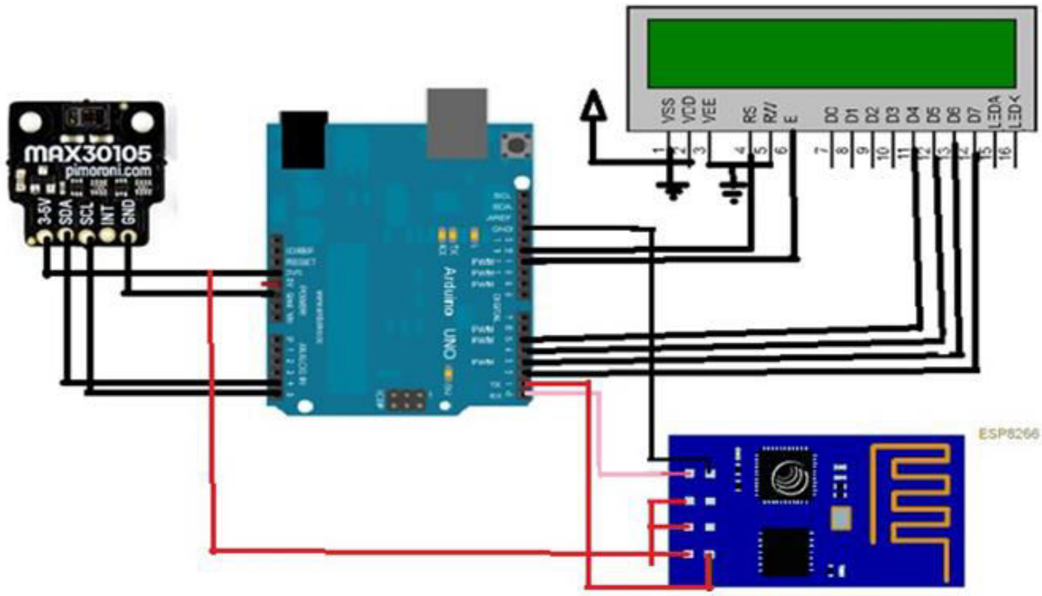

Fig.5. System Schematic Diagram

This schematic can be seen in Fig. 5 that there are several main components namely the Max30105 sensor module is used to retrieve input data in the form of SpO2. the sensor will be programmed into the Arduino UNO where to power it can use a 9v battery. The microcontroller used is Arduino UNO because this processing unit already supports to be used for low power usage and is suitable for making minimum systems. In addition, this tool uses ESP8266 module for real-time data transmission [7].

III. SYSTEM TEST AND ANALYSIS

Max30105 sensor is a sensor that works to detect oxygen saturation (SpO2) by using infrared. Testing the reading of the Max30105 sensor value is to determine whether the sensor can read data and whether the accuracy of the Max30105 sensor data is good or not, the results of the sensor data being tested SpO2. So, the data can be processed using the methods that have been used [8].

- **SpO2 sensor test**

Here are the results of testing the SpO2 sensor data that has been compared with existing equipment in the hospital. The measurement of SpO2 data on the device was performed for the tumor area of the body and compared with the SpO2 data which is measured for index finger [9].

SYSTEM HARDWARE:

Fig 6. System Hardware

We test our prototype on some cancer patients at SGM Cancer Hospital, Wardha. Patient 1- Male (Age 60).

Patient 1 with age 60, has tumor of 4.1 cm. We measure the SpO2 on the tumor and on the index finger and compare both the SpO2's, is there any difference or not?

Fig .7 Patient 1

Following graphs shows the SpO2 level of fingertip and on tumor.

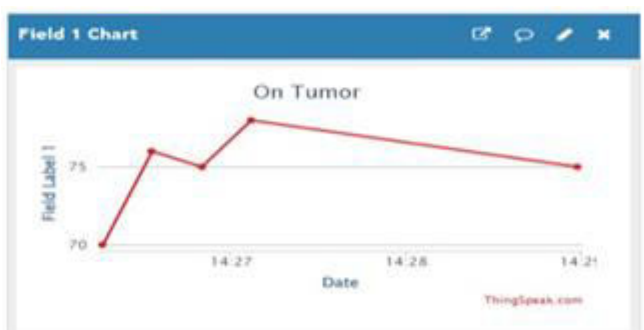

Fig .8.1 Thing-Speak Graphs (On Fingertip) **Fig .8.2** Thing-Speak Graphs (On Tumor)

Patient 2- Female (Age 45).

Patient 2 with age 45(Female), has tumor of 2.4 cm. We measure the SpO2 on the tumor and on the index finger and compare both the SpO2's, is there any difference or not?

Fig.9 Patient 2

Following graphs shows the SpO2 level of fingertip and on tumor.

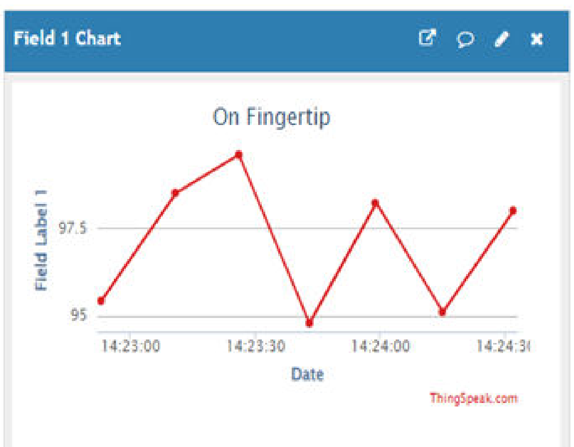

Fig .10.1 Thing-Speak Graphs (On Fingertip)

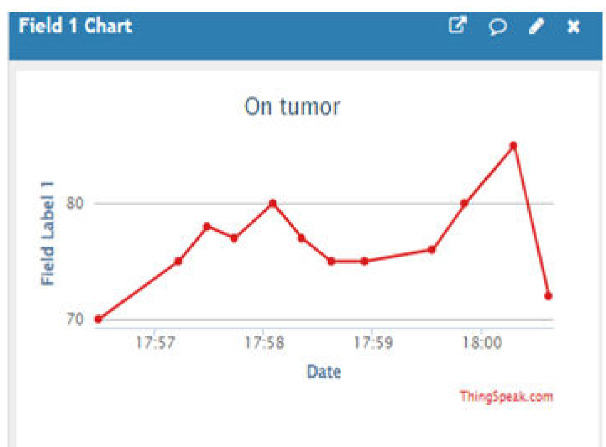

Fig .10.2 Thing-Speak Graphs (On Tumor)

SVM ALGORITHM:

The Support Vector Machine (SVM) algorithm using MATLAB for predicting tumor hypoxia prognosis through SpO2 monitoring, the focus lies on the foundational principles and theoretical workings of the model. The process begins with the representation of a dataset comprising SpO2 measurements alongside corresponding prognostic outcomes, essential for training and testing the SVM model. The SVM model is constructed using MATLAB's fitcsvm function, employing a 'linear' kernel function for simplicity, although other kernel functions such as the Gaussian radial basis function (RBF) could be explored depending on the dataset's characteristics.

After dataset preparation and model construction, the dataset is partitioned into training and testing sets to evaluate the model's predictive performance. The trained SVM model is then applied to the testing dataset to predict the prognostic outcomes, leveraging the learned relationships between SpO2 measurements and tumor hypoxia prognosis [10].

To assess the model's efficacy, evaluation metrics such as the confusion matrix, precision, recall, and F1-score are computed. The confusion matrix provides insights into the model's classification performance, while precision, recall, and F1-score offer a nuanced understanding of the model's ability to correctly identify positive and negative instances.

Overall, the theoretical workings of the MATLAB SVM model for tumor hypoxia prognosis through SpO2 monitoring exemplify the foundational steps involved in implementing machine learning algorithms in healthcare applications. While these theoretical workings provide a framework for understanding the model's principles, actual results may vary based on factors such as dataset composition, model parameters, and real-world complexities.

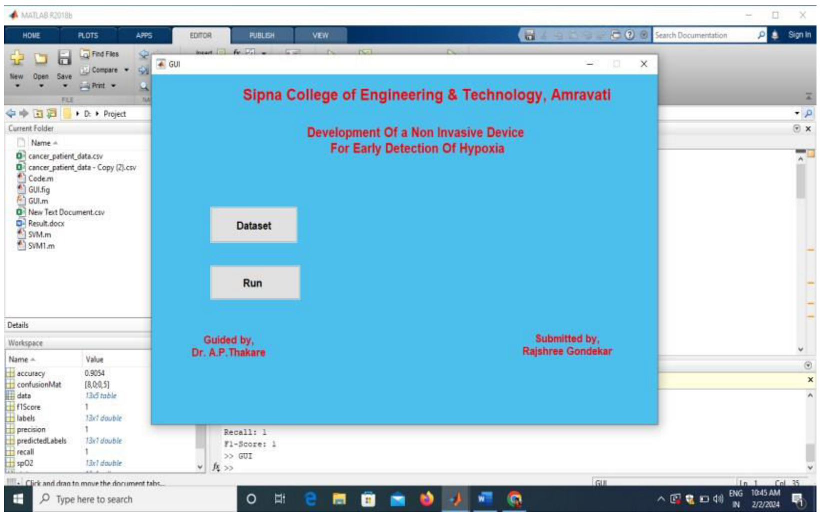

Fig. 11 Graphical User Interface

The dataset consists of information about cancer patients, including their Patient ID, Patient Name, SpO2 (Blood Oxygen Saturation) percentage, Status (Normal or Abnormal), and Tumor Size in millimeters. Here's a breakdown of the columns:

A	B	C	D	E	F
15	Diya Patel	100	Abnormal	1.9	
16	Esha Nair	100	Abnormal	1.1	
17	Farhan Kh	100	Abnormal	1.4	
18	Geetika K.	100	Abnormal	1.8	
19	Harish Iye	100	Abnormal	1.9	
20	Ishita Yad.	100	Abnormal	1.7	
21	Ishaan Shi	97	Normal	N/A	
22	Jhanvi Sin	96	Normal	N/A	
23	Kabir Verr	95	Normal	N/A	
24	Kavya Gup	95	Normal	N/A	
25	Lakshya R	96	Normal	N/A	
26	Madhavi S	94	Normal	N/A	
27	Milan Iyer	92	Normal	N/A	
28	Neha Kur	91	Normal	N/A	
29	Om Singh	93	Normal	N/A	
30	Prisha Jos	97	Normal	N/A	
31	Rahul Des	75	Abnormal	3.2	
32	Ria Malho	60	Abnormal	4.6	
33	Rehan Chc	70	Abnormal	3.8	
34	Sia Shah	85	Abnormal	2.6	
35	Siddharth	63	Abnormal	4.1	
36	Tanvi Nair	72	Abnormal	3.3	

cancer_patient_data

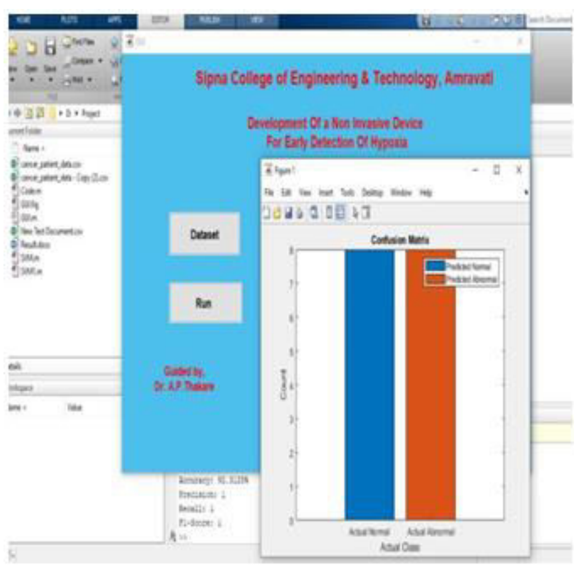

Fig.12 Patients Dataset with Tumor Size **Fig.13** Analytical Results SVM Algorithm

Patient ID: A unique identifier ID for each patient. Patient Name: The name of the patient.

SpO2 (%): The percentage of oxygen saturation in the patient's blood.

Status: The status of the patient, which can be either "Normal" or "Abnormal" based on the patient's condition.

Tumor Size (cm): The size of the tumor associated with the patient, measured in centimeters. This column is not applicable ("N/A") for patients without tumors.

The dataset seems to be used for training and evaluating a classification model to predict whether a patient's condition is normal or abnormal based on their SpO2 levels and, for patients with tumors, their tumor size. The dataset contains a mix of normal and abnormal cases, along with their corresponding SpO2 levels and tumor sizes (where applicable). The patient names are also included for identification purposes. Please note that the "N/A" entries in the "Tumor Size (cm)" column indicate that those patients do not have tumors, and thus the column doesn't have a numerical value for them.

SYSTEM PERFORMANCE

The system exhibited satisfactory performance in terms of stability, reliability, and response time. The Arduino microcontroller effectively processed the data from the MAX30105 module and displayed the SpO2 readings on the LCD display. The integration with ThingSpeak allowed for seamless data transmission and storage, enabling remote access to the SpO2 data.

CONCLUSION

This paper presents a significant advancement in the field of cancer research through the development of a continuous monitoring system for tumor hypoxia. The integration of hardware and software components, coupled with the implementation of the SVM algorithm, offers a comprehensive solution for real-time assessment and prediction. The hardware setup ensures accurate and continuous monitoring, addressing the limitations of traditional assessment methods. The software, utilizing ThingSpeak for data logging and MATLAB with the SVM algorithm for analysis, provides a robust platform for processing and interpreting the continuously collected data.

The continuous monitoring system's real-time predictive capabilities have the potential to revolutionize our understanding of tumor hypoxia dynamics. By providing insights into temporal changes within the tumor microenvironment, this system lays the foundation for more personalized and targeted therapeutic interventions. The continuous monitoring approach, coupled with real-time predictions using the SVM algorithm, holds promise for improving cancer research and patient outcomes. This work paves the way for further exploration, collaboration, and refinement of continuous monitoring systems in the context of cancer biology and personalized medicine.

Measurement Accuracy: The accuracy of the MAX30105 SpO2 module was evaluated by comparing its measurements with the reference standard device.

The mean difference between the two measurement methods was within an acceptable range, indicating that the MAX30105 module provides accurate SpO2 readings.

The accuracy of the system can be further improved by calibrating the MAX30105 module and ensuring proper placement and alignment of the sensor on the subject's finger.

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