SMART EMOTIONAL STRESS MONITOR

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ABSTRACT

Emotional Stress Monitor (ESM) kit is a wearable sensor device that used to measure the human stress level. Human skin offers some resistance to current and this skin resistance changes with the emotional state of the body and skin resistance varies inversely proportional to the stress. In the relaxed state, the resistance offered by the skin is as high as 2 mega ohms or more, which reduces to 500 kilo-ohms or less when the emotional stress is too high. This device is helpful to quantify the treatment of patients with some kind of mental condition by measuring their stress levels. Galvanic Skin Response (GSR) can be measured with the help of Ag-AgCl Electrodes which are 98.97% accurate.

We had used this device on patients before and after proper medical therapy of doctors. This will help us to quantify and highlight the changes in stress values of such patients by comparing results obtained before and after therapy given to the patient.

Key Words: Emotional Stress Monitor (ESM), Galvanic Skin Response (GSR).

I. INTRODUCTION

The study of physiological effects due to electrical changes in human skin began over 100 years ago. Féré found that, by passing a small electrical current across two electrodes placed on the surface of skin, one could measure momentary decrease in skin resistance in response to a variety of stimuli. In other words, skin became a better conductor of electricity when external stimuli were presented. Similarly Tarchanoff reported that one could measure changes in electrical potential between two electrodes placed on the skin without applying external current. Therefore Féré and Tarchanoff are said to have discovered the two basic methods of recording electrodermal activity in use today.

According to research by PsychLab, the skin is a selective barrier that serves the function of preventing entry of foreign matter into the body and selectively facilitating passage of materials from the bloodstream to the exterior of the body. There are two forms of sweat glands in the human body; the apocrine and the eccrine. The latter one is of primary interest to psycho physiologists. The primary function of the eccrine sweat glands is thermoregulation. However, according to Edelberg, the sweat glands on the palmar and plantar surfaces are more responsive to psychological sweating than other areas. Figure below shows the anatomy of the eccrine gland and various layers of skin.

The skin has electric properties that change relatively quickly and are closely related to psychological processes. These changes in electrodermal activity (EDA) and skin conductance are related to changes in eccrine sweating. As sweat is an electrolyte, the more the skins sweat ducts and pores are filled with sweat, the more conductive the skin becomes. The sympathetic branch of the autonomic nervous system (ANS) controls eccrine sweating, thus skin conductance reflects the arousal of the sympathetic ANS which accompanies various psychological processes. EDA and skin conductance have been used in a wide array of research, serving as indicators of such processes as attention, habituation, arousal, and cognitive effort in many different sub domains of psychology and related disciplines. In judgment and decision making (JDM) research, skin conductance is often used as an indicator of affective processes and emotional arousal.

We use the term skin conductance response (SCR) which is the measure of change in output voltage when a small input voltage is applied. Two electrodes are used to measure skin conductance at the finger tips as they are easily accessible and can collect data unobtrusively and reliably. Also eccrine sweating on the volar surfaces is different from other locations, as sweating in these skin parts is strongly related to mental processes rather than thermoregulation. Nowadays, there are a number of devices used for measuring skin conductance and resistance. Most of them follow a similar principle by keeping the current constant and measuring the change in voltage or by keeping the voltage constant and measuring the current. However, constant-voltage skin conductance systems have gained more popularity for direct measurement of skin conductance and resistance. These products are easily available in the market however they are quite expensive. Therefore, in this project we decided to design a simple skin conductance sensor that is cheap, sufficiently reliable, has low power consumption and capable of monitoring data in a comfortable and unobtrusive manner.

Skin conductance is usually measured in micro Siemens (μS) which is the reciprocal of resistance. However in this project, skin conductance is measured in millivolts (mV). As discussed earlier, this value is directly related to the level of arousal. The skin conductance signal is input into the analog port pin 25 of the microcontroller. The details of sensor are explained in the skin conductance response sensor section below.

Skin Conductance Response Sensor

Skin conductance response (SCR) is measured by passing a small current through a pair of electrodes placed on a surface of skin. The measured value can be in the form of resistance, conductance, voltage value or current value. In this project, the skin conductance sensor went through a few design modifications. The initial design consisted of three operational amplifiers. The non-inverting inputs of two amplifiers were connected to the electrodes while the inverting inputs were connected with each other through a resistor. The third operational amplifier was used as a comparator. The output from this setup was a voltage value in millivolts.

The biggest problem with EEG and EMG measurements are that they undergo problems of artifacts which can be due to hairs and just simple movements. To remove such artifacts either you have to abrade your skin or use a gel for better coupling. But sometimes gels stick on your electrodes unnecessarily and needs proper maintenance. These devices require much of circuitry and are not cheaper.

EEG and EMG does not give purest form of information for emotional changes and state of a person and these devices are not handy like GSR which requires only use of two electrodes which act as two terminals of resistance and readings are accurate and don't contain artifacts. Previously a lot of circuitry involving use of copper foil electrodes and voltage regulator plus dot led driver was being done and introduced in many projects. The output through such circuitry which we have earlier used were showing immediate results in form of LED's glowing but due to corrosion as well as destruction of its conductivity caused due to simultaneous soldering causes damage to the electrode and reduces the quality of the output. Filters and voltage regulators have been working okay but sensor was creating a problem. So we opted to use Ag-AgCl electrodes available in the market.

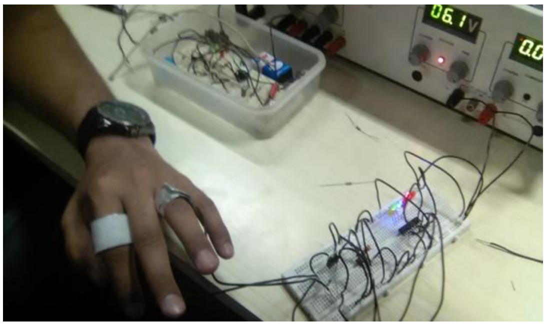

Figure 1: Use of copper electrodes in project.

II. LITERATURE SURVEY

In 1849, Dubois-Raymond in Germany first observed that human skin was electrically active. He immersed the limbs of his subjects in a zinc sulfate solution and found that electric current flowed between a limb with muscles contracted and one that was relaxed. He therefore attributed his EDA observations to muscular phenomena.

Thirty years later, in 1878 in Switzerland, Hermann and Luchsinger demonstrated a connection between EDA and sweat glands. Hermann later demonstrated that the electrical effect was strongest in the palms of the hands, suggesting that sweat was an important factor.

The controversial Austrian psychoanalyst Wilhelm Reich also studied EDA in his experiments at the Psychological Institute at the University of Oslo, in 1935 and 1936, to confirm the existence of a bio-electrical charge behind his concept of vegetative, pleasurable "streamings".

By 1972, more than 1500 articles on electro-dermal activity had been published in professional publications, and today EDA is regarded as the most popular method for investigating human psycho physiological phenomena. As of 2013, EDA monitoring was still on the increase in clinical applications.

A number of physiological markers of stress have been identified, including electro dermal activity, heart rate (HR), various indices of heart rate variability (HRV), blood pressure (BP), muscle tension, and respiration. Other than that, some biological markers that are known to change with changes in the stress level of the person, such as the blood composition, respiration and hormonal changes.

Galvanic Skin Response (GSR), sometimes called Electrodermal Activity (EDA) is directly correlated to the sympathetic nervous system activity and thus provides a powerful tool for monitoring arousal. In the research conducted by Poh et al, a system is proposed in the development of a novel, unobtrusive, non-stigmatizing, wrist-worn integrated sensor, capable of monitoring long-term, continuous assessment of GSR outside of a laboratory setting. The human body produces several measurable signals that indicate activity in various systems. One such bio-signal is the galvanic skin response (GSR). GSR reflects activation of the autonomic nervous system, which is responsible for control of visceral functions such as heart rate, digestion, respiration, and perspiration. The majority of these functions operate on an unconscious level. More specifically, GSR is linked to activity in the sympathetic nervous system. As a part of the autonomic nervous system, the sympathetic nervous system stimulates metabolic output to deal with external challenges. When the body is under stress, the sympathetic nervous system responds by elevating heart rate, blood pressure, and sweat production, as well as redirecting blood from the digestive system to the skeletal muscles, lungs, and brain in preparation for motor activity. GSR is considered to be a function of sweat gland activity and pore size. As the body comes under stress, sweat production increases, and the sweat ducts fill. Sweat is a weak electrolyte and a good conductor, so GSR is measured by applying a low voltage electric current to the skin. Increased sweat production creates several low resistance pathways across the surface of the skin.

In addition, the study also investigates the choice of electrode material affects performance by comparing the use of conductive fabric electrodes to standards Ag/AgCl electrodes. In the study, they decided to use Ag/AgCl disc electrodes with contact areas of 1.0 cm^2 (Thought Technology, Ltd) as recommended in the literature. These electrodes were chosen to be embedded along with the sensor in a wristband to provide a low degree of intrusiveness. In the study they decided to use the ventral side of the distal forearm as the recording site. The proposed system was validated with a commercial system such as Flexcomp Infinity (Thought Technologies, Ltd). Overall the complete wearable system as designed by the authors is compact (70 mm x 70 mm x 20 mm), lightweight (40.3 g), and the components used can be purchased off the shelf for approximately $150. In contrast, a commercial system such as the Flexcomp Infinity (Thought Technologies, Ltd.) measures 130 mm x 37 mm, weighs 200 g.

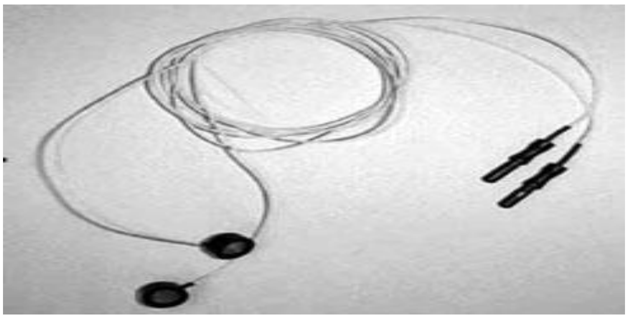

Figure 2: Ag-AgCl electrodes used in the study

III. EMOTIONAL STRESS MONITOR

3.1 Methodology

After the confirmation of the component for the hardware, the circuit simulation is designed first with programming part to display stress level on the Monitor. The methodology of the project can be divided in two parts.Figure shows the flow chart for this project.

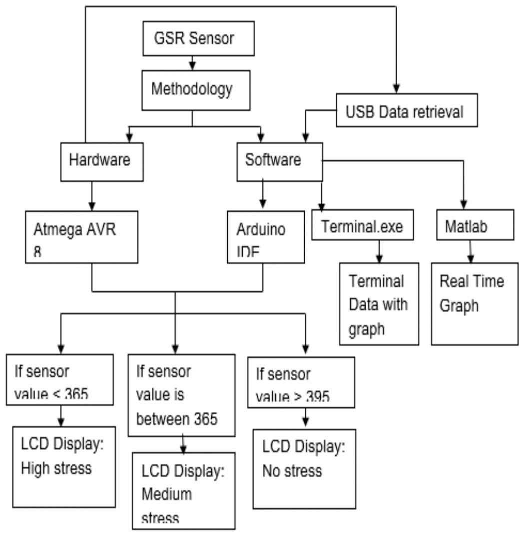

Figure 3: Methodology flow chart

The ESR system comprises the following components which are chosen as the best components while considering the drawbacks of the existing systems and to achieve the target.

Galvanic skin response (GSR) sensor

The GSR sensor is used to measure the changes in the skin's conductivity due to a stimulus. The sensor comes pre-calibrated so you can start experimentation right out of the box using any of the following guides. Just a few of the thousands of possible experimental subjects that can be done with the sensors are: physiological and psychological relationships and responses to stimuli, human biology demonstrations, lie detection, and many more. The GSR sensor uses the following units of measure:

- Micro siemens (µS) or Mega ohms (MΩ): A unit measuring electrical conductance or resistance.
- Arbitrary analog units (Arb): An arbitrary unit to demonstrate waves, frequencies, and periods.

Figure 4: Galvanic Skin Response (GSR) Sensor

Specifications:

- Input Voltage: 5V/3.3V.

- Sensitivity adjustable via a potentiometer.
- External measuring finger cots.

Note: The skin response time from the sudden effect is between 0.1 to 0.5 seconds. The level of the response changes dramatically from one person to another. The user must put his hand on a table, chair or on his lap and be still.

IV. WORKING

The working of this device can be easily explained with the help of the block diagram as shown below. A 6 Volts rechargeable battery and voltage regulator which provides 5 voltage supplies to GSR sensor, microcontroller and PL2303

USB Data Retriever .GSR sensor calculates GSR values and passes through an Opamp which produces digital output. Microcontroller calculates this GSR value in categories of stress like high stress, medium stress and no stress and displays this value on LCD and through PL2303 USB Data retriever shows these values on terminal software and simultaneously on MATLAB software in the form of real time graph.

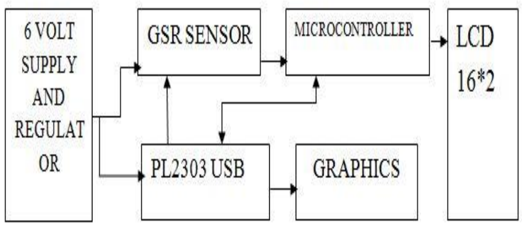

Figure 5: Block diagram

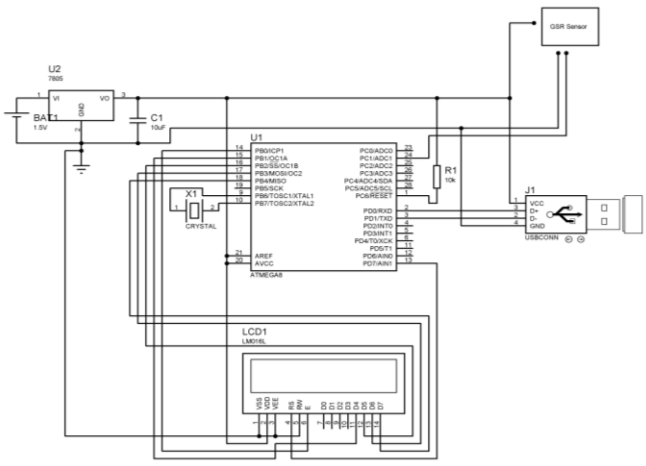

Figure 6:Schematic representation of device.

V. RESULTS

Patient 1:

Graphs of Patient 1:

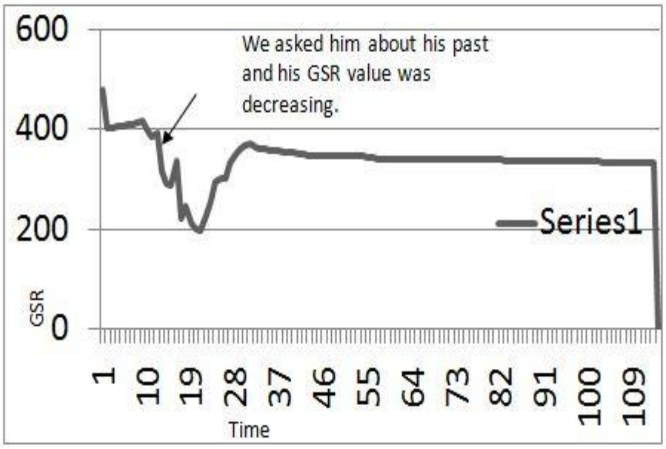

Figure 7: Graph before therapy

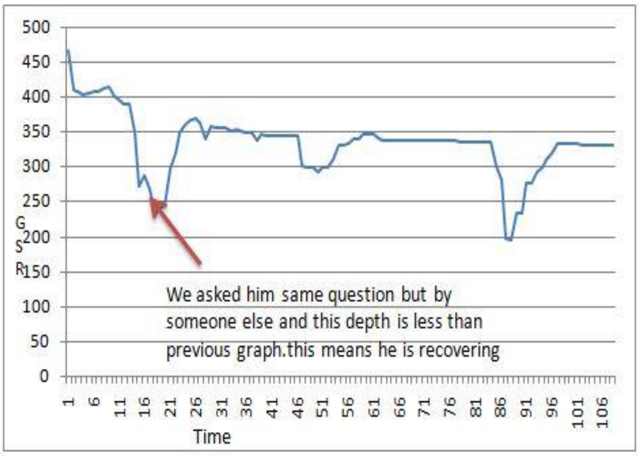

Figure 8: Graph after therapy

Patient 2:

Graphs of Patient 2 :

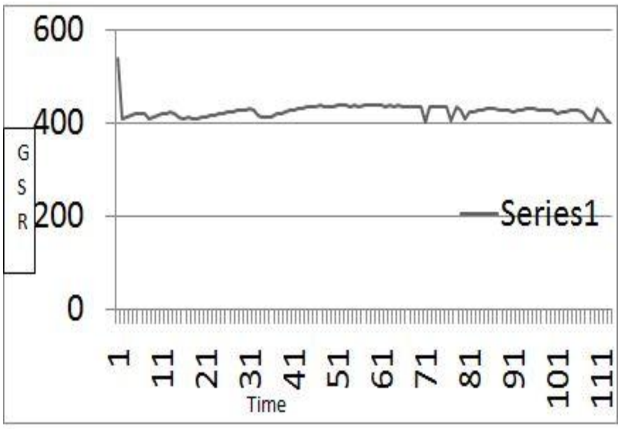

Figure 9: Before therapy

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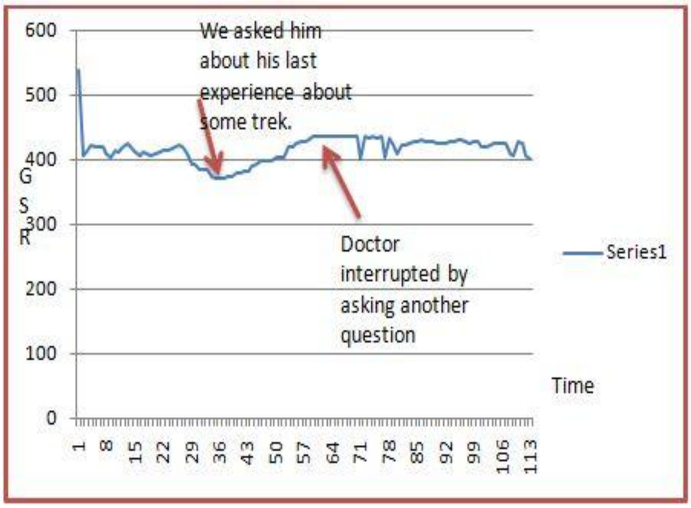

Figure 10: Graph after therapy

Patient 3:

Graphs of Patient 3:

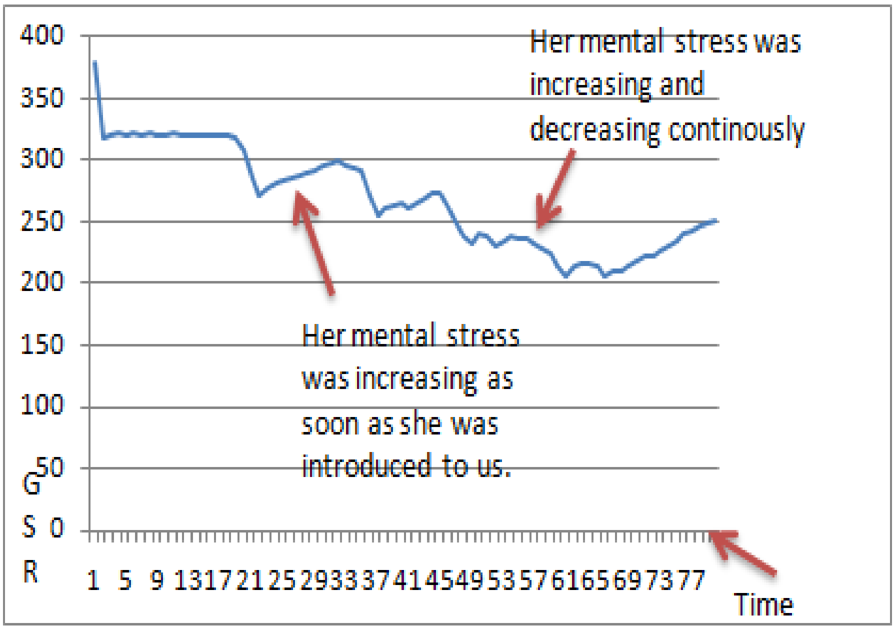

Figure 11: Graph before therapy

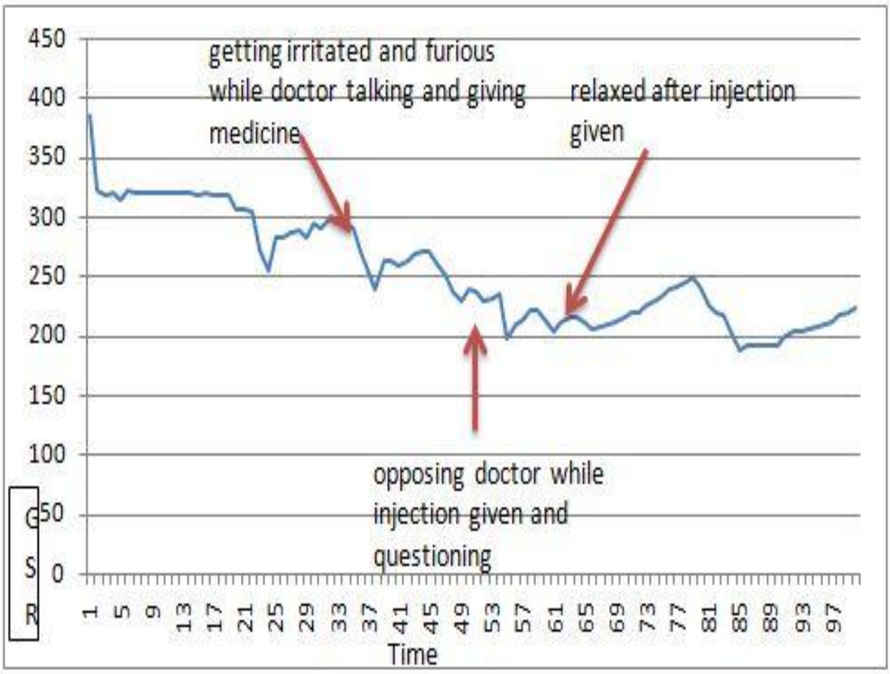

Figure 12: Graph after therapy

From the above results and testings, we can simply say that using this device was really helpful in assessing the condition of patients and to understand whether the patients are correctly responding to the therapy. From the three patients we have tested at a Hospital , we came to know that it is easy to understand the mental condition of a person by understanding the GSR values i.e. skin resistance and conductance. This in turn will save the time of the doctors and help them in giving proper therapy according to the condition. Also , it will reduce the amount of dosage to be given to such patients as regular monitoring of their GSR values i.e. their emotional changes will help doctors to decide how much dosage needs to be given to such patients and whether they are actually responding to the therapy or they have not been completely cured.

From the results of *Patient 1*, with the help of his GSR value, we can understand that he is reviving himself from his past and has shown improved response after the therapy which continued till a week. From the results of *Patient 2*, with the help of his GSR value, we understood that whatever results we were getting before one week were different when we conducted same test after therapy and he needs to be given proper treatment as he was feeling uncomfortable while talking about anything related to a great height as he was suffering from agrophobia i.e. fear from a great height. From the results of *Patient 3*, with the help of her GSR value, it was clear that she was hardly showing any improvement in her condition even after roughly a week of therapy and she is now more frightened from the injection as she is suffering from drug induced depressive disorder. All these results conveys the fact that this device can prove to be an effective tool for diagnosing the rate of recovery of individuals with some sort of mental illness or some kind of emotional stress that individual is going through.

VI. CONCLUSION

In this project, stress of a person can be determined by using two Ag-AgCl electrodes which tell about the stress level of a person and emotional changes by measuring activity of the stress hormones controlled by the sympathetic nervous system. The change in flow of blood through the vessels and sweat glands releasing sweat determine skin resistance and skin conductance which tell about the condition of sympathetic nervous system. The graph obtained from the device and output of value going less than on LCD indicates high or no stress.
It is a simple device and can be used to assess various mental conditions.

VII. FUTURE SCOPE

A Smart emotional stress monitor using skin resistance and conductance is a basic model to determine stress and emotional change of a person. This device can be further developed to design equipment like lie detectors, skin response meters; mental fitness meters etc. therefore this model, if further developed can be used in medical field, with sportsperson, forensic department and it even helps in improving the body fitness. We are also planning to combine this device with EEG as wireless and which will calculate both the result and indicate level of stress in a person.

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