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Pain Measuring Device Using Machine Learning

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ABSTRACT: The term 'pain' refers to the increase in the tolerance level of the reflux either in the patient's joint or in muscle. This tolerance level is referred to as the threshold value up to which the person can tolerate the reflux. Beyond this, the reflux is referred to as pain. Determining pain is very important in the cases of Osteoarthritis and other joint/muscle problems. About 78% of the world's population is analysed with proper pain value and hence are facing complications under drug dosage determination. The existing methods of measuring pain includes scales like Numeric Rating Scale, Visual Analog Scale etc which determines pain in the range of 1 to 10. However, the analysis is subjective. The clinicians ask the feedback of the patient as to rate their pain from the scale of 1 to 10. This is not accurate and efficient as the tolerance level varies from patient to patient. Thus for the same muscle tear, two different patients can experience two different values of pain based on their tolerance levels. Hence in order to determine the pain in the patient, an objective or quantitative analysis is required which is not available so far. The proposed solution determines pain by the process of inputting electrical impulse into the patient's pain area and getting the corresponding feedback as the output. The peak value in the output will be the pain value. The pain obtained can be further analysed using heat mapping and machine learning process. The heat mapping gives accurate results about the pain sustaining regions. This effect is called the "Orient effect".

I. INTRODUCTION

Pain measurement is very important to suggest the right dosage of drugs and therapies. This can treat the problems much faster and with less complexity. About 87% of people suffering from Osteoarthritis are not diagnosed with proper treatments due to improper pain analysis. The NRS and the VAS scales work on a subjective basis. Some of the other pain scales which works on similar patterns are

1. Verbal scale intensity scale: The scale has six levels of analysis ranging from no pain to extreme pain. The patient is asked to rate the pain within this range.
2. Categorical scale: This scale is meant for children which ranges from no pain to hurts more. The children are emotionally spaced in this scale.
3. Multidimensional scale: This scale has many subsystems like brief pain inventory, Mcgill pain intensity etc. They are based on subjective recognition of the pain.

These scales are however based only on the feedback of the patient which is therefore not accurate and efficient. Hence research is still being conducted by research organizations to analyse pain via objective algorithms. This can be done by using the process of electrical impulses. The factors affecting the pain value of the person includes the amount of reflux action (pain due to the joint problems) and the additional reflux due to long run reflux action.

The rest of the paper is divided into the following sections. The first section highlights the related works done. The second section deals with the principle of the proposed solution. The third section deals with the work plan. The fourth section deals with accuracy measurement. The fifth section deals with future enhancements and conclusions followed by references.

II. RELATED WORKS

Neil Cardno [1] worked on measuring pain in people suffering from osteoarthritis. He analysed the fact that measuring the tolerance alone will not work out. Hence he highlighted the usage of dolorimenter (a pressure based pain measuring device) followed by tolerance measurement. The unit of pain was dol. He claimed that patients having a pain value of more than 7 dol were considered to be in final stage Osteoarthritis. However his research did not give any leads on other muscle or joint pain. Moreover the pain level of people with 2nd and 3rd stage osteoarthritis were unknown.

Cowen [2] in his paper described the objective analysis of pain using physiological and biomarkers of the patients. He analysed different markers which are suitable for objective pain measurement and created a database for the same. He considered three different parameters like the autonomous reflux machinery, muscle recognition and muscle contradictory properties. His idea turned out to be successful for assessing pain during surgeries when the patients are unconscious. But it may not be suitable for real time or continuous monitoring purposes due to reasons like time consumptions and complexity of the process.

Chapman [3] in his work conducted a long term experiment on people to assess their pain in terms of both subjective and objective. He kept monitoring the patients everyday before and after taking pain relieving pills. The decrease in the pain level was considered to be a small change in the pain. So the change in the value was subtracted from the value obtained from NRS scale. Thus the highest tolerance level will be subtracted from the change in pill due to external factors like pills.

Bradley [4] in her work considered using a dolorimeter and a force gauge to measure the pain. The principal behind the idea was to apply the maximum force on the patient's body via a force gauge. The level up to which the patient can bear the force was considered to be the tolerance level. This step was followed by a dolorimeter experiment where the pain is measured by pressing the meter against the patient's painful region.

Richard [5] In his work claimed that pain can be measured objectively by validating the pain scales with the pain scale. The principle behind the idea was to take successive reading through pain scales and taking the average of the reading. Since the average is considered the pain value is much accurate and it is reliable. For each reading a pain map was drawn and was analysed using an interpolation algorithm. This further increased the accuracy. However for patients who are suffering from random sequence disorder may not get closer values every time. This may create inaccuracy in the pain measurement. This method is not suitable in general and broader terms.

Thus from the above works, it is observed that a relative pain measurement system with real time affinity is required to solve the challenges of pain measurement objectively.

III. PRINCIPAL OF PROPOSED SOLUTION

TENS: Transcutaneous electrical nerve stimulation is an electrical device which helps in relieving pain using electrical impulses. The TENS machine contains probes which are placed in the painful region. The machine is then switched on to pass electrical impulse to the body. The amount of impulse to be passed can be tuned by the user. As the user keeps tuning, at one particular point he maintains the same frequency. This value is considered to be the tolerance level. The timer is set for five minutes. The machine tends to reduce the pain by decreasing the tolerance level via relaxing the muscle. As the muscles are relaxed, the pain is reduced and hence the tolerance. But TENS cannot be used to reduce joint pains as the tolerance of joints is not measured. Hence it is limited only to muscle pain.

Proposed Solution: The proposed solution works in the reverse mechanism of TENS. Here, the device passes electrical stimuli to the body and instead of measuring the peak, it records the feedback response from the patient and is viewed graphically via an oscilloscope. The peak of this response is taken to be the pain value. Prior to this step, the tolerance of both the muscle and the joint will be estimated via a strain gauge. Since this method considers both the joint and the muscle tolerance, it is much accurate and efficient. Also the feedback's peak is taken as a whole insead of the input's response.

IV. WORK PLAN

A. Tolerance measurement: Here we are required to measure both the joint's as well as the muscle's tolerance level. A strain gauge with the known gauge factor is selected for this purpose. A strain gauge is a resistance dependent device. When this is placed over the patient's body, the resistance of the gauge is varied. As the resistance changes, at one particular point, the patient may feel discomfort. This point is taken as the tolerance point. The circuit arrangement is shown below. The number of strain gauges used can vary depending on the flexion rate of the patient as shown below.

Part of leg	Flexion rate (degrees)
Knee joint	35
Cortical bones	21
Shin bone	12

Stem of leg	8
Feet	2

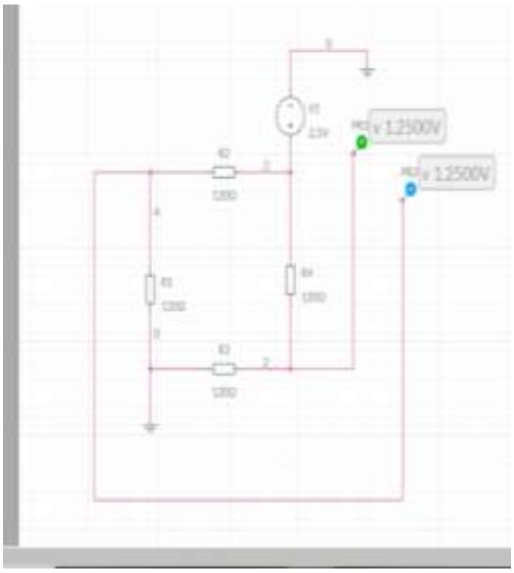

Figure 1: Strain Gauge arrangement.

Here R1, R4 focuses on joint (flexion angle 4 degrees) and R2, R3 focusses on muscles (Flexion angle 0 degrees). There are two voltage probes connected. They are for measuring the tolerance level of joints and muscles respectively. As the supply is turned on and the resistance is varied, opposite resistances are varied. The point of discomfort is noted. Accordingly, the change in the voltage in the probes are also noted. The green probe gives the joint tolerance and the blue one gives muscle tolerance. The total tolerance value is out by:
(Joint tolerance / Muscle tolerance)* Gauge Factor. The graphical data after calculation is displayed below.

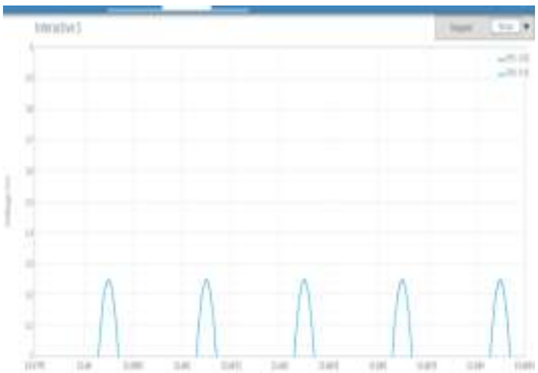

Figure 2: Graphical total tolerance data after calculation

B. Construction of Device: The model is constructed using smart draw and is displayed below. The power consumption by this device is very less as the power gets turned to zero every time it is calibrated. Thus the extra power that is lost during the experiment is compensated by calibration tuning. The circuit complexity is also less as compared with the circuit assembly of TENS.

Figure 3: Device Model

The outer layer of the tube is covered with glass silicate. The inner layer is a bunch of wire connections which produces the required electrical input. The bottom of the device has probes to connect the body and the device. The tuning of the input is automatic and need not be tubed by the user. A chargeable battery will be placed inside the device itself and can be reused.

C. Heat Mapping:

Using a thermal imager, heat mapping can be done to accurately know the painful regions of the patient. The following is the heat map generated in one of our experiments. It is divided into four regions ranging from poor to excellent. This range gives us the region of maximum pain and minimum pain. Thus the correct region of pain is detected using heat mapping.

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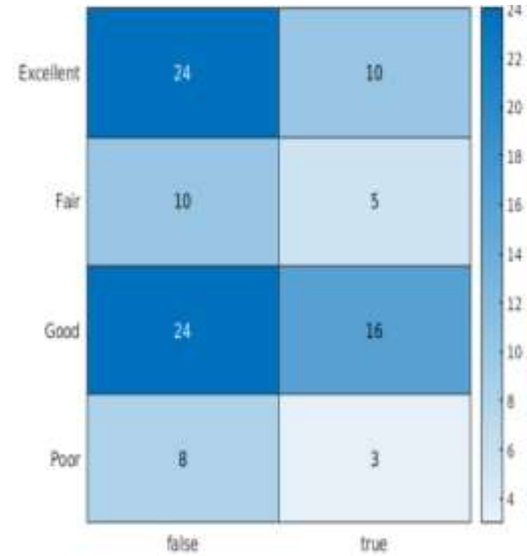

Figure 4: Heat map output data values

D. Working: When the region of pain and the tolerance level is detected, the electrical impulses are passed and the response feedback is extracted via an oscilloscope. The peak value of feedback extracted is the pain value.

E. Digital Conversion: The data obtained now is in numerical form, to make it machine friendly, it must be converted into digital/binary form to promote easy storage of recording. This is done by using ADC.

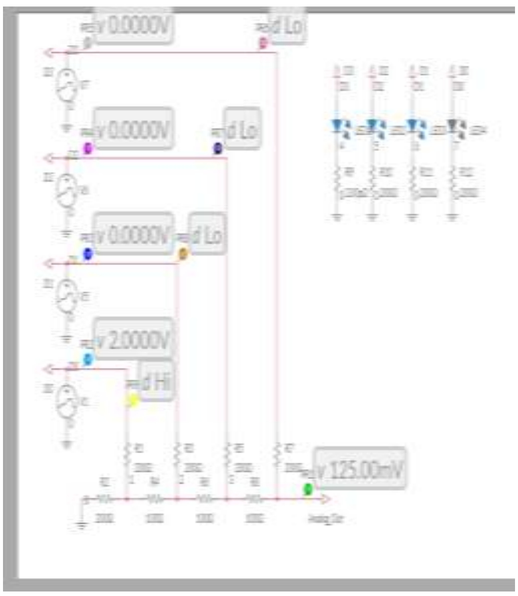
Figure 4: ADC Circuit assembly

V. ACCURACY MEASUREMENT

The device is self calibrated during each time of usage as every time the voltage is set to zero. Also, the accuracy of the proposed solution can be measured by comparing the results with biomarkers or using conventional scales.

FUTURE ENHANCEMENT

A. Clinical Trials: Inorder to bring this product to the market level, clinical trials need to be done so that the risk and quality factors can be considered.

B. Validation: Official Validation according to MDR regulations should be done to test patient safety.

C. Improvements in construction: The device can still be made simpler and hand.

D. Data Visualization: The data obtained can be transferred to the patient's mobile or any other monitor using an IOT and bolt module. This will help in faster and easier diagnosis.

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