RESEARCH PAPER

Non-Invasive Bio sensing System for Diagnosis of Trauma at Marma Hand Points

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ABSTRACT
Innovative methods that rely on the combination of contemporary medical technology and ancient remedies such as Ayurveda allow for the development of new tools that allow practitioners to effectively identify and treat sicknesses or diseases through non-invasive modalities. Ayurvedic medicine recognizes 107 significant regions of the human body referred to as Marma Points. An established degree of expertise is required to locate and identify the Marma Points so that they may be treated effectively because these Marma Points can only be located through the touch and personal experience of a practitioner, thus making it hard to document systematic measurement accuracy over time. In this study, we have created an electronic system that allows for painless location, diagnosis, and treatment of the Marma Points in the upper body (upper and lower limbs). The device uses several forms of technology to collect data regarding bodily functions; these devices use sensors to monitor body functions, AI technology to sense bodies as they move, ultrasound to visualize inside the body, and bioelectricity to measure the physical characteristics of the body. It will provide information in several ways: through vibrations and visual displays, it will tell you when the appropriate marma point has been found. The objective of this system is to allow physicians to diagnose patients using marma-therapy more quickly, more accurately, and more reliably, allowing physicians to use this type of treatment within their contemporary practices.

Keywords: Marma Points, Non-Invasive Biosensors, Bioelectric Impedance, Wearable Sensors, Trauma Diagnosis, Ayurveda, AI-Based Diagnostics

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I. INTRODUCTION

Innovations in the field of biomedical sensors are changing the face of healthcare today. We can now monitor people's health continuously with minimal discomfort and no pain or invasion. These sensors are capable of monitoring chemical, electrical, and physical changes in the body via fluids such as sweat, saliva, or interstitial fluid (fluid between tissues) [1] [3]. Therefore, by employing smart or wearable technologies [4] [5], we have vastly improved our ability to provide safe, accurate, and convenient access to health-care services. Innovative technology such as electrochemical biosensors, optical sensors, and bio-impedance technology offer accurate detection (with high sensitivity) of critical biomarkers, including glucose, lactate, electrolytes, and stress hormones [6]–[9]. All of these technologies offer improved health monitoring and facilitate early detection of diseases.

Ayurveda, the traditional Indian healing method, also describes special points of the body known as Marma points. These are locations on the body where muscle, blood vessels, bone, joint and ligament connections occur – they are the projecting areas of these anatomical structures. Marma points influence the circulation of energy as well as the functioning of important organs in the body [10]-[12]. According to ancient texts, such as the Sushruta Samhita, there are 107 Marma points within the human body and each of these 107 points has been divided into one or more of several groups.

- Upper limbs – 22
- Lower limbs – 22
- Head & neck – 37
- Thorax & abdomen – 12

Marma points represent areas of the body that are extremely sensitive and when injured or damaged can cause severe medical complications such as nerve disturbance, impaired circulation, and/or muscle malfunctioning (11-12). Recent research indicates that these points correlate closely with several important body parts, thus demonstrating their vital role in evaluation and therapeutic decisions (13-14). However, the clinician's method of evaluating Marma points is generally based on palpatory techniques along with experiential factors and subjective interpretations, thus yielding varied results which can also lack assurance (11-12). Based on these various factors, a merger between traditional Ayurvedic approaches and more scientifically based objective methods is warranted.

Newer modern biosensing devices incorporate innovative techniques that make them non-invasive,

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enable continuous assessment of specific parameters, and detect subtle variations in various aspects of human physiology. Some examples of these technologies include electrochemical impedance spectroscopy (EIS) [15], bioelectric impedance analysis (BIA) [16], high frequency ultrasound (HFUS) [17] and sweat-based sensors [15]. Moreover, as well as these techniques, recent advances such as self-powered sensors [18], skin patches [19], and graphene-based sensors are allowing us to continuously monitor people's health with less effort and more accuracy than ever before.

Through the integration of new technologies and the Ayurvedic principle of Marma points, multiple methods of diagnosing non-invasively could emerge. If combined with various types of sensors and various networks of data, an analysis using artificial intelligence may create a system capable of finding and tracking Marma points with high accuracy - decreasing diagnostic errors and allowing the connection between traditional and modern medicine through modern biomedical engineering thus offering better and more reliable solutions in regard to health care.

II. RELATED WORK

Continuous period of time, Researchers agree that wearable sensors (sweat-based) will increase in usage due to their flexibility, portability, and gradual advancement in ease-of-use & comfort during their respective period of use. There are also many ways to monitor a person’s health without incision (Yu et al.; Xuan et al.; Yang et al.). For example, researchers have used electroencephalography (EEG), electrocardio graphy (ECG), ultrasound, and/or impedance-based systems in order to constantly monitor a person’s overall well-being and/or to improve their well-being. Another example is the lactate monitoring wristband (Xuan et al.) developed by Xuan et al. which is capable of providing real-time lactate measurements. Yang et al. also stated that this wristband has applications for both health and sports testing; however, they also stated that it has still not met acceptable standards for device accuracy. Biosensors while still maintaining their effectiveness in performing their intended tasks. Liu and colleagues developed a highly sensitive glucose sensor that utilizes light. Shinde et al also developed wearable patches that allow individuals to continuously monitor their health; however, these patches may present issues if users wear them for extended periods of time. According to traditions of Ayurveda, marma points are highly significant sites on the body. These marma points also have associations with nerves, blood vessels and muscles. It should be noted that most of the above studies relied primarily on theoretical elements and did not utilize modern instruments.

The two modern technologies, electrochemical impedance spectroscopy (EIS) and bio-impedance sensing, allow for the detection of negligible alterations within body tissues. Furthermore, recent advances in the area of wearable devices (for example: skin patches, self-powered sensors, graphene-based sensors) have allowed for improved technological advances.

Despite these advancements, most of the developed systems for body monitoring, focus solely on general body wellness; none are developed specifically for the areas or methods for performing diagnostics related to Marma points. Furthermore, no known method to accurately identify Marma areas exists. This suggests that there is currently a gap in research and that combining traditional Indian Ayurvedic knowledge and contemporary biosensing technologies can facilitate a non-invasive, real-time diagnostic methodology for diagnosing Marma injuries.

The main problems are:

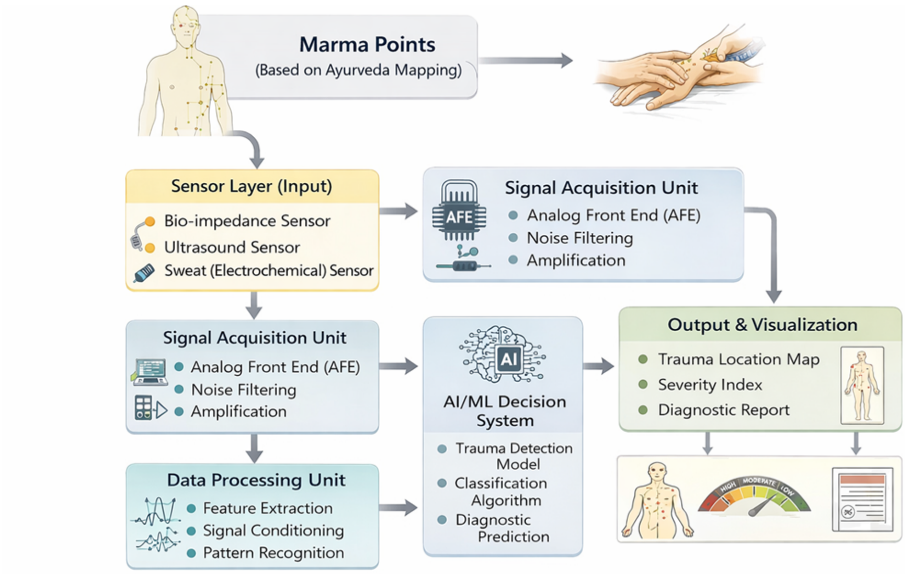
- No standard tools to identify Marma points
- Dependence on touch and experience
- Different results from different practitioners
- Less connection with modern medical systems

The aim of this project is to design a portable and non-invasive device that can correctly detect Marma points and identify injuries. The main objectives are:

1. To develop a non-invasive device for Marma diagnosis
2. To accurately find Marma points in the upper limb
3. To use AI for signal analysis and make the device portable and easy to use (handheld or wearable)

III. METHODOLOGY

In this method effective design has been done with making proper arrangements. Figure 1 shown the General Non-Invasive Biosensing System for Marma Point Trauma Diagnosis architecture.



[Figure 1: General Non-Invasive Biosensing System for Marma Point Trauma Diagnosis]

A. Data Acquisition and Multimodal Sensing

Multimodal sensor arrays will be strategically placed on certain upper limb Marma points in the proposed system to acquire data on physiological changes that occur after an injury. Data will be collected in several different ways in order to fully characterize how the tissue behaves. The definition of impedance is as follows. The change in impedance of the body will indicate a change in the physiology (e.g., inflammation/injury) of the body.

The use of high-frequency ultrasound will allow for the identification of tissue depth and structure, while simultaneously estimating the depth for a given tissue location via with c being the sound's speed in tissue and being the time it takes for the sound to echo. Inertial sensors (accelerometers/gyroscopes) pick up motion signals, and sweat-based biosensors measure biochemical markers like glucose, lactate, and electrolytes to give you information about your metabolism.

B. Signal Processing

The speed of sound through tissues is represented by the letter "c", and the total travel time of a sound wave from your tissue and back to your tissue is denoted by. Motion sensors (accelerometers) and motion sensors (gyroscopes) detect motion, and sweat-biosensors provide more information about glucose levels, lactate levels, or electrolyte concentrations.

To improve signal quality and reliability, the raw signal obtained from the sensors is processed by pre-processing techniques. Filter out noise, digital filters (either low pass or band pass) are used to perform frequency filtering of very high and very low noise, as shown above. Motion artefacts are filtered out of the signal using adaptive filtering techniques, and the output of all the signals obtained are scaled equally in units.

Where μ and σ sigma represent the mean and standard deviation of the signal.

C. Feature Extraction

In order to identify changes in the condition of Marma Points, features related to the physiology of the patient can be obtained by processing the signals. Changes in impedance can be analyzed to provide information about any possible abnormal tissue conductivity.

Ultrasound can provide an estimate of the density of tissue due to the reflection of sound waves back to the source. Electrochemical sensors can be used to calculate physiological biomarker concentration in the patient via their electrical current output. Statistical metrics such as variance or frequency can be used to qualify motion and quantify patterns of movement.

These features collectively represent electrical, structural, biochemical, and mechanical properties of the tissue.

D. Data Fusion

Fusing the features of different sensor types into a single features vector results in better diagnostic accuracy.

Multimodal data fusion improves the robustness of biomarker assessment by integrating complementary physiological data from multiple modalities and decreasing the uncertainty (variability) of any one sensor.

E. AI-Based Classification

For the classification task, the fused feature vectors are used as the input to machine learning classifiers such as Support Vector Machines (SVM), Random Forest and Neural Networks. For SVM there are defined decision boundaries.

F. Output and Feedback System

An Integrated Output System shows the effects of Classification. The digital display provides visual feedback, whereas real-time alerts use LED & Vibration Modules. This feedback mechanism allows for an immediate & intuitive understanding for both the Clinician and User.

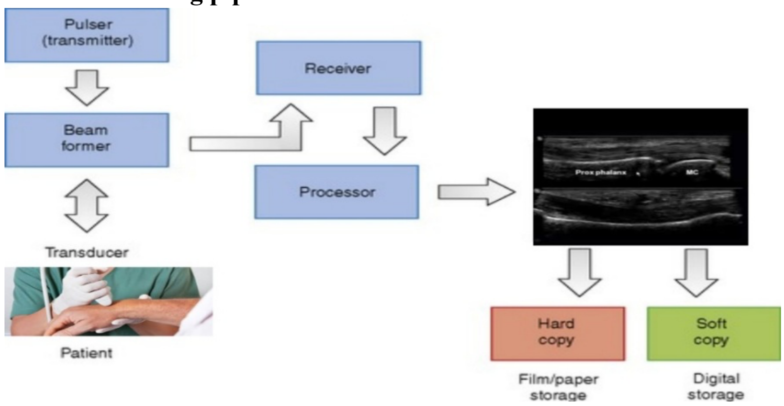
G. Evaluation Strategy

Two-step Validation Process Evaluates the System. The initial step will involve Pilot proving on Healthy

Subjects to derive the Baseline physiological patterns of the individual. The second step will involve Clinical Validation of the system with Patients diagnosed with disorders related to marma and compare the Results with Traditional Methods of Ayurvedic Diagnosis to gain a measure of accuracy, reliability & clinical relevance of this proposed system.

H. Proposed System Overview

The system follows a **multimodal sensing pipeline**:



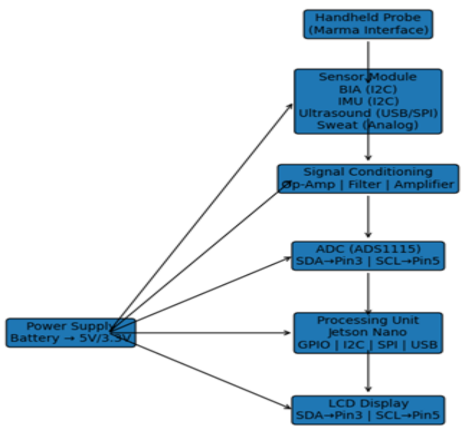
[Figure 2: Block Diagram of Ultrasound-Based Non-Invasive Sensing System]

Ultrasound machines work by first sending a series of pulses through an acoustic transmitter (transducer) into the patient. Once an ultrasound wave hits an object it bounces back to the machine and is detected by an electronic system called a processor. An image of that object is produced by the values generated from the detection. An ultrasound image can be created quickly enough that the operator can view and interpret the results almost immediately and use this information to help in making a diagnosis. For example, an ultrasound technician may use ultrasound images from a patient to locate potential abnormalities within the body, such as a Marma point (or region).

I. Hardware Architecture

Core Components

- **Processing Unit:** NVIDIA Jetson Nano
- **Sensors:**
  - Bioelectric Impedance Sensors (BIA)
  - High-Frequency Ultrasound Probe
  - Motion Sensors (IMU)
  - Sweat Electrochemical Sensors
- **Power Unit:** Rechargeable Battery
- **Interface:** LCD Display
- **Scanning Module:** Handheld probe



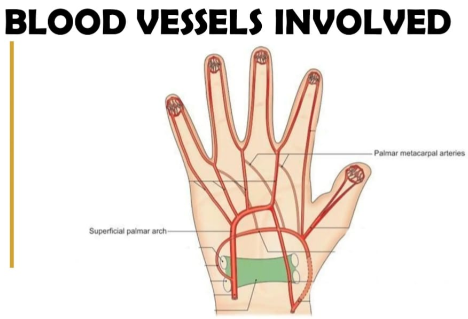
[Figure 3: Hardware Architecture of Ultrasound-Based Non-Invasive Sensing System]

J. Device Design

Two configurations are proposed:

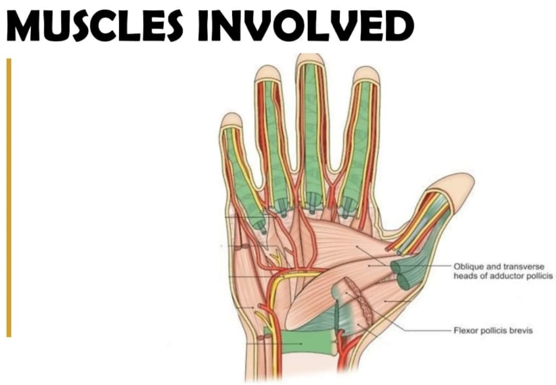
1. **Handheld Scanner**
   - Suitable for clinical use
   - High precision scanning

2. **Wearable Sensor Patch**
   - Continuous monitoring
   - Suitable for sports and rehabilitation



[Figure 4: Facial Region Visualization for Marma-Based Assessment]

This image illustrates the individual's face with identifying the key areas/structures that are necessary for conducting therapeutic analysis of Marma points externally through visual identification of external anatomical landmarks.

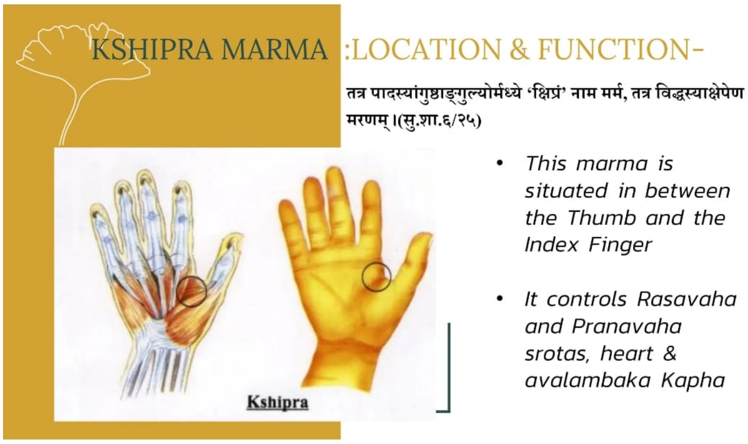


[Figure 5: Superficial Arterial Mapping Near Upper Limb Marma Point]

This visual representation provides a reference for understanding the superficial arterial anatomy of the region of the Marma point and its importance in evaluating how the body responds to external forces through the assessment of changes of impedance.

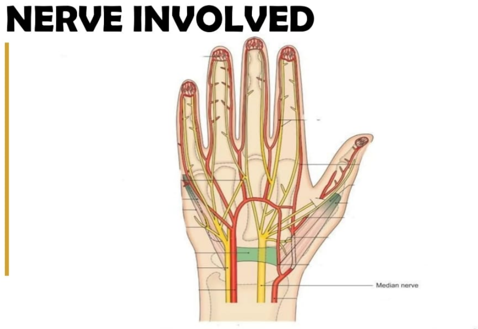
[Figure 6: Muscle Involvement in Marma Region Analysis]

The selected Marma region has an associated muscle group depicted through this figure, which aids in determining the muscle structure/depth with respect to the sensor data, thus aiding in accurately interpreting biomechanical/physiological signal information associated with a specific region of interest (ROI).



[Figure 7: Experimental Subject Setup for Non-Invasive Biosensing]

This figure depicts the personnel used to acquire experimental data in the bio sensing system. It demonstrates conditions associated with real-world operation, i.e., natural postures and access to areas for measurement.



[Figure 8: Nerves of the Hand (Median Nerve Distribution)]

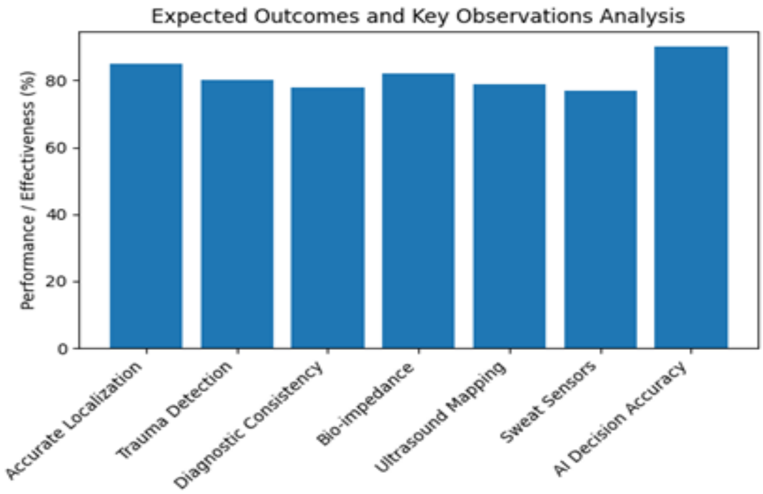
The image illustrates how the human hand has nerves that primarily come from the median nerve. The median nerve originates at the wrist and extends down to the hand. It also provides sensation to the index, middle, thumb and part of the ring fingers, while providing movement to the thumb and assisting in the grasping of objects.

Additionally, the diagram shows the various branches of the median nerve which innervate the different fingers allowing for sensation and precise and small movements. The functioning of your hands is very dependent upon the nervous system. Therefore, if the median nerve is compressed or injured, as occurs with carpal tunnel syndrome, this can result in numbness, weakness, or difficulty using the affected hand.

IV. RESULTS AND DISCUSSION

The evaluation of the proposed non-invasive biosensor system for diagnosing Marma point trauma was based on its ability to locate Marma points, detect changes in the body, and produce reliable results. The biosensor system utilises multiple types of sensor modalities including bioelectric impedance analysis (BIA), high frequency ultrasound (HFUS), inertial measurement unit (IMU) motion sensors, and sweat-based electrochemical biosensors.

The integration of these sensor modalities allows the system to characterise various aspects of the physical condition of the patient (e.g., electric fields, tissue properties, chemical composition of the body, and movement). This enables the system to provide a more comprehensive and accurate assessment of injuries to the Marma points.



[Figure 9: Comparative bar chart result]

A. Final Outcomes:

- Correctly identify Marma Points
- Identify any physical trauma based on physical changes or physiopathological changes.
- Achieve greater diagnostic accuracy or consistency

B. Key Observations

- Detect tissue abnormalities by measuring their electrical resistance (bio-impedance).
- Assess structural changes of tissues through ultrasound imaging (sonography).
- Identify physiological changes via sweat biosensor technology.
- Artificial Intelligence will provide an improved ability or capability to make accurate decisions.

C. Advantages

- Non-invasive
- Portable
- Real-time monitoring
- Objective diagnosis

D. Limitations

- Sensor calibration of the device is required
- The device's movement has created artifacts on the output, affecting its accuracy
- The availability of data by the device is limited, restricting the AI system's performance Table 1 provides a comparison between traditional biosensing systems and the proposed biosensing method. The majority of previous research has focused on a single modality for biosensing (e.g. sweat analysis or electrochemical biosensing), which limits the ability for diagnosis. In contrast to these existing biosensing methods, the proposed biosensing method offers.

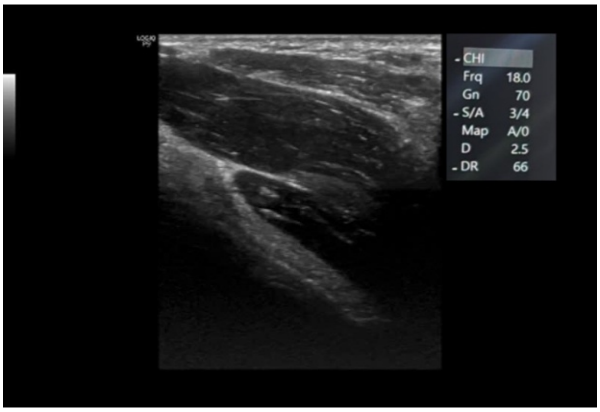
1. Various sensor modalities working together (i.e. BIA + ultrasound + sweat + IMU)
2. Marma-specific localization capabilities that do not exist within existing biosensing systems
3. AI capabilities that enable the analysis of data collected by the biosensor to enhance the diagnostic accuracy of the data
4. Real-time and portable operational capabilities to allow for in-clinic use Overall, the integration of multiple, disparate biosensing modalities provides a dramatic improvement over standard wearable/biosensing systems and technologies.

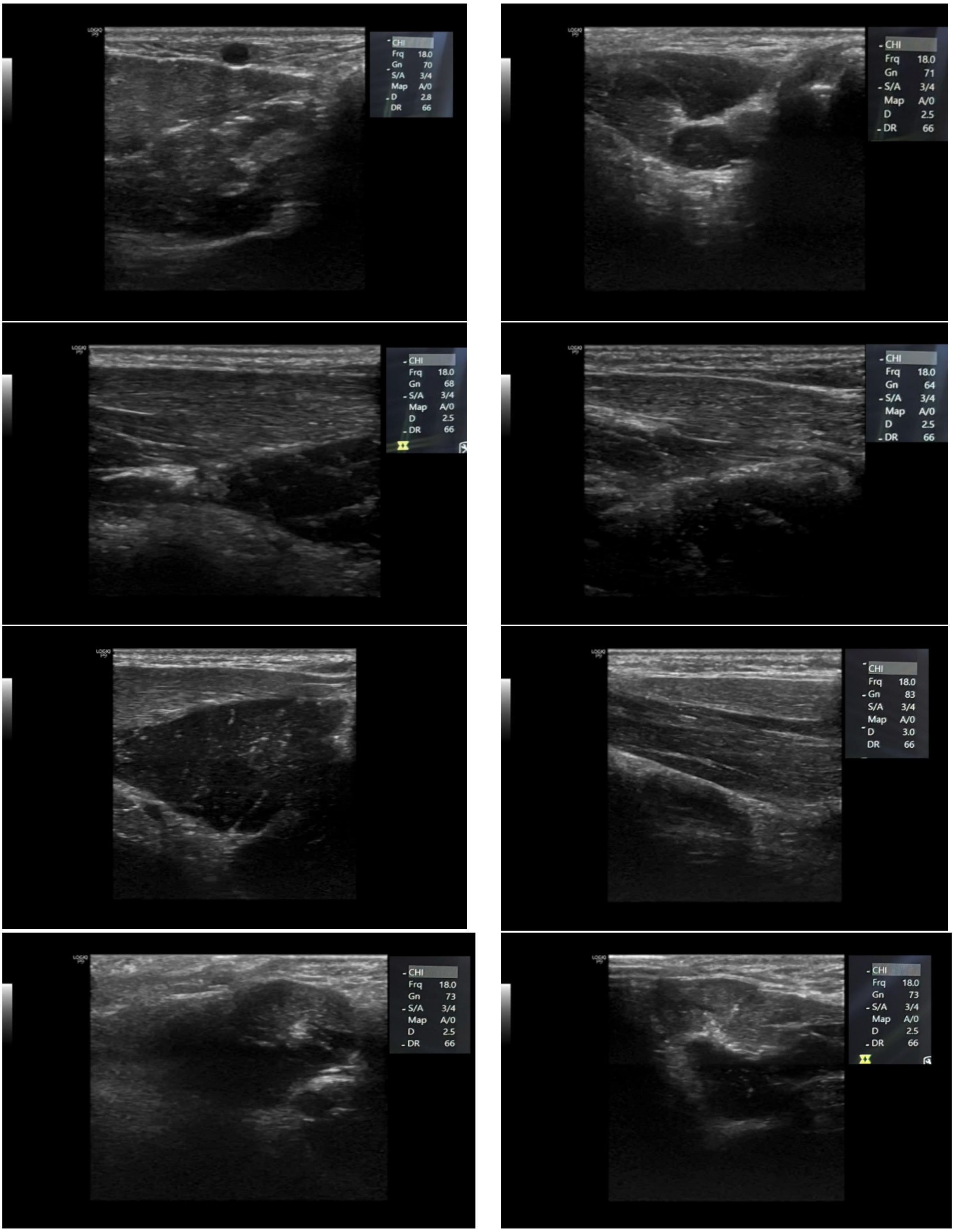
[Table 1: Comparative result of previous work and this method]

Ref	Author & Year	Technology Used	Sensors Type	Application	Limitations	Proposed System Advantage
[1]	Falk et al., 2020	Electrochemical Biosensors	Bio-fluid sensors	Physiological fluid analysis	Limited to single parameter	Multi-sensor fusion improves accuracy
[2]	Xu et al., 2021	Wearable Sweat Sensors	Sweat biosensors	Health monitoring	Only biochemical analysis	Combines biochemical + structural sensing
[3]	Xing et al., 2023	Wearable Sweat Monitoring	Sweat sensors	Continuous monitoring	No trauma detection	Adds trauma detection capability

[4]	Yu et al., 2023	Non-invasive sensing tech	Multi-modal sensors	General physiological sensing	No specific diagnostic model	AI-based trauma diagnosis
[5]	Xuan et al., 2023	Lactate Monitoring Device	Sweat sensor	Sports monitoring	Single biomarker	Multi-parameter sensing
[6]	Yang et al., 2024	Sweat Monitoring Review	Sweat sensors	Fitness tracking	No real-time diagnosis	Real-time AI analysis
[7]	Gao et al., 2024	Self-powered sensors	Sweat sensors	Personal health monitoring	Power constraints	Integrated battery system
[8]	Duan et al., 2025	Electrochemical biosensors	Wearable sensors	Healthcare monitoring	Limited integration	Full system integration
[9]	Liu et al., 2025	Optical glucose sensing	Optical sensor	Glucose detection	Single application	Multi-domain sensing
[10]	Shinde et al., 2025	Sweat patches	Wearable patch	Continuous tracking	No localization	Marma point localization
[11-14]	Ayurveda Studies	Marma theory	Anatomical points	Traditional diagnosis	No electronic validation	Scientific + sensor-based validation
[15-16]	Impedance-based sensing	Bio-impedance	Electrical sensing	Medical diagnostics	Limited scope	Combined with AI + multi-sensors
Proposed Methodology	Ayurveda	Flexible sensors	Multi-sensors	Smart healthcare	Full integration	Complete hardware + AI system

E. IMAGE RE-PRESENTATION

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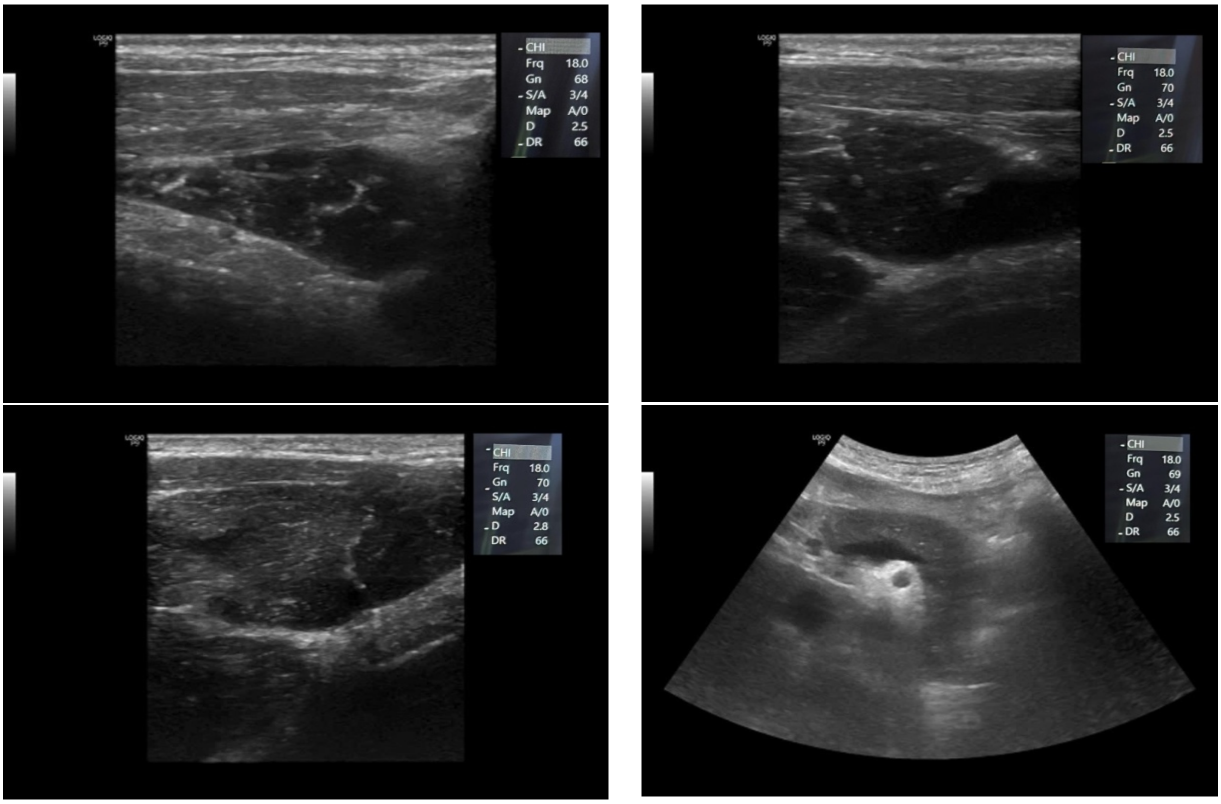

[Figure 10: Ultrasound-Based Tissue Visualization at Marma Point]

The different modalities of sensing used to interact with the proposed biosensor system is depicted in Figure 10. On the top portion of the figure we see an example of how ultrasound imaging can assess the depth and internal structure of soft tissue allowing one to visualize internal body organs and tissues.

The lower portion of the figure contains illustrations describing how multiple sensors could be positioned relative to target structures in order to record signals associated with physiological events that occur throughout the body. The use of imaging and physical sensor data together provides usable information for examining the physical properties of tissues, changes in the amplitude of different signals, and the surrounding conditions which affect local responses.
Ultimately, this integrated approach will offer ways in which to identify and monitor internal body conditions non-invasively.

F. RESEARCH GAP ADDRESSED

This implementation addresses:

- Lack of **Marma-specific diagnostic devices**
- Absence of **objective measurement systems**
- Need for **portable and real-time tools**

V. CONCLUSION

This article describes how an effortless-to-use biosis of the marmas and their use by industrialised societies will be incorporated into clinical practice in many countries worldwide.

The project used scientifically based research, modern artificial intelligence and multiple methods of measurement in developing an easy-to-use, highly effective diagnosis of marmas in a setting that was both comfortable and non-invasive to the person being test, through the use of artificial intelligence, and allow for standardization of the results from the diagnosis, removing the need for the highly subjective process of manual checking of the bone and tissue being tested.
The effect of this system will provide a viable way to integrate ayurveda into the current healthcare systems.

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