Safety Glove Detection Using Skin Impedance

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DOI: *https://doi.org/10.34293/acsjse.v3i2.78*

Abstract - *At the time of surgery, the entire gloves will protect the surgeon from bloodborne antibodies and the surgical carving tools from bacteria on the skin of the physicians. However, glove prick is very common, and perforation rates are as high as 71%.When treating people with highly contagious diseases like HIV-AIDS, Hepatitis, there are extremely high chances of doctors being affected. This tool can be used for forensic investigations, laboratory testing, and other tasks in addition to performing surgical procedures. It can also be used by sewage cleaners. The goal of this project is to offer treatment to medical professionals who are exposed to numerous bacteria while performing procedures on patients. The doctors are alerted to the puncture by finding it in a glove, enabling them to take the appropriate action.*
Keywords: *Glove, Puncture, Contagious Diseases, Surgical Procedure, Rupture.*

I INTRODUCTION

Protective Personal Equipment (PPE) is worn to minimize hazards that cause serious workplace hazards to personnel in the medical sector. Gloves form an essential part of the PPE kit that creates a barrier between the patient and the caregiver to avoid the passage of pathogens. There are many instances where the appropriate wearing of gloves has effectively avoided the transfer of contagious diseases. During surgical procedures, the entire gloves will protect the surgeon from bloodborne antibodies and the surgical carving from bacteria on the skin. While performing these procedures using sharp equipment, the chances of incisions occurring on the surface of the gloves are high. This often leads to the puncture of gloves. The glove perforation rates in doctors can be as high as 71% which can be hazardous to caregivers and surgeons.

Currently, Glove rupture detection systems are not available prevalently in the market. The proposed system deems to be one of its kind that uses the electrical activity of the skin like the galvanic skin response and the skin hindrance as its key parameter to detect any puncture, rupture, or failure in the glove. Double gloving, although with its demerits, is used by surgeons and physicians, causing discomfort when worn for longer durations. Therefore, we recommend that surgeons and other medical professionals use the "Glove puncture detection system" when carrying out longer-duration medical procedures.

The skin impedance of dry skin is generally higher than that of wet skin. When any bodily fluid comes in contact with the skin, the impedance of the skin reduces, and this is detected by the system and the alert is sent to the respective surgeon to immediately change the glove. This can thus prevent the exchange of bodily fluids, especially when dealing with patients affected with severely contagious diseases like HIV-AIDS and Hepatitis.

II EXISTING SYSTEMS IN MARKET AND THEIR DISADVANTAGES

2.1 Thick Material Gloves

Thick gloves have durability, but they are more expensive to use once and throw, take up more storage space, they are less comfortable to work with, and they have less dexterity and tactile sensitivity which are important for doctors during surgery.

2.2 Double Gloves

It has been asserted that the usage of "double gloving" may actually impair the surgeon's hand dexterity, tactile sensitivity, and 2-point discrimination (The volume to recognize that two neighboring items that get in touch with the skin are actually two separate points, not one, is known as Two-Point Discrimination (2PD).), diminishing their capacity and performance quality. Another issue can be an increase in needle stick injuries due to a loss of manual dexterity. Additionally, despite their habit of single-gloving, comfort, and little transmission risk, surgeons have a bad attitude toward double-gloving. Additionally, some people decide against using double gloves because they believe the evidence for its protection is weak.

III PAPER SURVEY

3.1 First paper

This study informs about the creation of a portable Galvanic Skin Response (GSR) sensor for pain sensors. GSR sensors can detect changes in dermis conductance. As a function parameter of perspiration ties, the signal outcomes produced are employed to gather autonomic nerve reactions. The electrical conductance or resistance in the palm may rise because of this reaction. The perspiration glands are active when the body is in affliction, which causes GSR, a physiological change in the skin as a result of changes in sweat gland activity. This prototype was created to track activity in response to light blows to the arms and the conductivity of the skin [1].

3.2 Second Paper

During surgery, glove perforation is frequent. In order to lower the contamination probability from antibodies in blood for both the operative unit and the patients, surgical gloves are utilized as individual protective devices. This analysis’ intention was to ascertain the occurrence of glove perforation during a general surgery department performing open abdominal surgery, as well as the risk variables associated with puncture. It was discovered that the non-dominant hand was primarily where the gloves were punctured (left). The thumb Finger (21.1%) and index Finger (21.1%) of the left-handed glove had the most holes. The non-ruling hand (left hand), which has a higher rate of puncture in physicians and lengthy surgeries, experienced the largest number of perforations. The surgical team may find it advantageous to switch out the gloves at definite intermission during operations or use an indicator glove mechanism [2].

3.3 Third Paper

It discussed how to measure cutaneous electrical conductivity in relation to body temperature and analysis. It is well known that when an internal or external stimulation happens, the skin exhibits an electrodermal reaction and turns into a good conductor of electricity. We employed smart sensors for temperature and humidity to measure the skin's moisture content. The signal conditioning hardware, sensors, and analog-to-digital converter make up the data acquisition system. In this, sampled data of the digital signal after 30 instants is used to discretize the continuous signal and reduce energy usage. The sampling of digital signals is what we suggest. We put a very low voltage (0.5 V) through these electrodes in order to measure the skin conductivity [3].

3.4 Fourth Paper

Human skin conductance, skin resistance, and stress levels are all measured via galvanic skin response analysis. Skin resistance, skin conductance, and stress levels can be measured using mathematical manipulation in a variety of contexts (such as while listening to music, performing mathematical computations, breathing, watching a movie, etc.). It is used to gauge the body's stress level and the conductance and resistance of the skin. The electrode detects the skin's resistance in relation to the body and outputs it to the opamp [4].

3.5 Fifth Paper

The surgeons used a double glove method when undertaking visceral procedures. Doctors missed more than 82% of perforations, which might have provided germs with an easy entrance point into the body. One potential preventative measure is to swap out the gloves every 90 minutes. Gloving up before surgery protects both the surgeon from the patient's microorganisms and the surgical field from those on the physician’s hands. In this investigation, the number of bacteria flowing via punctures in surgical gloves was measured [5].

3.6 Sixth Paper

Surgical gloves that are still in good condition work as a physical fence to stop the spread of blood-borne diseases. According to studies, unnoticed glove perforations happen more frequently the longer the gloves are worn. The purpose of this investigation is to verify that bacteria do indeed spread from the surgical site through microscopic holes in gloves. To detect microorganisms’ relocation from the surgical site through the ruptured glove, a tried-and-true approach was used. Over the course of a 6-month period, visceral procedures were performed using surgical gloves and the double-gloving technique. The inner glove was opened up so that organisms could be removed, and they were compared to microorganisms found on an intraoperative swab [6].

3.7 Seventh Paper

For medical workers, especially surgeons and operating room staff, blood-borne infections are a constant worry. Since surgical gloves are the primary barrier separating patients and hospital staff from the outside world, their dependability and effectiveness are essential. Unfortunately, high-risk procedures have glove perforation rates as high as 78%. Surgical gloves need to be effective as well as pleasant and simple to put on, and it is critical that any holes are found quickly. This double-blind accidental study's objectives were to determine whether volunteers could spot 30-micron beam holes in surgical gloves while carrying out a mock operation and to assess the Bio gel Indicator Glove System, which indicates punctures [7].

IV METHODOLOGY

4.1 User

The primary target user for the glove puncture detection system is the physician or surgeons who wear the Galvanic Skin Response sensor on their bodies. Any Skin electrode (e.g., ECG) is attached to the neck region of the user.

4.2 GSR Sensor

The Galvanic Skin Response sensor senses the body impedance of the physician when no puncture exists and stores it as the threshold value. The GSR Sensor electrode is attached to the skinelectrode. The sensor senses the real-time values every 10 to 15minutes such that if any puncture occurs, the bodily fluids come in contact with the user’s body which thereby decreases the skin impedance.

4.3 Arduino

The Arduino Uno is used to power the sensor and store the initial threshold value. The Arduino compares the current value with thatof the threshold such that if the current value is less than the threshold, the buzzer gets high and the LED goes on. The inbuilt ADC in the Arduino helps in converting the Analog voltage output from the sensor to a Digital ADC value.

4.4 Buzzer and LED

The buzzer goes high and the led gets on when the output from the Arduino indicates the current value is lesser than the threshold value.

4.5 Working Process

- During surgery, the doctor or the physicians wear the Galvanic Skin Response (GSR) Sensor on their body.
- Doctors or physicians can wear latex or non-latex gloves while performing surgeries.
- The GSR sensor senses the body impedance of the physician and stores it in the Arduino.

- The initial value is considered as the threshold value as no external fluids are in contact with the skin.
- GSR Sensor measures the difference in impedance of the physician with respect to the threshold.
- Output from the sensor is in the form of analog voltage which gets converted to digital form using the inbuilt ADC in Arduino.
- We convert ADC output value to voltage by using the following formula,

$$\text{Voltage} = \frac{\text{Output ADC Value} * \text{Supply Voltage}}{\text{Resolution Factor } (2^{10})} \text{ Volts} \quad (1)$$

- ADC output value is compared with the threshold value, which is already set and stored in the Arduino.
- When the current value is lesser than that of the threshold, the buzzer buzzes and the LED turns on, indicating that there is a puncture in the gloves.

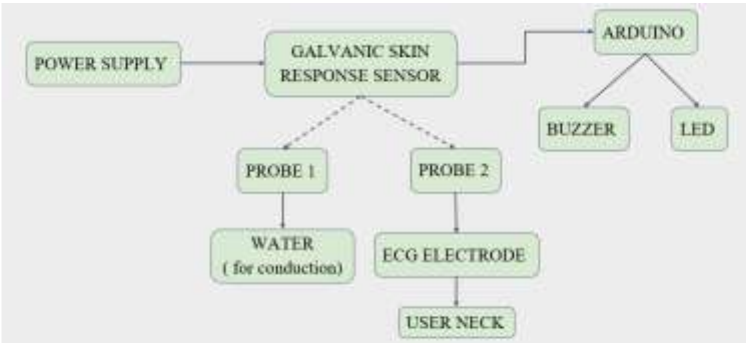

Figure 1: Block Diagram of the Proposed Methodology

V RESULT

We have designed a Glove Puncture Detection System that uses skin impedance as a key parameter to detect punctures or breaches in the glove. As the first step, we tested the sensors and all other components using the tester codes. Since the device requires the acquisition of skin impedance, we use skin electrodes to connect the device to the body.

The location of electrode attachment was decided by conducting several trials at different plausible locations on the body like the wrist, elbow, and neck.

Figure 2: Graph for Wrist Region

The graph for the wrist region shows that the ADC values for individuals fluctuate irregularly when compared to the threshold and this does not give a base for proper readings. We took 15 readings.

Table 1: Trials for Wrist Region

Subject	Threshold	ADC Value	Punctured
Sahana S	420	454	NO
Tanavi K	420	422	NO
Pratyay Das	420	410	YES
Thrisha P	420	396	YES
Anusha	420	408	YES
Shreya	420	433	NO
Sanjana	420	424	NO
Samyutha	420	420	-
Sahana S	420	336	YES
Sanjana	420	427	NO
Anusha	420	456	NO
Shreya	420	412	YES
Pratyay Das	420	441	NO
Samyutha	420	319	YES
Tanavi K	420	321	YES

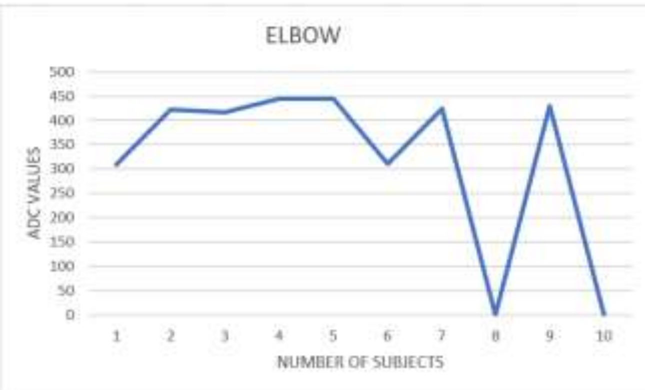

Figure 3: Graph for the Elbow Region

The graph for the elbow shows that the ADC values are again irregularly fluctuating for everyone. Some of them showed errors too. We took 10 Readings.

Table 2: Trials of Elbow Region

Subject	Threshold	ADC Value	Punctured
Sahana S	420	309	YES
Tanavi K	420	423	NO
Pratyay Das	420	416	YES
Thrisha P	420	444	NO
Anusha	420	444	NO

Shreya	420	311	YES
Sanjana	420	424	NO
Samyutha	420	error	error
Sahana S	420	430	NO
Tanavi	420	error	error

According to the trials, we have found the wrist and the elbow regions to be a hindrance to movement and to give varied outputs in comparison to the neck.

When the trends in the results are observed, the threshold for elbow region is set 420. The ADC Values were fluctuating between 309 to 444. These values are unstable.

Whereas the values for the wrist follow a trend where the values range from 319 to 456. These values again are a tad unstable and the electrode position causes a lot of hindrance in movement.

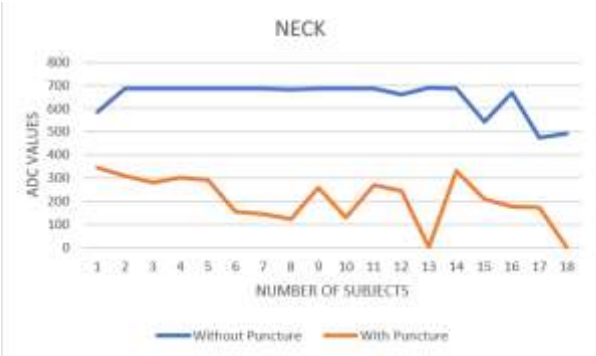

Figure 4: Graph for the Neck Region

The Graph shows the lines for punctured and non-punctured ADC values. The blue line is the without puncture values and the orange line is the values when punctured. As shown the non-punctured values are the least fluctuating and the punctured values give proper readings. The neck provides the least hindrance to movement. We changed the Threshold to check if the sensitivity remains the same.

Table 3: Trials for Neck Region

Subject	Threshold	Without Puncture	Punctured
Sahana S	350	584	344
Pratyay D	350	687	311
Tanavi K	350	687	282
Shreya	350	687	304
Samyutha	350	686	293
Sanjana	350	687	156
Anusha	350	687	146
Sahana	350	684	124
Anusha	350	687	260
Shreya	350	687	131

Sanjana	350	687	272
Shreya	350	662	244
Anusha	350	688	0
Sanjana	350	687	331
Samyutha	350	544	211
Shreya	350	668	177
Sanjana	350	474	175
Anusha	350	493	0

Looking at the results obtained from the neck region, we find that the values do not vary as much and the comfort level using it on the neck is much higher.

This is what makes the signal acquisition from the neck more plausible. The ADC values are converted into Voltage. This can be used to determine the impedance change.

The main aim is to design a wearable, accurate glove puncture or Glove Rupture detection system that can detect a breach in the glove every time a bodily fluid encounters the skin of the user, thereby varying the skin impedance and indicating that the glove has be enruptured. Continued trials are underway with respect to the neck regional attachment and so far the results obtained provide a stable output.

VI CONCLUSION

Anytime a person encounters bodily fluids, tissues, or blood, they must wear gloves. Therefore, the purpose of our product is to determine the skin impedance of dry skin and the skin impedance of skin in contact with liquid to determine when the glove is ripped. A significant component of our product is skin impedance. By immediately detecting a ruptured glove, this gadget assists in preventing the spread of illnesses during operations or routine checks, especially when patients have diseases like aids, etc.

Only temporarily do double gloves assist. It cannot serve as a long-term fix. A rupture prevents accurate detection and indication of the puncture. Given that using two pairs of gloves is a common technique, our device attempts to provide additional detection to the already existing gloves. Our device can be a permanent wearable solution that finds its applications in a wide plethora of fields including surgical operations, laboratory testing, forensics, etc.

Acknowledgement

We hereby acknowledge the immense support offered to us by our project guide Prof Nanditha HG, Department of Medical Electronics Engineering, Dayananda Sagar College of Engineering. We thank Our Head of Department Dr. Aswatha A.R., Department of Medical Electronics Engineering, for the continued support, motivation and guidance to undertake the project "Glove Puncture Detection System"

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