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BALLARI INSTITUTE OF TECHNOLOGY & MANAGEMENT

Autonomous Institute under VTU, Belagavi

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

DECLARATION

We, Kaisum Arshiya, Kamsala Pallavi, Maddileti Pujitha, and Nikki Pandey the students of Final Year B.E, Electronics & Communication Engineering, Ballari Institute of Technology & Management, Ballari, hereby declare that the project titled **"VenoliteX"** has been carried out by us and submitted in partial fulfillment of the course requirements for the award of degree in **Bachelor of Engineering** in **Electronics & Communication Engineering** of the Visvesvaraya Technological University, Belagavi during the year **2024-2025**. We do declare that this work has not been submitted previously by anybody for the award of any degree or diploma to any other university.

Place : Ballari	**Names**	**Signature**
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ABSTRACT

VenoliteX is a revolutionary healthcare solution designed to address two critical challenges in intravenous therapy: precise vein detection and real-time saline purity verification. Traditional methods depend on manual vein localization and lack mechanisms to monitor saline quality, leading to inefficiencies and potential risks to patient safety. This project aims to mitigate these issues by introducing an advanced, automated system that enhances the safety and reliability of saline or drip injections.

The methodology incorporates near-infrared imaging technology for accurate vein mapping, ensuring effortless identification of veins, even in challenging scenarios. Simultaneously, a spectroscopy-based approach enables precise analysis of saline purity, ensuring it meets required standards. These components are seamlessly integrated with IoT-enabled microcontrollers, allowing real-time data acquisition, processing, and monitoring to enhance clinical workflows.

Key results indicate a significant reduction in errors during vein localization and a robust mechanism to detect saline impurities, ensuring both precision and safety. By addressing critical gaps in existing systems, *VenoliteX* offers a transformative approach to intravenous therapy, improving healthcare outcomes and patient experience.

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Chapter 1

INTRODUCTION

1.1 Background and Recent Developments

In the medical field, intravenous (IV) therapy plays a crucial role in delivering fluids, medications, and nutrients directly into the bloodstream. Saline solutions are a common part of IV therapy, used to hydrate patients or as a base for delivering medications. However, ensuring the correct administration and purity of saline solutions poses challenges.

Traditional methods rely on manual vein detection, which can be error-prone and discomforting for patients, especially for individuals with small or difficult-to-locate veins. Similarly, saline solutions contaminated during preparation, transport, or storage can pose significant risks to patients. Recent advancements in sensor technology, microcontrollers, and IoT-enabled systems have provided innovative solutions for addressing these issues. For example, Total Dissolved Solids (TDS) sensors can be used to measure saline purity, while vein detection systems employing infrared light or neural networks can improve the accuracy of IV administration.

By integrating hardware such as ESP8266, I2C displays, and TDS sensors with software algorithms, the healthcare industry is witnessing a transformation toward automated and efficient systems. This project leverages these advancements to develop a cost-effective and user-friendly solution for improving IV therapy.

Figure 1.1: Saline-IV Drip Bottle

1.2 Problem Definition

The project addresses the following key challenges:

1. Vein Detection: Difficulty in identifying veins for precise saline insertion, leading to patient discomfort and multiple attempts.

2. Saline Purity: Contaminated or impure saline can lead to adverse health effects.

3. Manual Monitoring: Reliance on manual methods lacks consistency and accuracy, increasing the potential for human error.

The system aims to mitigate these problems by combining automated vein detection with real-time saline purity monitoring.

1.3 Motivation

The motivation for this project arises from the need to improve patient care and reduce the risk of medical errors during IV therapy. A system capable of automating saline administration and ensuring the quality of saline solutions can significantly enhance the efficiency and reliability of healthcare services. Furthermore, advancements in IoT, microcontrollers, and sensor technologies make it feasible to develop a compact and cost-effective solution. This project seeks to bridge the gap between available technology and real-world healthcare challenges.

1.4 Scope of the Project

This project focuses on the development and implementation of a smart saline monitoring and insertion system. The scope includes:

1. Vein Detection: Implementing a mechanism for accurate vein detection to minimize patient discomfort.

2. TDS-Based Monitoring: Using TDS sensors to measure saline purity and classify it into categories (e.g., pure saline, contaminated saline).

3. Feedback System: Providing real-time feedback using LEDs, buzzers, and an I2C display to guide healthcare professionals.

4. Hardware Integration: Utilizing components like ESP8266, Arduino IDE, LEDs, and TDS sensors for efficient system design.

The system is designed to be scalable and adaptable to broader applications in healthcare.

1.5 Objectives of the Project

The primary objectives of the project are as follows:

1. To design and implement a system capable of detecting veins for precise saline insertion.
2. To measure and classify saline purity in real time using TDS sensors.
3. To provide intuitive feedback through visual (LEDs, LCD) and auditory (buzzer) indicators.
4. To develop a cost-effective solution that is easy to operate and maintain.
5. To ensure the system is reliable, efficient, and suitable for deployment in healthcare environments.

1.6 Methodology

The project methodology involves:

1. Research and Design: Reviewing existing technologies and identifying the best components (e.g., ESP8266, TDS sensors).
2. Hardware Development: Connecting sensors, LEDs, and displays to the microcontroller and ensuring proper functionality.
3. Software Development: Programming the ESP8266 using Arduino IDE to implement algorithms for vein detection and TDS classification.
4. Integration: Combining hardware and software to create a working prototype.
5. Testing and Validation: Calibrating sensors, testing the system with various saline samples, and analyzing results to ensure reliability.

A structured approach ensures the system meets its objectives while maintaining cost efficiency and ease of use.

1.7 Organization of the Report

This report is organized into seven chapters:

Chapter 1: Introduction

Provides an overview of the project, including its background, objectives, scope, and methodology.

Chapter 2: Literature Survey

Discusses existing technologies, related works, and the technological gap that this project aims to fill.

Chapter 3: System Design

Details the hardware and software architecture, including component selection and system flow.

Chapter 4: Implementation

Explains the integration of hardware and software, supported by critical code snippets and circuit diagrams.

Chapter 5: Testing and Results

Describes the testing procedures, presents the results, and analyzes the system's performance.

Chapter 6: Conclusion and Future Work

Summarizes the project outcomes and suggests potential improvements.

References and Appendixes

Lists all sources of information and provides supplementary materials like datasheets and complete source code.

CHAPTER 2

LITERATURE SURVEY

2.1 Literature Survey on "An optimal method for identification of finger vein using supervised learning"

The identification of finger vein is very advanced biometric technique and also behave an important discipline in biometric area, accommodating growing attention in last years. In the same manner with the help of vein design allows high security of personal identification. In this research, we have applied PCA (principal component analysis) for extracting vein patterns and SVM (support vector machine) for classification. The method is purely depending on the different pattern qualities of the vein. The best optimal design has been used in developing the efficient framework. We are using the three publicly available datasets in the research i.e. THU-FVFDT2, SDUMLA-HMT, and FV-USM. Our results clearly indicate the superiority of our proposed framework. Biometric has speedily discriminated itself sustentation the numerous credible, fast, an accurate form depends on biometric features. The identification using biometric has been proved to be more efficient than other identification process [1].

Various biometric signatures, like hand geometry, iris, fingerprint, and face, have been used for user authentication and access control in today's security system. In existing biometric systems, signatures may be falsified and altered as they are in surface for the person body. The various undocumented newcomer has made their fingerprints unreadable [2]. Due to these existing issues, an identification of vein will represent the best alternative. The blood-vessel floods every part of the human body and further constructs an irregular, disorganised, intertwined tree. This special feature protects vein-based detection systems against modification [3]. Several researches on vein identification system has been published so far like identification of palm vein, finger vein and dorsal vein [4], [5], [6].

The imaging technology having infrared with 850 nm of wavelength was used to acquire vein images [7]. The charge-coupled device sensor in a camera is used to acquire image using filter of 825 N m to 990 N m and diode having infrared with 875 N m to 915 N m. To recognise an individual, device produce infrared lights, then haemoglobin in blood absorb IR rays, further, re-allowing construction of venous mesh in less than a second. For identification, venous mesh is contrast with the dataset stowed in the system.

The identification of finger vein technique has been classified into three categories: hybrid methods, machine learning methods and conventional methods. Based on the factors of categories, an existing system can be operated on either identification or verification mode. The general classification process consists of three main methods: pre-processing, feature extraction, and classification [8].

Currently, various systems which are based on machine learning have overcome the problem of existing systems. Additionally, the machine learning is characterised by speed and precision in comparison with existing system [9, 10].

To best of our belief, no research is found on the machine learning for the identification of finger vein. A problem has been arising while working with the machine learning during searching of optimal parameters that produce high identification rate. In order to achieve high recognition rate [11], [12], [13], we start with the succession of experiment with each perimeter we have estimated. First, we have taken the pre-processing methods and try to get the optimal method. Further, feature extraction, we have experimented various techniques but finally we have choose PCA. Finally, we have used several techniques for classification and decided that the SVM best fitted with the PCA. It is also observed that we have experiment our method with all the publicly available datasets such as THU-FVFDT2, SDUMLA-HMT, and FV-USM. More precisely, the objectives of our research work are as follows:

(1) We have introduced a finger vein identification system using machine learning technique.

(2) We have used the PCA as feature extraction and SVM as classification technique.

(3) We have used publicly available dataset such as THU-FVFDT2, SDUMLA-HMT, and FV-USM

(4) We are able to compare our proposed algorithm with the existing methods in terms of the recognition rate.

(5) The important features of our proposed algorithm are also discussed in details.

(6) We have also explained our proposed methodology in very easy way.

The rest of this research paper is summarized as follows.

2.1.1 Acquiring Images

The acquisition of the image is first step in finger vein identification system. The images are input through the publicly available datasets i.e. THU-FVFDT2, SDUMLA-HMT, and FV-USM as shown in figure 2.1.

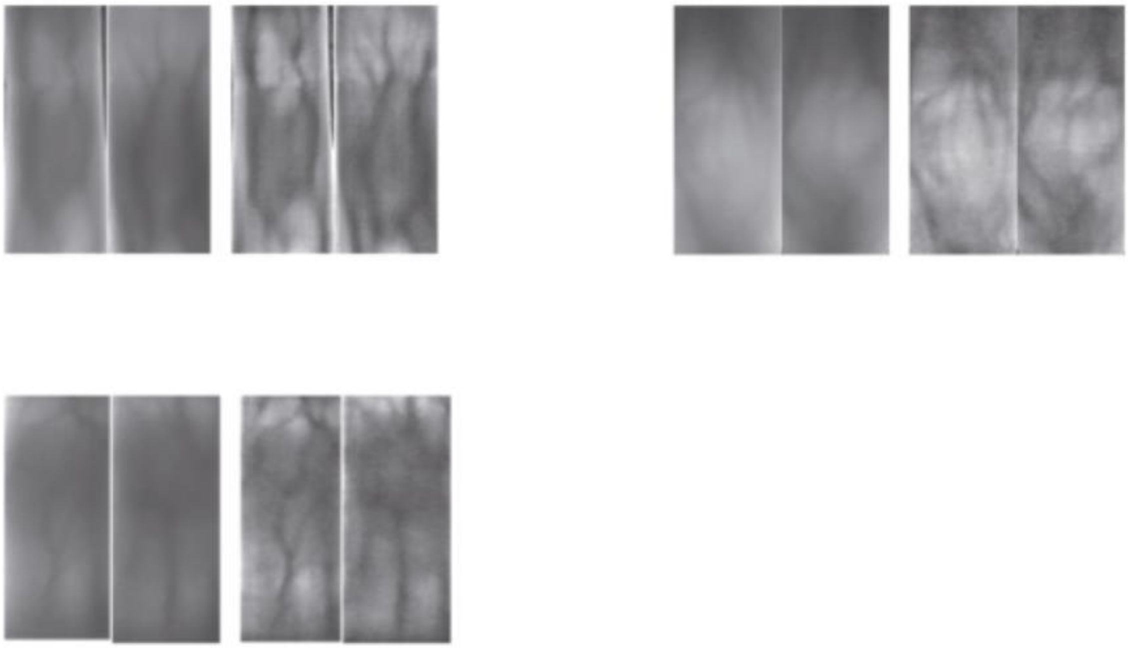


Figure 2.1: Images from Database Respectively.

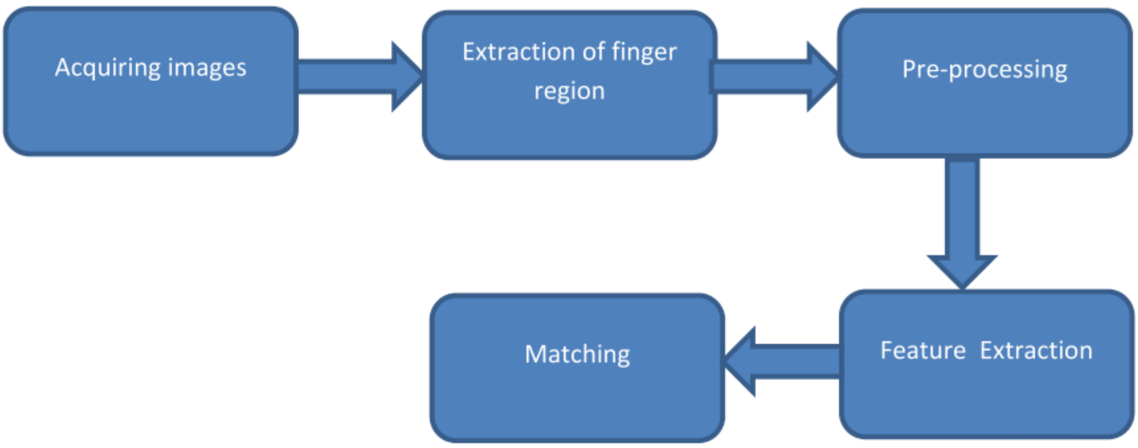


Figure 2.2: Methodology

2.1.2 Extraction of finger vein

The Extraction of finger vein is done for region of interest (ROI). The ROI of the given image is acquired by lower-limit. The multidimensional based filter is used in lower-limit. The ROI of extricated image is produced by intertwine the threshold and cropped image.

2.1.3 Pre-processing

The near-infrared illumination used in the time of image capturing method produces little noise and contrast in finger vein structure. Thus, pre-processing step is most important to increase the standard of given image. After the segmentation of ROI, we apply sharpening filtering and block local normalization. These methods improve the local details of vein structure while enhancing the recognition results. The segmentation of ROI may get the same region with proper finger patterns design for feature extraction. Apart from, better accuracy of extraction of ROI enhances the accuracy rate of the system while minimizes the calculation complexity of subsequent methods.

2.1.4 Feature extraction

This is very important methods in matching process. The edges and textures important feature finger vein images. The important fractal dimensions features are extracted with the help of PCA. Fractals are not regular geometric objects that have constant irregularity in each scale. Dimensions are the measurable metric of some kind such as depth, height, breadth, and length. They are explained as an indexing factor for featuring characterized fractal design as the ratio between variations in detail to variation in scale. The fractal dimensions are divided into grids and boxes.

2.1.5 Matching

The matching step for the introduced technique depends on the classification methodology to get the shift matrices of finger vein. The SVM method is used to calculate correspondence among finger vein patches to relate. Contrasting with the existing methods, this method combines the search strategy for matching larger patch sizes. Therefore, this process implements a fast technique to avoid searching for each pixel, which produces significant reduces the computation time.

2.1.6 Conclusion & Future Works

In this given work, we presented a new and robust technique based on the PCA and SVM. This learning system is capable of getting personal identification system using finger vein structures. The central idea of the proposed system is to enhance the accuracy rate using machine learning to train entire system. The superiority of the SVM is the distinction to the training set. The finger vein recognition system is very simple and dataset is small that produce the training process. This research has used many datasets holds dissimilar images. For this research, instead of using single dataset we used different finger vein datasets like THU-FVFDT2, SDUMLA-HMT, and FV-USM. In future, we apply some more machine learning and deep learning techniques to enhance the recognition rate of finger vein identification system.

2.2 Literature Survey on "A hybrid machine learning and embedded IoT-based water quality monitoring system"

Since access to clean and safe water is one of life's most basic needs, the exponential growth of the world's population makes it vital to guarantee a workable framework. Manually collecting samples and sending them to a research center for discovery and analysis is the typical approach for gathering information on water qualities. However, this approach is illogical in the long run because it requires a lot of time and labor. This paper aimed to construct, test, and evaluate the usefulness of machine learning and the Internet of Things (IoT) at water storage stations. First, we developed a system prototype and assessed its performance using classifier and reliability matrices. This study considers water's physical and chemical parameters to evaluate the level of water pollutants present in drinking water. The parameters measured include temperature, pH, turbidity, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Oxidation Reduction Potential (ORP), and electrical conductivity. After analyzing the sensor data, we used Artificial Neural Network (ANN) and Support Vector Machine (SVM) machine learning algorithms to forecast the impurity level of the water measured. The performance showed that the ANN models used have the highest accuracy and are the most suitable to predict water source and status. We also introduced a water treatment method to provide an automated corrective measure based on a specific amount of water contamination. Based on the system's results, we concluded that AI and IoT are more efficient in remotely monitoring safe and harmful water conditions.

Water is the most crucial chemical component in a person's life, making up 60% of their body, and is vital for maintaining the well-being of other living ecosystems [1]. People need water for everyday tasks such as washing, cleaning, irrigation, aquaculture, and other purposes. Access to clean, safe water is imperative for good health [2]. Clean water is also essential for a healthy environment, economic development, and providing support for families and social networks through government initiatives [3].

Maintaining water quality is crucial, as failure to do so will put human health and the balance of life at risk. Water pollution is the leading cause of illness and death worldwide, and diseases such as cholera and diarrhea are the most well-known waterborne illnesses [4]. According to statistics, diarrhea kills approximately 2.2 million people each year, mostly young children in developing countries. In many non-industrialized nations, people drink unclean or polluted water with little or no pre-treatment due to illiteracy and a lack of water quality monitoring mechanisms [5]. Evaluating the quality of drinking water regularly is crucial and is the responsibility of the general health division [6]. A comprehensive review and revision of water management policies at all levels, from a global to individual well level, is necessary due to the significant global water contamination problem. The traditional method of collecting water data involves collecting samples and sending them to a laboratory for analysis, but this approach is time-consuming and requires a lot of resources, limiting the frequency of water quality checks [7]. The Internet of Things (IoT) is one of the most innovative concepts today and has enormous potential to impact all aspects of human activity, offering endless opportunities for improvement. IoT connects physical objects to the internet and has been demonstrated to have tremendous potential in various sectors, including agriculture, health, business, sports, and government [8,9]. The implementation of IoT and machine learning in water quality monitoring systems has provided real-time monitoring with a higher degree of accuracy. Machine learning enables computers to imitate human behaviour and learn from mistakes, enabling them to function just as well as humans [10].

2.2.1 Water quality parameters

This study measures key water quality parameters. The following sentence is a comprehensive overview of the key water quality parameters that are measured, including temperature, dissolved oxygen (DO), pH, conductivity, oxidation–reduction potential (ORP), total dissolved solids (TDS), and turbidity. Among all these parameters, pH measurement is particularly crucial as it is used to indicate hydrogen concentrations, ranging from 0 to 14 g-equivalents per liter in fields like chemistry, biology.

2.2.2 Methodology

In this section, we explain how we designed and built our Hybrid IoT-based Water Quality Monitoring System. The system collects water data from sensors, which is then trained using machine learning algorithms SVM and ANN. We deploy the most accurate model to Google Cloud, where it can predict water quality values in real time. The ESP8266 Wi-Fi module sends the data wirelessly to the Cloud. Our system also has a control mechanism that treats the water if the ORP, pH, or both are extremely low.

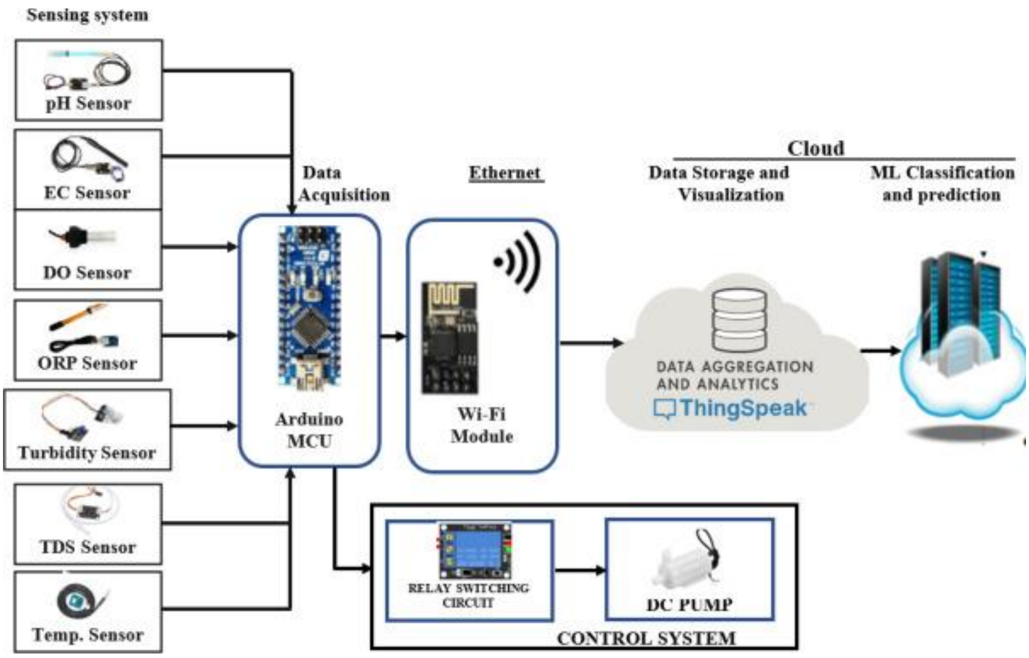


Figure 2.3: Block Diagram

The sensors amplifier boards, Arduino, and ESP8266 modules were assembled inside a plastic box measuring 4 cm x 4 cm x 2 cm. To prevent the sensors from sinking into the water, the sensor probes were attached to a floating material because the upper part of these sensors is not water-resistant. A waterproof junction box was used to protect all electronics from water damage caused by rainfall and water splashing around the prototype. The circuit was powered by four lithium batteries, and all.

2.2.3 Conclusion and Future Works

This research has resulted in a successful system that combines machine learning and IoT for monitoring water quality. The system can detect real-time variations in seven water parameters, including temperature, pH, turbidity, DO, TDS, ORP, and EC. The Arduino Nano and ESP8266 are used as mainboards for data logging and transmission to the Cloud. The system relies on ThinkSpeak server for storing and displaying the water parameters. The system uses SVM and ANN models to classify and predict.

2.3 General Survey

2.3.1 Survey in "Maternal deaths in Ballari hospital due to use of substandard ringer lactate solution"

Health Minister **Dinesh Gundu Rao** on Friday attributed the recent maternal deaths in Ballari district hospital to the use of substandard ringer lactate solution, an intravenous (IV) fluid that doctors commonly used to restore hydration and fluid balance in the body.

A sudden spurt in **maternal deaths was reported from Ballari district hospital from November 9 to November 11**. The deaths were reported to have occurred following caesarean section conducted on these three days at the maternity operation theatre in the hospital. Out of the 34 caesarean operations conducted during these three days, seven women developed complications such as acute kidney injury, requiring haemodialysis, and multi-organ dysfunction, the Minister said.

Of the seven, four women died, including one death on November 26. A confidential review of the deaths by a team of specialists constituted by the Rajiv Gandhi University of Health Sciences has revealed that there is no negligence or dereliction of duty by the doctors at the hospital. The report said that all protocols and patient care guidelines have been followed, he said.

Two of the remaining three women have been discharged from the hospital and one patient is recovering at VIMS Ballari. The Minister said the onset of complications following caesarean operations is being suspected to the ringer lactate solution supplied by M/S Paschim Banga Pharmaceutical Ltd to Karnataka State Medical Supplies Corporation Ltd. (KSMSCL).

Earlier, all 192 batches supplied by the said company were temporarily frozen by KSMSCL, even though only two batches (03BF2258 and 036BF2255) were declared not of standard quality on March 18 this year by the Drugs Control Department. Later, following the certificate of standard quality by Central Drug Laboratories, the usage of ringer lactate of 84 batches was permitted by KSMSCL on August 13, he explained.

Currently, ringer lactate solution batch 26.2.9 has been withdrawn from usage at all levels of healthcare across the State by KSMSCL and the ringer lactate fluids supplied to Ballari district hospital have been sent for testing, he said.

Figure 2.4: Ringer Lactate Solution

CHAPTER 3

METHODOLOGY AND IMPLEMENTATION

3.1 Flow diagram

3.1.1 Saline purity testing

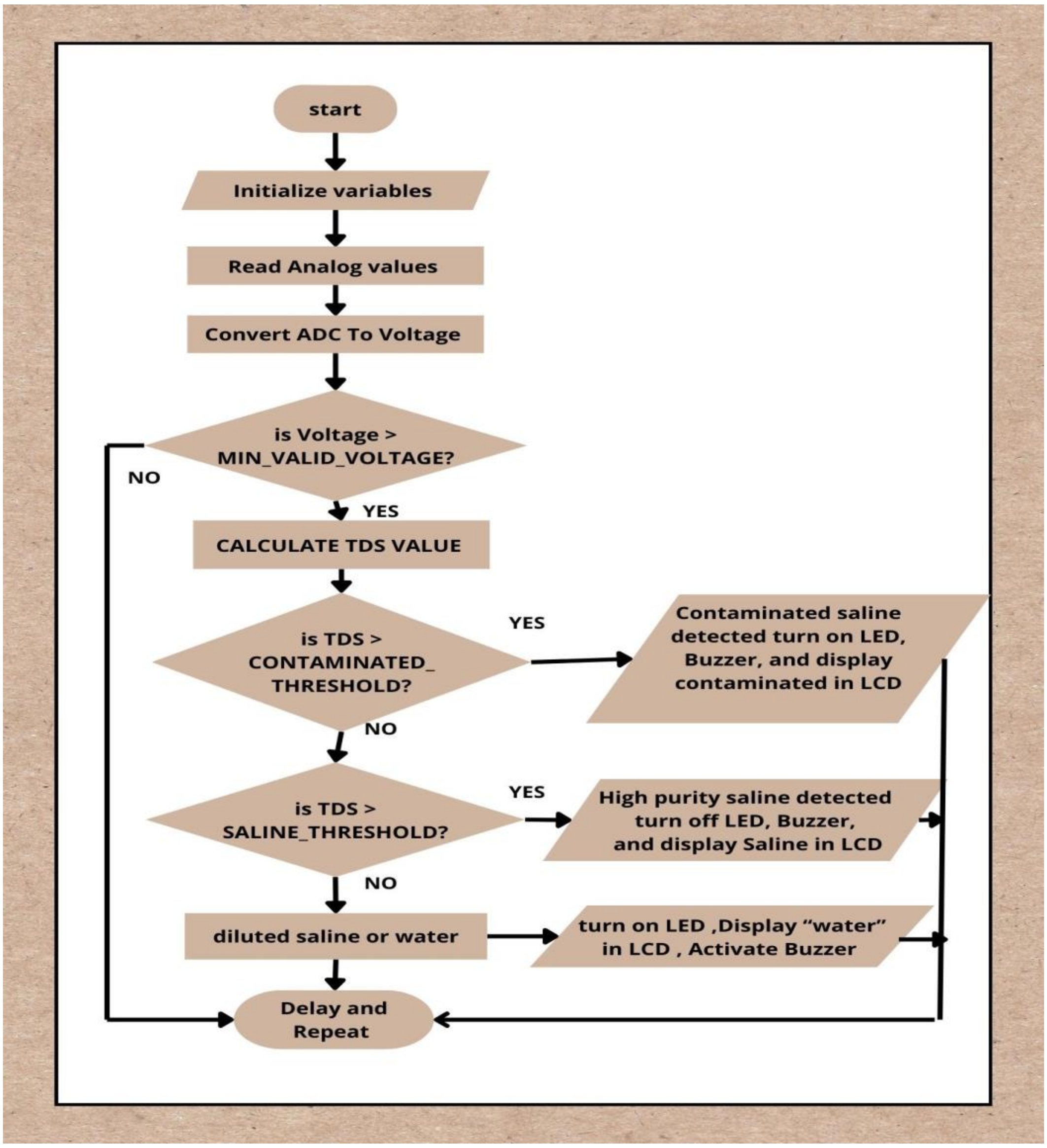


Figure 3.1: Flow chart of saline purity.

Explanation:

Step 1: Start: Begin the process.

Step 2: Initialize Variables: Set up all necessary variables for the system.

Step 3: **Read Analog values**: Input is taken as analog signals.

Step 4: **Convert ADC to Voltage**: Convert the analog signal to a voltage value.

Step 5: **Check if Voltage > MIN_VALID_VOLTAGE**:

- **No**: If the voltage is below the threshold, repeat the process.
- **Yes**: If the voltage is above the threshold, proceed to calculate the TDS value.

Step 6: **Calculate TDS Value**: Compute the TDS value using the voltage.

Step 7: **Check if TDS > CONTAMINATED_THRESHOLD**:

- **Yes**: If TDS exceeds the contamination threshold:
  - Turn on LED and buzzer.
  - Display "contaminated" on the LCD.
- **No**: Proceed to the next step.

Step 8: **Check if TDS > SALINE_THRESHOLD**:

- **Yes**: If TDS is within the range for saline:
  - Turn off LED and buzzer.
  - Display "saline" on the LCD.
- **No**: Consider the solution as diluted saline or water.

Step 9: **Diluted Saline or Water**:

- Turn on LED.
- Display "water" on the LCD.
- Activate the buzzer.

Step 10: **Delay and Repeat**:

Introduce a delay before restarting the process.

3.1.2 Veins detection

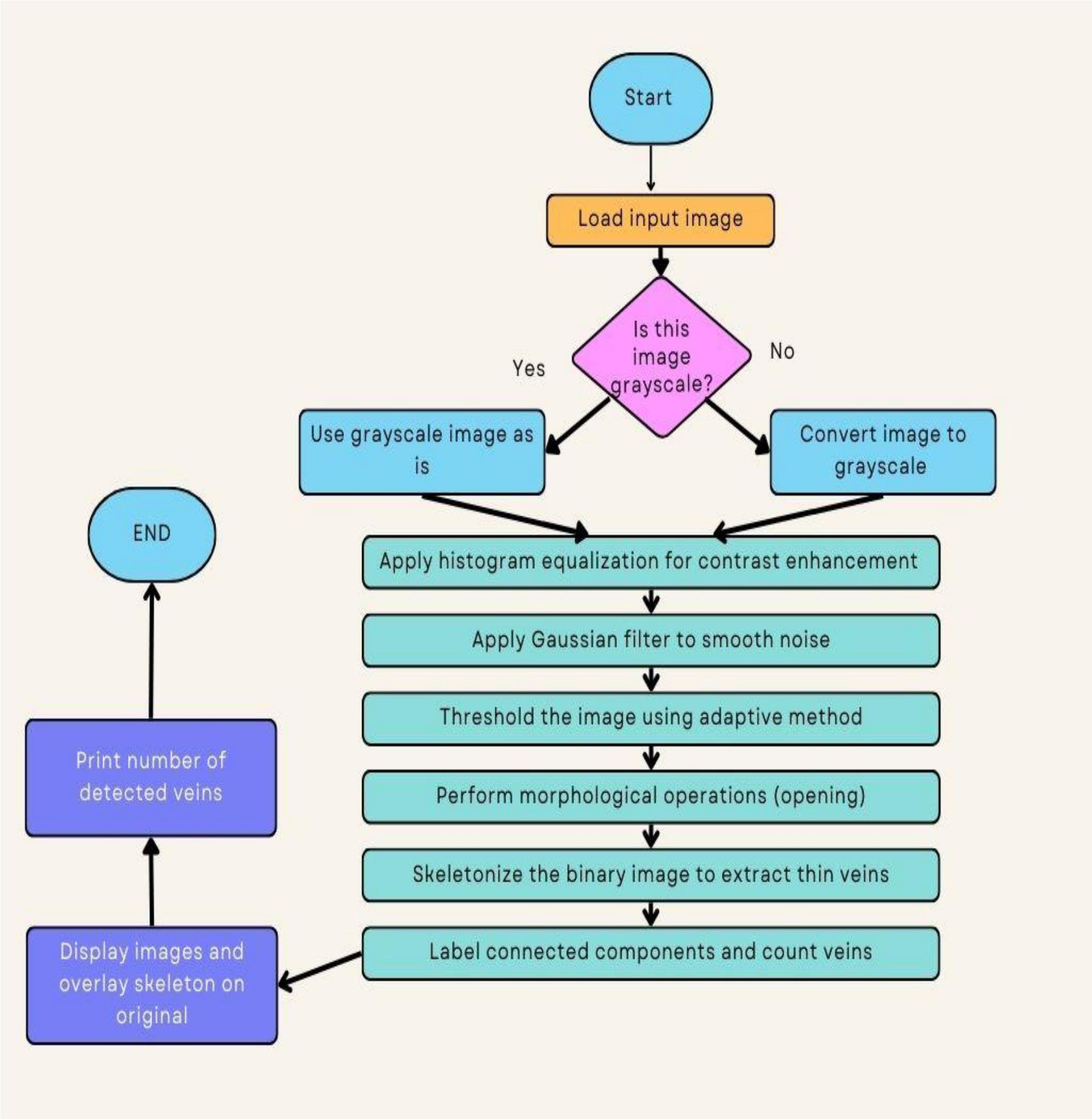


Figure 3.2 Flow chart of veins detection.

Explanation:

Step 1: Start: Begin the process.

Step 2: Load Input Image: Load the image that needs to be processed.

Step 3: Check if Image is Grayscale:

Is the image grayscale?

If Yes, use the grayscale image as is.

If No, convert the image to grayscale.

Step 4: Apply Histogram Equalization: Enhance the contrast of the grayscale image.

Step 5: Apply Gaussian Filter: Smooth out noise using a Gaussian filter.

Step 6: Threshold the Image: Use an adaptive method to binarize the image, separating veins from the background.

Step 7: Perform Morphological Operations: Use morphological opening to remove noise and enhance vein structures.

Step 8: Skeletonize the Binary Image: Reduce the binary image to a skeletonized representation, showing thin vein structures.

Step 9: Label Connected Components and Count Veins: Identify and count the connected components representing veins.

Step 10: Display Images: Overlay the skeletonized image on the original and display the results.

Step 11: Print Number of Detected Veins: Output the count of detected veins.

Step 12: End: Terminate the process.

3.2 Block Diagram

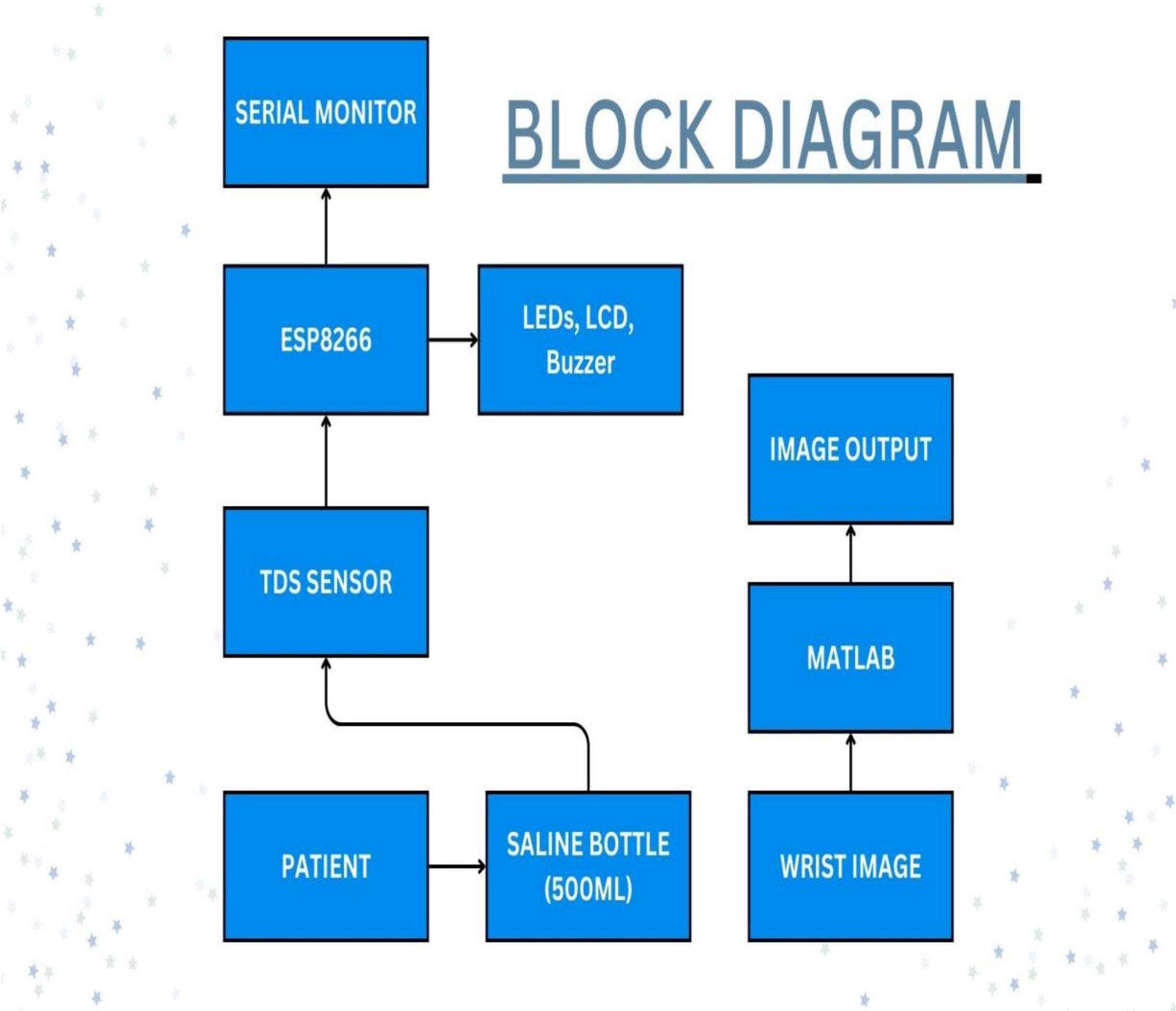


Figure 3.3: Block diagram of saline purity and veins detection.

Block Diagram Explanation:

This block diagram showcases two distinct systems—Saline Monitoring System and Vein Detection System—that work independently but serve a healthcare purpose.

1(a). Saline Monitoring System (Left Section)

This system monitors the quality of saline being administered to a patient.

Components:

- Patient: The end-user of the saline solution, requiring intravenous fluid administration. Ensures the monitored saline is safe and suitable for their health condition.

- Saline Bottle (500ml): A standard saline solution bottle containing a mixture of water and dissolved salts. This bottle is monitored for its chemical composition to detect contamination or degradation over time.
- TDS Sensor: Measures the Total Dissolved Solids (TDS) in the saline solution. TDS levels indicate whether the saline has the correct composition or if impurities are present. Output: Analog voltage signals corresponding to the TDS value.
- ESP8266: A Wi-Fi-enabled microcontroller used to process the TDS sensor data. It converts the analog signal from the TDS sensor into a digital value. Performs threshold analysis (e.g., comparing TDS with predefined safe ranges). Sends processed data to the serial monitor or other connected systems.
- Turn on and off LEDs and buzzer accordingly and display in LCD.
- Serial Monitor: A visualization interface (e.g., a computer screen or terminal). Displays real-time readings from the ESP8266. Outputs messages such as "High-Purity Saline Detected" or "Contaminated Saline Detected."

b. Vein Detection System (Right Section)

This system aids in locating veins for intravenous injections or cannula placement.

Components:

- Wrist Image: Captures a high-resolution image of the patient's wrist using a camera. The image is used to identify vein patterns, which are typically less visible to the naked eye in some patients.

2. MATLAB: A powerful image-processing tool used for analyzing the wrist image.

Key processes:

- Grayscale Conversion: Converts the image to grayscale for simpler processing.
- Histogram Equalization: Enhances the contrast, making veins more distinguishable.
- Gaussian Filtering: Smoothens the image to reduce noise.
- Thresholding: Differentiates the veins from the surrounding tissue by binarizing the image.
- Morphological Operations: Refines vein patterns by removing unwanted artifacts.
- Skeletonization: Converts veins into thin, accurate lines for easier visualization.
- Labeling and Counting: Identifies and counts the connected components (veins).

3. Image Output: The final processed image is displayed with vein patterns clearly marked. Skeletonized veins are often overlaid on the original wrist image for better interpretation.

3.2.1 TDS sensor

A TDS (Total Dissolved Solids) sensor is a device used to measure the concentration of dissolved substances in a liquid, such as salts, minerals, or impurities. It provides an indication of the liquid's purity by measuring the total ion content. The sensor is widely utilized in various applications, including water quality analysis, industrial fluid monitoring, and medical purposes like testing saline solutions.

The sensor typically consists of:

1. Probe: A pair of electrodes to measure electrical conductivity.
2. Circuitry: To convert conductivity into a TDS value.
3. Temperature Compensation Mechanism: Many TDS sensors include built-in temperature compensation to provide accurate readings under varying temperature conditions.

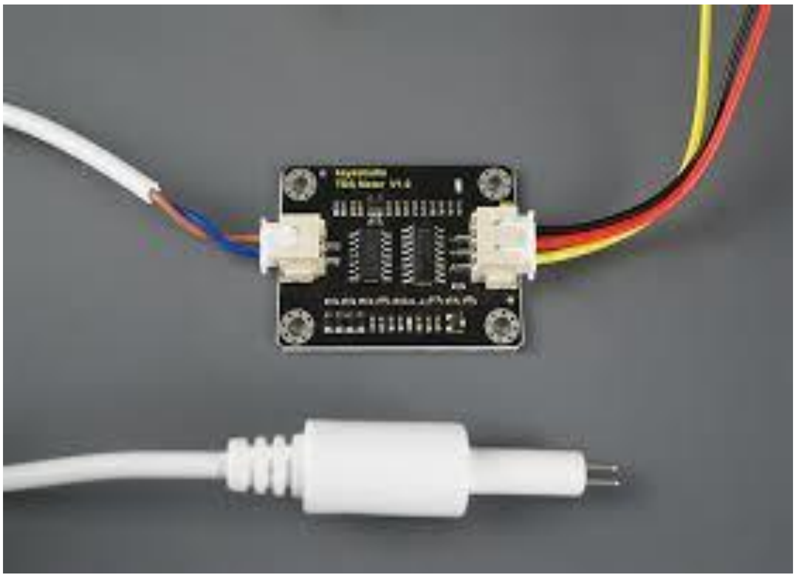


Figure 3.4: TDS sensor

Working:

The TDS sensor operates based on the principle that dissolved ions in a liquid enhance its electrical conductivity. Its working involves the following steps:

1. Immersion in Liquid: The probe, containing two electrodes, is immersed in the liquid to be analyzed.
2. Conductivity Measurement: A small alternating current (AC) is passed between the electrodes. The ions in the liquid conduct the current, and the amount of current passing through is measured. Higher dissolved ion concentrations result in higher conductivity.
3. Conversion to TDS Value: The conductivity reading is converted into a Total Dissolved Solids (TDS) value using a predefined conversion factor. This value is typically expressed in parts per million (ppm) or milligrams per liter (mg/L).
4. Temperature Compensation: Since conductivity varies with temperature, the sensor adjusts the measurements using a temperature compensation mechanism to ensure accuracy.
5. Output Signal: The TDS sensor outputs an analog signal proportional to the TDS value. This signal is processed by a microcontroller (e.g., ESP8266) to obtain the final TDS reading.

The **Liquid Crystal Display (LCD)** plays a crucial role in visually conveying the status of the detected solution during the process. It provides clear, real-time feedback based on the TDS (Total Dissolved Solids) value calculated by the system. If the TDS value exceeds the **CONTAMINATED_THRESHOLD**, the LCD displays the message "Contaminated," alerting the user to the presence of an unsafe or impure solution. When the TDS falls within the range of high-purity saline, surpassing the **SALINE_THRESHOLD** but below the contamination threshold, the LCD shows the message "Saline," indicating the solution is suitable for use. Conversely, if the TDS value is below the **SALINE_THRESHOLD**, the LCD displays "Water," signifying that the solution is either too diluted to be considered saline or is simply water. By providing these messages, the LCD ensures users are well-informed of the solution’s condition, enabling appropriate actions to be taken.

3.2.2 LCD Display

Figure 3.5: I2C LCD Display

The **Liquid Crystal Display (LCD)** plays a crucial role in visually conveying the status of the detected solution during the process. It provides clear, real-time feedback based on the TDS (Total Dissolved Solids) value calculated by the system. If the TDS value exceeds the **CONTAMINATED_THRESHOLD**, the LCD displays the message "Contaminated," alerting the user to the presence of an unsafe or impure solution. When the TDS falls within the range of high-purity saline, surpassing the **SALINE_THRESHOLD** but below the contamination threshold, the LCD shows the message "Saline," indicating the solution is suitable for use. Conversely, if the TDS value is below the **SALINE_THRESHOLD**, the LCD displays "Water," signifying that the solution is either too diluted to be considered saline or is simply water. By providing these messages, the LCD ensures users are well-informed of the solution's condition, enabling appropriate actions to be taken.

3.2.3 LEDs

Figure 3.6: LED's

The **LEDs (Light Emitting Diodes)** in the system serve as visual indicators to communicate the status of the detected solution. When the TDS (Total Dissolved Solids) value exceeds the **CONTAMINATED_THRESHOLD**, the LED turns **on**, providing a clear visual warning that the solution is contaminated and unsafe for use. In contrast, if the TDS value falls within the range of high-purity saline, between the **SALINE_THRESHOLD** and the contaminated threshold, the LED is turned **off**, indicating that the solution is pure and suitable for use. However, if the TDS value is below the **SALINE_THRESHOLD**, the LED is activated again to signal that the solution is either diluted saline or water. By using LEDs in conjunction with the LCD and buzzer, the system delivers a multi-sensory alert system that ensures users can quickly and accurately interpret the solution's condition.

3.2.4 ESP8266

The ESP8266 is a powerful and cost-effective Wi-Fi microcontroller module designed by Espress if Systems. It is widely popular in Internet of Things (IoT) projects because of its ability to seamlessly connect devices to the internet. Compact and versatile, the ESP8266 includes a 32-bit Ten silica L106 processor with clock speeds of up to 80 MHz (or 160 MHz), flash memory for storing data, and GPIO pins for interfacing with sensors and other devices. It supports the full TCP/IP stack, making it an excellent choice for wireless communication in IoT applications. The ESP8266 operates in three main Wi-Fi modes: Station Mode, where it connects to an existing Wi-Fi network; Access Point Mode, where it creates its own network for devices to connect; and Station + Access Point Mode, combining both functionalities. This flexibility enables the module to work as a client, a host, or both simultaneously.

When interfaced with a sensor, such as a TDS sensor, the ESP8266 captures analog data through its ADC pin and processes it. For example, in a water monitoring system, it might measure the TDS levels and upload this data to a cloud platform using protocols like HTTP or MQTT. It can also act as a local server, displaying processed data on devices connected to its Wi-Fi network. Additionally, the module supports custom programming through tools like Arduino IDE, NodeMCU, or Micro Python, allowing developers to tailor it to their project requirements.

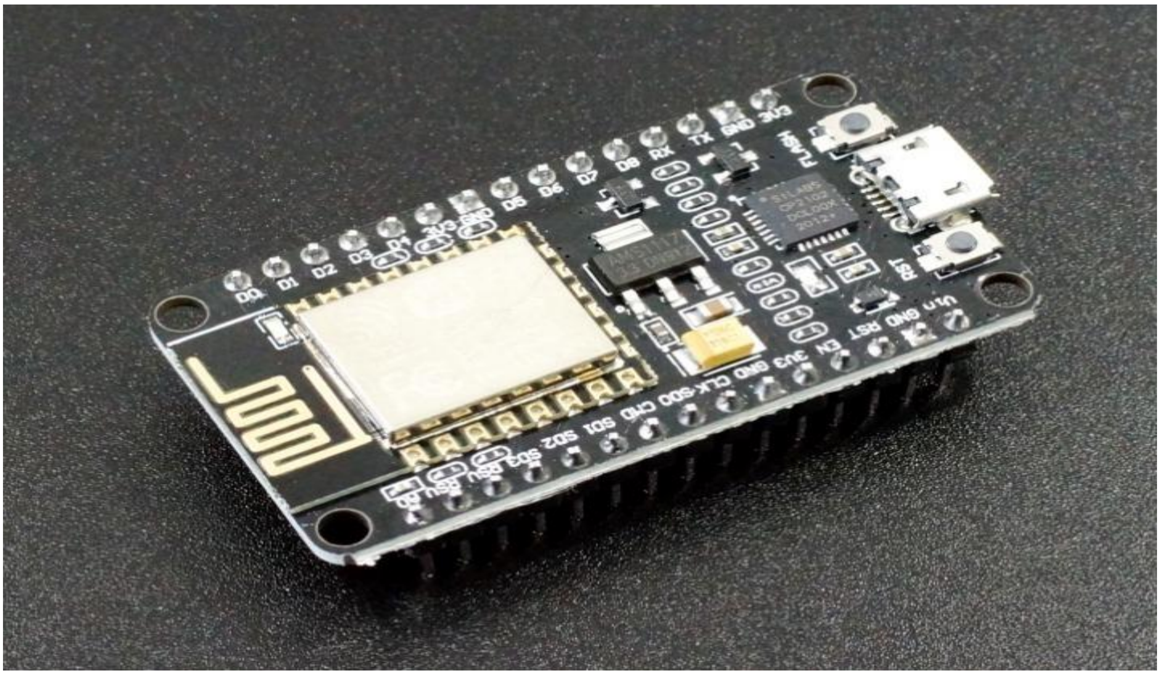


Figure 3.7: ESP8266

Its low power consumption, compact design, and robust performance, the ESP8266 is used in applications ranging from home automation and wearables to industrial monitoring and smart city projects. It is an essential component in IoT systems, providing reliable wireless connectivity and efficient data handling.

3.3 Pictorial View of Proposed System

MATLAB is a high-level programming language and numeric computing platform that's used for technical computing. It's used in engineering and scientific applications, such as data analysis, image processing, and algorithm development.

Vein detection refers to the process of identifying the location of veins beneath the skin using technology that typically involves shining near-infrared light onto the area, which is then reflected back to a camera, allowing the visualization of veins as darker lines against the surrounding tissue due to the different light absorption properties of blood compared to other tissues; this is often used in medical settings to facilitate easier blood draws or intravenous access, particularly in patients with difficult-to-find veins.

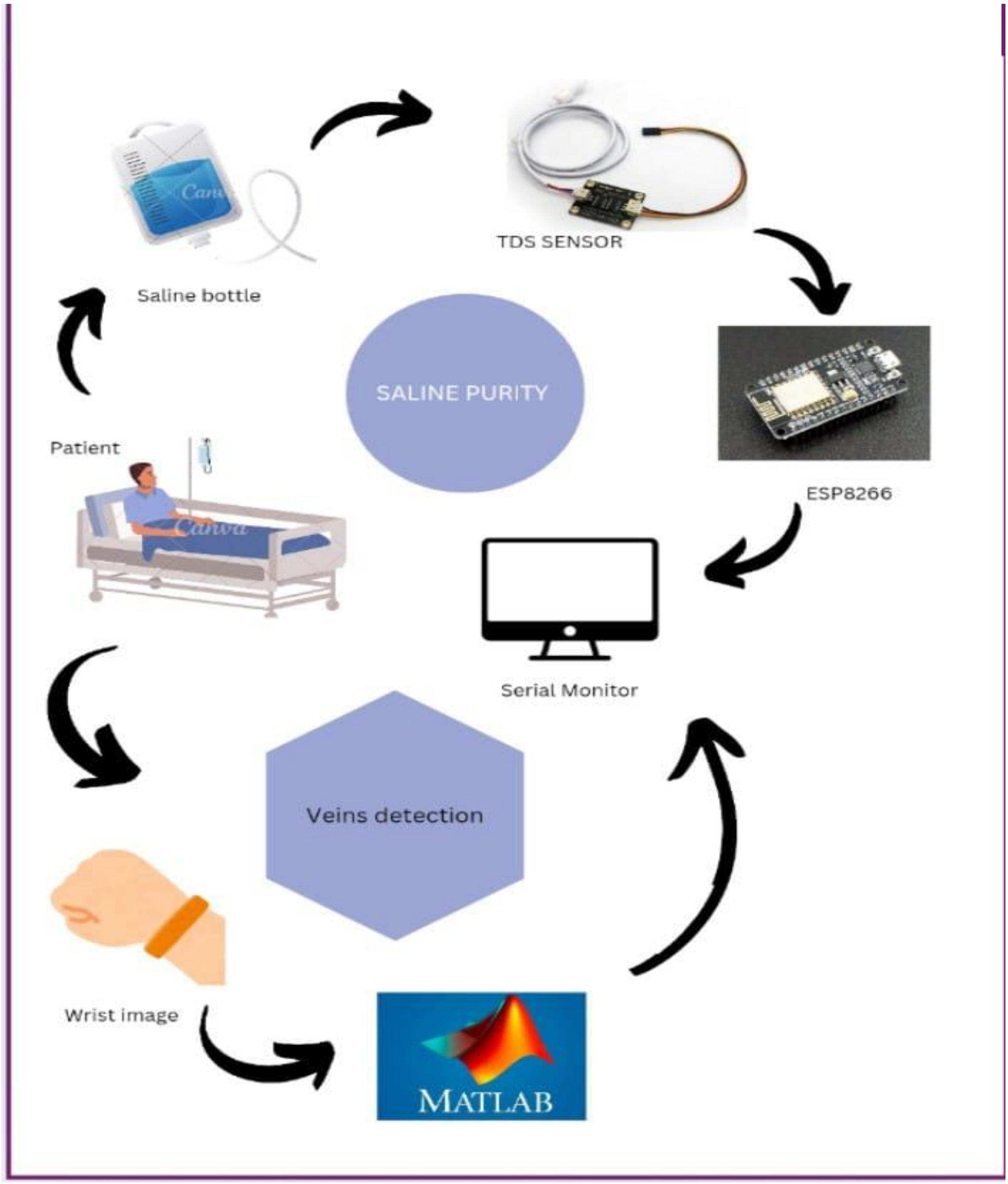


Figure 3.8: A Pictorial view of the proposed system

Explanation:

The image demonstrates an integrated system for **saline purity monitoring** and **vein detection** to ensure safe and efficient intravenous (IV) administration.

1. Saline Purity Monitoring:

- A **TDS sensor** measures the saline solution's purity, detecting impurities or contaminants. The data is transmitted to an **ESP8266 microcontroller**, which processes and displays the results on an LCD and a serial monitor.

- The system provides real-time feedback with audio-visual alerts, confirming whether the saline is safe for use. This ensures quality control and protects patients from potential harm caused by contaminated solutions.

    1. **Dry Case:** The system detects no liquid and displays "Dry Condition" on the LCD and serial monitor, with no LED or buzzer activation.
    2. **Water Detected:** The system identifies regular water and displays "Water Detected" on the LCD and serial monitor, accompanied by a **white LED** and a soft buzzer alert.
    3. **Contaminated Liquid:** When the liquid is found to be contaminated, the LCD shows "Contaminated Liquid Detected," the serial monitor indicates the presence of impurities, and a **red LED** flashes with a loud buzzer alert.
    4. **Saline Detected:** Upon detecting pure saline, the system displays "Saline Detected" on the LCD and serial monitor, with **no LED or buzzer** activation

2. Vein Detection:

- A **wrist image** is captured to locate veins for accurate IV insertion. Using **MATLAB**, advanced image processing techniques like contrast enhancement and edge detection are applied to highlight veins clearly.

- The processed image is displayed, enabling precise identification of suitable insertion points, reducing the risk of errors and improving patient comfort.

By integrating **saline purity monitoring** with **vein detection**, this system ensures safe, efficient, and patient-friendly IV administration while offering versatile applications in healthcare settings.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Results displayed on LCD

The system designed using an ESP8266 microcontroller, an LCD display, a TDS sensor, LEDs, and a buzzer effectively detects and classifies liquids based on their Total Dissolved Solids (TDS) content. When the TDS sensor is not immersed in any liquid, the LCD displays the message "Dry", and the serial monitor outputs "No valid input detected (sensor not connected or dry)." This ensures the system alerts the user of the absence of valid input. When the TDS sensor is immersed in water or a very dilute solution, the LCD displays "Water", and the serial monitor shows "Liquid Detected: Not saline (Possible water or very dilute solution)." In this state, the white LED glows, and the buzzer emits a low-tone beep, indicating safe liquid detection. On the other hand, when the TDS sensor detects a contaminated saline solution, the LCD displays "Contaminated", and the serial monitor outputs "Liquid Detected: Contaminated Saline." In this case, the system activates the red LED, and the buzzer produces a high-tone beep, warning the user of potential contamination. This multi-state functionality ensures real-time monitoring of liquid quality while providing clear visual and auditory feedback, making the system reliable and user-friendly for applications such as water quality analysis or contamination detection.

On the 1st page of LCD screen the system designed using an ESP8266 microcontroller, an LCD display, and a TDS sensor successfully detects the presence or absence of a liquid to measure its Total Dissolved Solids (TDS). When the TDS sensor is not immersed in a liquid, the system identifies this condition as "dry" and displays the message "Dry" on the LCD. Simultaneously, the serial monitors outputs the message "No valid input detected (sensor not connected or dry)."

Figure 4.1: First page of LCD screen

On the 2nd page of LCD screen when the TDS sensor is immersed in water or a very dilute solution, the system accurately identifies the liquid as non-saline. The LCD displays the message "Water", indicating that the detected liquid is safe. On the serial monitor, the message "Liquid Detected: Not saline (Possible water or very dilute solution)" is shown, providing detailed feedback to the user. Additionally, the system activates the white LED and the buzzer emits a low-tone beep, serving as visual and auditory indicators of water detection. This functionality highlights the system’s ability to reliably detect and differentiate safe liquids, ensuring efficient and user-friendly operation in applications such as water quality monitoring.

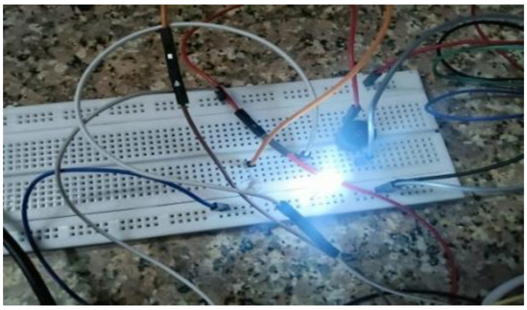


Figure 4.2: Second page of LCD screen

On the 3rd page of LCD screen when the TDS sensor is immersed in contaminated saline, the system successfully identifies the liquid as unsafe. The LCD displays the message "Contaminated", indicating the detection of a potentially harmful liquid. On the serial monitor, the message "Liquid Detected: Contaminated Saline" is shown, providing precise feedback for the user. In addition, the system activates the red LED, and the buzzer produces a high-tone beep, serving as clear visual and auditory alerts of contamination. This functionality demonstrates the system’s capability to effectively detect and alert users to unsafe liquids, ensuring enhanced reliability for applications like water safety monitoring or contamination detection.

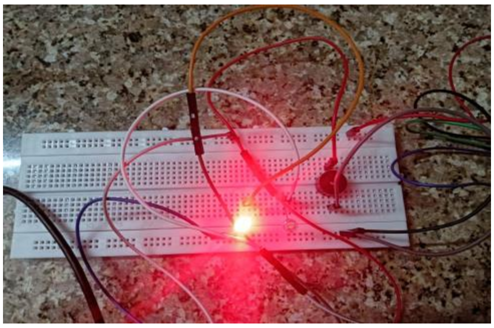
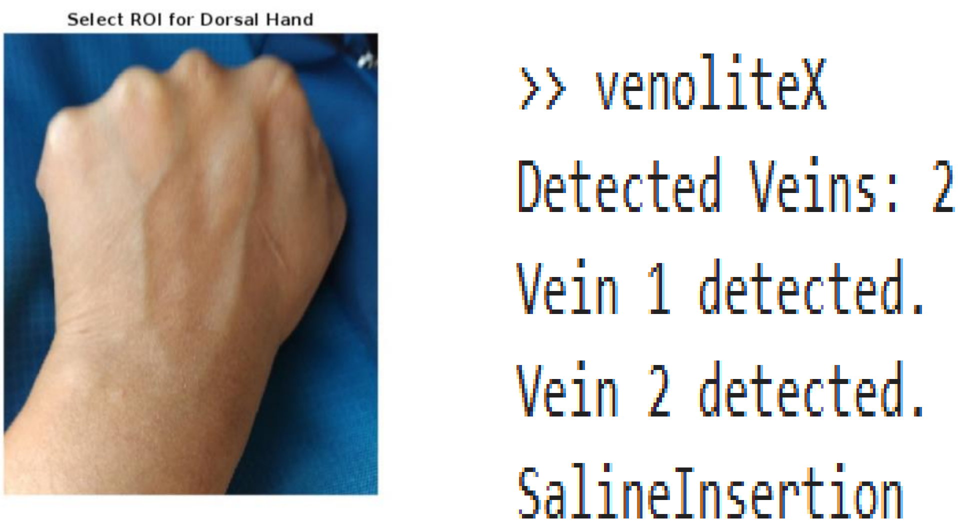


Figure 4.3: Third page of LCD screen

On the 4th page of the LCD screen, when the TDS sensor is immersed in saline water, the system successfully identifies the liquid as saline. The LCD displays the message "Saline Detected", indicating the precise identification of the liquid. On the serial monitor, the message "Liquid Detected: Saline Water" is displayed, providing detailed feedback for the user. Additionally, the system activates the yellow LED, and the buzzer produces a moderate-tone beep, offering clear visual and auditory alerts of the liquid being saline. This functionality highlights the system’s ability to accurately identify saline water, ensuring its effectiveness in scenarios such as water analysis and quality checks**.**

Figure 4.4: Fourth page of LCD screen

In Figure 4.5, the MATLAB output successfully detects and highlights the vein patterns from the dorsal hand image used as input. The figure visually represents the detected veins with enhanced clarity, ensuring precise identification. The vein regions are prominently marked within the image, facilitating easy analysis. Additionally, the MATLAB command window displays the message "Figure 4.5: Veins Detected with Dorsal Hand Input," offering detailed confirmation of the detection process. This output demonstrates the system's robust performance in vein pattern recognition, showcasing its suitability for applications in medical diagnostics and biometric systems.



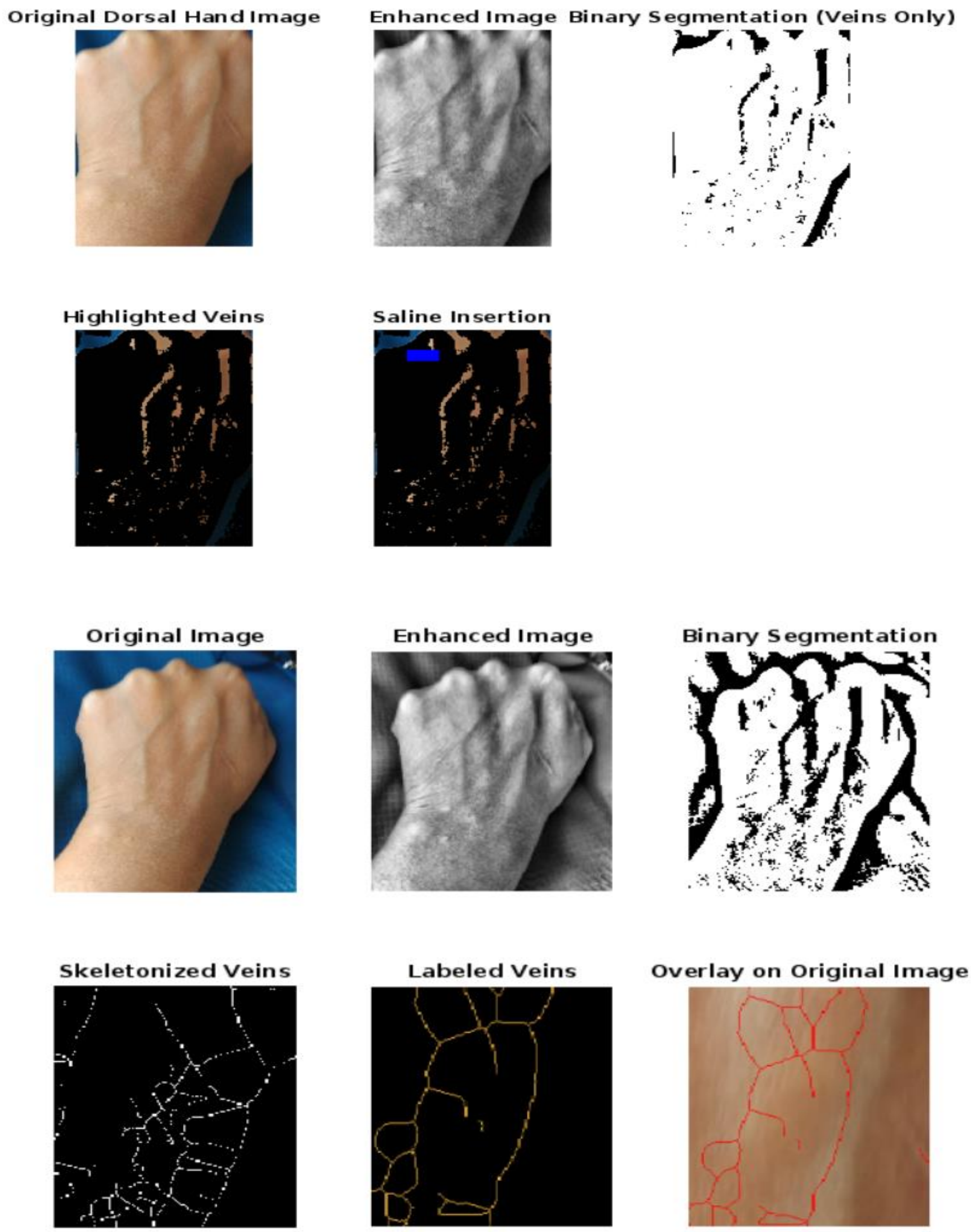


Figure 4.5: Veins detected with dorsal hand as input

4.2 Advantages

★ Multi-Sensory Feedback System: The combination of LEDs, an LCD, and a buzzer ensures layered notifications for users, accommodating different environmental conditions.

- Fail-Safe Mechanism: The system identifies when the sensor is not in use or improperly connected, preventing false readings and ensuring reliability.
- Portable and Compact: Its small size and lightweight design make it suitable for mobile applications, such as field testing or emergency water quality assessments.
- Automation Potential: The system can be integrated into automated water purification or monitoring setups, triggering corrective actions based on contamination levels.
- Eco-Friendly Monitoring: By detecting contamination early, the system can help reduce wastage of water and promote sustainable usage.
- Versatility: The system can easily be modified to work with other liquid sensors, expanding its application to industries like agriculture, food processing, and healthcare.

4.3 Disadvantages

- Sensor Wear Over Time: Continuous use of the TDS sensor in contaminated or harsh liquids can reduce its lifespan and accuracy.
- Limited Context Awareness: The system cannot distinguish between safe and harmful contaminants beyond TDS levels, which might lead to false positives or negatives.
- Dependency on Liquid Contact: The system requires direct immersion in liquids, making it less suitable for non-contact testing scenarios.
- Not Suitable for High TDS Precision: While it detects general ranges, it may lack the precision needed for scientific or regulatory-grade TDS measurements.
- Maintenance Overhead: Regular calibration, cleaning of sensors, and replacement of components (like LEDs or buzzers) may increase maintenance efforts.
- Environmental Restrictions: The system's performance may degrade under extreme conditions, such as very high salinity, humidity, or temperature extremes.
- These points provide a distinct perspective, emphasizing aspects like eco-friendliness, automation potential, and sensor durability.

Chapter 5

CONCLUSION & FUTURE ENHANCEMENT

5.1 Conclusion

The TDS-based liquid detection system effectively identifies and classifies liquids into three states: dry (no liquid detected), water (non-saline or dilute solution), and contaminated saline. The system utilizes an ESP8266 microcontroller, a TDS sensor, LEDs, an LCD display, and a buzzer to provide real-time feedback through visual and auditory alerts. When the TDS sensor is not immersed, the system accurately detects the "dry" state, displaying "Dry" on the LCD and outputting "No valid input detected (sensor not connected or dry)" on the serial monitor. When the sensor is placed in water, the system identifies it as non-saline, displaying "Water" on the LCD, outputting "Liquid Detected: Not saline (Possible water or very dilute solution)" on the serial monitor, and activating the white LED with a low-tone buzzer. For contaminated saline, the system detects the unsafe liquid, displaying "Contaminated" on the LCD, outputting "Liquid Detected: Contaminated Saline" on the serial monitor, and activating the red LED with a high-tone buzzer. The system is cost-effective, portable, and easy to use, making it suitable for water quality monitoring, contamination detection, and environmental applications. However, the sensor's dependency on calibration and environmental factors, as well as its limited capability to detect specific contaminants, may require enhancements for more advanced applications. Despite these limitations, the project showcases the integration of hardware and software for efficient and user-friendly liquid quality assessment, offering a strong foundation for future developments in IoT-enabled monitoring systems.

5.2 Future Enhancement

- ✓ Integration with IoT: The system can be enhanced by integrating IoT functionality to enable remote monitoring and real-time data logging, making it suitable for large-scale and distributed applications.
- ✓ Multi-Parameter Detection: Additional sensors can be incorporated to measure parameters like pH, temperature, turbidity, and specific contaminants, providing a more comprehensive analysis of liquid quality.
- ✓ Advanced Calibration Mechanism: Implementing an automatic calibration system can improve accuracy and reduce the need for manual intervention.
- ✓ Battery-Powered Operation: Adding a rechargeable battery or solar-powered module can make the system portable and independent of a continuous power supply.
- ✓ Data Storage and Analysis: Incorporating an SD card module or cloud integration can allow long-term data storage for trend analysis and reporting.
- ✓ Improved Display and User Interface: Using a touchscreen or OLED display can enhance the user interface, providing better visualization of data and system status.
- ✓ Wireless Connectivity: Adding Bluetooth or Wi-Fi modules can enable the system to connect with mobile apps or other smart devices for easier control and monitoring.
- ✓ Robust Enclosure Design: A waterproof and dustproof enclosure can protect the components, making the system more durable and suitable for harsh environments.
- ✓ AI-Based Analysis: Integrating AI or machine learning algorithms can help predict contamination patterns or identify specific contaminants based on sensor data.
- ✓ Scalability for Industrial Use: The system can be scaled up for use in industries such as water treatment plants, food processing, and agriculture by connecting multiple sensors to monitor larger volumes of liquid.

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APPENDIX I

Real Time Data Analyzer (ESP8266)

Specifications

Microcontroller	ESP – 8266 32 – bit
NodeMCU Model	Clone LoLin
NodeMCU Size	58mm x 32mm
Carrier Board Size	n/a
Pin Spacing	1.1” (27.94mm)
Clock Speed	80 MHz
USB to Serial	CH340G
USB to Connector	Micro USB
Operating Voltage	3.3V
Input Voltage	4.5V – 10V
Flash Memory/SRAM	4 MB/ 64 KB
Digital I/O Pins	11
Analog In Pins	1
ADC Range	0 – 3.3V
UART/ SPI/ I2C	1/ 1/ 1
WIFI Built – In	802.11 b/ g/ n
Temperature Range	-40C – 125C

Table 1: Specifications of ESP8266

Power Pins: There are four power pins. **VIN** pin and three **3.3V** pins.

- **VIN** can be used to directly supply the NodeMCU/ESP8266 and its peripherals. Power delivered on **VIN** is regulated through the onboard regulator on the NodeMCU module – you can also supply 5V regulated to the **VIN** pin.
- **3.3V** pins are the output of the onboard voltage regulator and can be used to supply power to external components.

GND are the ground pins of NodeMCU/ESP8266.

I2C Pins are used to connect I2C sensors and peripherals. Both I2C Master and I2C Slave are supported. I2C interface functionality can be realized programmatically, and the clock frequency is 100 kHz at a maximum. It should be noted that I2C clock frequency should be higher than the slowest clock frequency of the slave device.

GPIO Pins: NodeMCU/ESP8266 has 17 GPIO pins which can be assigned to functions such as I2C, I2S, UART, PWM, IR Remote Control, LED Light and Button programmatically. Each digital enabled GPIO can be configured to internal pull-up or pull-down, or set to high impedance. When configured as an input, it can also be set to edge-trigger or level-trigger to generate CPU interrupts.

ADC Channel: The NodeMCU is embedded with a 10-bit precision SAR ADC. The two functions can be implemented using ADC. Testing power supply voltage of VDD3P3 pin and testing input voltage of TOUT pin. However, they cannot be implemented at the same time.

UART Pins: NodeMCU/ESP8266 has 2 UART interfaces (UART0 and UART1) which provide asynchronous communication (RS232 and RS485), and can communicate at up to 4.5 Mbps. UART0 (TXD0, RXD0, RST0 & CTS0 pins) can be used for communication. However, UART1 (TXD1 pin) features only data transmit signal so, it is usually used for printing log.

SPI Pins: NodeMCU/ESP8266 features two SPIs (SPI and HSPI) in slave and master modes. These SPIs also support the following general-purpose SPI features:

- 4 timing modes of the SPI format transfer
- Up to 80 MHz and the divided clocks of 80 MHz
- Up to 64-Byte FIFO

SDIO Pins: NodeMCU/ESP8266 features Secure Digital Input/Output Interface (SDIO) which is used to directly interface SD cards. 4-bit 25 MHz SDIO v1.1 and 4-bit 50 MHz SDIO v2.0 are supported.

PWM Pins: The board has 4 channels of Pulse Width Modulation (PWM). The PWM output can be implemented programmatically and used for driving digital motors and LEDs. PWM frequency range is adjustable from 1000 μs to 10000 μs (100 Hz and 1 kHz).

Control Pins: are used to control the NodeMCU/ESP8266. These pins include Chip Enable pin (EN), Reset pin (RST) and WAKE pin.

- **EN:** The ESP8266 chip is enabled when EN pin is pulled HIGH. When pulled LOW the chip works at minimum power.
- **RST:** RST pin is used to reset the ESP8266 chip.
- **WAKE:** Wake pin is used to wake the chip from deep-sleep.

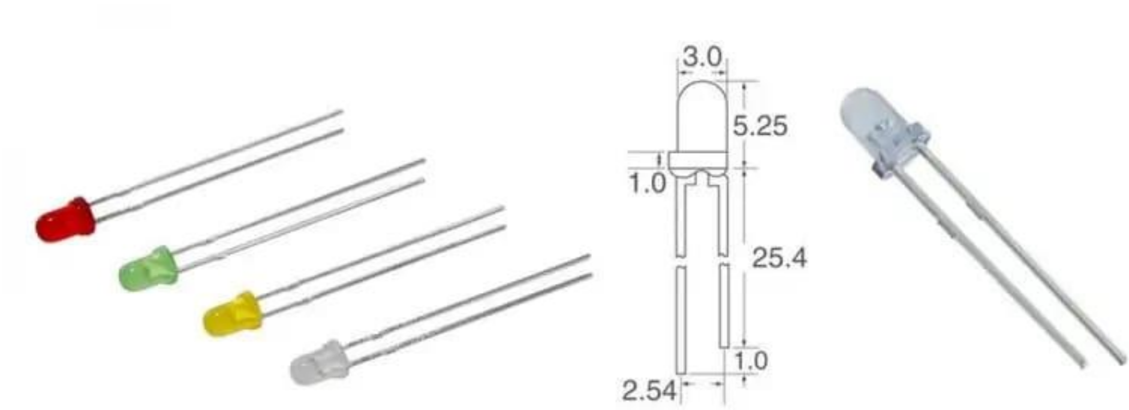
APPENDIX II

LED

Specifications

3mm LED Model	WC0283-01
LED Colour	Super Bright White
Intensity	6,000mcd
Colour Frequency	6000 – 6500
Viewing Angle	28^{o}
Lens	Water Clear

Table 2: Specifications of LED



Electrical Characteristics

Voltage	2.6V – 2.9V
Typical	2.8V
Current	18mA

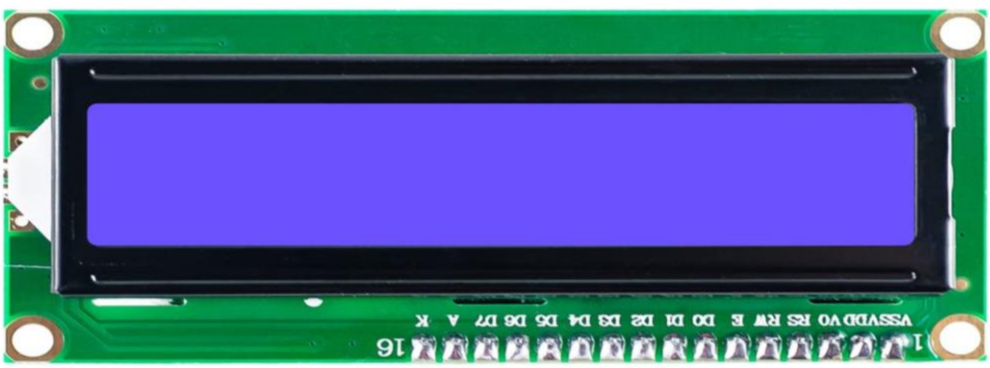
Table 3: Electrical Characteristics of LED

I2C LCD Display

Specifications

Number of Characters	16 characters x 2 Lines
Module Dimension	74.2 x 25.2 x 6.3 mm
View Area	61.0 x 15.1 mm
Active Area	56.2 x 11.5 mm
Dot Size	0.55 x 0.65 mm
Character Size	2.95 x 5.55 mm
Character Pitch	3.55 x 5.95 mm
Duty	1/16, 1/5 Bias
View Direction	6 o'clock
Blacklight Type	LED
IC	ST7032i
Interface	I2C

Table 4: General Specifications of I2C Display



Interface Pin Function

Pin No	Symbol	Description
1	VOUT	DC/DC voltage converter. Connect a capacitor between this terminal and VIN when the built-in booster is used.
2	CAP1N	For voltage booster circuit (VDD-VSS) External capacitor about 0.1u~4.7uf
3	CAP1P	For voltage booster circuit (VDD-VSS) External capacitor about 0.1u~4.7uf
4	VDD	Power supply (3.0/5.0V)
5	VSS	GND
6	SDA	In I2C interface DB7 (SDA) is input data. SDA and SCL must connect to I2C bus (I2C bus is to connect a resister between SDA/SCL and the power of I2C bus).
7	SCL	In I2C interface DB6 (SCL) is clock input. SDA and SCL must connect to I2C bus (I2C bus is to connect a resister between SDA/SCL and the power of I2C bus).
8	RST	RESET (Low active)

Table 5: Pin Configuration I2C LCD Display

Electrical Characteristics

Supply Voltage for Logic	VDD – VSS	3.3 – 5V
Supply Voltage for LCD	VLCD	4.5V
Input High Voltage	VIH	0.7 VDD – VDD V
Input Low Voltage	VIL	0 – 0.2 VDD V
Output High Voltage	VOH	0.8 VDD – VDD V
Output Low Voltage	VOL	0 – 0.2 VDD V

Table 6: Electrical characteristics of I2C LCD Display

Absolute Maximum Ratings

Item	Symbol	Min to Max
Operating Temperature	T_{OP}	-20 to +70 ℃
Storage Temperature	T_{ST}	-30 to +80 ℃
Input Voltage	V_{IN}	-0.3 to V_{DD} +0.3 V
Power Supply Voltage	$V_{DD} – V_{SS}$	-0.3 to +6.0 V
LCD Driver Voltage	V_{LCD}	7.0 V_{SS} to -0.3+V_{SS} V

Table 7: Absolute Maximum Ratings of I2C LCD Display

TDS Sensor

Specifications

Input Voltage	3.3 – 5.5 V
Output Voltage	0 – 2.3 V
Working Current	3 – 6 mA
Measurement Range	0 – 1000 ppm
Accuracy	$\pm$ 10% F.S at 25ºC
Module Size	42 x 32 mm
Module Interface	PH2.0 – 3P or XH2.54 – 3P
Electrode Interface	XH2.53 – 2P

Table 8: Specifications of TDS Sensor