VEIN DETECTOR

Course Name: PROTOTYPING & TESTING

Course Code: DS3001

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1. INTRODUCTION:

The automatic blood drawing and injecting machine is an innovative medical device designed to streamline blood sampling and injection processes. This project aims to develop a system that can accurately and safely detect the vein and then collect blood samples and administer injections, reducing the need for manual intervention by healthcare professionals.

Brief Working Principle:

Vein detection using ultrasound guidance identifies suitable veins for medical procedures. Once a vein is located, a robotic arm controlled by AI accurately inserts the needle into the vein. The system then performs either blood sampling or injection with precision. After the procedure, the needle is safely withdrawn, and the patient's arm is released, ensuring a smooth and automated process from start to finish.

2. MOTIVATION:

The idea of developing this automatic blood drawing machine is highly motivated to improve the accuracy and efficiency of the work and also the patient experience.

3. LITERATURE SURVEY:

Focus Area	Location	Key Findings	Collaborators
Reducing Human Error & Increasing Precision	Major Academic Hospital + IIT Delhi	Automated blood drawing with infrared and AI reduced missed veins and retries.	Academic hospital, IIT Delhi
Addressing Shortage of Skilled Workers	Rural Maharashtra	Mobile automated unit enabled accurate blood draws with minimal supervision.	Healthcare authorities, pilot teams
Enhancing Safety & Hygiene	Urban Clinics, Mumbai	Auto-disinfection and safe needle disposal reduced contamination and injuries.	Tech startups, urban healthcare providers

Identified Gaps:

• While pilot studies focused on the full system (blood draw + safety + sterilization), limited literature isolates the vein detection module for standalone evaluation or optimization.

• Vein detection performance across different skin tones, ages, and lighting conditions remains underreported.

• Existing prototypes are rarely tailored for low-cost implementation in mobile or rural settings, especially just for vein detection.

4. **SCOPE OF STUDY:**

Vein detection is a crucial aspect of various medical procedures, including blood sampling, injection, and catheterization. Accurate vein detection is essential to reduce the risk of complications, such as nerve damage, bleeding, and infection. Traditional methods of vein detection rely on visual inspection, which can be challenging, especially in patients with dark skin or obesity. Automated vein detection systems have been developed to improve the accuracy and efficiency of vein detection. These systems use near-infrared (NIR) imaging or ultrasound imaging to capture images of veins beneath the skin. Machine learning algorithms are then used to analyze these images and detect vein patterns.

5. **METHODOLOGY:**

The market standards highlight the use of Raspberry Pi 4B for most affordable systems, while high-end models rely on laptops. The depth of penetration ranges from 1.5 mm to 3 mm, with the 940 nm wavelength being the most commonly used. This reflects a balance between image clarity, portability, and cost efficiency across different vein detection technologies.

6. **DELIVARABLES:**

The following are the list of material required to build the circuit for this project.

Raspberry Pi 4 B
RPi NoIR Camera V2 (8MP)
940nm IR LED
940nm IR Photodiode (prefiltered)
5V 2A Power Supply
MicroSD Card.

The system utilizes a Raspberry Pi 4 B to run image processing algorithms, which detect veins using infrared light. The RPi NoIR Camera V2 captures high-resolution images, while the 940nm IR LED and photodiode highlight veins by detecting haemoglobin absorption. A stable power supply and MicroSD card storage support the system's operation.

7. **SIMULATIONS AND PROTOTYPING:**

- Simulation is done on TinkerCAD.
- Since the actual components to make the circuit are not available completely on software for simulation, we used different components in the simulator that does the same work as the components we require.
- How It Maps to Real Components:

Simulation Component	Actual Component
Arduino Uno (Tinkercad)	Raspberry Pi Zero W (Real)
LDR Sensor (Tinkercad)	940nm IR Photodiode
IR LED (Regular LED in simulation)	940nm IR LED
Detection LED	Indicator LED or Camera System

In reality, the Raspberry Pi Zero W will replace the Arduino Uno, but the wiring logic remains the same.

- Connections in Tinkercad:

Components	Aurdino Uno Pin	Connection Details
LDR -One side	5V	Provides power
LDR -Other side	A0 + 10kΩ resistor to GND	Reads light intensity
10kΩ Resistor	Between LDR & GND	Pull-down resistor
IR LED (Simulated Emitter)	Pin 9	Anode (+)
330Ω Resistor (IR LED)	Between LED Cathode (-) and GND	Limits current
Detection LED	Pin 8	Anode (+)
330Ω Resistor (Detection LED)	Between LED Cathode (-) and GND	Limits current

- Wiring Guide (Using Raspberry Pi 4B):

Component	**Raspberry Pi Zero W Pin**	**Connection Details**
940nm IR LED (Emitter)	GPIO16	Anode (+)
330Ω Resistor (IR LED)	Between LED Cathode (-) and GND	Limits current
940nm IR Photodiode (Detector)	One leg to 3.3V, other to ADC with 10kΩ to GND	Analog signal
10kΩ Resistor	Between Photodiode Output & GND	Pull-down resistor
Detection LED (Indicator)	GPIO15	Turns on when veins detected
5V Power Supply (MT3608 Boost)	VCC & GND	Powers RPi Zero W

- Sample Simulation:

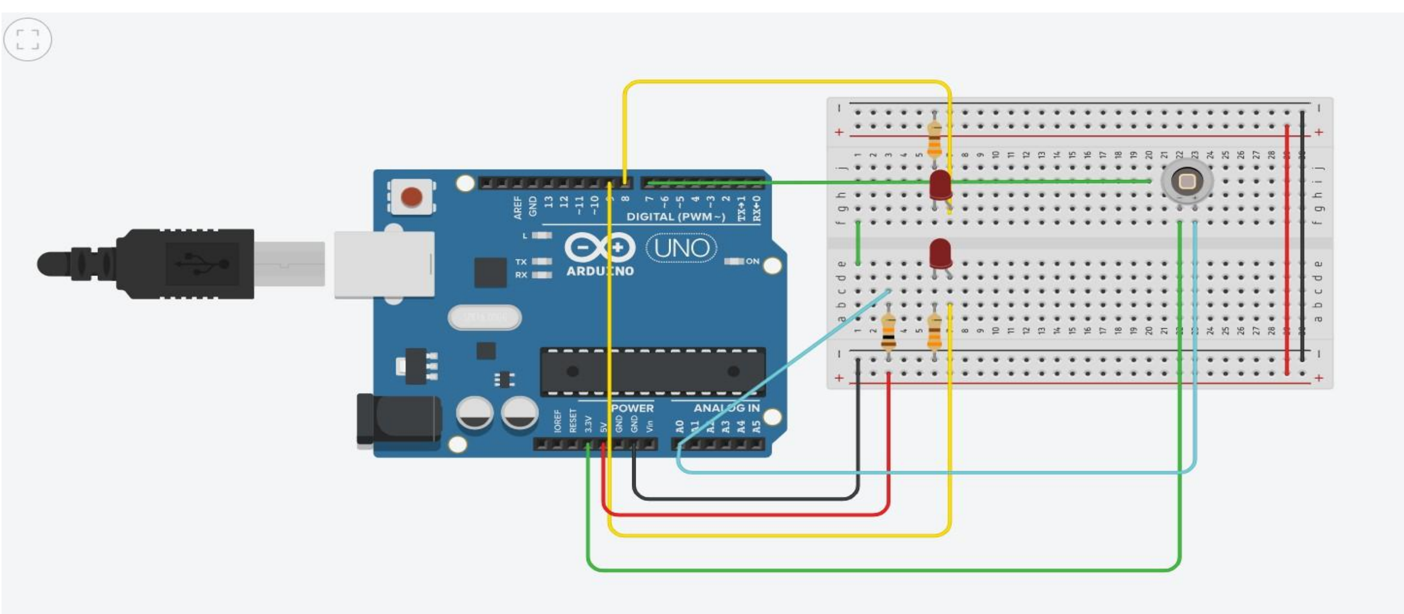

Fig: Circuit simulation

- Final Prototype:

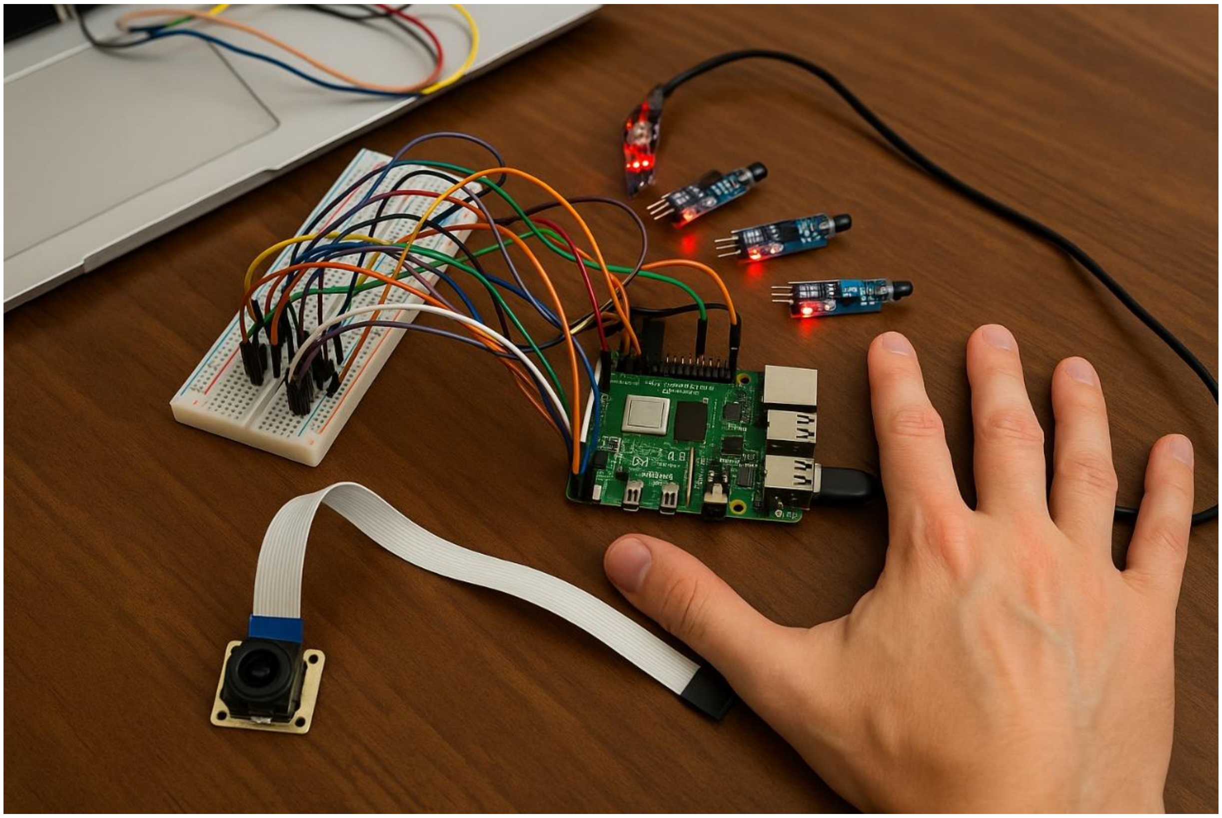

Fig: Final Circuit

- Code Used For Raspberry Pi 4B:

```
import cv2
from picamera2 import Picamera2
import numpy as np

def enhance_veins_only(frame, mode='bw'):
    gray = cv2.cvtColor(frame, cv2.COLOR_RGB2GRAY)
    median = cv2.medianBlur(gray, 5)
    blur = cv2.GaussianBlur(median, (21, 21), 0)
    highpass = cv2.subtract(median, blur)
    clahe = cv2.createCLAHE(clipLimit=3.0, tileGridSize=(8, 8))
    enhanced = clahe.apply(highpass)
    normalized = cv2.normalize(enhanced, None, 0, 255, cv2.NORM_MINMAX)

    if mode == 'bw':
        return normalized
```

```
    elif mode == 'heatmap':
        heatmap = cv2.applyColorMap(normalized, cv2.COLORMAP_JET)
        return heatmap
    else:
        return normalized

picam2 = Picamera2()
picam2.preview_configuration.main.size = (640, 480)
picam2.preview_configuration.main.format = "RGB888"
picam2.configure("preview")
picam2.start()

cv2.namedWindow("Vein Detection", cv2.WINDOW_NORMAL)
print("Press 'q' to quit | 'h' for heatmap | 'b' for black & white")

mode = 'bw'

while True:
    frame = picam2.capture_array()
    output = enhance_veins_only(frame, mode=mode)
    cv2.imshow("Vein Detection", output)

    key = cv2.waitKey(1) & 0xFF
    if key == ord('q'):
        break
    elif key == ord('h'):
        mode = 'heatmap'
    elif key == ord('b'):
        mode = 'bw'

cv2.destroyAllWindows()
picam2.close()
```

8. OBSERVATIONS & RESULTS:

The side-by-side comparison demonstrates the effectiveness of our vein detection system in accurately identifying veins that are not visible to the naked eye. Using infrared imaging, the prototype successfully highlights the vein structure, validating its potential for enhancing precision in medical procedures such as blood drawing.

9. FUTURE PLAN:

"PORTABLE & AFFORDABLE VEIN DETECTOR"

As we advance our automated vein detection system, our next steps involve integrating a Raspberry Pi-controlled setup comprising IR LEDs and photodiodes with the Raspberry Pi NoIR Camera V2 to capture high-quality infrared images of veins. This imaging data will be processed in real time to accurately detect vein locations under the skin. One of our key enhancements includes projecting the detected vein map directly onto the patient's skin using a compact projection module. This feature aims to guide medical professionals for more precise and confident needle insertion.

To ensure the system remains practical in clinical and field environments, we plan to optimize power efficiency by refining the MT3608 boost converter and Li-ion battery integration. This will extend battery life and support portable use in resource-limited settings.

Additionally, we are developing an intuitive, user-friendly interface that allows medical staff to easily operate the system and interpret the projected vein patterns without requiring technical expertise.

Ultimately, our goal is to build a cost-effective, portable, and efficient prototype that enhances the accuracy of vein detection and improves the overall experience for both healthcare providers and patients.

8. REFERENCES:

- https://www.medicaldevice-network.com/news/vitestro-autonomous-devicebloodcollection/?cfview
- https://www.researchgate.net/publication/382763497_A_Noninvasive_Vein_Finder_Based_on_a_Tuned_Microwave_Loop_Resonator
- https://www.frontiersin.org/journals/medicine/articles/10.3389/fmed.2023.1251963/full