# Comparative Analysis of Vein Detection Techniques

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***Abstract*—Currently in biomedical field a lots of techniques are available for vein detection. Various projects are also going on vein detection. Various image processing software are also being used by researchers. Vein puncture is commonly performed every day in hospitals. Both doctors & nurses facing difficulties in accessing veins in critical situations for giving drug through injections. Also during conflicts like war & catastrophe has shortage of experienced nurses & doctors. This paper viewed different approaches for vein detection using different technique. In this paper the vein image, working method along with block diagram, advantage, software used, results & further improvements for the techniques are compared.**

***Keywords— Vein detection, image processing, injection.***

## I. INTRODUCTION

Getting proper location of veins is very important for both patients & doctors. For many medical processes doctor requires to give intravenous injection for patient recovery. In case if injection is not placed in proper position of vein then a patient will suffer from lots of pain. If the patient is child then it will become very difficult for doctor to manage. For fatty, low blood pressure, dehydrated, trauma, sicked (due to vomiting) & for child patients both doctors & nurses facing difficulties for detecting the vein for delivery of drug through the vein. Distress, anxiousness, pain can be caused by more vein puncture.

Following are some cases where vein detection is required.

- Chemotherapy:

Chemotherapy is the use of anticancer drugs designed to slow or stop the growth of rapidly dividing cancer cells in the body. Cancer patients are usually stuck with needles many times. Since chemotherapy can cause veins to collapse, it can become very difficult for nurses to find veins.

- Dehydration:

Due to lack of water in body, the veins won't appear clearly. When you encounter a fever, you regularly experience the ill effects of expanded sweating which can prompt liquid and loss of electrolyte. You may likewise eat or drink less liquid because of feeling unwell. This blend of decreased liquid admission and sweating can prompt gentle lack of hydration. Other causes like vomiting, increased urination, Diarrhoea etc. also causes dehydration.

- For children:

Discovering veins in kids and new born babies may be troublesome and puncturing them regularly with a needle is to a great degree upsetting for the kid.

- Transferring blood:

In this either blood or its components are transferred from one person body into another person's body.

- Skin changes:

Darkening of the skin, burns and dry itchy skin, rashes makes difficult to access the veins.
And many other situations required vein detection [1].

The general block diagram for vein detection is a. s. Fig 1

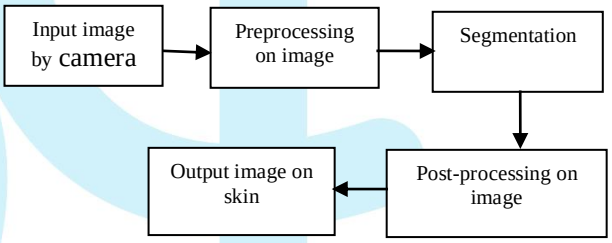



Fig. 1. The general block diagram for vein detection

First the vein image is acquired by Visual/IR/NIR camera. Each camera has its own characteristics. Still NIR camera is giving best performance [4]. Preprocessing is performed to remove noise & to improve the quality of input image acquired [3]. Processes like applying ROI, filtering are involved in this step. For separating vein part from its background segmentation is performed. Further post-processing is performed to get more improved image [3].

Several methods are used to detect the veins & using this detection a lots of applications are developed for various fields. This include security, biomedical, biometrics and computer vision. Using IR imaging for detection of veins, modified web camera & using matlab & labview for

processing of image by taking real time snapshots was performed to get portable & cost effective system [1]. To get real time low cost imaging ring of NIR led with driver circuit powered from laptop with CV software for processing vein detection was performed [2]. Using IR light source, CMOS camera & head mounted display vein image is observed to give intravenous injection [5]. Using various NIR led arrays for acquiring vein & feature extraction is performed [6]. Verification system for hand vein & statistical analysis was performed & also concluded that there is no similarity for left & right hand vein of same person [7]. Various biometric applications included web account using vein image as password [8]. Two methods of relative & fixed lengths of sides was considered for selecting region of index ROI for extraction of features for recognition using palm veins [9].

The rest of the part of this paper is organized as follows. Section II include various vein detection techniques. Section III include performance parameters for vein detection techniques. Section IV include software used for vein detection techniques. Section V include results and discussions. Section VI include conclusion.

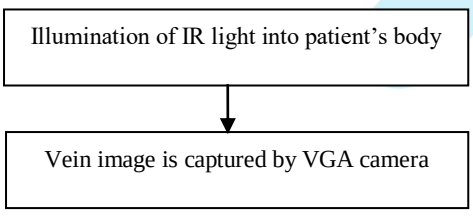
## II. VARIOUS VEIN DETECTION TECHNIQUES

Various techniques are praposed for detection of veins. In this paper we compared 3 techniques which are currently introduced by researchers. Every technique explained below has different approach. Technique can be chosen based on the requirements & application required.

### *A. Detection of vein using IR rays.*

The technique can be understood with help of flowchart given below in Fig. 2.

In this the system contains 48 Infra-red led in form of ring with video graphics camera. Using USB cable camera was interfaced with laptop. NIR led provides IR rays. The veins viewed more dark because blood vessel in veins absorbs IR light rays [5]. Some reflected IR light is converted into image by CMOS sensor. Then this image given for conversion from RGB into grayscale image [9]. Then histogram equalisation is performed to adjust or distribute the intensities of image equally [10], [11]. Then image enhancement is performed to display the veins clearly [10].Using median filter the noise can be removed [15], [16]. Next segmentation is performed to separate the veins from its background using adaptive threshloding [17], [18].



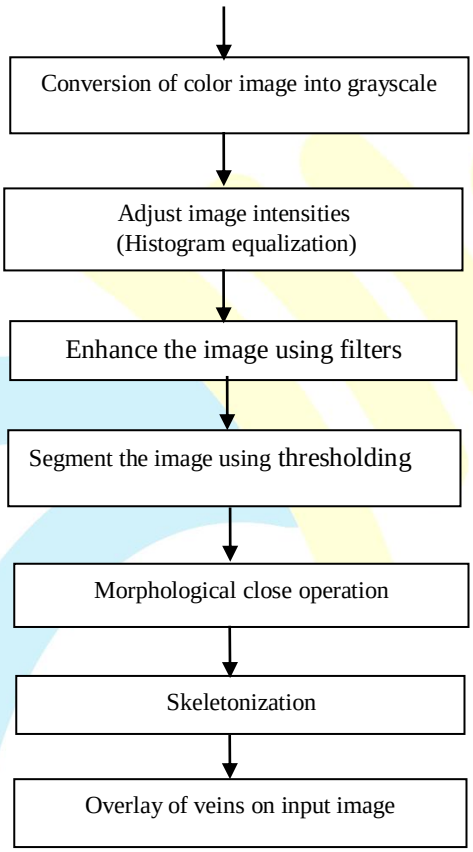




Fig. 2: Various steps involved in detection of veins using IR rays

Then morphological operation is performed to remove small dark objects from the background [18], [21]. Then skeletonization is used to reduce foreground regions in single binary image to skeletal portion. In final step the veins are overlayed on the input image.

### *B. Detection of vein using PHI*

PHI stands for pinhole imaging. Array of PHI electrode are used for vein detection. Electrodes are kept 1 cm apart.
Simulation: Comsol Multiphysics Software is used to build a simple model of human forearm.
Assumption:
Blood vessel (veins) has high conductivity than subcutaneous tissues.

Fig. 3 shows 4*4 Pigeon Hole Imaging (PHI) matrix using 4 electrode.

| | | | |
|---|---|---|---|
| $Z_{11}$ | $Z_{12}$ | $Z_{13}$ | $Z_{14}$ |

| | | | |
|---|---|---|---|
| $Z_{21}$ | $Z_{22}$ | $Z_{23}$ | $Z_{24}$ |
| $Z_{31}$ | $Z_{32}$ | $Z_{33}$ | $Z_{34}$ |
| $Z_{41}$ | $Z_{42}$ | $Z_{43}$ | $Z_{44}$ |

Fig. 3: 4*4 PHI matrix using 4 electrodes [22]

They used cylindrical electrodes for injection of current & measuring the voltage. (For measuring impedance)

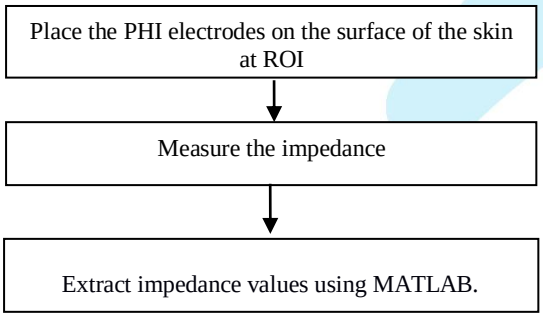
For impedance measurement the interface of current in AC/DC module is considered.

For every pixel of PHI matrix impedance was measured. Table 1 shows major parts considered for human forearm.

Table 1: Six major parts & its model consideration

| Sr. No. | Major Part | Modeled as |
|---|---|---|
| 1 | Skin | Elliptical cylinder |
| 2 | Muscle | Elliptical cylinder |
| 3 | Nerve | Cylinder |
| 4 | subcutaneous fatty layer | Elliptical cylinder |
| 5 | Veins (blood vessel) | Cylinder |
| 6 | Radius | Cylinder |

The technique can be understood with help of flowchart given below in Fig. 4



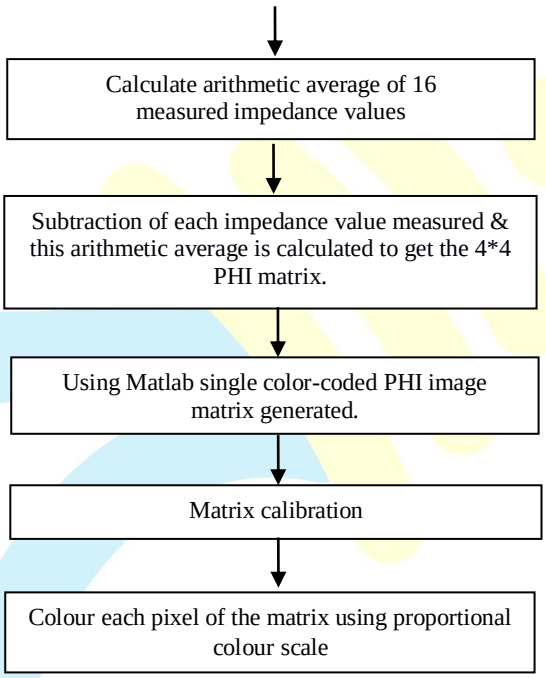




Fig. 4: Various steps involved in detection of veins using PHI

Due to assumption the impedance of blood vein measured is less than surrounding tissues. They placed the PHI electrodes on the surface of the skin at ROI & measured the impedance. These impedance measured values were extracted using matlab.

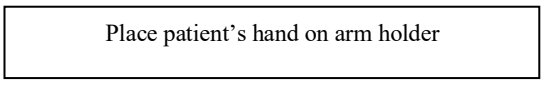
Then they calculated arithmetic average of 16 measured impedance values. Then subtraction of each impedance value measured & this arithmetic average is calculated to get the 4*4 PHI matrix.

Using matlab single color-coded PHI image matrix representing the conductivity distribution was generated. This matrix used to obtain different images corresponding to different shapes. This had 3 dimensional depth sensitivity.

Further matrix calibrated for detection of negative values & positive values were replaced by maximum negative value magnitude. They coloured each pixel of the matrix using proportional colour scale. They used blue for lower impedance & dark red for higher impedance.

*C. Detection of vein using AID*

AID stands for Automatic Injection Device. In this technique after detecting the veins, the device is capable of giving injecting medicine automatically.
The technique can be understood with help of flowchart given below in Fig. 5



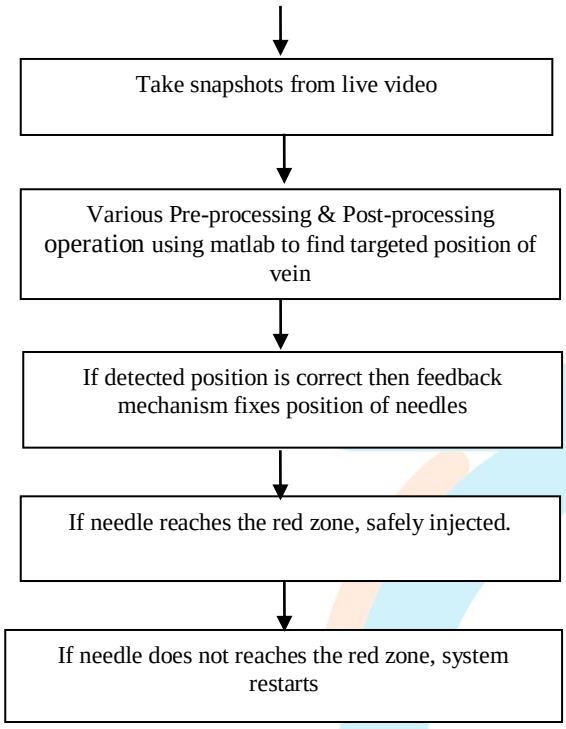



Fig. 5: Various steps involved in detection of veins using AID

In this technique the IR camera attached to injection unit. Snapshots are taken from live video. For finding targeted vein position & giving injection to that target, snapshot or frame is processed. If vein position are identical for successive frames then vein position is correctly detected. Then feedback is considered for fixing needle at the right pixel position. Camera is set such that the position of pixel for needle is not depend on movement of injecting device. The proposed algorithm is aimed to match the aligning the tip of needle & targeted vein position for giving injection.

## III. Performance Parameters

Detection of vein using IR rays:

Contrast
It is important parameter for evaluation of image quality.
Contrast is the difference of colour & brightness of one object with other object.
Contrast enhancement is useful for perceiving various features of images easily.
In this technique simple histogram equalisation (HE) technique is applied to enhance the contrast [19], [20].

Detection of vein using PHI:

Impedance
It is ratio of voltage to current.
$Z_1=V_1/I_1$

It is measured 2 times. First on electrodes1 & 2 the current is injected which is $I_1$=I & voltage $V_1$ on electrodes 3 & 4 is measured. Now shifting the arrangement by $90^0$ so $I_2$=I is injected on electrodes 2 & 3 & voltage $V_2$ on electrode 1 & 4 is measured.
This impedance values are used for obtaining PHI matrix.

Detection of vein using AID:

Inclination angle
The path & site is called inclination angle which describes injection perfectly.
For subcutaneous injection normally $45^0$ inclination angle for longer needle & $90^0$ inclination angle for shorter needle is considered.

Contrast
It is important parameter for evaluation of image quality. Contrast is the difference of colour & brightness of one object with other object.
Contrast enhancement is useful for perceiving various features of images easily.
In this technique simple histogram equalisation (HE) technique is applied to enhance the contrast [19], [20].

Speed of injection:
Speed of both needle penetrating at specific depth at required position & plunger speed for forcing the fluid to desired position.
It is necessary for safe injection.
The Yong's modulus which is measure of ability of the material remain unaffected to changes in length when under the tension & toughness of the skin are responsible for force.

## IV. Software Used

Table 2 shows software used for the techniques.

Matlab: Used for processing on data, plotting of functions and data, implementing the algorithms.

Open CV: It stands for Open Source Computer Vision Library. Incorporates image processing into a wide variety of coding languages. It has C, C++ and Python interfacing running on Linux, Android, Mac, and Windows.

COMSOL Multiphysics:
It is environment for modeling and simulating scientific and engineering the problems.

Table 2: Software used for the techniques

| Technique Name | Software Used |
|---|---|
| Detection of vein using IR rays | Open CV |

| | |
|---|---|
| Detection of vein using PHI | Matlab, COMSOL Mutiphysics |
| Detection of vein using AID | Matlab |

## V. Results & Discussion

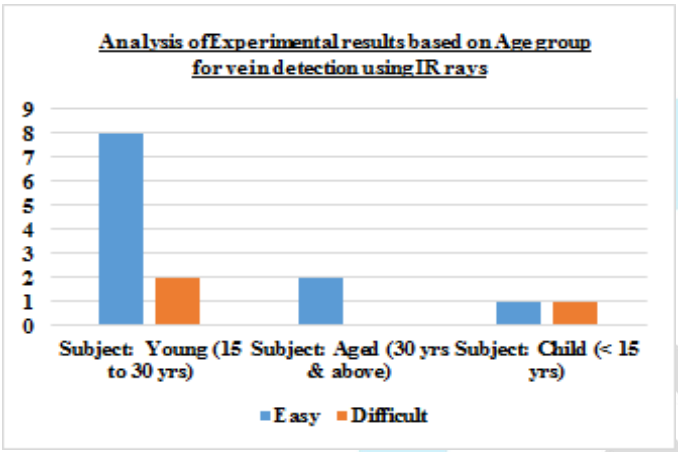


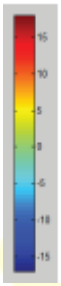

Fig. 6: Analysis of experimental results for vein detection using IR rays (Data [22])

From Fig. 6, Totally 14 patients are considered.
For 15 to 30 age group detection is very easy than aged & child group.
No difficulties faced for group 30 & above age group using technique 1.
Again for child difficulty is faced.

For detection of vein using AID only simulation study is performed. It is implemented for simplified model for forearm. Evaluation need more understanding of the technique & improvements. Still not used on patient's vein images [23]. Only aligning of veins with needle is performed. This was calculated using corrected vein position & detected vein position by subtraction.

For vein detection using PHI they Coloured each pixel of the matrix using proportional colour scale for simplified model of the forearm. This technique performed simulation only using 0.1A current. Practically safe value should be used. This technique is not applied on patients.

Fig 7. Shows color scale to generate the PHI matrix.



| |
|---|
| Red for higher impedance |
| Blue for lower impedance |

Fig. 7: Colour scale used for forming PHI colour coded matrix.

They used blue for lower impedance & dark red for higher impedance.

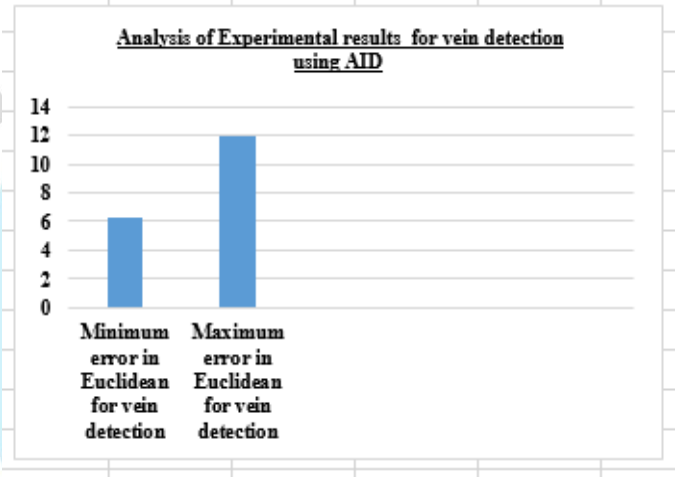



Fig. 8: Analysis of experimental results for vein detection using AID (Data [24])

From Fig. 8, minimum error between detected vein position & correct vein position is 6.25.
Maximum error between detected vein position & correct vein position is 11.89.

Table 3 & Table 4 shows the comparison of vein detection techniques.

Table 3: Comparison of vein detection techniques

| Technique | Input | Injection | Performance parameters |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Detection of vein using IR rays | Vein Image: Forearm | Manual Injection | Contrast |
| Detection of vein using PHI | Vein Image of forearm is converted into impedance values from electrodes | Manual Injection | Impedance |
| Detection of vein using AID | Vein Image: Forearm | Automatic Injection | Inclination angle & Speed of injection |

Table 4: Comparison of vein detection techniques

| **Technique** | **Advantage** | **Remark on trials** | **Further Development** |
|---|---|---|---|
| Detection of vein using IR rays | > Not destroying healthy tissue >Portable >Inexpensive | Tried on patients | IR imaging part required more focusing |
| Detection of vein using PHI | >Not destroying healthy tissue >Portable >Inexpensive | Not yet | Trade-off between resolution & loss of depth sensitivity |
| Detection of vein using AID | >Not destroying healthy tissue >Portable >Cost effective | >Only vein detection is tried >Automatic injection is not tried. | System can be designed by considering various inclination angle |

## VI. RESEARCH ISSUES

Databases should be easily available with free of cost.
Soft computing techniques can be tried out for vein detection.

## VI. CONCLUSION

In this paper we compared the current techniques available for vein detection for the intravenous injection. We represented the vein detection requirements & the current state of art techniques. We also compared input type, type of injection, performance parameters, advantages, remark on trials & further development needed for the better performance of techniques.

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