Research Protocol

Low Cost Near Infrared Spectroscopy

1. Introduction

1.1. Summery

In this project I discuss the outcomes of the low cost near IR spectroscopy and how it accuracy with image processing. In my proposed project I used Near IR LED lights with small screen for detecting and capturing purposes. It highly effect for the cost as well as the accuracy. Most researchers mention as in their own devices function with vibration spectroscopy or the proceed with projection technology. But here I used a method as a image guided technology and for detecting and capturing I used a CMOS camera and Infrared LED lights. In my proposed project I use OpenCV as my algorithm and when the device detects an image algorithm will smooth it and show in the screen with a picture. The image has been preprocessed after being captured. We must create an algorithm to depict the vein patterns in the output, and we must refine the algorithm to provide a more accurate and understandable vein map. The device we are creating includes a near-infrared light source, camera module, a display, and screen a single board computer. Using the data from clinical trials, we'll carry on the investigation and pinpoint peripheral vascular disorders (PVD) in the future.

1.2. Research Problem

Mainly we focus on the vein detecting with the near IR spectroscopy. Nowadays there are so many machines for the vein detecting but those are highly cost and in the current situation of the country it is heavy for the users. So for the users as well as for the student who are involving with the relevant fields, we hope to inventing low cost infrared spectroscopy. Using the low cost near infrared spectroscopy easily identifying the veins and capturing the veins in human body. Worldwide there are millions of blood test for a day and they analysis the diagnostic. Using the near infrared spectroscopy they can find veins very easily. Normally these thing are done by the laboratory and for that they want a machine. But some highly cost machines are unavailable in some laboratory. As well as in the battle field normally doctors are used cut down method to find the vein. for that the low cost near infrared spectroscopy is the best solution.because of it is portable and low cost device.

2. Literature Review

Infrared spectroscopy are mostly used in many fields and nowadays it takes highly cost. For the spectroscopy so many invents were found but all the invents are highly cost. on this project we are trying to find a low cost near IR Spectroscopy for the all users who needs to use the spectroscopy for the spectrum. Using the infrared LED light panel and the screen, try to detect and capturing the veins in the human body. For the Infrared spectroscopy there are so many research also done by many researches. This portion of the essay includes the many studies that numerous researches conducted to address the aforementioned issue. They have used so many methods and the devices for the relevant fields. The technique they employed and the criteria they utilized to establish the detecting and capturing methods are described individually in this section. Due to the fast development of microorganisms, there is a rising need for a unique, efficient, and precise approach to testing blood samples and distinguishing diseased from healthy ones.

Fourier Transform Infrared (FTIR) spectroscopy can reveal information about the biochemical makeup and ow a pathological disease develops. With the promise of giving biomedical professionals easier, faster, and more objective diagnoses, FTIR spectroscopy has progressed quickly during the past few decades. However, there have only been a few articles to date that have discussed the use of FTIR spectroscopy in this field. This project explains the fundamental FTIR concepts, as well as the most current developments in FTIR spectroscopy technology, lab-on-a-chip integration, and biological field applications. In this work, the possibility of using FTIR to discriminate between ill and healthy samples is investigated, with applications to routine blood analysis, early cancer detection, and HIV detection. The research also considers how FTIR technology may be applied in a lab-on-achip arrangement and further refined for tiny, portable medical devices that might be used for point-of-care monitoring. The authors are aware of no published study that has looked at these topics. The findings of this analysis will so close this knowledge gap. Even though FTIR is still expanding continuously in the field of biology, there are increasingly more studies that are focused on topics inside the FTIR framework. Future advancements in FTIR may have a significant impact on the medical sector's finances as well as other sectors (such as hospital architecture and lab technician procedures). FTIR has proven to be a rapid, simple, inexpensive, practical, and accurate method with high-quality results and minimal environmental impact. It may also bypass much of the already in-use equipment and the majority of the chemicals required to do blood tests.[1]

Phlebotomy and venous cannulation are the two most often and distressing invasive procedures performed on young patients. The purpose of this pilot research was to assess the potential use of a novel vein imaging technique in reducing the requirement for skin punctures by detecting superficial veins. 50 children under the age of 16 who often required peripheral venous catheterization or venous blood samples as a part of their clinical treatment participated in a study of the Vein Viewer. The doctors and nurses doing the operations were given a questionnaire with 10 questions about their experience with utilizing this equipment. 50 youngsters under the age of 18 underwent 12 cannulations and 38 venipunctures over the course of a 9-month period (mean age 6.67 years). Eleven doctors, sixteen registrars, twenty senior house officers, and three nurses each answered 50 surveys. The imaging gadget was rated beneficial by 72% of respondents, 8% disagreed, and 20% were unclear. The use of near-infrared technology simplified venipuncture and venous cannulation in a pediatric population. Also required are controlled research on minorities' children and kids in certain age groups[2].

On the review of the research project they discuss about the cannulation using the infrared technology. They try to make a low cost near infrared device to guiding for cannulation. This device can used by the medical practitioners as well as students to develop their skills. In the device they developed a reflectance type vein finder (optical) using the three LED lights which having 960nm wavelength, infrared CMOS sensor camera, Infrared filters for given wavelength, and image processing software (Open source). After that real in- vitro human test in two ways. Arm as well as dorsal hand which 242 subjects. It also consider the skin tones, age and BMI. In this device it works with real time vein pattern recognition in the both sites. And it capable for do the test in different skin tones different ages and different BMIs. Because when the BMI change the distance goes to change. But using this device we can do the test successfully because of the LED that we are using. Device improved up to capturing the vein images with having a perfect view of the vein patterns. In this device 14 out of 242 were reported that non visible. The results showed a considerable improvement in vein visibility without the use of a tourniquet. The capabilities of the developed vein finder may be considered as a useful guiding aid for locating the vein for cannulation, providing venous access for a blood sample, therapy, and other medical needs at a very cheap cost when compared to commercially available vein finders. The developed vein finder may be used as a training tool by medical professionals and students alike.[3].

This review examines past and current research on the use of near-infrared (NIR) reflectance/transmittance spectroscopy (NIRS) for real-time assessment of solid wood density and moisture content. The majority of NIRS applications on solid wood have been focused on the use of multivariate statistics as exploratory tools for the prediction of physical, chemical, and mechanical parameters, including moisture content, density, stiffness, cellulose, and lignin content. However, only a small number of studies on the use of NIRS transmittance techniques on solid wood and the creation of optical models have been documented. NIRS technology has the potential to be used in the forest products industry as a rapid tool for online testing and monitoring of wood characteristics[4].

According to the research that I read they discuss about what are the general issues that can be occurred in an our project. Data processing as well as advanced chemometric techniques are take advantage about upgrade to infrared procedure. High performing computers and chemometric techniques are mingle with near and mid infrared spectroscopy to give a new platform for the analysis, imaging, quantitative, discriminant, identification and classification draw a diagram of molecular structure. IR required samples but weakened total reflectance and remote sensors are adapting to measure samples in their ways. The application of ATR-FT-IR for online real-time monitoring of an aspirin manufacturing process is demonstrated in the first paper in this issue. The in situ real-time analysis of salicylic acid and acetic anhydride was changed for the ATR-FT-IR method. Target transformation of the resulting components was performed after PCA analysis of the spectra and the relationship of absorbance versus time for the raw materials and products during the reaction process. We discuss how to recognize bruised fruit using shortwave infrared hyperspectral imaging in the fourth paper we chose. In this work, HSI spectral data in the 400–1100 nm range were used to inspect honey peaches for bruising defects. These data were made up of feature variables, RGB measurements, and HSI color space. To create a discrimination method appropriate for identifying and categorizing fruit bruising, these data were analyzed using principal component analysis, feature extraction, partial least squares qualitative discriminant analysis, and extreme learning machine discriminant modeling.[5].

With the development of research procedures, it is now possible to monitor biological changes and metabolic processes using a variety of spectroscopic techniques. Vibrational spectroscopy deserves special attention among the several spectroscopic methods now in use that are based on various interactions between

radiation and matter. The method is commonly used to gather structural data on biological systems for in situ and in vivo studies. Both experiments and the materials are unaffected, and neither are they harmed. The technique aids in locating tissues, and their constituent parts, and investigating their interactions. Analyses both quantitative and qualitative may be performed using vibrational spectroscopy. It needs minimal to no sample preparation or chemical alterations and may be used to explore materials in a variety of physical states. In addition to one another, the Raman and infrared spectroscopies are used. The interpretation of the IR and Raman bands is based on a comparison of the spectra of the study materials and the reference substance. The identification of band positions in observed spectra, the assignment of specific bands to related bonds and functional groups, and the observation of spectral parameter changes are frequently the foundations of spectrum analysis.[6]

3. Methodology

3.1.The Overall Methodology

Low-cost near-infrared (NIR) spectroscopy can also be used for vein detection, which involves detecting the location of veins in the body. The overall methodology for low-cost NIR spectroscopy for vein detection typically involves the following steps:

3.1.1. Instrumentation

In this Project I supposed to make a device using the Infrared LED panel with CMOS camera to detect the vein visualization and screen for the visualized and capturing the image. I plan to make a device to fully functioning and to capture the image. In this project my main task is design the device and develop device with capabilities of identifying veins and capturing it as well as capturing and showing it on the screen accurately. We have to design a portable device with low cost. generally whole process can be divided to the few sub components.

3.1.2. Patient preparation

The next step is to prepare the patient for the procedure. This may involve cleaning the skin surface, applying a warm compress to dilate the veins, and ensuring that the area being scanned is well-lit. and we have to make sure that the patient is under good light source because as the parameters

that I followed for the vein visualizing, that the lightning condition is directly effect for the detecting Because the skin tone is highly effect for that as well as the background lights can be effect for that.

3.1.3. Scanning

The NIR spectrometer is used to scan the area where the veins are located. The device emits near-infrared light, which penetrates the skin and is absorbed by the blood in the veins. The reflected light is then detected by the device, and the location of the veins is identified.

3.1.4. Analysis

Once the scan is complete, the data is analyzed to identify the location and size of the veins. This information can be used for medical procedures such as blood draws, intravenous (IV) catheter insertion, and other medical procedures that require access to veins.

As well as the wavelength should be consider for the device. Because we are propose to capturing the images using CMOS camera and use the infrared LED lights. So for that we have to think about the wavelength. We have to make visible contrast in order with the surface and the area that we want to visualized. From the hardware part I have to assemble it correctly and after that from the device which detect and capturing the images as well as fill it to microprocessor and it display the captured images on screen in real time. If it will be happened then we have to test it for the patients or the users who want to use it and take a feedback and after the feedback we have to plan the future works. Then we have to process with the image capturing. For that we use OpenCV python package with some machine learning applications. For this project I supposed to gathering the data from the consultants as well as the medical students. By asking questionary and taking the past data from the doctors. For the device requirement I need a small display and one side computer as well as the IR LED lights. In this project I use the OpenCV and CLAHE algorithms. For that I have to take some advices and guidelines from the those who are expert in hardware. Because of that I use the IR LED. In the IR LED there are many wavelengths.

3.2. The Experimental Methodology

The study participants may be asked to lie down in a comfortable position, and the area where the vein detection is required will be cleaned and prepared. The NIR imaging technology will be used to detect the veins, and the data will be recorded for analysis. The data collected may include the accuracy of the vein detection, the time taken for the detection, and the ease of use of the technology. The study may also involve the use of other equipment such as ultrasound machines or vein finders to compare the accuracy of the NIR imaging technology with other methods of vein detection. The participants may be asked to provide feedback on their experience with the technology, and any discomfort or issues they may have encountered during the study. The data collected will be analyzed using statistical software to determine the effectiveness of the technology in detecting veins accurately. The results of the study will be presented in a thesis and published in relevant conferences and journals for the benefit of the scientific community.

4. Ethics Consideration

4.1. Collaborative partnership

4.1.1. The study is to be conducted in a selected location in the Faculty of Computing, General Sir John Kotelawala Defence University where the principal investigator, supervisor are attached to.

4.1.2. Furthermore, as stated in 4.1.1, the principal investigator, supervisor, and the cosupervisor are affiliated to the Faculty of Computing, General Sir John Kotelawala Defence University, and therefore, have direct collaboration with the community where the study is to be conducted.

4.1.3. The research will provide benefits to the community as a whole since detecting vein patterns in human body is concerned as the ultimate aim of this research.

4.2. Social Value

4.2.1 This research has the potential to benefit multiple stakeholders, including emergency patients, healthcare professionals, medical researchers, and society as a whole. By providing a more accurate and reliable vein detecting tool, patients can receive better quality care, leading to improved health outcomes and an overall better quality of life. In addition, healthcare professionals can benefit from this research by having access to a more effective tool to use during medical procedures. This can help improve the accuracy and speed of procedures, leading to more efficient and effective care. Medical researchers can also benefit from this research by gaining a better understanding of the underlying mechanisms of the condition. This can help in the development of new treatments and therapies, ultimately leading to better health outcomes for patients. Furthermore, the positive impact of this research extends beyond the medical field, as it can also have an impact on society as a whole. By improving the productivity of healthcare professionals and reducing healthcare costs, this research can help to alleviate some of the burdens on the healthcare system, ultimately benefiting society as a whole.

4.2.2 The dissemination of study findings will be done as the Final Thesis of the BSc(Hons) in Computer Science degree program followed by the principal investigator. This thesis will provide a comprehensive overview of the study design, methodology, data analysis, and key findings. In addition, the research findings will be published in relevant academic conferences and journals. These publications will enable the broader scientific community to review and validate the findings of the study. By publishing the results in academic conferences and journals, the study's impact can be maximized, and the findings can reach a wider audience of researchers, healthcare professionals, and other stakeholders. Moreover, the research findings will also be disseminated to relevant healthcare organizations and regulatory bodies. This will ensure that the study's findings are used to improve patient care and inform the development of guidelines and policies for the use of vein detecting tools during medical procedures. Overall, the dissemination of study findings through various channels will ensure that the results of the research are widely available to relevant stakeholders, leading to potential

improvements in healthcare outcomes and practices.

4.3. Assessment of Risks/Benefits

4.3.1. Infrared LED (Light-Emitting Diode) light is a non-ionizing form of radiation and is generally considered safe for use in medical applications. However, like any medical procedure, there may be some risks associated with its use.The primary risk associated with the use of Infrared LED light in medical procedures is the potential for skin burns or tissue damage if the light is applied for too long or if it is too intense. Therefore, it is essential to follow established guidelines and procedures for the safe use of Infrared LED light during medical procedures. Healthcare professionals should be trained in the proper use of Infrared LED devices, including the appropriate power settings, duration of use, and the distance from the skin to avoid skin burns. Another potential risk associated with Infrared LED light is eye damage. Infrared light can damage the retina, causing eye damage or even blindness. Therefore, it is crucial to use proper eye protection during the use of Infrared LED light. Finally, there may be some potential risks associated with the use of Infrared LED light in certain patient populations, such as those with sensitive skin or skin conditions. In such cases, the healthcare professional should consider alternative methods for detecting veins or consult with a medical professional before using Infrared LED light. Overall, the risks associated with the use of Infrared LED light are generally low, and they can be mitigated by following established guidelines and procedures for the safe use of Infrared LED devices.

4.3.2. The study on Low Cost Near Infrared Spectroscopy has numerous potential benefits for research subjects. By participating in the study, research subjects can gain a better understanding of vein detecting and its potential impact on their health. This increased awareness of vein patterns and their importance can empower individuals to take proactive steps towards managing their health and seeking appropriate medical care. Furthermore, the study may provide access to screening and early detection of vein conditions that might otherwise go undetected. Early detection of vein conditions can lead to earlier treatment and intervention, resulting in improved health outcomes and a better quality of life for those affected. Additionally, research subjects can contribute to the advancement of medical knowledge by

participating in the study. By providing valuable data and feedback, research subjects can help medical researchers better understand the underlying mechanisms of vein detecting and develop new and innovative techniques for detecting veins. Moreover, participating in the study may help individuals identify if they are at high risk for developing vein conditions, allowing them to seek further evaluation and treatment as needed. This proactive approach to healthcare can lead to better health outcomes and a better quality of life for those affected. Overall, the study on Low Cost Near Infrared Spectroscopy has significant potential benefits for research subjects, including increased awareness of vein detecting, access to screening and early detection, improved health outcomes, and the opportunity to contribute to medical research.

4.3.3. To minimize risks associated with the use of IR LED and CMOS camera in the study on Low Cost Near Infrared Spectroscopy, several steps can be taken.

Firstly, the research team should ensure that the IR LED is operated within safe power limits to prevent potential harm to the research subjects. The IR LED should also be placed at a safe distance from the skin to avoid any potential burns or damage to the skin.

Secondly, the CMOS camera should be used in accordance with the manufacturer's guidelines to ensure safe operation. This may include adjusting the exposure time and gain settings of the camera to minimize the amount of light exposure to the research subjects.

Thirdly, all research subjects should be thoroughly screened before participating in the study to identify any potential contraindications or risks associated with the use of IR LED and CMOS camera. Research subjects should also be informed about the potential risks and provided with the necessary information to make an informed decision about their participation.

Finally, the research team should ensure that appropriate ethical and safety guidelines are followed throughout the study, including obtaining informed consent from research subjects and implementing appropriate measures to protect their privacy and confidentiality.

By taking these steps, the potential risks associated with the use of IR LED and CMOS camera in the study on Low Cost Near Infrared Spectroscopy can be minimized, ensuring the safety and wellbeing of research subjects.

4.3.4. To enhance the benefits of the study on Low Cost Near Infrared Spectroscopy, the research findings will be disseminated through various channels, including publication in conferences and journals. By sharing the research findings with a wider audience, healthcare professionals, medical researchers, and society as a whole can benefit from the insights gained from the study. Publication in conferences and journals allows for peer review and feedback from other researchers in the field, leading to a more comprehensive understanding of the findings and potential avenues for further research. Furthermore, sharing the research findings through these channels can increase awareness of the study and its potential benefits, leading to broader adoption of the techniques developed and improved health outcomes for those affected by vein conditions. Overall, disseminating the research findings through publication in conferences and journals can enhance the impact of the study and ensure that the benefits of the study are realized by a wider audience.

4.3.5. The support provided to research participants in the study on Low Cost Near Infrared Spectroscopy can be categorized into medical, psychological, and other forms of support. Medical support may include a thorough screening process before participation in the study to identify any potential contraindications or risks associated with the use of IR LED and CMOS camera. If any medical issues are identified, appropriate measures will be taken to ensure the safety and wellbeing of the research participants. For example, research participants who are identified as high-risk may be advised to seek further evaluation and treatment.

Psychological support may be provided to research participants to help address any concerns or anxieties they may have about participating in the study. For example, research participants may be provided with information about the study and the potential risks and benefits to help them make an informed decision about their participation. Additionally, research

participants may be offered counseling or other forms of support to help them cope with any stress or anxiety related to the study.

Other forms of support may include logistical support, such as transportation to and from the study site, as well as assistance with any other needs or concerns that may arise during the course of the study. For example, research participants may require assistance with scheduling appointments or managing their medications, and the research team may provide assistance with these tasks.

Overall, the support provided to research participants in the study on Low Cost Near Infrared Spectroscopy is designed to ensure their safety and wellbeing, as well as to help address any concerns or anxieties they may have about participating in the study. By providing comprehensive support, the research team can help to ensure that the study is conducted in an ethical and responsible manner, and that the potential benefits of the study are realized for all participants.

4.4. Consent

4.4.1. The initial contact with potential participants in the Low Cost Near Infrared Spectroscopy study will be conducted in person, and informed consent will be obtained from each participant before any study procedures are carried out. During this process, the research team will provide participants with information about the study, including its purpose, procedures, potential risks and benefits, and the rights and responsibilities of participants. Participants will be given the opportunity to ask questions and clarify any concerns they may have. The research team will also explain the participant's right to withdraw from the study at any time and how confidentiality will be protected. The goal of this process is to ensure that participants understand the study and can make an informed decision about their participation in a responsible and ethical manner.

4.4.2. In the Low Cost Near Infrared Spectroscopy study, informed consent will be obtained from each participant by having them sign a consent form agreeing to participate in the experimental study. The consent form will include information about the study's purpose, procedures, potential risks and benefits, the participant's rights and responsibilities, the confidentiality of

their information, and their ability to withdraw from the study at any time. The research team will provide participants with a copy of the consent form to keep for their records. By signing the consent form, the participant indicates that they have read and understood the information provided and that they voluntarily agree to participate in the study.

4.4.3. In the Low Cost Near Infrared Spectroscopy study, the research team will provide participants with information about the research orally, which includes details about the study's purpose, procedures, potential risks and benefits, and the rights and responsibilities of participants. Additionally, a hard copy of the informed consent form will be distributed to each participant to obtain their agreement to participate in the study. The consent form will include all the necessary information in writing, including details about confidentiality, the ability to withdraw from the study, and contact information for the research team. By providing information in both oral and written form, the research team can ensure that participants have a clear understanding of the study and can make an informed decision about their participation.

4.4.4. In addition to providing information about the study orally and in writing, the Low Cost Near Infrared Spectroscopy research team will encourage participants to ask any questions or express any concerns they may have about the study. The team will provide in-person counseling to each participant to ensure that they have a clear understanding of the study and are comfortable with their decision to participate. By offering personalized counseling and support, the research team can address any issues or conflicts that may arise and ensure that each participant's needs are being met. This approach can help build trust between the research team and the participants and promote a positive research experience for all involved.

4.4.5. In the Low Cost Near Infrared Spectroscopy study, participants have the right to withdraw their consent to participate in the study at any time. This means that if a participant begins to feel uncomfortable or experiences any negative side effects, they can choose to stop participating in the study without any penalty or consequence. The research team will make it clear to participants that they have this right and will provide instructions on how to withdraw consent if necessary. Additionally, the team will ensure that any

data collected from the participant up to the point of withdrawal will be handled in accordance with ethical and legal guidelines to protect the participant's privacy and confidentiality. By providing participants with the option to withdraw their consent at any time, the research team can prioritize the well-being and autonomy of the participants and promote a safe and ethical research experience.

4.4.6. There will be no incentives/rewards/compensation provided to the participants.

4.4.7. The procedure for re-consenting of the research is not applicable.

4.5. Confidentiality

4.5.1. In the Low Cost Near Infrared Spectroscopy study, data and samples will be obtained from the participants in a non-invasive manner using an infrared LED and a CMOS camera. The participants will be asked to place their arm on a platform, and the infrared LED will be shone on their skin to detect the vein patterns. The CMOS camera will capture images of the vein patterns, which will be analyzed to obtain data on the vein characteristics. The data obtained will include information on the vein size, depth, and pattern, as well as the hemoglobin concentration in the blood. These data will be stored securely on a password-protected computer system to ensure confidentiality and privacy. Additionally, blood samples may be collected from participants to obtain further information on their blood chemistry and biomarkers. Blood samples will be collected using sterile techniques by a trained medical professional. The samples will be stored in a secure laboratory and will be analyzed using standard laboratory procedures to obtain the necessary information. Throughout the data and sample collection process, the research team will prioritize the safety and comfort of the participants. The team will ensure that participants are fully informed about the procedures and that their privacy and confidentiality are protected at all times.

4.5.2. The length of time that data and samples will be kept will depend on the specific requirements of the study and any relevant regulations or guidelines. Typically, researchers are required to keep study data and samples

for a certain period of time after the study has ended, in order to ensure that the data is available for analysis and potential replication. In general, the length of time that data and samples will be kept should be clearly outlined in the study protocol and informed consent documents, and should take into account any applicable ethical considerations, as well as any regulations or guidelines from relevant regulatory bodies. It is important for researchers to ensure that they are following all relevant regulations and guidelines for data and sample retention, in order to protect the rights and privacy of research participants, as well as to ensure the accuracy and integrity of study data.

4.5.3. The collection of personal identification data is necessary for several reasons, including:

4.5.3.1Ensuring accuracy: Collecting personal identification data, such as name and date of birth, helps to ensure that the data collected from each participant is accurate and can be linked to the correct participant. This is especially important in studies that involve multiple data collection timepoints, as it helps to ensure that data is consistently and accurately linked to each participant.

4.5.3.2. Protecting participant confidentiality: In many cases, personal identification data is collected alongside study data in order to protect participant confidentiality. By using unique identifiers, such as participant ID numbers, instead of participant names or other identifying information, researchers can ensure that participant confidentiality is maintained while still being able to accurately link study data to each participant.

4.5.3.3. Meeting regulatory requirements: Depending on the nature of the study, certain regulatory bodies may require the collection of personal identification data in order to ensure that ethical and legal standards are met. For example, studies involving the use of controlled substances or medical interventions may be subject to additional regulations related to participant identification and data collection.

Overall, the collection of personal identification data is an important aspect of many research studies, and is often necessary in order to ensure accuracy, protect participant confidentiality, and meet regulatory requirements. It is

important for researchers to be transparent with participants about the reasons for collecting personal identification data, and to ensure that appropriate measures are in place to protect participant confidentiality throughout the study.

4.5.4. Access to personal data of research participants will be limited to the principal investigator and research team involved in the study. The data will be kept strictly confidential and will not be shared with any third party without explicit consent from the participant or as required by law. Any personal data collected will be stored securely with access restricted to authorized personnel only. Participants will be assigned a unique identifier code to maintain anonymity, and any identifiable information will be kept separately from research data. All data handling and storage procedures will be in compliance with relevant data protection regulations.

4.5.5. The confidentiality of research participants will be ensured by implementing various measures throughout the research process. These measures include:

4.5.5.1. Participant anonymity: Participants will be assigned a unique identifier code to maintain anonymity, and any identifiable information will be kept separately from research data.

4.5.5.2. Secure data storage: Any personal data collected will be stored securely with access restricted to authorized personnel only.

4.5.5.3. Limited access to data: Access to personal data of research participants will be limited to the principal investigator and research team involved in the study.

4.5.5.4. Data encryption: Any personal data collected will be encrypted to prevent unauthorized access.

4.5.5.5. Non-disclosure agreements: All researchers involved in the study will be required to sign non-disclosure agreements, ensuring that they do not disclose any personal data outside of the research team.

4.5.5.6. Data protection compliance: All data handling and storage procedures will be in compliance with relevant data protection regulations.

By implementing these measures, the confidentiality of research participants will be ensured throughout the research process.

4.5.6. The data and sample storage procedures will be in accordance with ethical and legal standards for human subject research. All data and samples collected will be stored in a secure and confidential manner. The data will be stored on a password-protected computer or server, and only authorized researchers will have access to the data. Samples will be stored in a secure and locked storage area, with limited access to authorized personnel only. Personal identification data will be stored separately from research data, and all data will be coded to maintain participant confidentiality. Any paper records will be kept in a locked and secure filing cabinet. The length of time that data and samples will be stored will be specified in the informed consent form. After this time period has elapsed, the data and samples will be securely destroyed. Any identifiable information will be deleted or de-identified before sharing or publishing research findings.

4.5.7. The disposal of data and samples will be carried out in a responsible manner in accordance with ethical guidelines and regulations. Any personal information collected during the study will be securely destroyed or deleted in a manner that ensures confidentiality. Samples will be disposed of in a manner that does not pose a risk to the environment or public health. The disposal procedure will be documented and carried out in accordance with relevant guidelines and regulations.

4.6. Rights of the participants

4.6.1. The research participants are entitled to withdraw from the study at any time, and they can do so by contacting the principal investigator.

4.6.2. Participants in the study are encouraged to ask any questions they may have directly to the principal investigators. Additionally, if participants have any complaints or concerns, they can bring them to the attention of the

principal investigator, as well as the supervisor and co-supervisor. This ensures that any issues or concerns are addressed promptly and appropriately.

4.6.3. The principal investigator is the designated contact person for research subjects, and they can be reached through the provided contact details such as phone number and email address. Participants are encouraged to contact the principal investigator for any questions or concerns related to the study.

4.6.4. The results of the study will be disseminated in the form of the principal investigator's thesis work and published works in journals and conferences. The participants of the study will have access to these publications and can gain a better understanding of the study's findings.

4.6.5. The research participants will have access to the published work resulting from the study through the conference proceedings and journal websites where the work will be published. They can download or obtain the published work by following the appropriate links and instructions provided by the conference or journal.

4.7. Fair participant selection

4.7.1. In the case of the Low Cost Near Infrared Spectroscopy study, the study population may be selected based on specific criteria, such as age, gender, and health status. For example, the study may focus on adults between the ages of 18 and 65 who are generally healthy and have no known vein conditions. The selection of the study population should be based on scientific reasoning, taking into account the research question and objectives, feasibility of the study, and ethical considerations. The sample size should also be large enough to provide sufficient statistical power and minimize the risk of biased results. Overall, the justification for the selection of the study population should be clearly stated in the research proposal, including the rationale for the inclusion and exclusion criteria, and how the selected population is expected to contribute to the research question and objectives.

4.7.2. The inclusion and exclusion criteria are guidelines used to determine the eligibility of participants for the study. In this study, the inclusion criteria are individuals who are willing to participate, aged 18 years or older, have no

history of any severe health conditions, and have visible veins in their arms. The exclusion criteria are individuals who have a history of blood clotting disorders, skin conditions or injuries in the arm, tattoos, or any other condition that may affect the accuracy of the study results. Additionally, individuals who are pregnant or breastfeeding are also excluded from the study. The criteria are put in place to ensure that the study is conducted on a homogeneous population and to minimize the impact of confounding factors on the study results.

4.8. Responsibilities of the researcher

4.8.1. The provision of medical services to research participants refers to the medical care that may be required by the participants during the course of the study. In some cases, participants may experience adverse effects or complications related to their participation in the study, which may require medical attention.To ensure the safety and well-being of the participants, the study should have a plan in place for providing medical services to research participants. This may include providing access to medical professionals or facilities that can provide appropriate care in the event of an adverse event or complication. The provision of medical services should be outlined in the study protocol, which should specify the type of medical services that will be provided, the criteria for determining when medical services are necessary, and the process for accessing these services. In addition, the study team should ensure that participants are aware of the availability of medical services and the process for accessing them. This information should be included in the informed consent process, and participants should be provided with contact information for medical professionals or facilities that can provide care if needed. Overall, the provision of medical services is an important aspect of ensuring the safety and well-being of research participants and should be carefully considered in the design and implementation of any study.

4.8.2. Continuation of care after the research is completed will be provided to the participants if any health issues are identified during the research study. In such cases, the participants will be referred to appropriate medical professionals for further care and treatment. The principal investigator will ensure that the participants are provided with necessary information and

guidance for obtaining continued care, if required. Additionally, the participants will also be provided with a summary of the research findings upon completion of the study.

4.8.3. The investigators declare that there are no conflicts of interests and, as a result, there is no plan to manage any conflicts.

4.8.4. As the study is not applicable to ethical, legal, social, or financial issues, there is no need for prevention measures. However, in general, to prevent or minimize potential issues, researchers can follow ethical principles and guidelines, obtain appropriate approvals and informed consent, ensure confidentiality of participants, provide necessary support and care, and adhere to relevant laws and regulations. They can also establish clear protocols for data and sample storage, disposal, and sharing, and ensure that any conflicts of interest are disclosed and managed appropriately. Additionally, researchers can engage with stakeholders, including participants, communities, and relevant organizations, to address any concerns and ensure that the study is conducted in a transparent and responsible manner.

4.9. Vulnerable populations

4.9.1. The experiment will be conducted on healthy individuals of diverse age groups ranging from 20-60 years to ensure a comprehensive understanding of the impact of the IR LED and CMOS camera on different age groups. Furthermore, the study will involve participants of different skin tones and gender to eliminate any biases that may arise due to demographic differences. This selection criteria will enhance the generalizability of the study findings to the broader population.

4.10. Community based research

4.10.1. he research has potential impact and relevance on the community in which it is to be carried out in several ways. Firstly, it may contribute to the improvement of healthcare by identifying more accurate and efficient methods for measuring blood oxygen levels. This could lead to the development of new medical devices or improvements in existing devices,

which could benefit not only the study participants but also individuals in the broader community who require medical monitoring. Secondly, the research may generate new knowledge and insights into the relationship between skin tone, gender, and accuracy of blood oxygen measurement, which could have implications for medical treatment and monitoring in diverse patient populations. Thirdly, the study may raise awareness and interest in the importance of research and technology in healthcare, which could potentially inspire members of the community to pursue careers or education in these fields. Overall, the research has the potential to contribute to improved healthcare outcomes and increased awareness and interest in research and technology, which could benefit the community in numerous ways.

4.10.2. The design of the research will be done by a team consisting of the principal investigator, the supervisor, and a medical supervisor.

4.10.3. Since the procedure used in this study does not involve direct or indirect interaction with the community, the procedure for obtaining community consent is not applicable. However, the study will adhere to ethical guidelines and standards to ensure that the rights of all participants are protected, and the research is conducted with integrity and transparency.

4.10.4. The community will benefit from the research findings related to detecting veins accurately, which will improve patient safety. This information will be disseminated through published papers and conference presentations. The study will also provide training and capacity building to the research team and medical personnel involved in the study. Participants will be informed about the benefits of the study, including the potential to improve medical procedures and patient safety. The informed consent process will ensure that participants understand the study and its potential benefits, as well as any risks or discomforts involved.

4.10.5. The community will have access to the results of the research through the Thesis work of the principal investigator and published work in relevant conferences/journals. This will ensure that the findings of the study are disseminated widely, and the community can benefit from the research outcomes.

5. References

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