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Smartphone-based Sickle Cell Disease Detection and Monitoring for Point-of-Care Settings

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Abstract: ***Sickle cell disease (SCD), a haematological illness that affects people all over the world, can lead to painful episodes, anaemia, organ damage, stroke, and even death. Sub-Saharan Africa and other nations with scarce resources are where it is more prevalent. Traditional laboratory-based diagnostic techniques for SCD are laborious, complicated, and unable to be completed at the point-of-care (POC) and at home. To distinguish between sickled and normal red blood cells (RBCs), optical microscope-based classification and counting requires a large amount of time, expensive setup, and experienced human labour. The need for a POC and home-based test to detect and track SCD and lower mortality in areas with limited resources exists. The effective therapy of SCD can benefit from an early and prompt diagnosis. This article discusses For the purpose of taking RBC photos from the SCD patients under normoxia and hypoxia, we used a smartphone-based image capture technique. To distinguish RBCs from the patient's blood before and after cell sickling, a computer algorithm is created. We acquired the same percentage of sickle cells in blood samples using the developed smartphone-based technology as those obtained using the traditional method (standard microscope). The created testing technique demonstrates the Potential savings from using a smartphone to administer the test could lower the entire cost of diagnosing and treating SCD, making the procedure more useful in environments with limited resources. Our system is very helpful in determining the seriousness of the SCD and does not call for any specific storage requirements. This is the distinguishing benefit of our method over previous hemoglobin-based POC diagnostic methods.***

Keywords: Sickle cell disease, Point-of-care, Red Blood cells,Smartphone based, blood samples.

I. INTRODUCTION

A single point mutation in the beta-globin gene results in the hereditary illness known as sickle cell disease (SCD), which is widespread throughout the world. Valine replaces the 6 glutamic acid, which causes normal haemoglobin to change into HbS. RBCs with a sickle shape are produced when the HbS polymerizes at low oxygen levels. They become hard and sticky due to the sickling of the cells, which has a negative impact on the efficiency of oxygen transport and blood circulation. Both toddlers and adults who have the condition experience acute vaso-occlusive discomfort. Children born in environments with few resources are more likely to develop SCD. From a 2008 census of the USA population, the Centres for Disease Control (CDC) identified roughly 100,000 cases of people with homozygous genotypes, mostly in African Americans. The most common illness in sub-Saharan Africa, SCD has the highest mortality rate among children under the age of five. Every day, almost 700 infants in Africa are born with SCD. Due to inadequate SCD diagnosis and care, more than half of them pass away. Any organ in the body, particularly the spleen, might be harmed by this illness. Due to the lack of splenic functioning, children with SCD are more likely to develop systemic infections. The lung is another important organ that SCD affects. SCD patients have a high chance of developing pulmonary hypertension at a young age, which significantly raises the death rate for children. Numerous morbidities and fatalities associated with SCD are also caused by cerebral vascular diseases. The most typical risk factors linked to SCD are stroke and silent infarction. A kid with SCD is 200 times more likely than a healthy child to experience an ischemic stroke, which is defined as a stroke that occurs between the ages of 2 and 5 and is caused by a blood clot blocking a blood vessel in the brain.

II. OBJECT OF THE STUDY

Global smartphone adoption has created new opportunities for POC- and home-based biomedical diagnostics. Numerous add-ons have been created to work with cellphones so they can improve their imaging skills and monitor medical issues.

Rapid imaging, identification, quantification, and monitoring of infections and disorders have all been accomplished using smartphone-based approaches. For POC diagnostics, several researchers have created mobile phone-based fluorescence microscopy instruments. These gadgets have proven to perform as well as conventional laboratory techniques. Researchers created a platform based on magnetic levitation to find sickled cells.

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The devised system does away with the requirement for pricey centrifuge equipment and microscopes for SCD detection. Instead, it makes use of magnetic levitation and a smartphone to take pictures of the RBC floating in the magnetic field. An external LED illuminates the sample, and a lens is used to improve the image.

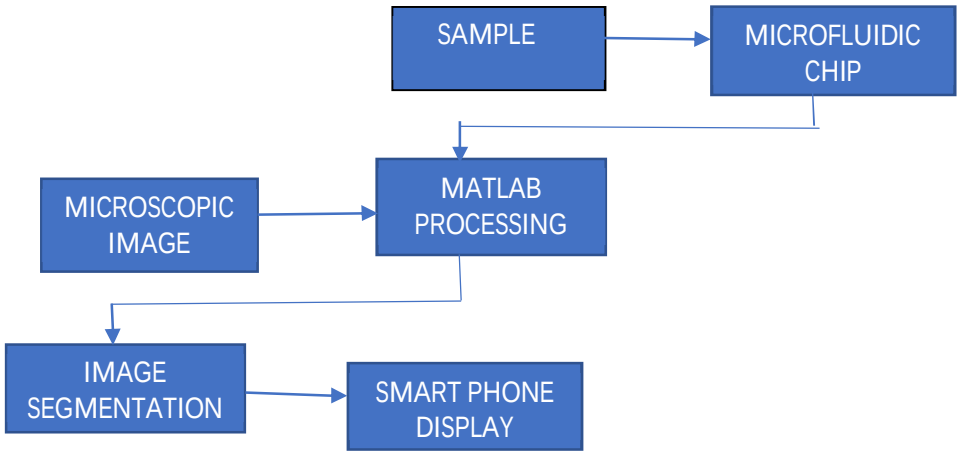
Because sickle cell levitation patterns are fundamentally different from those of healthy RBC, this characteristic can be utilised to identify the illness. This method can only be used to identify SCD, while it could be improved to identify disease severity or sickle cell trait (SCT).

III. METHODOLOGY

Our POC and home-based portable and standalone setup for the diagnosis and treatment monitoring of SCD based on shape change in RBCs under hypoxia is described in this publication. It is made out of a 3D structure that has been specifically created and is simple to attach to a smartphone camera.

The microchip holding the blood sample is supported by an external lens to improve the image quality. An external LED is used to illuminate the sample, and the smartphone camera is used to take pictures of the cells. Using a MATLAB-written computer algorithm, the recorded images are further examined. Based on their morphology, sickled cells and normal RBCs may be automatically separated from one another.

The created arrangement is affordable and can drastically lower the cost per test. simply applied in various situations located at home. It has the ability to both diagnose SCD and be used to track treatment. By using our method, it is feasible to calculate the proportion of sickled blood cells and maybe change the medication's dosage. With little human interaction, the entire diagnostic process can be finished in 16 minutes.



IV. DESCRIPTION OF THE HARDWARE USED

A. Smartphone

A smartphone is a portable computer device that combines mobile telephone functions and computing functions into one unit. They are distinguished from older-design feature phones by their stronger hardware capabilities and extensive mobile operating systems, which facilitate wider software, access to the internet (including web browsing over mobile broadband), and multimedia functionality (including music, video, cameras, and gaming). Smartphones typically contain a number of metal–oxide semiconductor (MOS) integrated circuit (IC) chips, include various sensors that can be leveraged by pre-installed and third-party software (such as a magnetometer, a proximity sensor, a barometer, a gyroscope, an accelerometer, and more), and support wireless communication protocols (such as Bluetooth, Wi-Fi, or satellite navigation).

B. Microfluidic Chip

Microfluidic chip helps to determine the behavioral change of the microfluids. Microfluidic channels that permit the processing of the fluid allows us to view the separated component from the sample.

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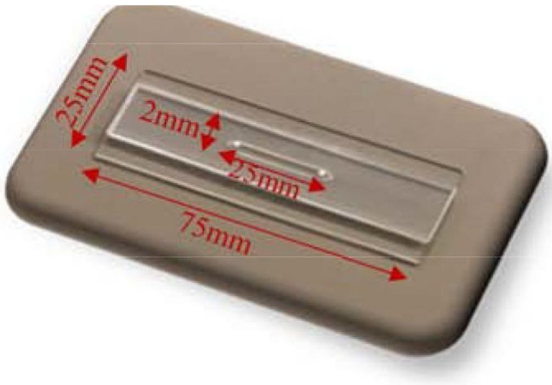


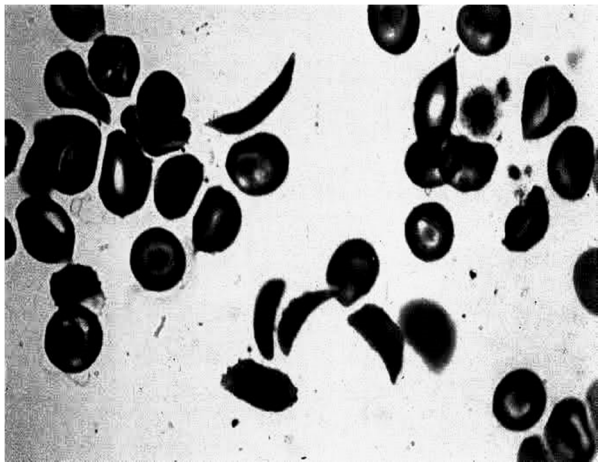
V. DESCRIPTION OF THE SOFTWARE USED

MATLAB (an abbreviation of "MATrix LABoratory") is a proprietary multi-paaradigm programming language and numeric computing environment developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.
Here matlab is used for the purpose of image processing where it helps to detect and anayse the presence/absence of the sickle cell disease. A microscopic image of the sample is been uploaded to the MATLAB software to get the output.

A. Processing The Image

The input image is been processed for the detection of the sickle cell disease into the grey scale image. The conversion of grey scale image helps to detect a accurate result. The sickle shaped rbcs are indicated if the sample is affected. If the normal shapes rbcs are detected then the sample is not affected.

B. Experimental Results



VI. CONCLUSION

"Smartphone based sickle cell disease detector" is a most needed one around the world, since nowadays people are in need of moving towards the medical labs for the detection of the disease. People fear if it is a sickle cell disease that have been affected whenever they feel a reduction in RBC count, hypoxia condition and any blood related defects. These fears can be thrown away by detecting the disease at the home itself using a smartphone for the better confirmation of the disease.

VII. FUTURRE WORK

In this project we are in need of getting the microscopic image of the sample and is processed using a software. In the forthcoming days it can be designed into a hardware model which can be sold in the market areas as like the present invention of the glucometer with the detection of the sickle shaped rbcs for the confirmation of the disease.

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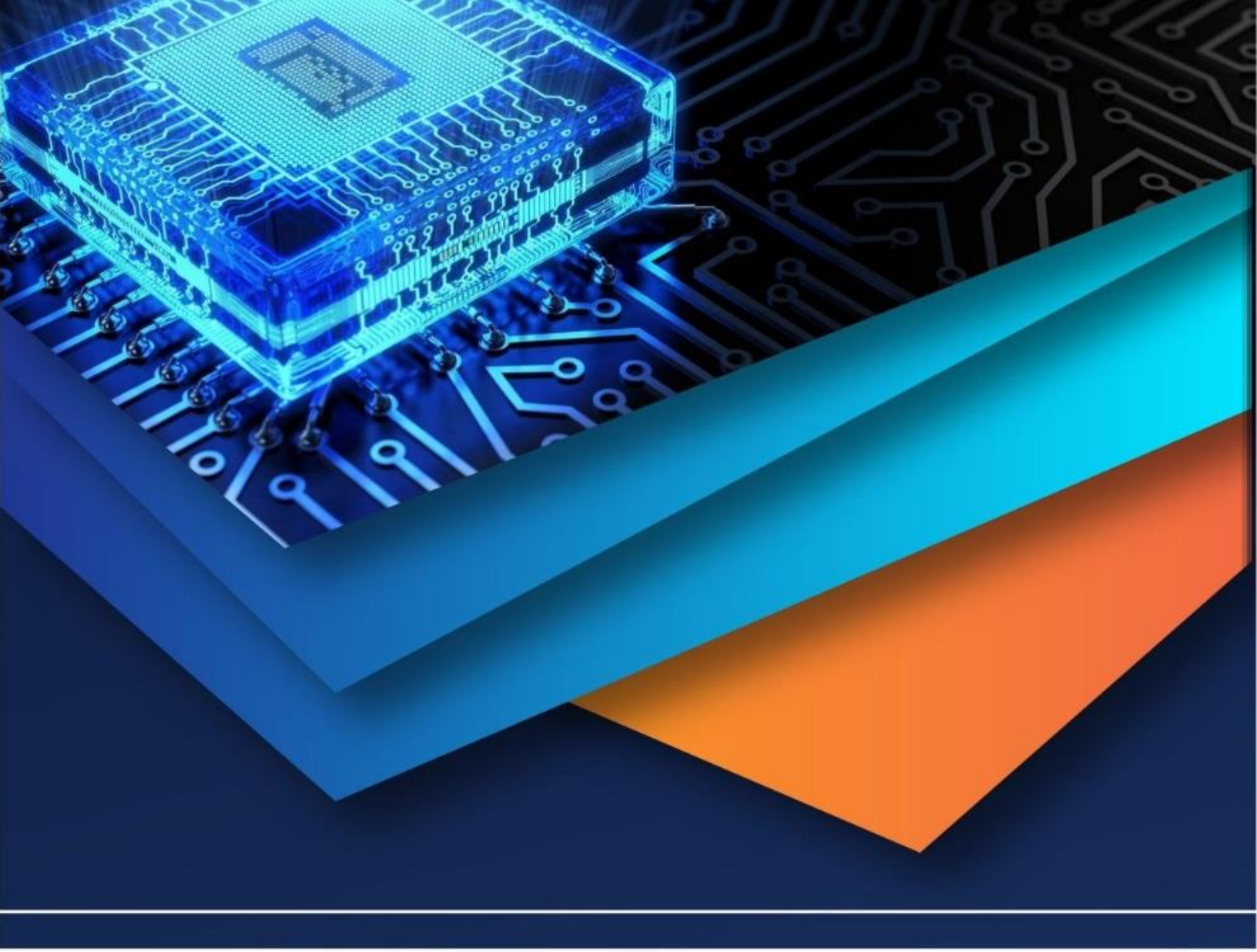

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