PORTABLE DIAGNOSTIC DEVICE FOR ANEMIA IN DEVELOPING COUNTRIES

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Problem Statement

To develop a cost effective, accessible point of care solution for a portable device with magnification and resolution capabilities adequate to measure red blood cell size to determine the mean corpuscular volume (MCV) from a peripheral blood smear.

Motivation

Developing countries often lack resources and manpower to diagnose common medical conditions such as anemia. Many types of anemia are amenable to treatment using inexpensive, readily available medications. Since anemia is one of the most common causes of preventive illnesses worldwide, an accurate, point of care tool to diagnose anemia would be useful.

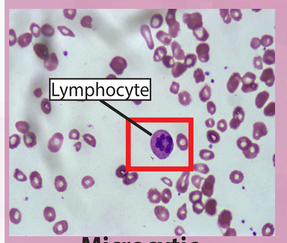
Abstract

Anemia is a leading cause of preventable death in developing countries because it often left undiagnosed and untreated. The overall goal of this project is to develop a cost effective, point of care diagnostic tool with the ability to differentiate between types of anemia. This requires a device with magnification and resolution capabilities to measure erythrocyte size and shape. This semester was largely committed to determining those capabilities.

Testing

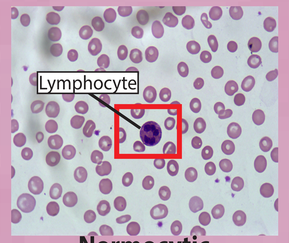
Through testing, the quality of microscope as well as the magnification needed to analyze blood smears for the analysis of MCV will be determined. A series of microscopes including a research grade, handheld, and homemade model will take a picture of the same portion of a blood smear and the pictures will be compared to determine the lowest cost device that provides adequate magnification and resolution for the analysis required. A slide with a laser etched ruler will be used to determine the real resolution of each device.

Phase 1 - Visually Detecting Anemia



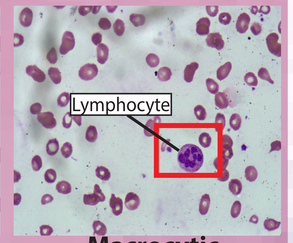
Microcytic

- Larger white space area to RBC area ratio
- RBC is smaller than lyphocyte
- MCV is less than 80.



Normocytic

- Proportional white space are to RBC area ratio
- RBC is smaller than lyphocyte
- MCV is approximately 80.



Macrocytic

- Proportional white space area to RBC area ratio
- RBCis larger than lymphocytes
- MCV is greater than 80.

Phase 2 - Determining Magnification and Resolution

Microscope Model	Microscope Type	Picture	Camera	Magnification	Numerical Aperture/Resolution	Cost	Camera Resolution
Olympus Bx41	Research Grade		SPOT idea	20,40,100, 200	1.1 NA	30,000	3megapixels
Proscope HR	Diagnostic Grade		Proscope	1-10,30N,50,100,200,400,500,1000	1,310,720 effective pixels	300	1.3 megapixels
Reichert Series 310	Educational Grade		AM423XC Dino-Eye	200,400,1000	.65 NA	100	1.3 megapixels
AM4113T5X Dino-Lite Premier	Toy		Dino-Lite	500 max	1.3 megapixel	450	1.3 megapixel
2mm diameter Edmund Optics ball lens	Do-It Yourself		Citrus	100	?	20	3 megapixel

The table above represents the different grade microscopes tested. The goal was to determine the most cost effective solution that can achieve 400X magnification and has a numerical aperture capable of resolving an image to view the external shape of erythrocytes. Based on the conclusion of this testing phase, the best microscopy option will be applied to the design.

Results

Using two pictures of different sections of the same peripheral smear ImageJ calculated significantly different cell densities. This proves that the distribution of cells throughout a peripheral smear is not constant and a section representative of the distribution in the human body cannot be obtained. Because of this, a cell count performed on any two sections of a peripheral smear will result in a different number resulting in an inaccurate result. This can be solved through the use of a hemocytometer, which will produce an even distribution of cells on a grid of known size.

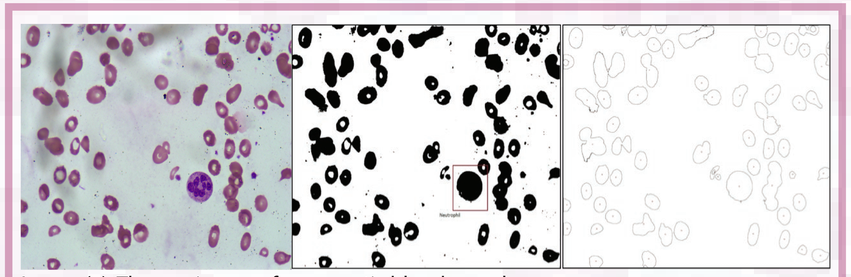


Image (a). The raw image of macrocytic blood sample.
Image (b). The theshold image of the same blood same produced by ImageJ to analyze cells based on light intensity.
Image (c). Post-analysis image showing the cells recognized and counted.

Future Work

Phase 1. To design a smartphone application interface and magnification hardware that can detect anemia based on two inputs - the hemoglobin concentration inputed by a pulse oximeter and the MCV derived by ImageJ from a peripheral blood smear.
Phase 2. To classify and differentiate the types of anemia based the cell morphology or shape observed in the ImageJ images by comparing the images to an archived library of images of red blood cells with potentially similar abnormalities.
Phase 3. To develop a customized treatment plan for specific anemias that could assist health care employees at the point of care.

The development of this diagnostic tool could lead to the development of similar tools to diagnose other common treatable conditions at the point of care.-

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