DEERWALK INSTITUTE OF TECHNOLOGY

Tribhuvan University

Institute of Science and Technology

LEUKEMIA DETECTION USING DIGITAL IMAGE PROCESSING

A PROJECT REPORT

Submitted to

Department of Computer Science and Information Technology

DWIT College

In partial fulfillment of the requirements for the Bachelor's Degree in Computer Science and Information Technology

Submitted by

Nischal Badal

June, 2020

DWIT College

DEERWALK INSTITUTE OF TECHNOLOGY

Tribhuvan University

SUPERVISOR'S RECOMMENDATION

I hereby recommend that this project prepared under my supervision by NISCHAL BADAL entitled **“LEUKEMIA DETECTION SYSTEM USING DIGITAL IMAGE PROCESSING”** in partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Information Technology be processed for the evaluation.

…………………………………………

Ritu Raj Lamsal

Head, Electronics Department

Deerwalk Institute of Technology

DWIT College

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DEERWALK INSTITUTE OF TECHNOLOGY

Tribhuvan University

LETTER OF APPROVAL

This is to certify that this project prepared by NISCHAL BADAL entitled **"LEUKEMIA DETECTION SYSTEM USING DIGITAL IMAGE PROCESSING"** in partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Information Technology has been well studied. In our opinion it is satisfactory in the scope and quality as a project for the required degree.

……………………………………	…………………………………………
[Supervisor]	[External Examiner]
Designation	Academic designation
DWIT College	IOST, Tribhuvan University

ACKNOWLEDGEMENT

I would like to express my deepest appreciation to all those who provided me the possibility to complete this project. A special gratitude I give to my project supervisor, Mr. Ritu Raj Lamsal, whose contribution in stimulating suggestions and encouragement, helped me to coordinate me through the project and also in writing this report.

Furthermore, I would also like to acknowledge with much appreciation the crucial role of Mr. Milan Lamichhane and Mr. Hitesh Karki who gave the permission to use all required equipment and the necessary materials to complete the task “Leukemia Detection using Digital Image Processing". I have to appreciate the guidance given by other supervisors as well as the panels especially in our project progress and demonstration that has improved our interpersonal skills thanks to their comment and advice.

Nischal Badal
631, Batch of 2020
June 2020

ABSTRACT

Leukemia refers to the cancer that involves malfunction of blood-forming tissues of the bone marrow. When a person has leukemia, the bone marrow does not work properly. The diagnosis of leukemia frequently follows a routine blood test that results in an abnormal blood cell count. Applying Image processing techniques into the microscopic blood sample image can ease the detection of abnormal blood cells causing Leukemia. Unlike the manual process, the computerized system has less types of errors as it eliminates human errors. This project involves conversion of microscopic blood smear samples into three different color models as RGB, CMYK, YCBCR as each of them has different accuracy counting the number of blood cells. The automated system performs different Image Processing techniques to blood smears and counts the number of blood cells: Red Blood cells and White Blood cells. The final diagnosis is obtained analyzing the count of blood cells in each of the color models.

Keywords: *RBC; WBC; Microscopic; Blood smears; Image Processing; Diagnosis; Leukemia;*

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LIST OF ABBREVIATIONS

RBC	Red Blood Cells
WBC	White Blood Cells
RGB	Red Green and Blue
CMYK	Cyan, Magenta, Yellow and Key (Black)

LIST OF SYMBOLS [OPTIONAL]

Symbol	Name	Definition
≈	Approximately equal	Approximation
≥	Inequality	Greater than or equal to
±	Plus - minus	Both plus and minus operations

CHAPTER 1: INTRODUCTION

1.1 Overview

Cancer detection has always been a challenging task for a hematologist for diagnosis and treatment planning. The manual detection of Leukemia, or Blood Cancer, is subjective in nature and may vary from expert to expert depending upon many factors such as knowledge, skillset and accuracy. The automated detection system from microscopic images helps in alleviating the above-mentioned problems and provides better results if biologically interpretable and clinically significant feature-based approaches are used for the identification of the disease.

In leukemia, bone marrow produces abnormal white blood cells. Compared with the normal blood cell, abnormal cells do not die when they should therefore the number of abnormal white blood cells become numerous and affect the working of normal white blood cells. This leads to an imbalance of the blood system in the human body.

Classification of leukemia can be done on the basis of how quickly this disease spreads and becomes serious. It can be either chronic or acute. Generally, leukemia can be divided into 4 types that are:

- Acute Lymphocytic Leukemia (ALL): Usually occurs in children aged 2-10 years. This type of leukemia is most common. It also always occurs in adults.
- Acute Myeloid Leukemia (AML): This type of leukemia is common in children under the age of 1 year. It is extremely rare in teenagers. Even so it is mostly for adults aged 40 years.
- Chronic Lymphocytic Leukemia (CLL): This type of leukemia often happened to older patents. It is extremely rare in patients under the age of 40.
- Chronic Myeloid Leukemia (CML): This type of leukemia can occur in all but the most common is for adults age after 45 years.

1.2 Background and Motivation

In blood disease, the most dangerous disease is blood cancer i.e. leukemia. It needs to be diagnosed fast and accurate. The microscopic image of blood smears can be processed through an automation system following a series of image processing algorithms to count the RBC and WBC numbers. This can ease the manual process and minimize the cost incurred in the detection process as Images are cheap and do not require expensive testing and lab requirements. In addition, the human errors can be minimized and a good accuracy can be maintained.

1.3 Problem Statement

The current scenario of detection of leukemia is based on the expertise of medical staff as doctors and laboratory technicians. They undergo the manual process of counting blood cells of microscopic blood smears. The process is expensive, time-consuming and any kind of error occurred can result in false positive diagnosis. This process can be computerized by developing an automated system to detect leukemia using similar methodology as the health professionals carry out. The computerized system is efficient, cheap and has good accuracy compared to the manual process. As in some cases of leukemia, the leukemic cells (or harmful cells) tend to spread rapidly which needs to be detected very fast and the computerized system does so.

1.4 Objective of the Project

The main objective of this project is to ease the process of leukemia detection with comparatively less error rate. With the help of a computerized system, human errors can be neutralized. This system overcomes the related constraints in visual inspection of Leukemia. Also, another objective would be to apply theoretical knowledge of digital image processing techniques as Image Enhancement, Thresholding, Mathematical morphology, labeling, etc into a real world problem.

1.5 Scope of the Project

The scope of this project are medical staff or professionals who have to diagnose the presence of leukemia or not in a particular patient's blood sample. As this system works on microscopic samples of blood, it might not be suitable for everyone out there to test their blood for the presence of cancer cells. This system also provides the count of blood cells as RBC and WBC, it can alternatively be used in skepticism analysis of human blood.

1.6 Outline of the Report

The outline of the report is organized as shown in the block diagram in Figure 1:

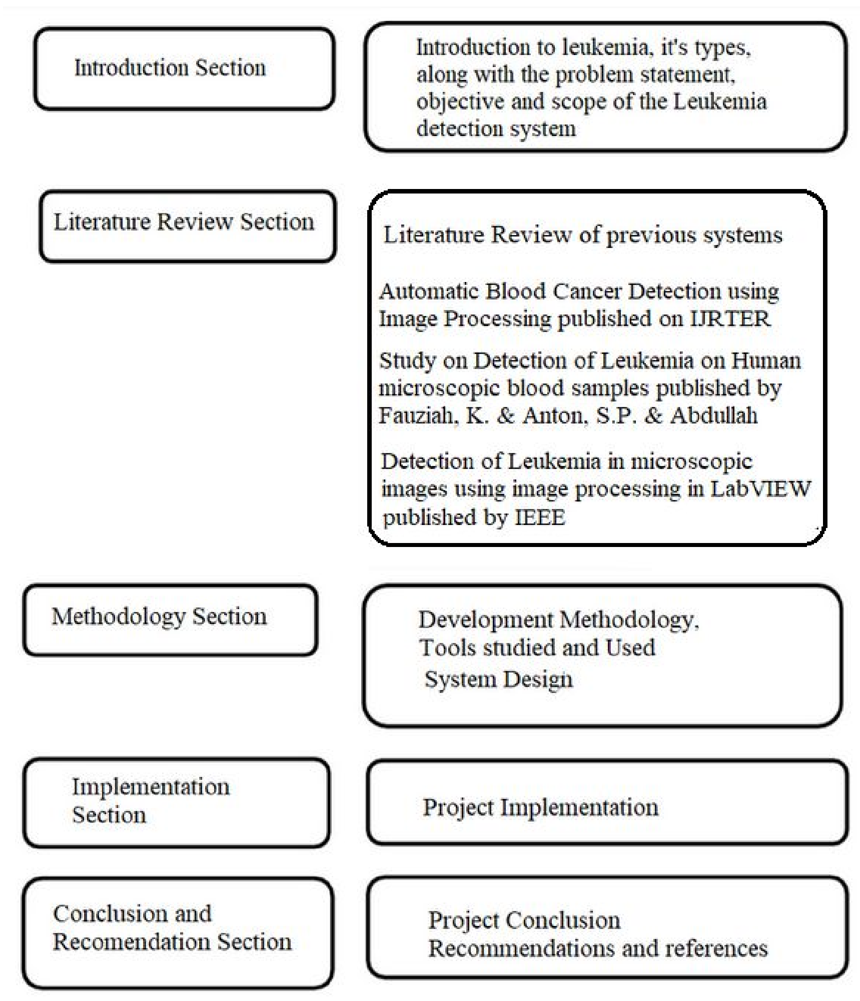


Figure 1: Project Report Outline

CHAPTER 2: REQUIREMENT AND FEASIBILITY ANALYSIS

2.1 Literature Review

Many research as well as studies have been carried out to analyze the computerized system to detect leukemia using Image processing. As for the literature review, I have selected to review the below publications which helped in completion of this project.

Automatic Blood Cancer Detection Using Image Processing

(https://www.ijrter.com/papers/volume-4/issue-3/automatic-blood-cancer-detection-using-image-processing.pdf)

This is a proposed system to detect leukemia using similar Image Processing techniques. It used only one color combination i.e. RGB and applies Grey Scale conversion as enhancement. Leukemia Detection using Digital Image Processing is similar to this proposed system but contains multiple color options to obtain higher accuracy. Using multiple color models, the enhancement process is more accurate to count the number of blood cells.

Detection of leukemia in human blood samples based on microscopic images: A study. Journal of Theoretical and Applied Information Technology.

This is a study carried out by Fauziah, K. & Anton, S.P. & Abdullah, in 2012 which applies K-means Clustering for the segmentation of white blood cells in human blood samples. Blood cells segmentation is used for the detection and classification of the sickle cell anaemia. It proposes the theory that WBC with giant nuclei results in leukemia. Reinforcement Learning is proposed to classify types of leukemia by analyzing features in microscopic images and changes on texture, geometry, color and statistical analysis. This study focuses on diagnosis all other kind of blood diseases using Machine Learning.

Detection of Leukemia in microscopic images using image processing

(https://ieeexplore.ieee.org/document/6949840)

This report published by Chaitali Raje and Jyoti Rangole published on 2014 International Conference on Communication and Signal Processing implements LabVIEW and MATLAB to predict the leukemia using statistical parameters such as mean, standard deviation which segregates white blood cells from other blood components i.e. erythrocytes and platelets. It applies geometrical features such as area, perimeter of the white blood cell nucleus which is investigated for diagnostic prediction of Leukemia.

2.2 Requirement Analysis

The basic requirements for this system to work is a computerized system having MATLAB software as the system is built on it. This system inputs microscopic samples of blood images and outputs a predicted count of RBC, WBC and diagnoses the presence of Leukemia. Moreover, requirements can be categorized as follows.

2.2.1 Functional Requirement

Functional requirements of Leukemia Detection System using Digital Image Processing can be:

- The user shall input the microscopic sample of blood smears
- The system shall use three different color models as RGB, CMYK and YCbCr
- The system shall show different processed image with the technique applied
- The system shall count the number of RBC and WBC and shall predict the presence of leukemia or not
- The user shall be able to analyze the results shown by the system

2.2.2 Non-Functional Requirement

Similarly, some of the Non-functional could be:

- Microscopic Image must be entered into the system
- The image quality must be high
- The processing system on which system is run must be able to operate MATLAB
- The GUI must be designed correctly to provide understandable output

2.3 Feasibility Analysis

This system is designed and developed for the medical professionals who can carry out further tests or diagnosis if the potential leukemia is detected. The feasibility of the system is checked in many aspects as described in the following.

2.3.1 Technical Feasibility

MATLAB is used for the implementation of the system. It is tested with the different blood samples obtained from different sources as Kaggle, Inno-DB and Google containing both leukemia and non-leukemia blood samples. MATLAB is selected for this project as it provides different functionalities for image processing implementation. The image sample is loaded from the computer and it is accordingly processed. Analyzing the above mentioned points, this system is technically feasible as it only incurs the cost of MATLAB premium feature.

2.3.2 Economic Feasibility

The economic aspect of this project consists of the indirect costs which can be work hours, laptops and internet services as well as report printing. Since it is a college project and does not require any specific additional hardware systems, the only incurred cost is to buy a licensed MATLAB software. All the references and resources are freely available on the internet. The user only needs a single handheld device (e.g. desktops, laptops, etc.) to use this system.

2.3.3 Operational Feasibility

The system is fully operational and it solves the problem with a great accuracy and success rate. As mentioned earlier, the scope of the system is the medical staff and for them it is easy to use as the UI is minimalistic. The system satisfies the requirements mentioned in the requirements phase and is developed as according to the proposed statement. For the testing of the operational phase of the system, multiple images of leukemia as well as non-leukemia image samples were tested and two out of three color models provided the true prediction.

2.3.4 Schedule Feasibility

The schedule feasibility analysis is carried out using the CPM method. With CPM, critical tasks were identified and interrelationship between tasks were identified which helped in planning that defines critical and non-critical tasks with the goal of preventing time-frame problems and process bottlenecks. The Critical path obtained through the CPM Network is 70 days i.e. the project can be completed in 70 days.

Activity(Notation)	Predecessor	Duration(Days)
Research on Leukemia (A)	-	15
Image input in RGB color (B)	A	10
Conversion to CMYK color model (C)	B	10
Conversion to YCbCr color model (D)	B,C	15
Image Segmentation and pre-processing (E)	B,C,D	20
Feature Extraction (F)	E,D	10
Cell counting and Prediction(G)	H	5
TESTING (H)	F,G	5

Table 2: CPM Process and Duration

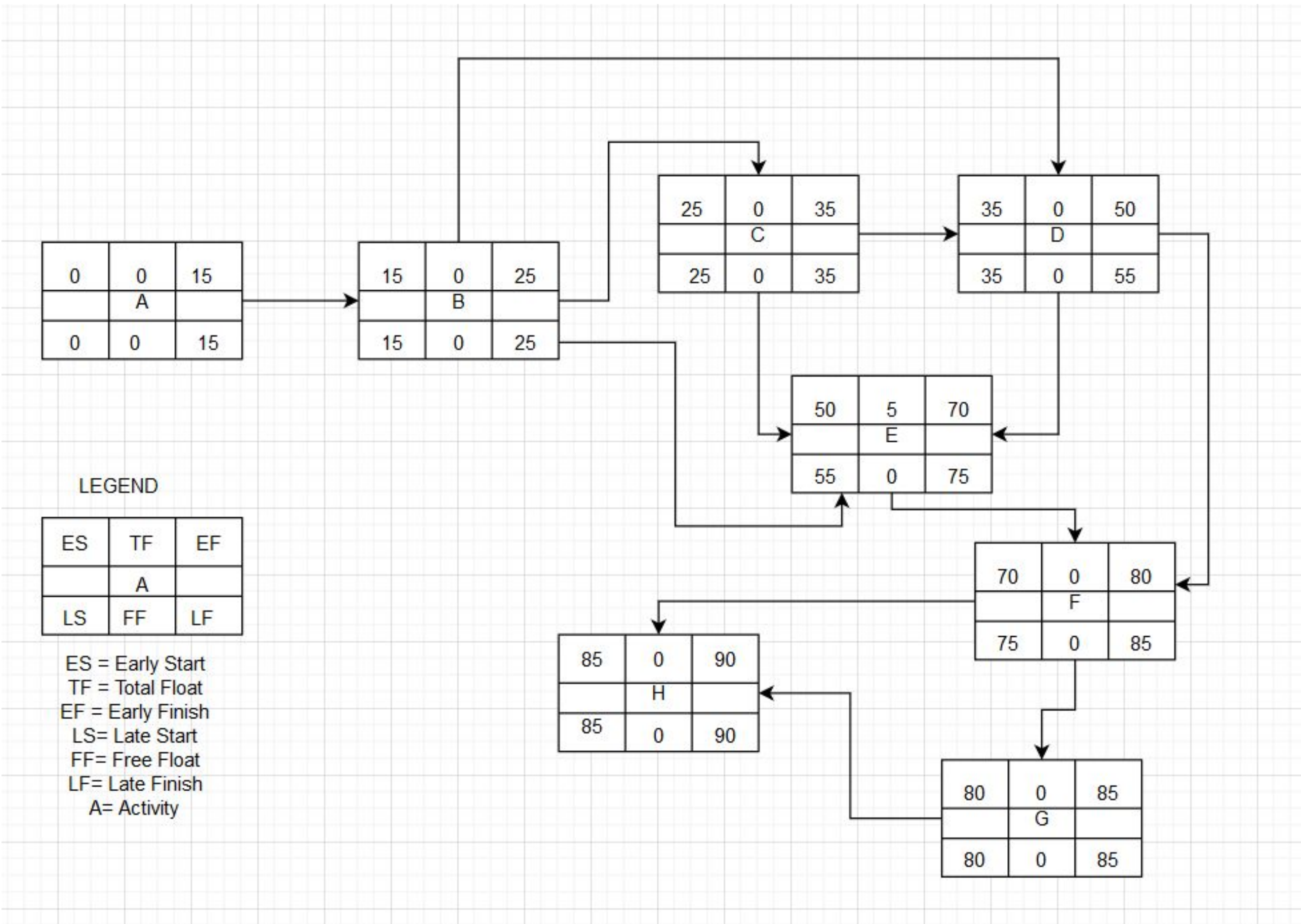


Figure 2- Network diagram to identify critical path

CHAPTER 3: METHODOLOGY

There were many methodologies to develop a system to process an input image applying different Image processing techniques to obtain the required information or prediction. Similarly many tools were available such as LavVIEW, MATLAB, etc which used different functionalities to obtain the result. Among all the tools and techniques, MATLAB provides easy functionalities to acquire images and process them such as image preprocessing, feature extraction, cell counting, etc. Three color models are used in the system to perform the same tasks and they, in most of the cases, provide similar prediction but in some cases the prediction can be different. Since the project is based on edge detection of WBC cells and counting of cells, different color models were applicable on the system. A person is infected with leukemia if the percentage in the cell is greater than 20% as the infected cells do not die in the required time and are affecting working of other normal cells.

3.1 Data Preparation

3.1.1 Data Collection

Leukemia can be of two major types: chronic and acute. In chronic, leukemic cells act like normal white blood cells at the beginning and slowly grow out to be harmful. While acute leukemic cells spread very fast and become severe at a short period of time. Kaggle contains the microscopic samples of all types of leukemia. Not to depend on only one source of data, another data platform Anno-DB also provides multiple data of microscopic blood samples or blood smears. These data were collected to test the accuracy of the system.

3.1.2 Data Selection/Filtering

The data filtering was not much necessary for this project as the testing phase was done manually. The processing steps were visible in the UI and the results were displayed accordingly.

There were some false positive cases which were saved by the system to detect them if repeated cases occurred.

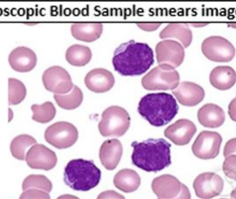
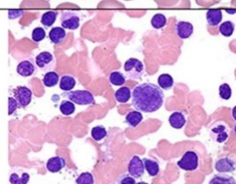
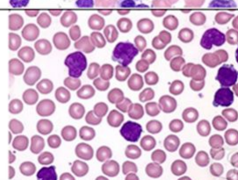
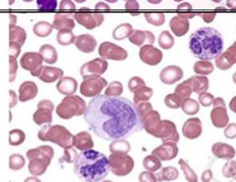
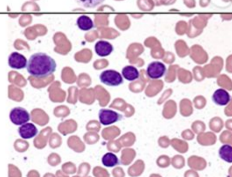
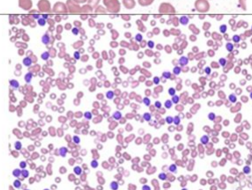
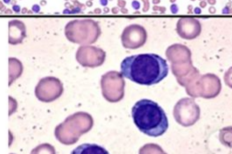
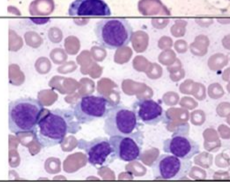
Microscopic Blood Sample smears image	Conditions
	T-cell prolymphocytic Leukemia
	
	
	Juvenile Myelomonocytic Leukemia
	Chronic Lymphocytic Leukemia
	
	Plasma cell Leukemia
	Hairy cell Leukemia

Table 2: Dataset of all types of Leukemia

3.2 Algorithms Studied and Implemented

3.2.1 Algorithms

This project implemented different steps of Digital image processing combined to work as an algorithm. These steps include Image Acquisition, conversion of RGB to CMYK and YCBCR color models, Image segmentation, Image preprocessing, Enhancement of image to remove noise, feature extraction and finally the cell counting to count the number of RBCs and WBCs. After the RBC and WBC is counted, if the presence of WBC is greater than 20%, potential leukemia is detected. Following are the description of algorithms used in the completion of this project:

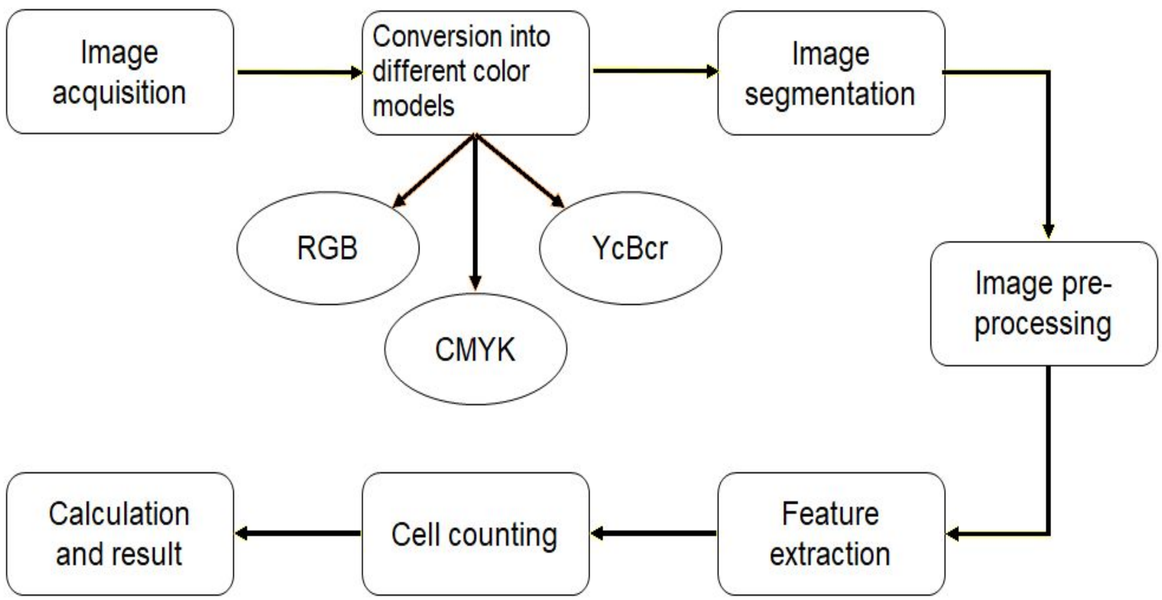


Fig 3: Workflow diagram

Image Acquisition

In image processing, acquisition is defined as an action of retrieving images from a source that can be hardware-based source or software based source for processing. It is the first step in the workflow sequence because without an image of a microscopic blood sample, no processing can be done. The image that is acquired is completely unprocessed and is the result of whatever hardware was used to generate it, which can be very important in some fields to have a consistent baseline from which to work.

Conversion of RGB image into CMYK and YCBCR

RGB is a color model or color system that constructs all the colors from the combination of Red, Green and Blue colors. The red, green and blue use 8 bits each, which have integer values from 0 to 255. This makes 256*256*256=16777216 possible colors. Similarly, the CMYK color model is a subtractive color model, based on the CMY color model, used in color printing, and is also used to describe the printing process itself.

CMYK refers to the four ink plates used in some color printing: cyan, magenta, yellow, and black referred to as key. In YCbCr, the Y is the brightness (luma), Cb is blue minus luma (B-Y) and Cr is red minus luma (R-Y). The difference between YCbCr and RGB is that YCbCr represents color as brightness and two color difference signals, while RGB represents color as red, green and blue.

The Image acquired is now converted into three different color models as mentioned above. These three image segments are now processed in the same steps afterwards sequentially. The main purpose to use three different color models is to compare the outputs because in some of the cases, different predictions are obtained as the detection of cells in a particular image can be different according to the color combinations used.

Image Segmentation

Image segmentation is the process of partitioning a digital image into multiple segments. These segments or sets of pixels are known as image objects. The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images. In this project, segmentation is done to the WBC to locate boundaries so that it can be further processed and counted.

Image Preprocessing

Image preprocessing is an improvement of image data that suppresses unwanted distortions or noises and enhances the features of images that are important for further processing. Image can be preprocessed as pixel brightness transformations, geometric transformations, using local neighbourhood of processed pixels and image restoration techniques. Image preprocessing can also be used to transform/enhance images. In this project, pre-processing helps to remove the noise in the microscopic sample of the images.

Feature Extraction

Feature extraction is a type of dimensionality reduction that efficiently represents interesting parts of an image as a compact feature vector. This approach is useful when image sizes are large and a reduced feature representation is required to quickly complete tasks such as image matching and retrieval. Feature extraction is done in the image output obtained from the preprocessed image to add a bounding box to the segmented white blood cells.

The bounding box represented in Fig 4 is the bounding box added to the cells using feature extraction.

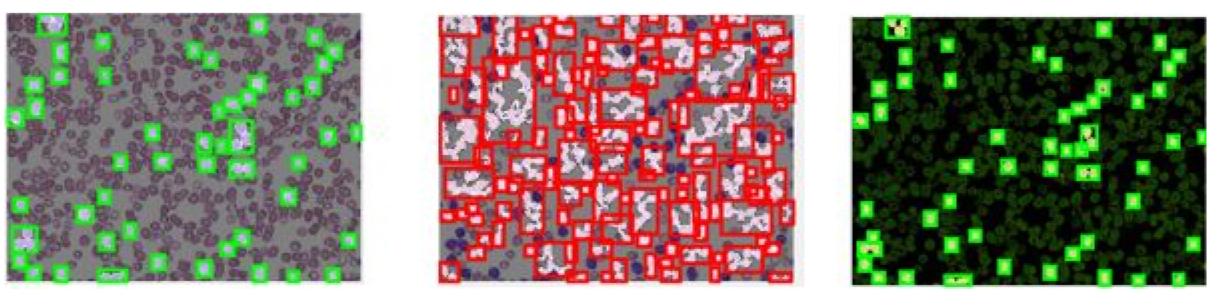


Fig 4: Bounding box in cell images

Cell Counting

After the cells are marked with a bounding box, they are counted in numbers of RBC and WBC cells. The percentage of total cell count is determined and the ratio of RBC and WBC is calculated so that the potential leukemia is predicted.

Calculation and Result

Finally, the ratio is compared and if the occurrence of WBC is greater than 20%, potential leukemia is diagnosed or else no leukemia is diagnosed. This is done in all of the three color combinations and there might be two cases detecting leukemia and one not detecting. Further procedures can be carried out after the detection of leukemia through the computerized system.

3.2.2 Suitability of Algorithms

Microscopic images of blood samples can also be processed using Deep Learning technique to count the number of blood cells as well to predict the possibility of leukemia. But using Digital Image Processing technique is easy to implement and the output of the image is displayed after every sample. It is an incremental process i.e. the result obtained from the previous step is set as an input to the next step. MATLAB has in-built functionalities which ease the processing of images from acquiring the images, segmentation, feature extraction to counting of cells. Also, the three color models are easy to convert and compare the results accordingly. Moreover, Digital Image processing produces reasonable output with good accuracy and properly implemented in the fields where the input is image or any other procedures are to be carried out to an image. The algorithm used in the project is suitable and accurate while the system developed is efficient and resolves the problem statement.

3.3 System Design

UML Diagram	Description
Use Case Diagram	Represents interaction between system and its environment
System Flow Chart	Step by step workflow of the system

Table 3: UML Diagrams and Descriptions

3.3.1 Use Case Diagram

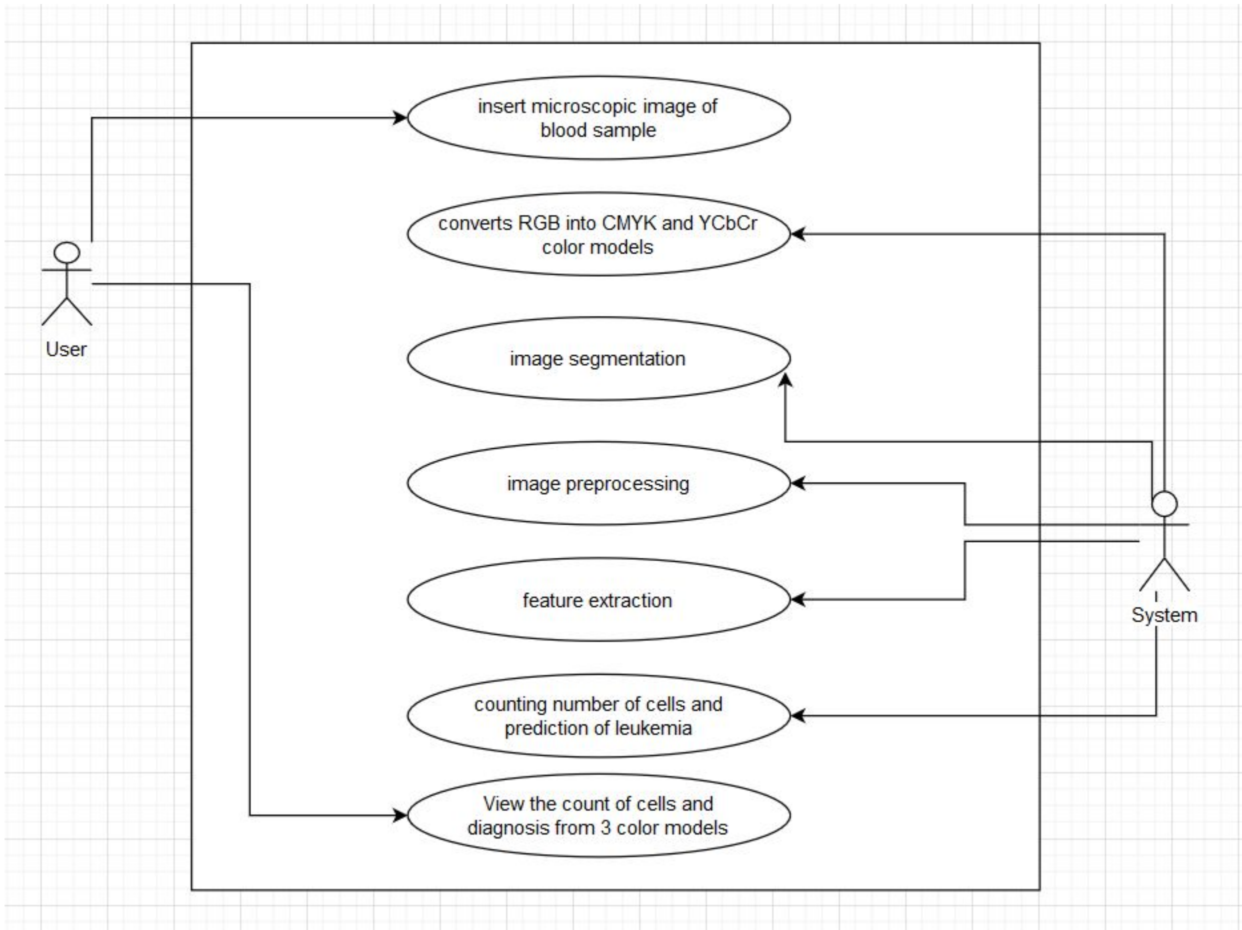


Figure 5- Use-case diagram

As shown in the above figure 5, there are two actors in the environment of Leukemia Detection System: User and System. A user can insert microscopic image sample and view the results while system carries out all the mentioned steps to determine the count of WBC and RBC cells simultaneously.

3.3.2 System Flow Chart

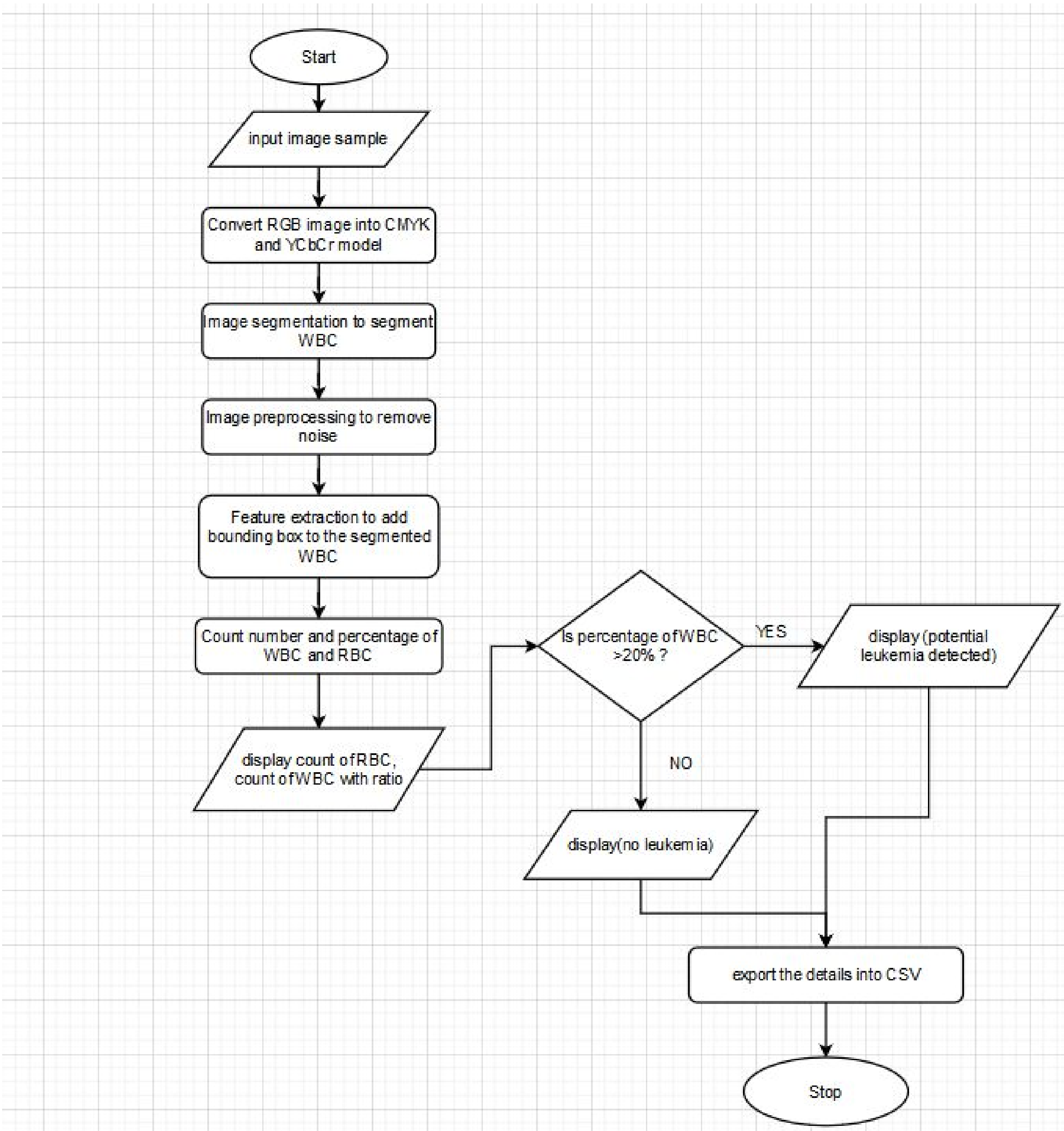


Figure6: System Flow chart

CHAPTER 4: IMPLEMENTATION AND EVALUATION

4.1 Tools and Technologies Used

MATLAB is a multi-paradigm numerical computing environment and proprietary programming language developed by MathWorks. It covered both the IDE and programming language part of the project. Similarly, once the processing is completed, the results are exported to a CSV format which consist of count of cells and prediction obtained from the system.

4.2 Implementation

The implementation of the system was initiated by acquisition of the image. Initially MATLAB takes image path and loads the microscopic image sample to convert it into CMYK and YCbCr models. Functional programming approach is used to implement functionalities of each processing algorithm and all of the three converted image samples are passed through each of the functions simultaneously. After completion of one cycle of steps (say for RGB) the count of RBC and WBC is displayed and the percentage of them is determined accordingly. And the conditional statement is executed to determine the presence of potential leukemia or not.

The output of every processing in which takes the input as image and gives output as an image are displayed for a time period of 2 seconds. This process is repeated for all the other color models as well. Finally after completion of all processing, calculation is displayed in all of the models and the final output is obtained.

4.3 Testing and their Results

After the development of the system, it is tested with multiple blood sample images to check its accuracy. In the first test case, one of the leukemia types is tested as an input to the system. Here, Plasma Cell 1 as referred in *Table 1* is checked into the system. Two of the three color models detect the presence of leukemia in the cell as shown in the *Figure 7* below.

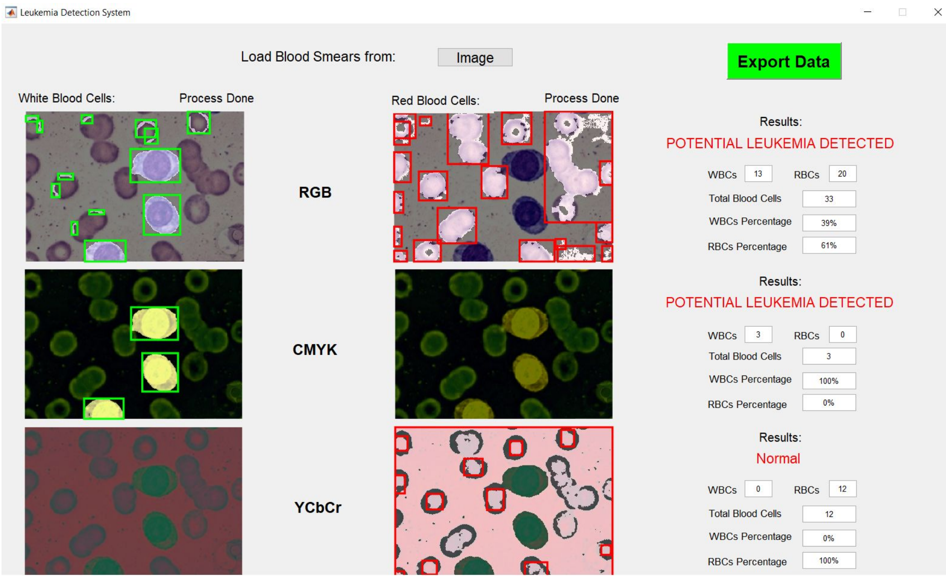


Figure 7: Test case of Leukemic cell

Similarly for the other test case, non leukemia cells as in are tested into the system and RGB and CMYK color models detected that there is no leukemia. These test cases verified the working of the system to detect leukemia.

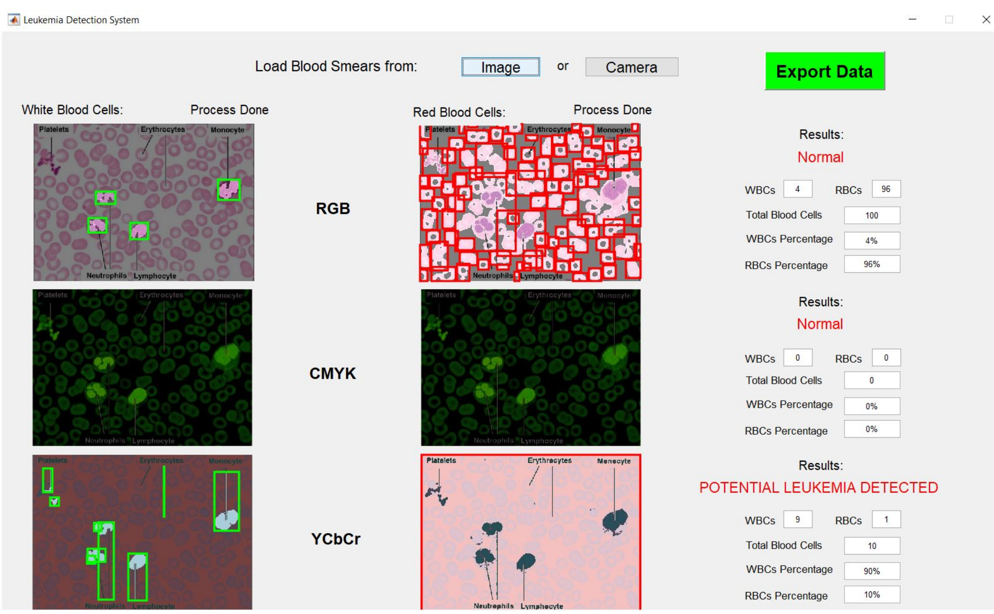


Figure 8: Test case of non-leukemic cell

CHAPTER 5: CONCLUSIONS AND LIMITATIONS

5.1. Conclusions

Leukemia Detection System using Digital Image Processing is an image processing system that takes microscopic images of human blood samples as an input and counts the total number of RBC and WBC count in the respective area of blood. It uses multiple color models as RGB, CMYK and YCbCr models and applies different image processing techniques as acquisition, segmentation, pre-processing, feature extraction and counting of cells to produce a prediction based on the count of cells. Being a college-project, it was not developed commercially but can be extended to that type. This system was intended to ease the process of manual detection of leukemia in human blood cells which was totally dependent upon the medical professional.

Leukemia is a fast-spreading disease as it directly affects victims bone marrow which is responsible for the production of blood cells. The manual detection process of leukemia follows a series of blood tests and might contain human errors which can be a question of life or death to the victim. Leukemia must be detected very quickly and patients must be treated using other medical procedures. This project is intended to minimize time, money and efficiency factor obtained during the diagnosis of leukemia. It also compared three color models to obtain accuracy statements as the CMYK model offers more accurate segmentation compared to RGB. And finally as a record, it stores all the tested cases into CSV format. YCBCR has a more luminous component than other color combinations.

It would be no surprise that in the future more computerized systems will take place into testing and diagnosis part of medical science as a machine intended to perform a particular task will be accurate and efficient than humans. Having a minimalistic design and good computational capability, the hectic tasks of medical professionals can be somehow simplified by a computerized system into tasks like Leukemia Detection. If provided proper resources and tools, this project surely will be beneficial for the proper diagnosis in a very less amount of time comparatively.

5.2. Limitations

This input to this system is microscopic images only. Hence it can be a greater limitation to the places where there is no facility to acquire microscopic samples of human blood. Similarly, it makes use of a MATLAB tool which requires higher processor capacity which might be also a limitation to most of the healthcare places. It produces three types of prediction based on three different color models. In some cases, all three of them might produce similar input while in some cases, because of the color variations, the result might be different. In that case, the user of the system must validate any one of the predictions and use it as a diagnosis. These are the limitations of the system.

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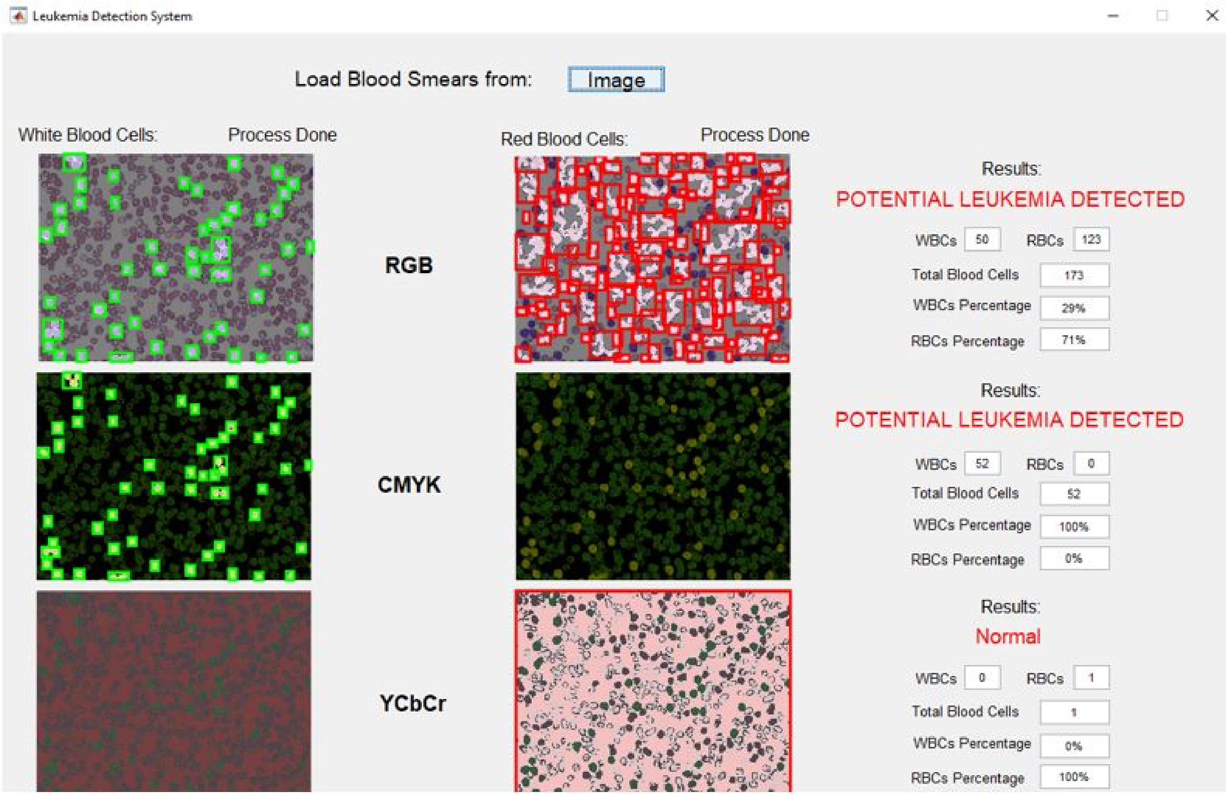
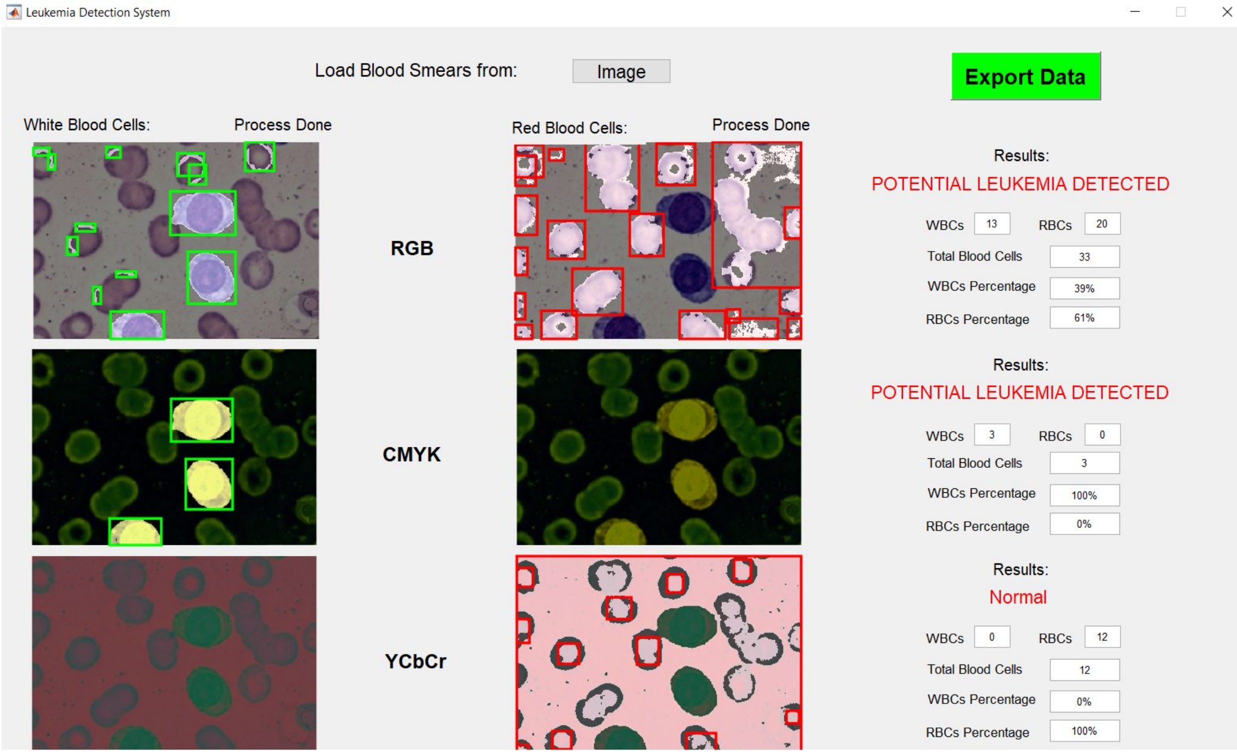
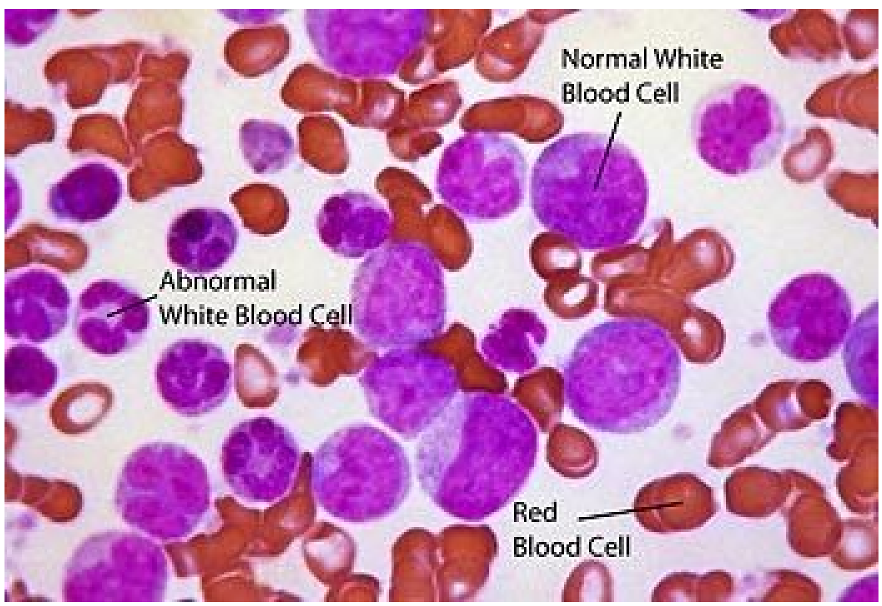
APPENDIX I



A	B	C	D	E	F	G
ColorSpace	WBCs	RBCs	Total	WBCsPercent	RBCsPercent	Prediction
RGB	3	27	30	10%	90%	No potential Leukemia


Leukemia Detection System
Load Blood Smears from:
Image
Export Data
White Blood Cells:
Process Done
Red Blood Cells:
Process Done
RGB
CMYK
YCbCr
Results:
POTENTIAL LEUKEMIA DETECTED
WBCs 13
RBCs 20
Total Blood Cells 33
WBCs Percentage 39%
RBCs Percentage 61%
Results:
POTENTIAL LEUKEMIA DETECTED
WBCs 3
RBCs 0
Total Blood Cells 3
WBCs Percentage 100%
RBCs Percentage 0%
Results:
Normal
WBCs 0
RBCs 12
Total Blood Cells 12
WBCs Percentage 0%
RBCs Percentage 100%


Normal White Blood Cell
Abnormal White Blood Cell
Red Blood Cell