4.1 Introduction

In the previous chapter, part of the methodology used to implement the malaria diagnosis system have been discussed. The work discussed in the previous chapter comprises the steps from image acquisition step to feature extraction step and classification.

In this chapter, the results that obtained from the system are described and discussed and the performance of the malaria diagnosis system is evaluated.

4.2 Results of Image Pre-processing

Figure 4-1 shows an image captured from the Reference Laboratory of Malaria, in Sudan Ministry of Health, before and after size rescaling. Figure 4-1a is the captured image with size of (700 × 600 pixels). Figure 4-1b gives the resultant image after image rescaling operation.

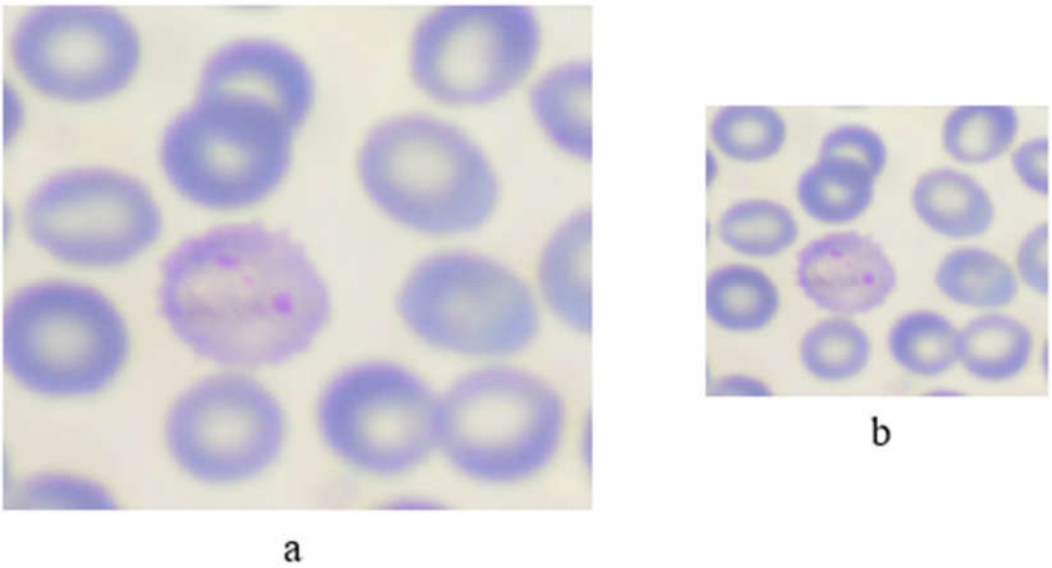

Figure 4.1: Test results of image rescaling, a. captured image, b. rescaled image.

The effect of noise reduction using median filter is presented in figure 4-2.

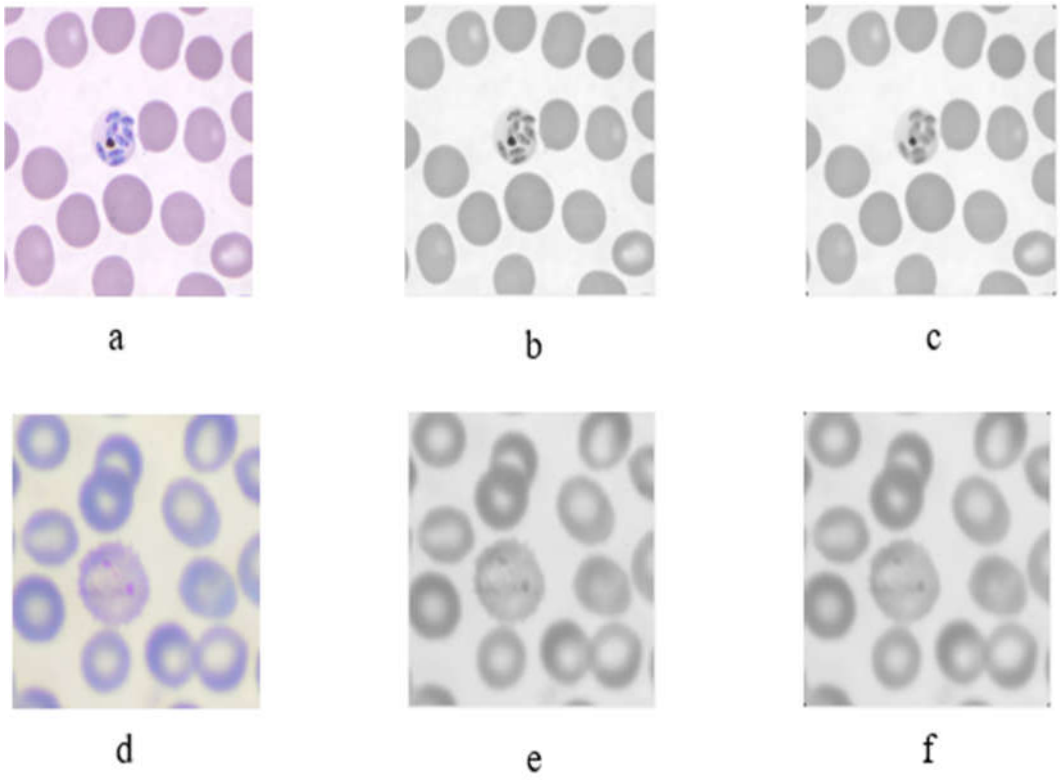

Figure 4-2: Effect of image filtering, a. and d. rescaled CDC and captured images respectively, b. and e. grayscale images, c. and f. filtered images.

The results show that for both images, the noise is removed and the degradation is corrected by median filtering. By performing median filtering random noise is smoothed and this led to an improvement in the quality of the image.

4.3 Results of Image segmentation

Both objectives for image segmentation, isolate the RBCs from the background and extract all the RBCs were tested at this section.

4.3.1 Isolate RBCs from the background and edge detection

The results of RBCs Isolation steps for CDC image are presented in figure 4-3 and Figure 4-4.

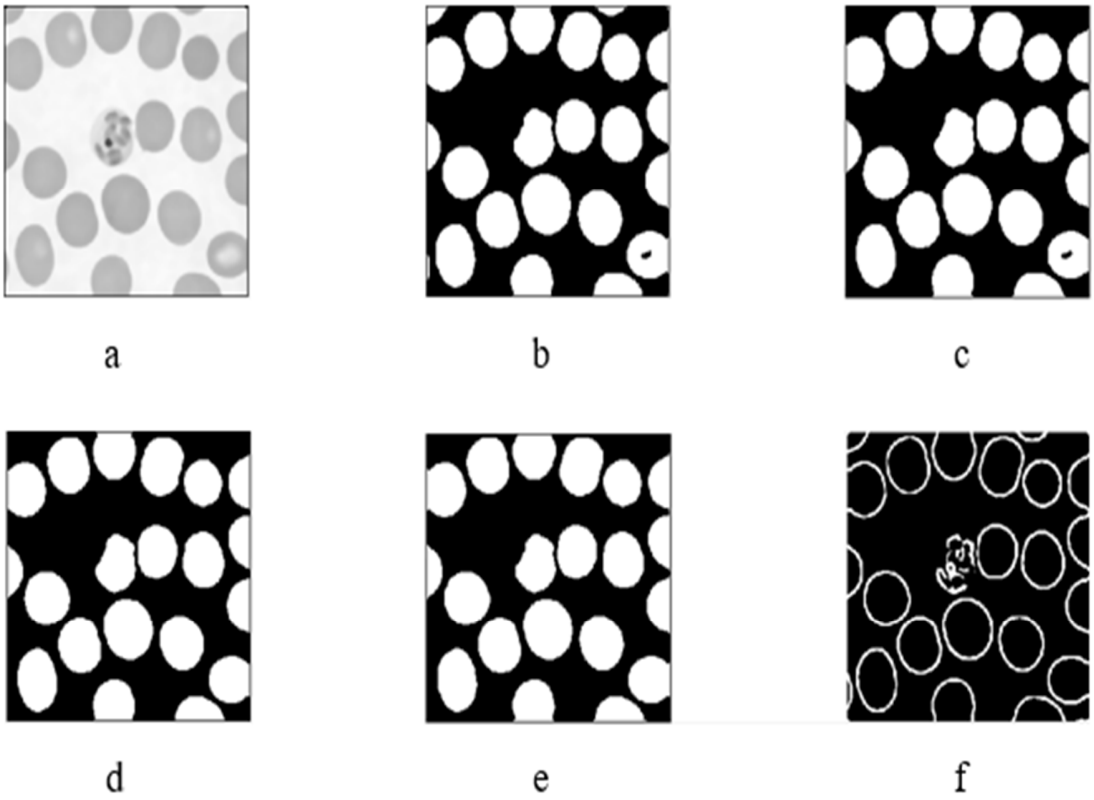

Figure 4-3: Isolation of RBCs from background, a. pre-processed grayscale image, b. converting to binary image, c. removing small objects, d. filling holes, e. labeling objects, f. edge detection.

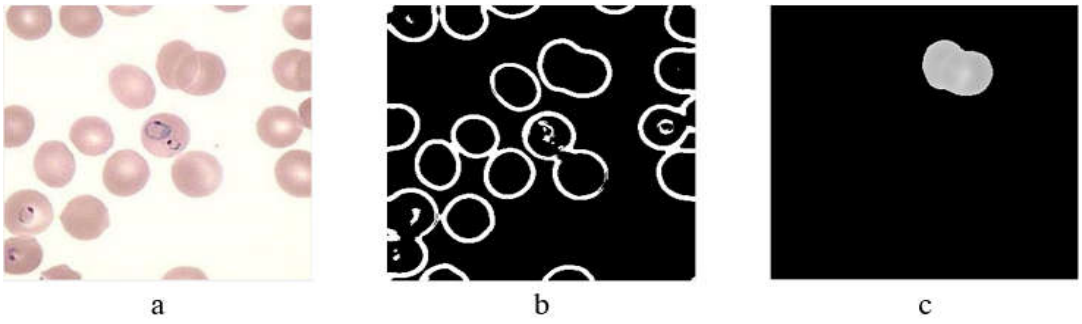

Figure 4-4: overlapped RBCs, a. raw CDC image, b. edge detection, c. overlapped RBCs.

4.3.2 Results of RBCs extraction

RBCs extraction is applied to CDC image and the output results are presented in figure 4-5.

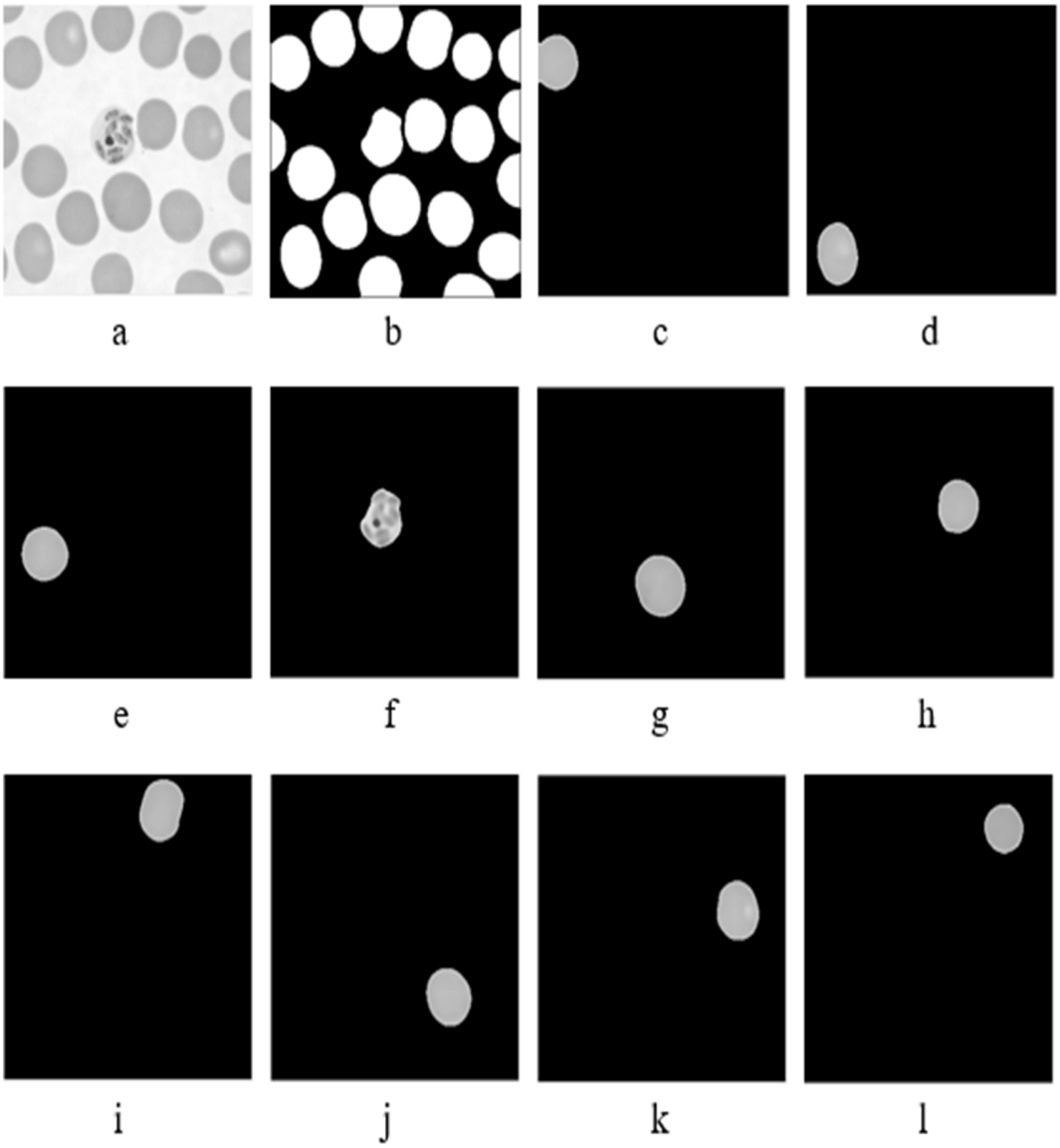

Figure 4-5: RBCs extraction, a. the grayscale image, b. the labeled image, c. to l. - extracted objects (RBCs).

4.4 Graphical user interface (GUI)

A graphical user interface (GUI) is a pictorial interface to a program. A good GUI can make programs easier to use by providing them with a consistent appearance and with intuitive controls like pushbuttons, list boxes, sliders, menus, and so forth. The GUI should behave in an understandable and

predictable manner, so that a user knows what to expect when he or she performs an action.

Figure 4-6 and Figure 4-7 show the GUI components of this developed system.

(1) Is button used to choose image.
(2) Is where the selected image shown.
(3) Is the button used to run code for malaria parasite.
(4) Is a Message describe the selected image either infected or non infected.

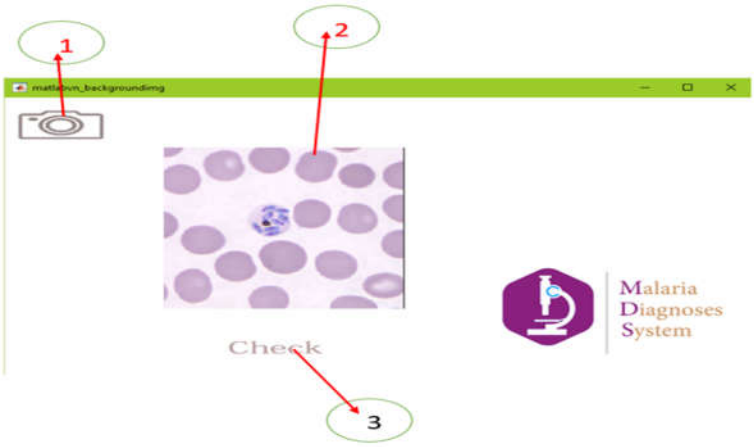

Figure 4-6: GUI before run the algorithm.

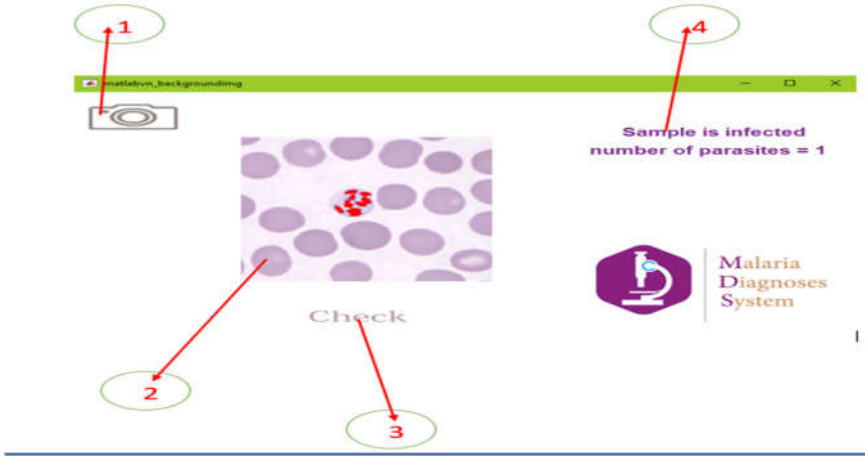

Figure 4-7: GUI after run the algorithm.

4.5 Results for Features Extraction

The feature extraction algorithm is applied to CDC image, the image contains a total of 20RBCs and one infected RBC. A sample of the results of Features Extraction is given in table 4-1.

Table 4-1: sample of extracted features.

RBC number	Threshold >130	Skewness	Variation	Normal/ Up-Normal
1	0	2.77989	64.23655	Normal
2	0	2.32404	104.1066	Normal
3	0	1.998603	67.92763	Normal
4	0	2.495626	74.59135	Normal
5	0	1.591345	85.35314	Normal
6	0	2.675091	77.51536	Normal
7	0	2.90013	71.85598	Normal
8	0	2.783095	52.22435	Normal
9	92	-0.9435	1034.293	UP-Normal
10	0	2.535043	81.23054	Normal
11	0	2.484983	84.73054	Normal
12	0	2.432689	78.48586	Normal
13	0	2.521222	61.39612	Normal
14	0	2.53286	64.92074	Normal
15	0	2.018177	68.2876	Normal
16	0	2.311986	151.8075	Normal
17	0	0.82716	245.2989	Normal
18	0	2.597855	80.44302	Normal
19	0	2.464794	100.183	Normal

4.6 Results of image classification

Features that selected to represent the data as normal and abnormal. For classification both of developed algorithm and ANN classification techniques were used and the accuracy and performance of each of them were calculated.

4.6.1 Result for the developed algorithm

The algorithm is applied to CDC image randomly and the results are depicted in figure 4-8.

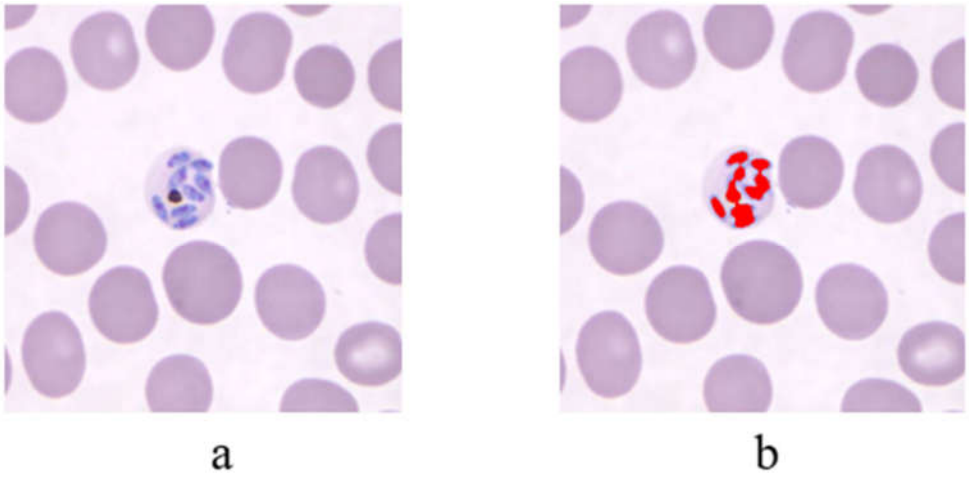

Figure 4-8: Classification results, a. original image, b. detection using developed algorithm.

The massages which illustrated in figure 4-9 is final result of the classification step.

Figure 4-9: Output messages a. Normal, b. Up-normal.

4.6.2 Artificial Neural Network (ANN) Results

In ANN many windows and graphs appear when running it which clarify the architecture of the network that was created. Two windows are opening immediately after running the created network the first one is the neural

network training which illustrates the neural network architecture, algorithm that used, progress, and plots that can show. The next window that will next appears is the pattern recognition neural network architecture, in this case there are two input set to get two output set also (normal and abnormal), and the hidden layers were set to be 20 layers as recommended in chapter Three. Then from the neural network window four figures were plotted by checking in their icon which are: performance, training state, error histogram, and confusion matrix. Figure 4.10 shows Neural Network Architecture.

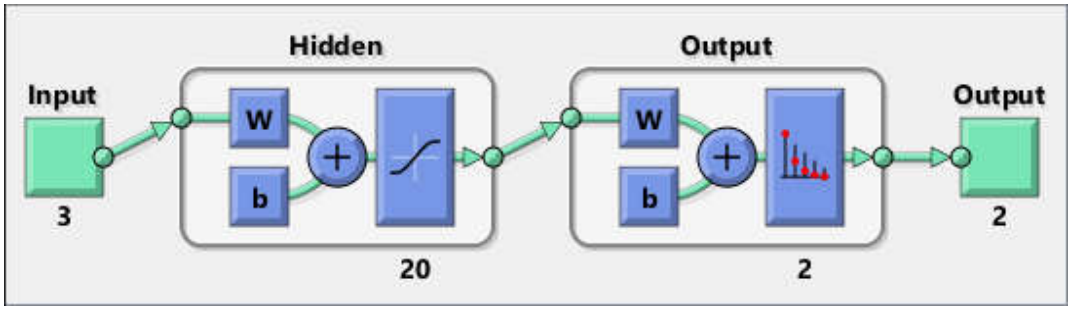

Figure 4.10: Neural Network Architecture.

4.6.3 Performance Evaluation of Classification

The performance of both classification methods was calculated using the below statistical terms:

A true positive (TP): Results when a test indicates a positive status when the true status is also positive.

A true negative (TN): Results when a test indicates a negative status when the true status is also negative.

A false positive (FP): Results when a test indicates a positive status when the true status is negative.

A false negative (FN): Results when a test indicates a negative status when the true status is positive.

The sensitivity of a test (or symptom): Is the probability of a positive test result (or presence of the symptom) given the presence of the disease.

$$\text{Sensitivity} = \frac{\text{TP}}{\text{TP + FP}} \times 100 \quad (4.1)$$

The specificity of a test (or symptom): Is the probability of a negative test result (or absence of the symptom) given the absence of the disease.

$$\text{specificiity} = \frac{\text{TN}}{\text{TN + FN}} \times 100 \quad (4.2)$$

Accuracy: Accuracy is how close a measured value is to the actual (true) value.

$$\text{Accuracy} = \frac{\text{Number of Correct Data}}{\text{Number of All Data}} \times 100 = \frac{\text{TP +TN}}{\text{TOTAL}} \times 100 \quad (4.3)$$

Table 4-2: performance evaluation of ANN classification.

Results \ Status	Abnormal	Normal	Total
Positive	**46** (TP)	**2** (FN)	**48**
Negative	**0** (FP)	**576** (TN)	**576**
Total	**46**	**578**	**624**

From table 4-2, **TP = 46, FP = 0, FN = 2, TN =576, Total = 624**, and by applying in the above equation:

$$\text{Sensitivity} = \frac{\mathbf{46}}{\mathbf{46+0}} \times \mathbf{100} = \mathbf{100}\ \%$$

$$\text{specificiity} = \frac{\mathbf{576}}{\mathbf{576+2}} \times \mathbf{100} = \mathbf{99.65}\ \%$$

$$\text{Accuracy} = \frac{\mathbf{46+576}}{\mathbf{46+576+0+2}} \times \mathbf{100} = \mathbf{99.68}\ \%$$

It is clear that from the performance evaluation of the ANN the accuracy is (99.68 %) which means artificial neural network gives more accurate result for the data used in this study. Therefore, for final classification step ANN classification method was chosen and applied in the proposed system.