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Design of Automated Scanning Mechanism for Microscopic Biopsy

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Abstract: *Microscopic biopsy image analysis is an essential technique for cancer detection. The main challenge in this procedure is due to the manual identification, there is a high risk in missing to identify the cells. In order to alleviate this challenge, an automated scanning mechanism for microscopic biopsy is proposed. Firstly, the stage movement of the microscope is controlled by using the motorized mechanism. Then, using sensors at the extreme points of both X-Y axis of the microscope stage to automate the scanning of slide by detecting the edge of the stage. Finally, the camera connected through the eye piece from the lens of the microscope captures a number of images of the cells from the specimen. Using the images captured, the cancer cells are identified by segmenting nucleus and cytoplasm using watershed algorithm and optimal thresholding. The performance of this proposed system is evaluated by obtaining a number of images of the cells and also tested by multiple specimen sample without missing any cell in an automated manner, neither using manual tuning of knobs nor using the remote control.*

Index term *– microscope, stepper motor, limit switch, camera, segmentation, watershed algorithm, optimal thresholding.*

I. INTRODUCTION

A biopsy is a medical procedure, during which a small sample of tissue is removed from a part of the body. The sample of tissue is then examined under the microscope to look for abnormal cells. Sometimes the sample is tested in other ways. Most accurate method used by pathologists is the histopathology biopsy images, that is, the examination of microscopic tissue structure of the patient. Histopathology is the study of symptoms and indications of the disease using the microscopic biopsy images. Thus biopsy image analysis is a vital technique for cancer detection. A biopsy is the only sure way to diagnosis most cancers. Imaging tests like CT scans and X-rays can help identify areas of concerns, but they can't differentiate between cancerous and noncancerous cells. Chih-Chung et al. [1] designed a concentric filter device and an immune-binding method to create a significant size difference of target cells and increased the efficiency of seperation to identify rare cells. To create a significance size difference between targeted rare cells and normal blood cells, an immune binding method that utilizes PS beads coated with Anti-human EpCAM antibody is used to target and to enlarge MCF-7 cells. This method cannot provide the accurate detection of target cells since there are chances of clogging, deformation of cells and not only that, target cells cannot only be identified by sizes.

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Robert A.A. Campbell et al. [2] proposed a set-up which has a 3 axis motorized stage and a handheld control-pad which allows the user to direct the stage motion. It allows fixed-size motion steps by the direction pad. It provides a storage for up to four different stage positions and return to these positions. This system needs to have manual care since it uses handheld control-pad and only four positions of the slide can be stored. Fuyong Xing et al. [3] proposed a framework for nucleus segmentation with shape preservation. It uses a deep convolution neural network (CNN). The CNN model is implemented with the CUDA parallel computing platform, and Matlab is used for the iterative region merging algorithm, sparse shape prior model and local repulsive deformable model and machine with 3.5 GHz Intel Xeon CPU and 128 GB memory. This model is very changeling and complicated and cannot be used in small scale places. Emad A.Mohammed et al. [4] proposed a method to segment normal and CLL lymphocytes into nucleus and cytoplasm using watershed algorithm and optimal thresholding. Boqiang Liu et al. [5] have developed a classifying and diagnostic system for the hematopoietic cells. A morphological gradient is proposed for the segmentation of the nucleated hematopoietic cells.

II.PROPOSED MODEL

Imaging tests like CT scans and X-rays can help identify areas of concerns, but they can't differentiate between cancerous and noncancerous cells. A biopsy is the only sure way to diagnosis most cancers. It is important for doctors to perform biopsy on their patients when symptoms are diagnosed. For this biopsy image analysis is a vital technique for cancer detection. The proposed automated scanning system consists of four sections. The motor setup and the stage setup are used for the automated working of the microscope, whereas the camera setup is used for obtaining the images of the specimen slide, finally the images are segmented and cancer cells are identified.

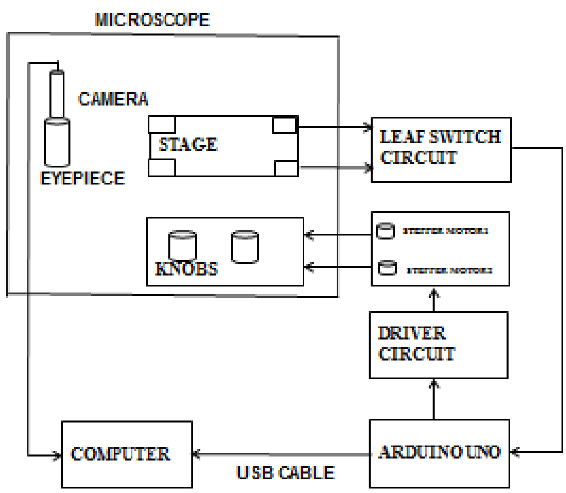

Fig. 1. Block diagram

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A. Motor setup

Here, two stepper motors are used with a driver circuit. These two stepper motors are held in a position by using the stand assembly which consists of two square shaped frames that is placed one above the other for holding the stepper motors. These frames are designed according to the dimensions of the stepper motor that is used foe this system. The setup assembly is fixed over the graduated locator markings of the microscope stage, which is in motion when the upper knob (or upper pulley) is rotated.

Fig. 2. Motor setup

Fig. 2, shows the motor setup where the pulleys are fixed over the control knobs (lower knob and upper knob) of the microscope stage which is connected to the gear of the stepper motor using belts. Pulley systems are used when there is a need to transmit rotary motion. When the motor is turned on it revolves the driver pulley wheel. The belt causes the driven pulley wheel to rotate as well, winding out the rope. This rotation movement causes the control knobs (lower knob and upper knob) to produce movement without manual tuning. This motor setup provides the automated movement of the control knobs.

B. Microscope stage setup

The control knobs are controlled automatically because of the motor setup. This causes the slide to move along the two graduated locator markings (scales X and Y). When the slide reaches the extreme end point of the two graduated locator markings, it causes a disturbance in the functionality of the motor setup. Thus to avoid this, the microscope stage is setup by using limit switches. Four limit switches are positioned such that, when the graduated locator markings reach their end points, it comes in contact with the switches. In return, the processor identifies that the graduated locator markings have reached their end points thus the stepper motor stops functioning.

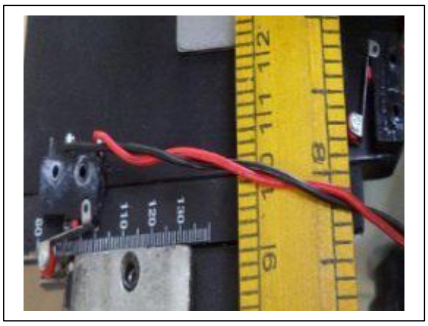

Fig. 3. Microscope stage setup

C. Camera setup

Here, in this setup a celestron digital microscope imager is used to capture the images of the specimen sample from the microscopic slide. This imager replaces the eyepiece of the microscope so that the specimen sample can be viewed comfortably on the computer screen.

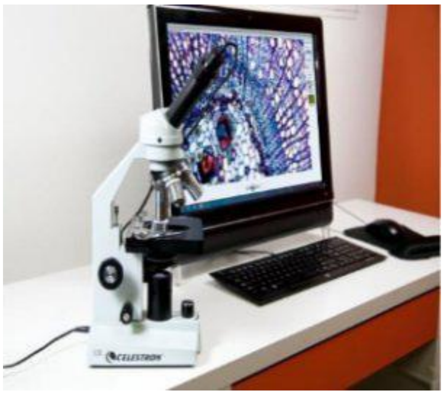

Fig. 4. Camera setup

D. Detection of cancer

The images captured are used to detect the cancer cells. It uses a simple method of grayscale thresholding called Otsu's approach. It is used to segment the nucleus and the cytoplasm depending on the fact that the nucleus appears darker than the surrounding components. The algorithm reads the color blood film image and converts it into grayscale. Then it computes the optimal thresholding of the gray image. This resulted image is then converted to binary image using the computed threshold value. Further, the canny edge detector is applied on the thresholded image. Morphological operations such as dilation, hole filling, erosion are done to remove the noise resulting from thresholding and edge detection.

1. Nucleus Segmentation

For nucleus segmentation, after performing morphological operations, the scattered regions other than the nucleus are removed. This results in the creation of a mask which only contains the nucleus.

2. Cell Segmentation

After performing morphological operations, chebyshev distance transform is applied. Then watershed algorithm is applied and a mask is created for the central connected component.

3. Cytoplasm Segmentation

After obtaining the nucleus mask and cell mask, the cytoplasm mask can easily be obtained by subtracting the nucleus and cell mask.

Thus by obtaining the masks, nucleus and cytoplasm can easily be segmented. There is a suspicion of cancer when the nucleus is irregular in shape and the size of the nucleus is larger than the size of cytoplasm.

III. RESULT

The performance of this proposed system is evaluated by obtaining a number of images of the cells and identifying the cancer and non-cancerous cells. It is also tested by using multiple specimen sample. Images are obtained without missing any cell in an automated manner, neither using manual tuning of knobs nor using the remote control.

Fig. 5. Capturing the images of cells

IV. CONCLUSION AND FUTURE WORK

With the automated scanning mechanism, it is easy for the doctors to scan the entire specimen slide without missing any cell and identify cancer. In this setup there is no need for manual tuning and the images are obtained using the camera which is viewed in the computer. The accuracy of this system is also relevant which makes the diagnosis procedure easier without any complication. Further, to enhance the accuracy of the segmentation, local thresholding must be used to overcome the Otsu's assumption.

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