Towards a Cost-efficient Digital Microscopy for Pathological Analysis

Supervisor: Md. Shahriar Karim

By Md. Shihab Uddin, Akiba Amrin, Ebna Saykot Rayhan

Department of Electrical Engineering and Computer Science, North South University

Problem

- A significant challenge to ensure quality health facilities for all the people in any developing country is its scarce resources such as expert hands and available funds for the expensive equipment.
- For instance, a simple calculation reveals that to equip approximately 18000 community clinics in Bangladesh with a traditional lab microscope (of about 15000 Taka per unit) requires around 27 crores, in addition to the cost of recruiting expert hands.

Proposed Solution

- This project addresses the problems mentioned above by developing a low-cost digital microscopy concept and necessary digital interfaces to perform pathology image analysis.
  - To reduce the cost, the proposed system considers Foldscope[1], a cheap, portable microscope to take images of the biological samples.
  - The system requires minimum expertise to use as it integrates standard smartphone available in the market and provides the built-in image analysis module needed.
- The efficacy of the system is demonstrated through bacterial species classification and quantification. However, the framework is extendable to other diagnosis purposes, such as blood cell detection and quantification, etc.

Methodology

- The Deep Learning Classification Model and Image Processing Colony Counting Algorithm are deployed in an Amazon EC2 Ubuntu server.
- The services are connected to a web app interface using Django web framework that can be accessed from any web browser.
- User can upload images from a device through the web application with an integrated microscope and get the results.

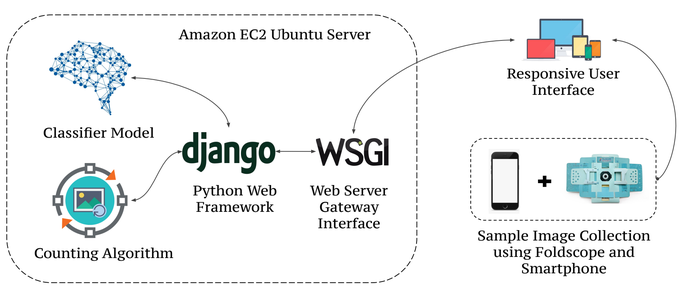

Fig. 1: Overview of the developed pathological analysis process

Low-cost Microscopy

- Foldscope is a paper microscope, designed to give optical quality similar to conventional research microscopes.
- A Foldscope can magnify a sample up to 2000x based on the availability of additional lens.
- Image enhancement techniques were implemented to increase the quality of the captured image.

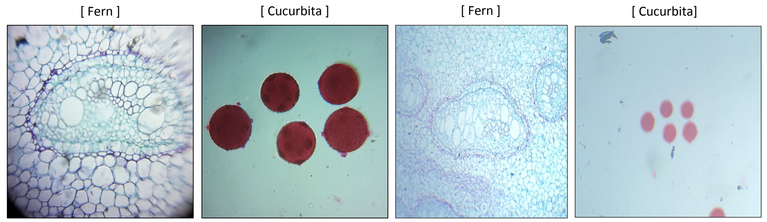

Fig. 2: Comparison of images taken by Foldscope and traditional lab microscope.

Test Case: Bacterial Colony Count

- For accurate analysis, the raw image is pre-processed using Pyramid Mean Shift Filter and converted to grayscale.
- Euclidean Distance of each pixel is computed from nearest zero pixel to generate distance map for connected component analysis.
- The watershed algorithm was employed for merged colony detection and separation.

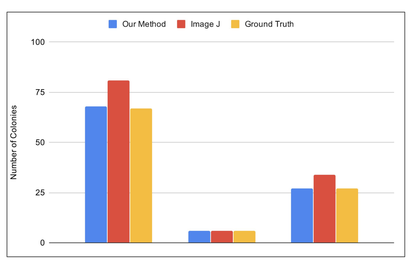

Fig. 3: Comparisons of our colony counting algorithm with traditional methods.

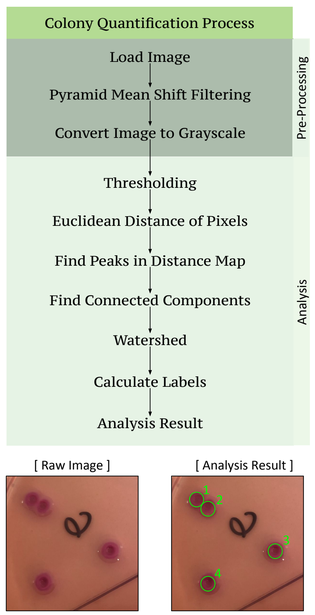

Fig. 4: Flowchart of colony quantification.

Test Case: Bacteria Species Classification

- The prevailing classification model[2] had 97% accuracy using 660 images of 33 different bacteria species.
- In the proposed method, dataset was further optimized that minimizes the validation loss by about 31%. Also, the accuracy of the classifier increases by about 2.03%.

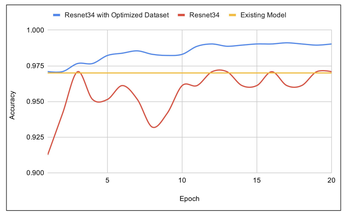

Fig. 5: Accuracy curve of different deep learning models

Results

- The developed deep learning model can classify different bacteria species with 99.03% accuracy. The method does not experience any overfitting or underfitting issues.
- Image processing technique can quantify bacterial colony formed on agar plate with acceptable accuracy.
- A web application is developed, combining all these algorithms together to provide a one-stop solution for the quantification of bacterial contamination.

Future Works

- The future goal for this project is to develop a lightweight, offline smartphone application to overcome the dependency of a stable internet connection.

Acknowledgement

Heartfelt thanks of gratitude to the person who backed us up in every difficulty that we faced with this project, supported us with his invaluable assistance, our instructor Md. Shahriar Karim. Thanks to NSU Genome Research Center for some of the discussions.

References

[1] James S. Cybulski James Clements and Manu Prakash. 2014. Foldscope: Origami-Based Paper Microscope. (June 2014). https://doi.org/10.1371/journal.pone.0098781

[2] Bartosz Zieliński, Anna Plichta, Krzysztof Misztal, Przemysław Spurek,Monika Brzychczy-Włoch, and Dorota Ochońska. 2017. Deep learning approach to bacterial colony classification.PloS one12, 9 (2017),e0184554.

[3] Geissmann Q . 2013. OpenCFU, a New Free and Open-Source Software to Count Cell Colonies and Other Circular Objects. PLOS ONE 8(2): e54072. https://doi.org/10.1371/journal.pone.0054072