Digital Image Processing of Holographic Images for Cancer Cells Detection

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Introduction

Figure 1: IMECs' Cell sorter chip.

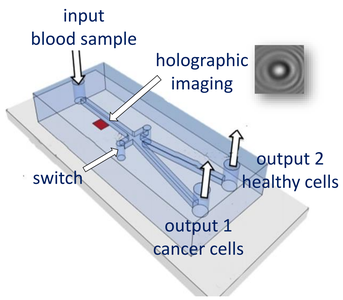

Figure 2: IMECs' Cell sorter setup.

In this thesis, we contributed in IMEC Cell Sorter's Chip research. The chip receives a blood sample ,containing of cancer and blood cells, and aims to filter out the cancer cells. The chip used holographic image processing techniques to detect and define the type of each cell.
The chip aims to prevent cancer metastasis by filtering out the cancer cells for the blood of the patient.

Goals

In the context of this thesis, we received holographic images of White Blood Cells; granulocytes, monocytes and t-lymphocytes. We goal to process them and to define their cell type, while achieving the following goals;

- Implement a metric that selects the sharpest reconstruction among the reconstructions of a holographic image in different optical depths.
- Select a classifier with high and accurate classification results.

Examined White Blood Cells

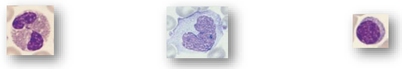

Figure 3: The three different types of White Blood Cells that we used in this thesis as seen by a microscope; granulocyte, monocyte and t-lymphocyte (from left to right).

Image Dataset

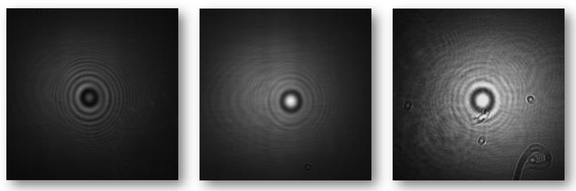

Figure 4: Holographic image dataset; granulocyte, monocyte and t-lymphocyte (from left to right). (2048 x 2048 pixel resolution)

Algorithm overview

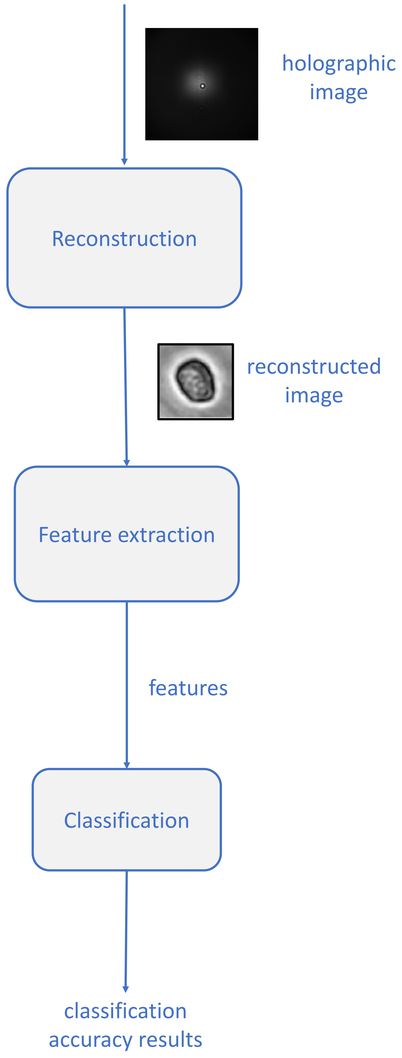

Figure 5: The algorithm is divided into three parts; reconstruction, feature extraction and classification

Pseudocode

```
For i={granulocytes, monocytes, t-lymphocytes}
   Reconstruction(holographic images of i)
End
For i= {granulocytes, monocytes, t-lymphocytes}
   Feature Extraction(reconstructed images of i)
End
Classification
```

1st part: Reconstruction

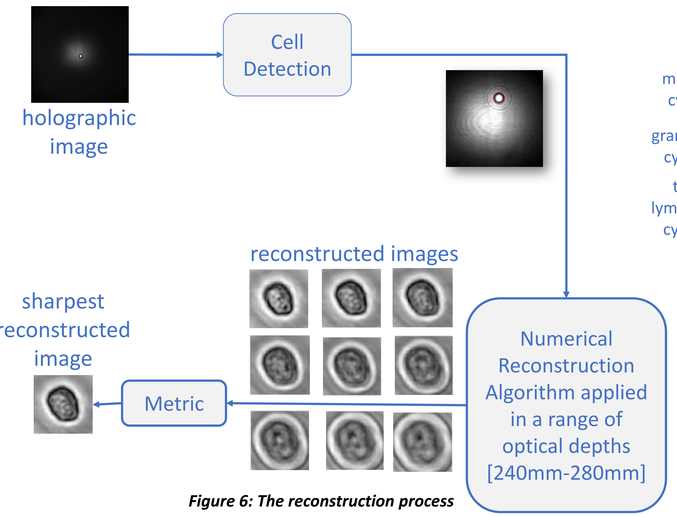

Figure 6: The reconstruction process

2nd part: Feature extraction

Extracting features from the selected from the metric reconstructed image. The features are the following:

- cell size
- cell color
- deviation of cell colors
- cell gradient
- core size
- area ratio,
- core gradient
- granule size

3rd part: Classification

For the Classification we used 10-fold cross validation and we tried the following classifiers:

- Random Forest
- Support Vector Machines
- Artificial Neural Networks

Experiments & Results: 1st experiment

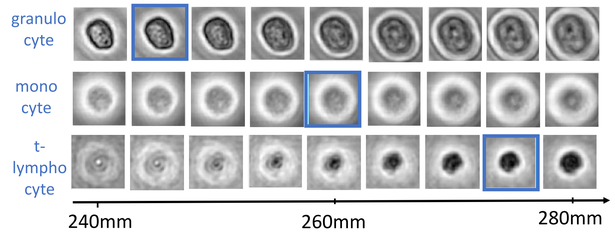

Figure 7: The metric selects the sharpest reconstructed image

Classifiers \ Percentages	Overall accuracy (%)	Precision (%)		Recall (%)	
Random Forest	91.8	1	93.8	1	90.1
		2	91.5	2	88.6
		3	90.7	3	94.9
Support Vector Machines	89.2	1	93.7	1	82.2
		2	89.4	2	87.6
		3	86.6	3	95
Artificial Neural Networks	91.5	1	92.9	1	91.4
		2	90.8	2	89.4
		3	91.1	3	92.9

Table 1: The Classification Results of the 1st experiment
1: granulocytes (557 images) 2: monocytes (483 images) 3: t-lymphocytes (800 images)

Experiments & Results: 2nd experiment

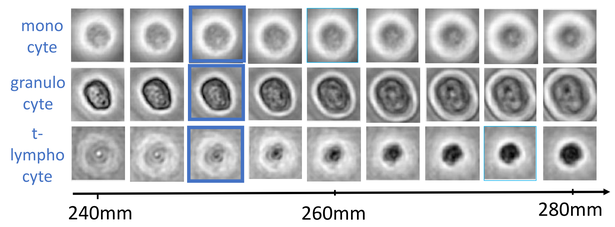

Figure 8: Metric is not used, the reconstruction with optical depth equal to 250mm is selected

Classifiers \ Percentages	Overall accuracy (%)	Precision (%)		Recall (%)	
Random Forest	**96.1**	1	95.2	1	93
		2	96.4	2	98.4
		3	96.8	3	92.1
Support Vector Machines	93.6	1	91.6	1	90.1
		2	91.2	2	96.9
		3	96.5	3	93.7
Artificial Neural Networks	95.2	1	94.2	1	92.3
		2	93.9	2	98
		3	96.7	3	93

Table 2: The Classification Results of the 2nd experiment
1: granulocytes (557 images) 2: monocytes (483 images) 3: t-lymphocytes (800 images)

Conclusions

In the first experiment, we used the metric that we proposed for selecting the optical depth that produces the sharpest reconstruction from raw holographic data. The technique of using of such a metric is proposed in the related literature. However, in the second and the third experiment, we didn't use this metric and instead we selected one specific optical depth, which corresponds to a reconstruction which is not the sharpest one. The classification results were higher in the second experiment comparing to the first one. The higher accuracy was 96.1% and achieved from the Random Forest Classifier. This means that without using a metric which selects the sharpest reconstruction, which is a method proposed from the literature, we have higher classification results.

With the use of the metric all the reconstructions resemble visually to a circular cell. Without using the metric, the selected reconstructions are resemble less to each other. So, without the use of the metric, we extract features from images that differ with each other and its easier to extract discriminative features from the reconstructions, which lead to higher classification results.

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