Clustering Based Fusion System for Blastomere Localization

By

Shimaa Mohamed Khder Abd EL Mokhtar

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Biomedical Engineering and Systems

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Key Words:
Microscopic images; Automatic localization ; Image processing; Blastomere; IVF

Summary:
Microscopic digital image processing paves the way to deep study and evaluation of blastomere identification and/or localization to provide specific selection for in vitro fertilization (IVF) transfer. The main purpose of this thesis is to develop an automated image processing system which assist embryologists to study and investigate the behavior of developing pre implanted embryos wishing to improve IVF outcomes. The proposed method's objective is calculate the number of blastomeres based on a clustering based fusion system, where the clustering algorithm enhance the results. Experimental results on a dataset of 50 embryo images with various blastomere numbers and sizes confirm that the proposed method identifies blastomeres with average Precision, sensitivity, and Overall Quality of 87.9%, 92.9%, and 82.3%, respectively.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.

I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

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Nomenclature

ART	Assisted Reproductive Technologies
ICM	Inner Cell Mass
ICSI	Intra Cytoplasmic Sperm Injection
IVF	In Vitro Fertilization
TE	Trophectoderm
ZP	Zona Pellucida
CHT	Circular Hough Transform
FSH	Follicle Stimulating Hormone
LH	Luteinizing Hormone
LSCF	Least Square Circle Fitting
CLAHE	Clip Limited Adaptive Histogram Equalization
HE	Histogram Equalization
ICSI	Intracytoplasmic Sperm Injection
IUI	Intrauterine Insemination
CDF	Cumulative Distribution Function

Abstract

Microscopic digital image processing paves the way to deep study and evaluation of blastomere identification and/or localization to provide specific and sensitive selection for in Vitro Fertilization (IVF) transfer. Analyzing the morphology and the morpho-kinetic parameters of the early cleaving embryo improves embryo quality assessment. Cleavage stage spans the first 72 h post-fertilization, in which the embryo is divided into smaller embryonic cells (blastomeres) at specific time-points. However, the obviousness and occlusion of blastomeres and artifacts such as fragmentation make automatic localization of blastomeres using a single embryo image a challenging task.

The main purpose of this thesis is to develop an automated image processing system which assist embryologists to study and investigate the behavior of developing pre implanted embryos wishing to improve IVF outcomes.

The proposed method's objective is to calculate the number of blastomeres based on a clustering based fusion system, where the system is formed of a preprocessing module, including the noise reduction using several filters including Gaussian and median filters were employed in parallel, followed by an enhancement step using clip limited histogram equalization algorithm. The second module in the proposed system is based on effective edge detector, which was then employed to precisely determine the boundaries of blastomeres. Blastomeres extraction was employed using circular Hough transform. Finally, clustering based on decision fusion of different systems has been investigated and compared with systems in the literature.

The data set used in this study was collected from international Islamic center for population studies and research, Al-Azhar University, Cairo, Egypt. The data is formed of 15 and 35 embryo microscopic images, with various blastomere numbers and sizes forming a total number of 68 blastomeres for 48h, and 35 with various blastomere numbers and sizes forming a total number of 275 blastomeres for 72 h post-fertilization, respectively. The detection accuracy reached 93%, whereas the false detection reached 9% in case of 48h post-fertilization embryo images Whereas, the performance decreased in case 72h post-fertilization embryo microscopic images to reach 84%, detection accuracy and 7% for the false detection reached due to the increase of the number of blastomeres and the overlapping of them. The proposed results are considered promising compared to the studies in comparison.

Chapter 1 **: Introduction**

Overview

This chapter provide an accurate identification for the purpose of this Thesis. Firstly, an overview of the Assisted Reproductive technology (ART) and in vitro fertilization (IVF) treatment are proposed, which lead to the importance of the selection suitable backup embryos. After that, the different embryo grading systems is described, followed by the objective of this thesis. In the end, description of the contents of each chapter will be provided.

During the last few years, Microscopic digital image processing has experienced a dramatic expansion in biomedical engineering field and clinical medicine compared with other fields. Due to the advances in microscope, providing high resolution digital images, Digital image processing and decision support systems were introduced to provide automated systems and software that reduce the overall cost by saving a significant amount of expert times as well as enhance the accuracy and decrease the human error in diagnosis[1].

Such systems are required in so many fields such as medicine, biological research, test tube baby, cancer research, drug testing, which requires few analysis modules of the blood cells like cell segmentation, classification and cell counting, investigating the sub-cellular structures and studies on living cells. For example, Vromen et al. [2] proposed a segmentation method for red blood cells, where other studies such as Bikhet et al. [3] were concerned with the segmentation of the white blood cells. Another track for blood diseases classification such as malaria that has been studied by Ross et al. [4]

This thesis is related to the development and implementation of automatic system that automatically localize blastomeres of electronic microscopic images in order to determine which of them are appropriate for re implantation. These blastomeres are the result of the combination between woman’s ovum and the man's sperms in the fertilization lab. Embryos will be then formed from these fertilized ova. Accurate grading of these embryos will keep the mother and infant from obtaining numerous medical issues that may happen because of the excess of one embryo implantation.