RESEARCH PROPOSAL

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Time period: 6-month research + 1-month language.

Title:

Investigating human embryonic development through deep learning techniques (Transformers/Generative models) for embryo selection in In Vitro Fertilization (IVF).

Keywords:

Image processing, deep learning, embryo selection, gene expression, morphological quality, explainable computer vision analysis, transformers.

Overview:

In Vitro Fertilization (IVF) is a widely used assisted reproductive technology, which involves the selection of the best quality embryo for implantation. The selection process is subjective, and relies heavily on morphological criteria, leading to lower success rates. Recent studies have proposed the use of machine learning algorithms and deep learning techniques to improve embryo selection based on gene expression profiles and morphological quality [1]. In this research proposal, we aim to investigate human embryonic development through image processing and deep learning techniques to improve the accuracy of embryo selection in IVF. The proposal can be represented as the flowchart shown below:

Embryo Classification → Embryonic Component Segmentation → Embryo Analysis

Motivation:

The current selection process for embryos in IVF is based on subjective visual assessment and morphological criteria, which is not always accurate. Improving the accuracy of embryo selection can significantly increase the success rates of IVF. Recent studies have shown that machine learning algorithms and deep learning techniques can significantly improve embryo selection [2],[3]. However, these studies focus on either gene expression profiles or morphological quality. Integrating image processing techniques with recent deep learning models such as transformers [4] /generative models [5] can provide a more comprehensive analysis of the embryo's potential for implantation.

Experimental Material and Methods:

1. Collection of embryonic images: We will collect high-resolution images of day 5 embryos at different developmental stages using embryo-scop.The day 5 embryo images will be taken from public repositories.

2. Image pre-processing: We will perform quality control and normalization of the embryonic images to ensure consistency across different samples.
3. Embryo classification [6]: We will use the transformers-based model to classify the embryos based on their morphological quality and select the best-quality blastocysts (Day-5 embryos).
4. Embryonic component segmentation: We will segment the embryonic components at the blastocyst stage [7] from the classified embryos like inner cell mass(ICM), blastocoel(BC), trophectoderm(TE), and zona pellucida(ZP) using probabilistic diffusion models [8].
5. Model evaluation: We will evaluate the performance of the developed model on an independent dataset and compare it with the performance of the existing methods.

Future Scope:

In the proposed research, we will use deep learning models to classify the embryos based on their morphological quality, followed by segmenting the embryonic components and analyzing them using a transformer-based deep learning method. In further research, we can investigate the relationship between embryonic components and gene expression profiles using multi-omics data. This can provide a more comprehensive understanding of the molecular mechanisms underlying early embryonic development and can lead to the identification of new targets for improving embryo selection.

Schedule of Work and Milestones:

- *Month 1-2*: Collection of embryonic images and image pre-processing and embryo classification.
- *Month 2-3*: Embryonic component segmentation.
- *Month 3-4*: Analysis using the transformers.
- *Month 5-6*: Model evaluation month and writing of research paper and submission to a peer-reviewed journal.

Expected Outcomes:

The proposed research is expected to improve the accuracy of embryo selection in IVF and provide insights into the molecular mechanisms underlying early embryonic development. The use of image processing techniques in combination with deep learning models can provide a more comprehensive analysis of the embryo's potential for implantation. The research findings can lead to the identification of novel biomarkers for improving embryo selection and can contribute to the development of personalized medicine in reproductive health.

References:

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