🧬 AI-Powered IVF Embryo Quality Prediction

Abstract

This project presents an **AI-powered embryo quality prediction system** designed to support embryologists in **In Vitro Fertilization (IVF)** treatment. Using a **Convolutional Neural Network (CNN)** enhanced with **Grad-CAM explainability**, the system predicts embryo viability from microscopic images and integrates AI scores with traditional **morphological parameters** (Expansion, ICM, TE). The deployed **Streamlit web app** offers real-time predictions, heatmaps, and PDF/CSV export. The system achieved **83% test accuracy**, showing promise as a clinical decision-support tool under the **AI for Social Good** track.

Problem & Motivation

- IVF success rates remain modest, largely dependent on **embryo selection**.
- Current manual morphological assessment is:
- **Subjective** – prone to inter-observer variability.
- **Time-consuming** – limits scalability in clinics.
- **Moderately predictive** – limited correlation with outcomes.
- Our solution: **AI-driven, explainable, and reproducible embryo assessment**.

Methodology

- **Datasets**: Kaggle embryo and blastocyst datasets (~840 images, imbalanced 85:15).
- **Preprocessing**: Normalization, resizing (224×224), augmentation (rotation, zoom, flip).
- **Model**: Custom CNN (11M parameters) with weighted loss for imbalance.
- **Explainability**: Grad-CAM heatmaps highlight clinically relevant regions (ICM, symmetry, fragmentation).
- **Composite Scoring**:

$$\text{Score} = Expansion + ICM + TE + (AI_{\text{probability}} \times 5)$$

- **Deployment**: Streamlit app with multi-image upload, adjustable threshold, Grad-CAM visualization, and PDF/CSV export.

Results

Metric	Value
Test Accuracy	83.3%

Metric	Value
Precision (Viable)	0.45
Recall (Viable)	0.60
Precision (Non-viable)	0.93
Recall (Non-viable)	0.87
Optimal Threshold	0.48 (F1 = 0.54)

Key Insights - Model focuses on **inner cell mass** and **blastocyst symmetry**. - Grad-CAM aligns with embryologists' visual assessment.

Impact & Clinical Relevance

- **Standardization**: Reduces subjectivity in embryo assessment.
- **Efficiency**: Enables faster evaluation of multiple embryos.
- **Decision Support**: Provides a reproducible second opinion for embryologists.
- **Accessibility**: Scalable to resource-limited fertility clinics.

Limitations & Future Work

- Small, imbalanced dataset → expand with clinical collaborations.
- Static images only → extend to **time-lapse morphokinetics**.
- Binary classification → extend to full **Gardner grading**.
- External validation and clinical trials needed.

Conclusion

This project demonstrates that **AI can enhance IVF embryo assessment**, offering: - **Objective predictions** - **Explainability via Grad-CAM** - **Practical deployment as a web tool**

With further validation and dataset expansion, this system has the potential to **improve IVF success rates globally**, directly aligning with the mission of **AI for Social Good**.

🔗**Live Demo**: [Embryo Score Predictor]