Intelligenza artificiale per le banche degli occhi: un nuovo strumento per la valutazione corneale

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Endothelial Cell Density

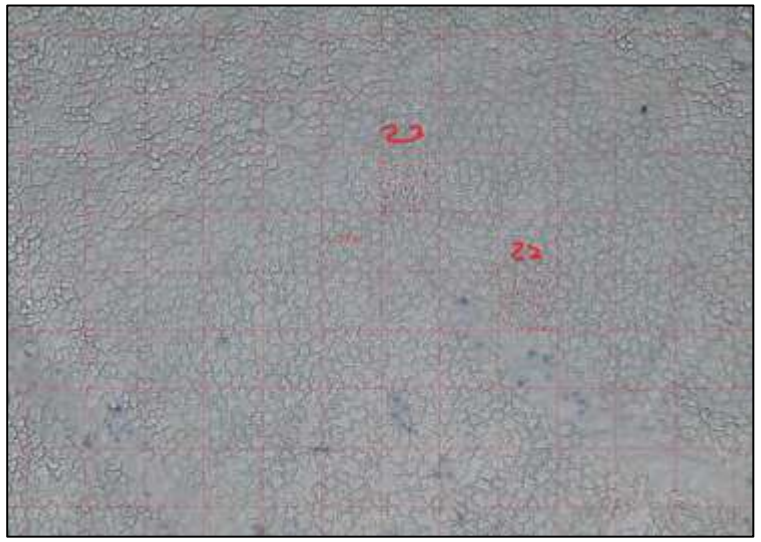
Endothelial Cell density evaluation is a key step to ensure graft quality.

Endothelial Cell Density Evaluation

Endothelial cell density (ECD) is a primary determinant of corneal graft viability. **Low donor ECD is directly associated with reduced graft survival and post-operative corneal edema.**

Manual Cell Count

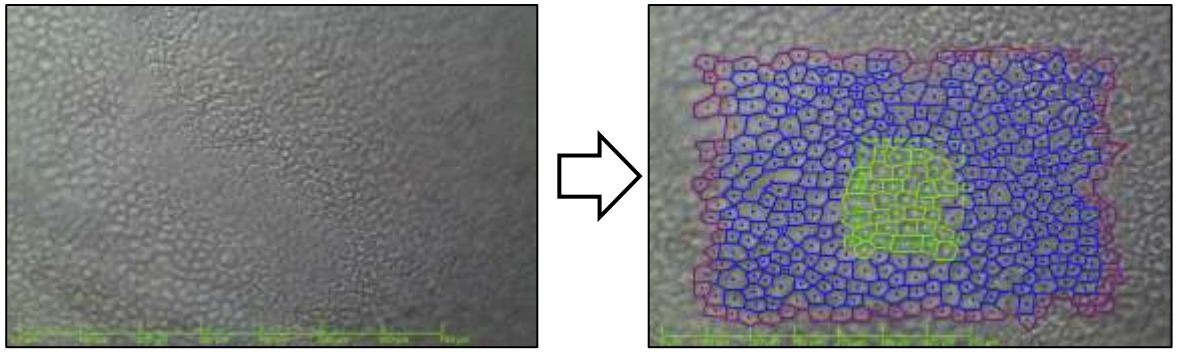
Eye bank technician performs **direct cell counting** via **light microscopy**. Is **always applicable** and **multiple areas** of the endothelial surface **are analyzed**.



Results however **depend on operator experience** and are subject to inter-observer variability.

Automated Software

Dedicated **cell-count software analyzes** light microscopy images to **automatically determine ECD**, reducing manual workload and improving throughput.



Can image a small portion of endothelial surface, not representing the real ECD count, and thus **can be discordant to the operator's** evaluation, without possibility to edit the results. The **analysis algorithms are trained on generic images**, resulting in less than optimal performance **and limited adaptability to the specific cases.**

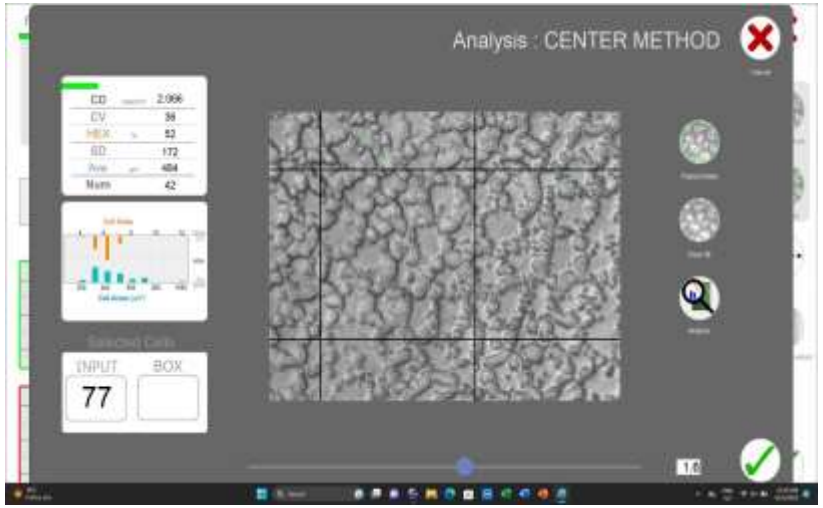
Endothelial Cell Density Evaluation

What we need

- More **accurate data**, **including more images** into analysis

- Possibility to obtain **more comprehensive data**:
  - Endothelial cell mortality
  - Morphological parameters

- **Stronger interaction between eye bank technician and analysis software**



Piaia M. et al. A Novel Hybrid Software-Assisted Method to Evaluate Quantitatively Corneal Endothelium From Light Microscopy Images. 2026

Solution

DEEP-LEARNING BASED AI TOOL

- **More images analyzed** at the same time

- **Evolving system**, the more is used, the more precise.

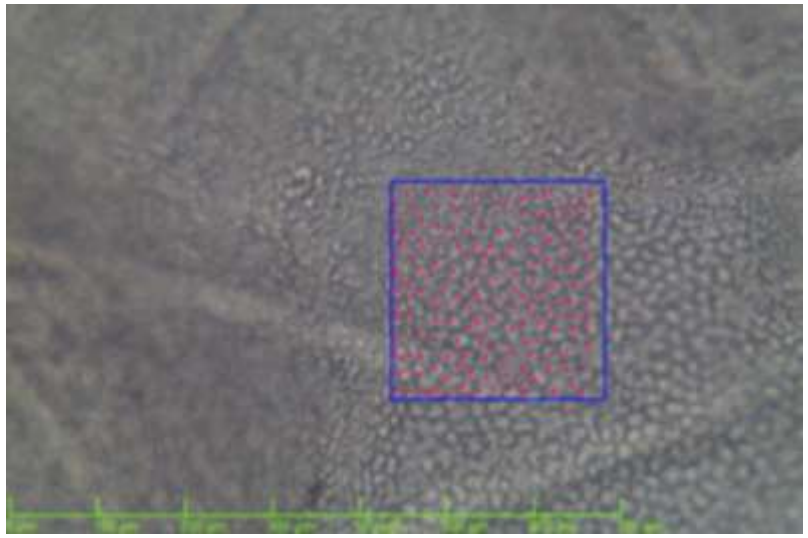
- **Possibility** to **correct and tune the analysis**

- Possibility to **obtain endothelial** cells **mortality and morphology** data

Experimental Design

Collection of **3621 100X images from** human **corneas endothelia** stored at 4°C or in Deswelling medium at 31°C

Light Microscope (LM) **image cell-by-cell manual annotation**



- Done by **one experienced technician**
- **ROI Annotations classification** based on analysis quality (red ,yellow, green)

Creation of a subset of green-annotated **images**, with **2600 ROI** total, **to perform AI training**

Not annotated ROI analysis using trained deep-learning AI model

Comparison between technician counted ECD **and AI counted ECD**

AI-assisted ECD Evaluation

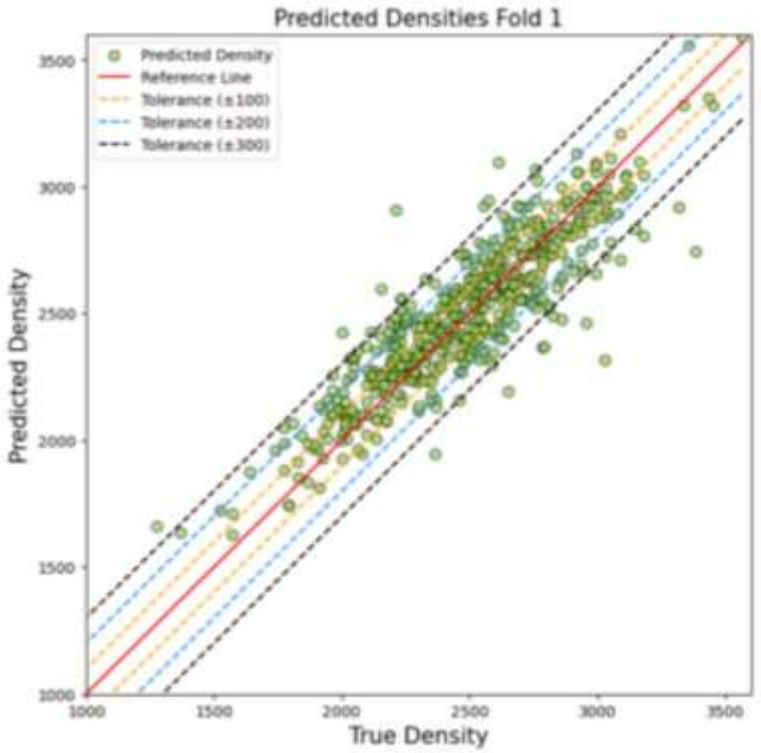
Deep-learning models were benchmarked **against trained eye bank technicians**. Agreement improved substantially with wider tolerance thresholds:

±100 cells/mm²
53.01% agreement

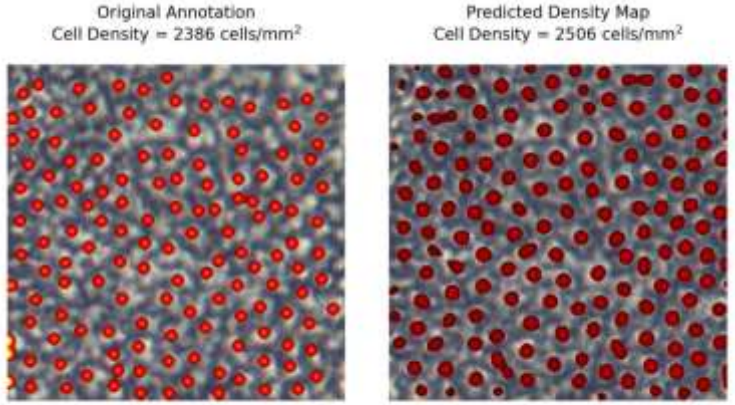
±200 cells/mm²
82.16% agreement

±300 cells/mm²
94.19% agreement

Operator vs. AI — Agreement Rate



At an **accepted tolerance of ±300** cells/mm², **AI achieves over 94% concordance** with expert technicians — supporting its role as a reliable **decision-support tool.**



Polymegathism Evaluation

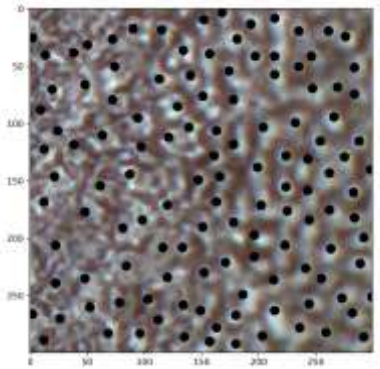
Goal

Develop a deep-learning based **algorithm to estimate the coefficient of variation** of corneal endothelium images, starting from point-like annotations

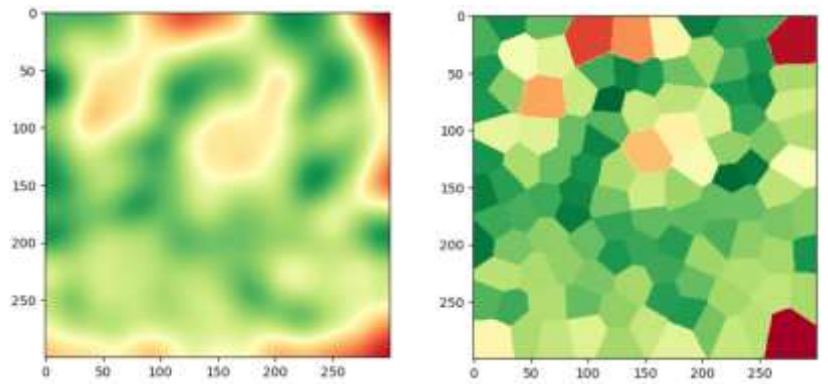
$$CV\ (\%) = \left(\frac{Standard\ deviation}{Mean}\right) \times 100$$

How

Point-wise **cells' annotations do not allow direct polymegethism assessment**



Derived data representations, e.g., **density maps or pseudo-segmentations, may be a suitable visual support** to tissue evaluation and, possibly, a proxy for quantitative estimations



Conclusions and future steps

AI Algorithm showed:

- Promising concordance in ECD determination compared to eye bank technician
- Overtime improvement of the model thanks to deep-learning approach
- To provide augmented visual representations of data (density maps and pseudo-segmentations) as a support for polymegethism assessment

Future Steps

- Endothelial cells mortality evaluation
- Identification and quantification of cell-free and disorganized areas

Thank You for Your Attention

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