Role of Artificial Intelligence in Ophthalmology

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- | Best Eye Hospital |

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Introduction

- Artificial Intelligence (AI):-is a branch of computer science that enables machines to **perform tasks that typically require human intelligence**, such as learning, reasoning, problem-solving, perception, and decision-making.
-



Why ophthalmology is ideal for AI ?

- Ophthalmology relies heavily on **high-resolution imaging**:
- Fundus photographs
- Optical Coherence Tomography (OCT)
- Visual fields
- Corneal topography
- These standardized images are **perfect for training AI models** (especially deep learning).
- **2. Structured and Quantitative Data**
- Most ophthalmic data (e.g., axial length, IOP, RNFL thickness) are **numeric and structured**.



3. Early Digital Adoption

Ophthalmology was among the **first specialties** to adopt:

- Electronic medical records
- Digital imaging
- Automated diagnostic machines

🧠 This **data-rich environment** enables robust AI development and validation.

4. Time-Sensitive Diseases Benefit from AI

Diseases like **glaucoma, diabetic retinopathy, and AMD** can cause **irreversible vision loss** if not caught early.

AI allows:

- **Faster screenings**
- **Early detection in rural/remote settings**
- **Automated triage**

🚑 Improves access and **prevents blindness** with early intervention.

Applications of AI in Ophthalmology

- • Disease detection & diagnosis
- • Risk prediction
- • Image analysis
- • Treatment planning
- • Patient monitoring





AI in Diabetic Retinopathy (DR)

- • AI algorithms (e.g., Google’s DeepMind, IDx-DR)
- • Automated detection from retinal fundus images
- • High sensitivity and specificity
- • FDA-approved tools

AI in Age-related Macular Degeneration (AMD)

- • Optical Coherence Tomography (OCT)-based diagnosis
- • Classification of dry vs wet AMD
- • Predictive analytics for progression

AI in Glaucoma

- • Early detection via optic nerve head analysis
- • Intraocular pressure data and visual field integration
- • Monitoring progression over time

AI in Cataract Detection

- • Slit lamp and fundus imaging analysis
- • Preoperative grading of cataract severity
- • Surgical outcome prediction models

Teleophthalmology & AI

- • Remote screening programs
- • AI-assisted triage and referral
- • Expanding access in rural/underserved areas

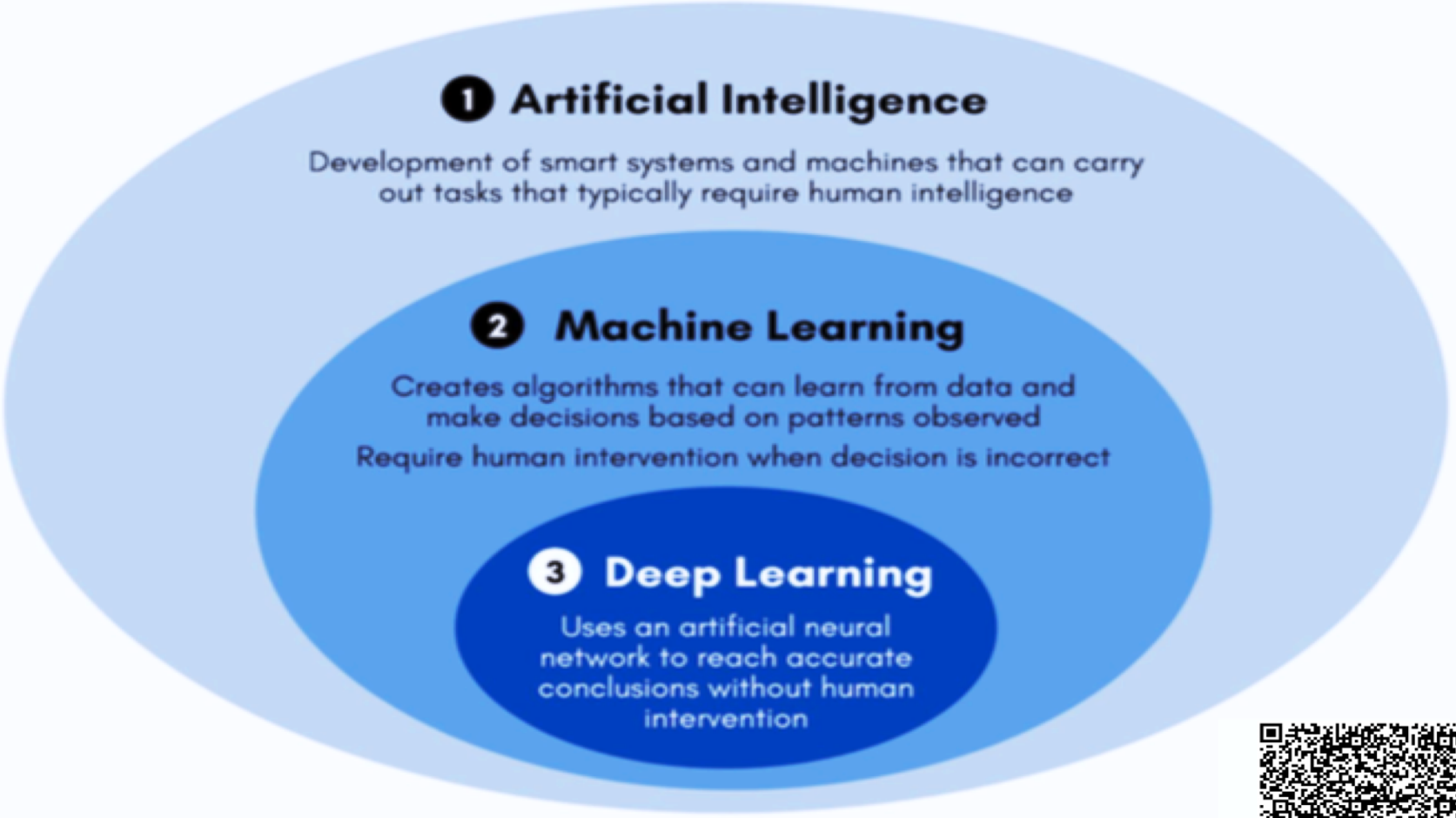
Surgical Assistance & AI

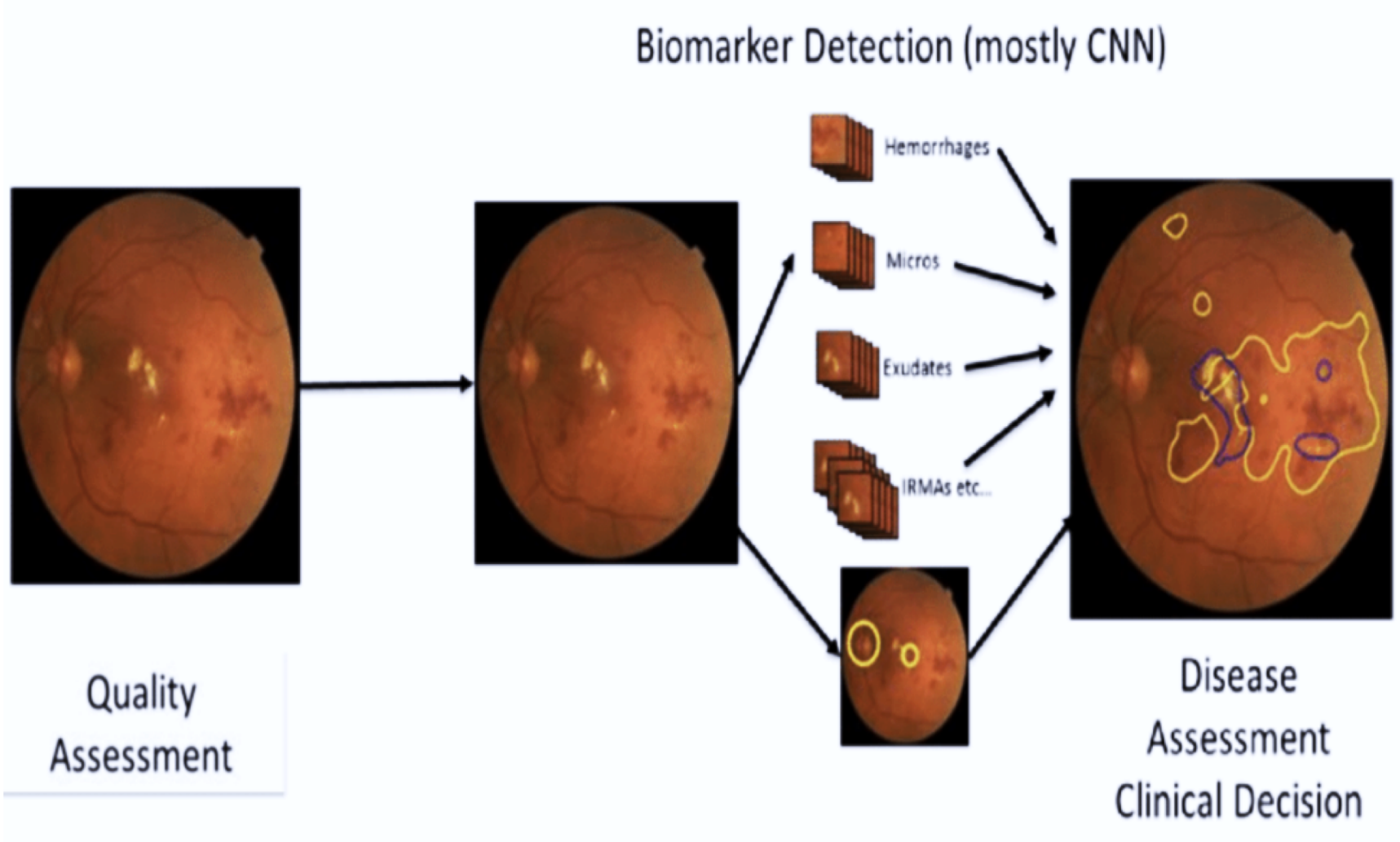
- • Robotic assistance in cataract surgery
- • AI in surgical video analysis for training
- • Real-time feedback and complication prediction

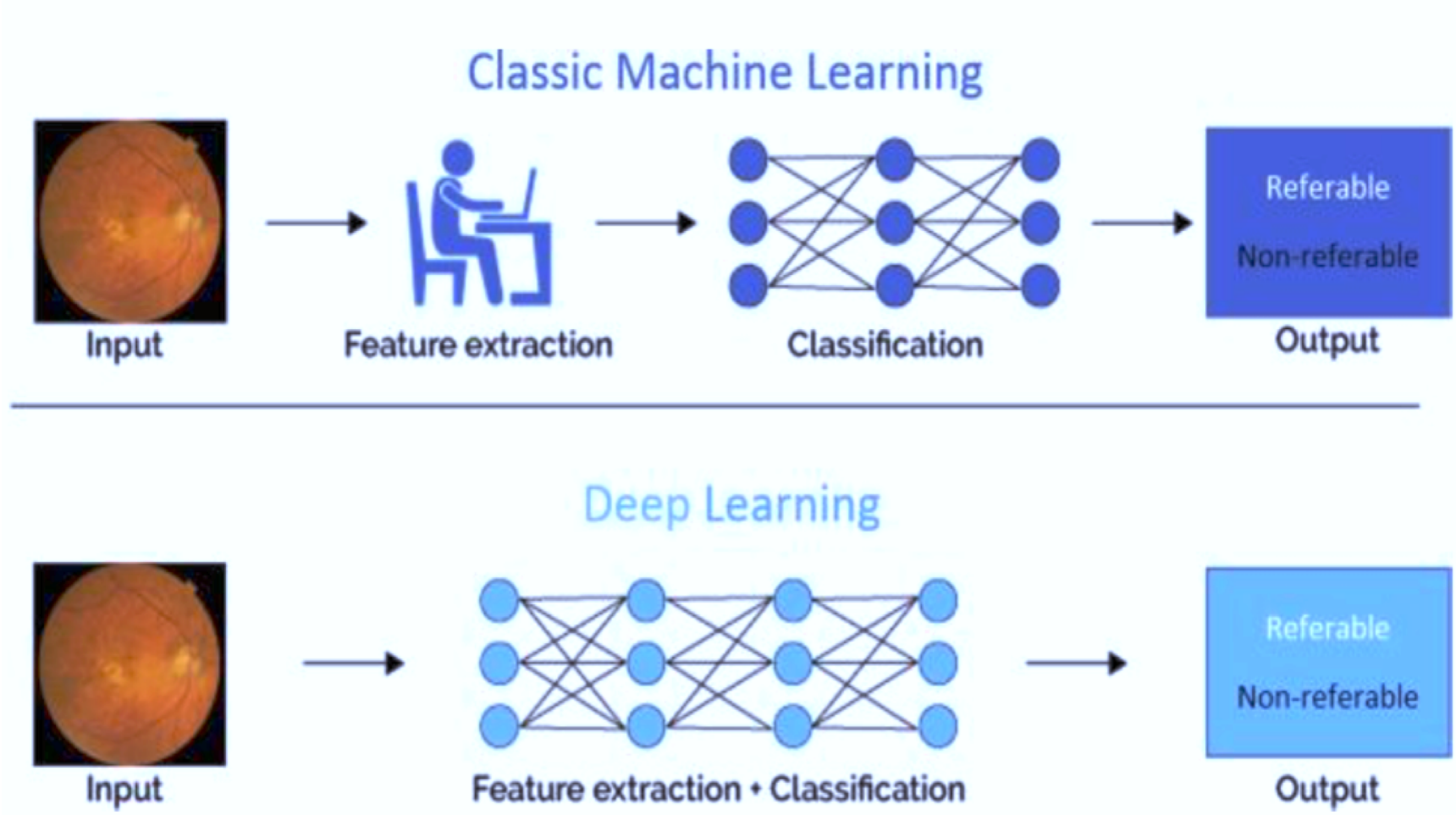
Benefits of AI in Ophthalmology

- • Faster and accurate diagnosis
- • Reduces workload of ophthalmologists
- • Standardized and objective assessments
- • Scalable screening programs

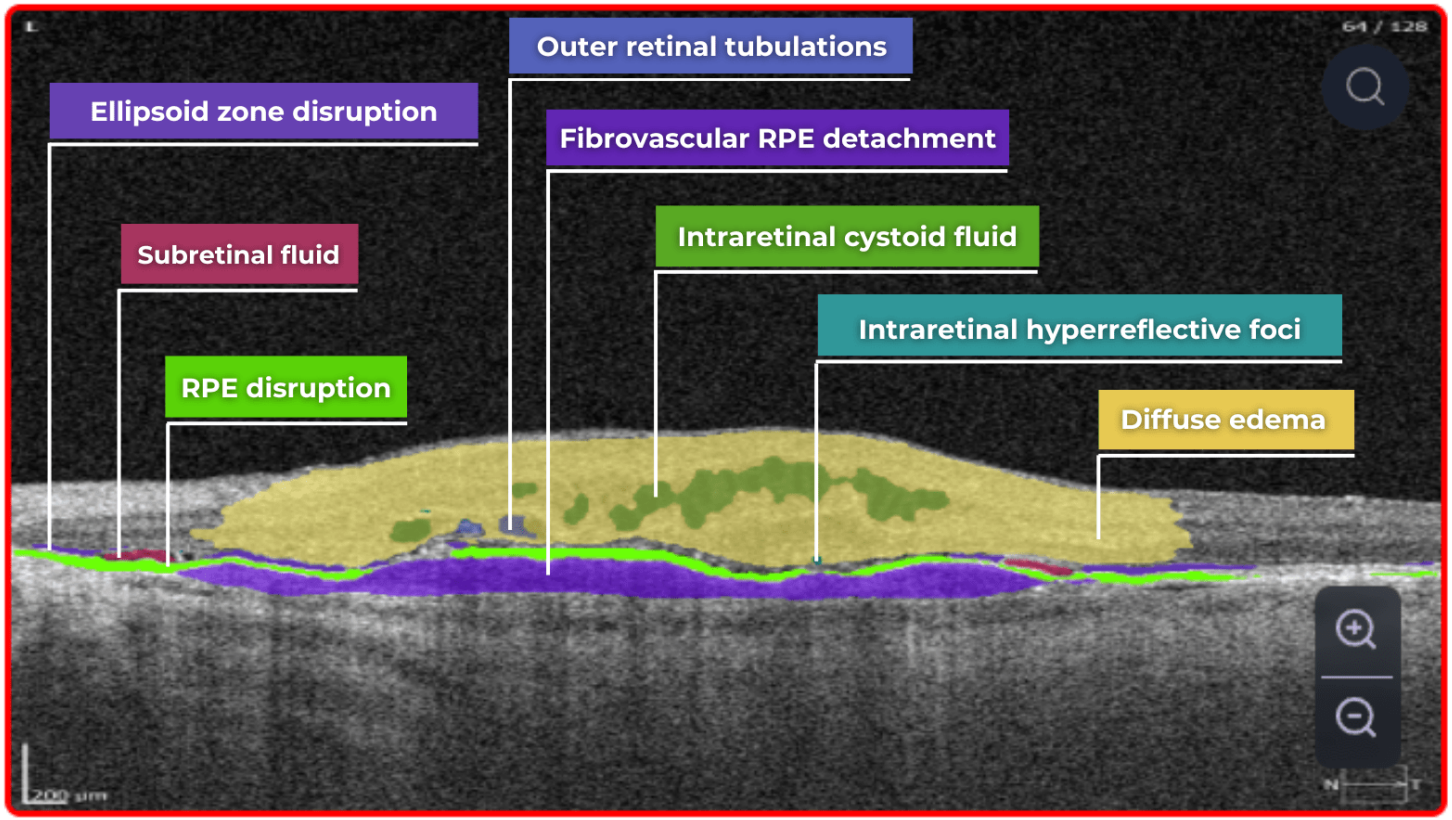
ARTIFICIAL INTELLIGENCE VS MACHINE LEARNING VS DEEP LEARNING

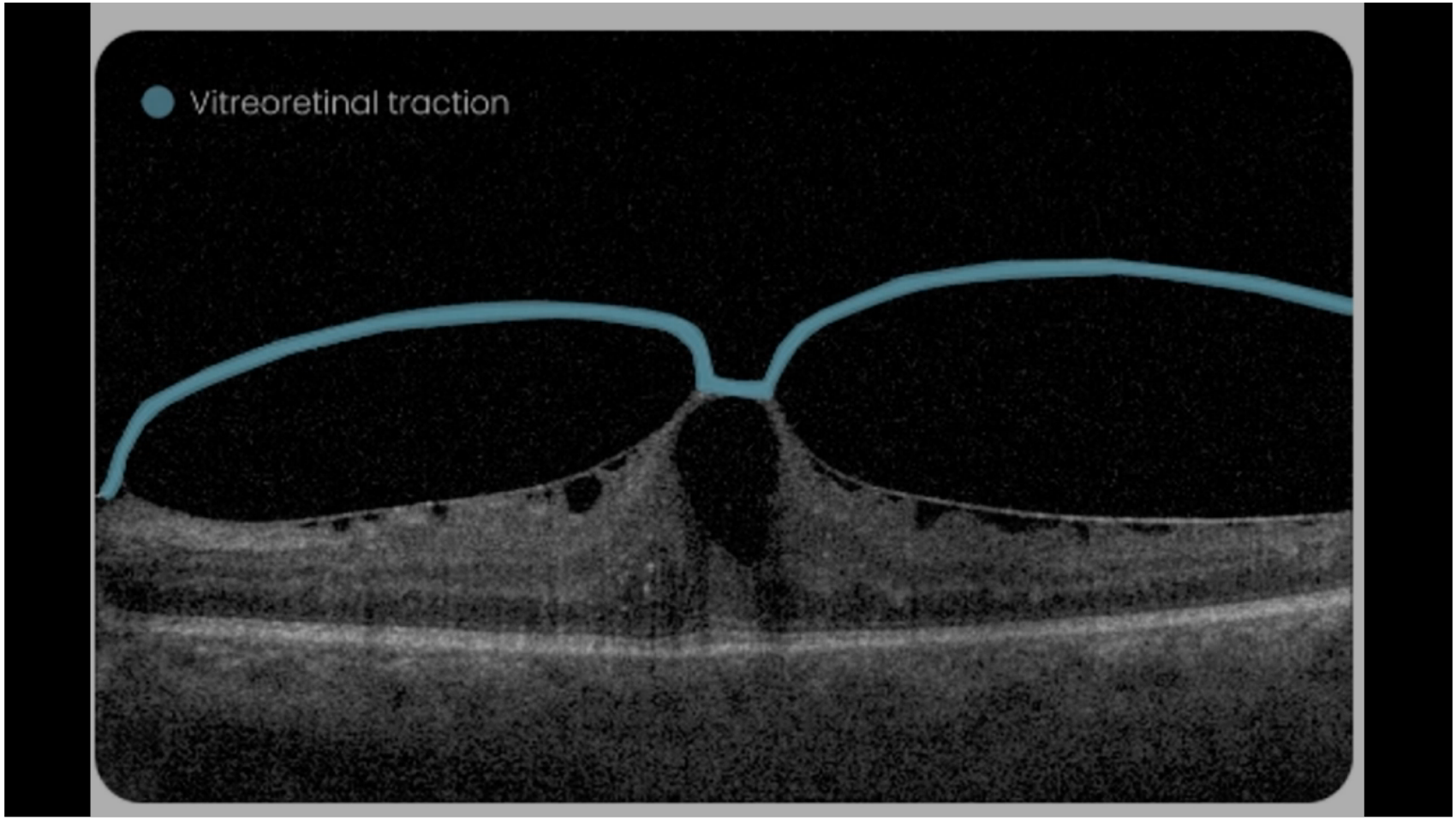



Biomarker Detection (mostly CNN)
Hemorrhages
Micros
Exudates
IRMAs etc...
Quality Assessment
Disease Assessment Clinical Decision



Convolutional Neural Networks (CNNs)


Outer retinal tubulations
Ellipsoid zone disruption
Fibrovascular RPE detachment
Subretinal fluid
Intraretinal cystoid fluid
Intraretinal hyperreflective foci
RPE disruption
Diffuse edema
64 / 128
200 µm
N
T


Vitreoretinal traction

How AI Assists in IOL Selection

1. Data Integration
- AI systems use:
- Biometric data (axial length, anterior chamber depth, corneal curvature)
- Corneal topography and tomography
- Patient age, lifestyle, and prior refractive surgery history
- Surgical technique and incision location

2. Machine Learning Algorithms
- Predict post-operative refractive outcomes
- Suggest optimal IOL power and type (monofocal, multifocal, toric)
- Adapt and improve over time with new surgical data

3. Real-time Decision Support
- AI tools integrated with surgical planning software (e.g., ZEISS CALLISTO, Alcon VERION) offer live recommendations during surgery

Benefits

- Higher accuracy in refractive outcomes
- Personalized lens selection
- Improved patient satisfaction
- Particularly helpful in:
- Post-LASIK or post-RK patients (irregular corneas)
- High myopia or hyperopia cases
- Toric lens alignment for astigmatism

AI-Powered IOL Calculator Comparison Chart (2025)

Calcuiator	AI Method	Best Use Cases	Inputs Required	Accuracy	Website
Hill-RBF Calculator	Radial Basis Function (Machine Learning)	Post-refractive, short/long eyes	AL, K, ACD w TW, LT (optional)	★★★★☆	rbfcalculator.com
Barrett Universal II	Complex AI-like algorithm (non-ML)	All eyes, especially extremes	AL, K, ACD. optional LT, VIW	★★★★★	ioiformula.org
Kane Formule	Hybrid (AI+ (Theoratical Optics)	Most accurate in general use	AL, K, ACD.,LT CCT, Gender	★★★★★	Online & Premium Planning Software
Ladas Super Formula AI	AI-driven formula fusion	Complex or unpredictable ceyes	Varies components of multiple formulas	★★★★☆	Web and some OEM software
PEARL-DGS Formula	New-gen ML and AI logic	Complex anatomy, research use	AL, K, ACD, LT	★★★★☆	Not widely public

AI Errors in IOL Calculators

- AI-based IOL calculators (like **Hill-RBF**, **Ladas Super Formula AI**, **Kane**, **Barrett Universal II with AI**, etc.) are powerful, but **not flawless**.
- Errors can arise from both **algorithmic limitations** and **clinical input quality**.
- **Algorithm Bias**
- AI models may be **trained on specific populations** (e.g., Western, Caucasian eyes).
- May perform **poorly on Indian, Asian, or pediatric eyes** unless retrained on diverse data.

Hill-RBF Calculator Version 3.0

Patient

ID	BESTEYE00220121
Name	MOHANLAL
First name	SHARMA
Date of birth	01.06.1955 DD.MM.YYYY
Gender	Male

Surgeon

Name	HANSPAL SINGH
First name	BHINDER
E-Mail	hanspal@besteyehospital.com
Calculation ID	qiUHQ4

OD

Target Refr.[D] 0.00

1 HAAG-STREIT LENSTAR LS 900

AL	21 mm	K1	42	90.00	D/°
CCT	550 µm	K2	42	180	D/°
ACD	1.25 mm	n	1.3375		
LT	5 mm	WTW	13 mm		

2 Biconvex 1:1

Manufacturer	any
Model	any
A-Constant	118.5

any - any

Hill - RBF

IOL[D]	REFR[D]
30.50	0.77 ⚠
31.00	0.39 ⚠
31.50	**0.01** ⚠
32.00	-0.38 ⚠
32.50	-0.77 ⚠

Constants: A=118.50
IOL Power @ Emmetropia [D]: 31.51
⚠ RBF calculation out of bounds. Use with caution!

OS

Target Refr.[D] 0.00

1 HAAG-STREIT LENSTAR LS 900

AL	21 mm	K1	42	90.00	D/°
CCT	400 µm	K2	42	180	D/°
ACD	1.25 mm	n	1.3375		
LT	5 mm	WTW	13 mm		

2 Biconvex 1:1

Manufacturer	abc
Model	abc
A-Constant	118.5

abc - abc

Hill - RBF

IOL[D]	REFR[D]
30.50	0.70 ⚠
31.00	0.33 ⚠
31.50	**-0.06** ⚠
32.00	-0.44 ⚠
32.50	-0.84 ⚠

Constants: A=118.50
IOL Power @ Emmetropia [D]: 31.43
⚠ RBF calculation out of bounds. Use with caution!

? (docs/

3.0.2

- **Diagnostic and Screening AI Tools**
- These tools primarily focus on analyzing images and data to detect and diagnose eye conditions, often with high accuracy and autonomy.
- **LumineticsCore (formerly IDx-DR)**: This is the first FDA-approved AI system for autonomously detecting diabetic retinopathy (DR) from retinal images. It can be used by non-specialists in primary care settings, improving access to screenings and workflow efficiency.
- **Google DeepMind's AI (Verily/ARDA - Automated Retinal Disease Assessment)**: This AI model is designed to detect diabetic retinopathy and age-related macular degeneration (AMD). It uses deep learning trained on thousands of retinal scans and has demonstrated specialist-level accuracy, helping to identify early signs before symptoms appear.
- **RetinaLyze**: An AI-based screening tool for real-time detection of diabetic retinopathy, glaucoma, and AMD. It aims to improve early disease detection rates, particularly in underserved regions.
- **EyeArt (by Eyenuk, Inc.)**: An FDA-cleared autonomous AI system for detecting diabetic retinopathy from retinal images, providing immediate results that allow for prompt action by physicians.
- **ZEISS VISUHEALTH AI**: This system combines AI with advanced imaging technologies to detect and manage diabetic retinopathy. It can be used with handheld retinal cameras for remote and community screenings.
- **Altris AI**: An AI decision support system for OCT analysis that automates the selection of pathological OCT scans and detects over 70 pathologies and biomarkers. It's vendor-neutral and helps with early glaucoma risk assessment and quantitative biomarker analysis for monitoring disease progression.
- **EyeFound**: A multimodal AI model trained on over 1 million data points, integrating data from OCT, fundus photography, and clinical records to generate holistic diagnoses and predictions. It also shows potential in predicting cardiovascular risk and neurodegenerative disorders from retinal scans.

Best Practices to Minimize AI Errors in Ophthalmology

1. Use AI as a second opinion, not the sole decision-maker
2. Always verify results with human clinical judgment
3. Ensure good image quality and device compatibility
4. Prefer tools trained on diverse datasets, including Indian populations
5. Use explainable AI where possible
6. Conduct local validation studies before full deployment

Limitations & Challenges

- • Data privacy and consent issues
- • Need for high-quality, diverse datasets
- • Black-box nature of some algorithms
- • Regulatory and ethical concerns



Errors and Limitations of AI in Ophthalmology

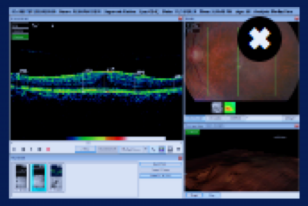
Area	Common AI Errors	Limitations
Glaucoma	• False positives in large optic cups • Misses early nerve fiber layer changes • Misclassification of mild NPDR as curmal • Artifacts causing false alerts	– Depends heavily on OCT quality – Difficulty with variable disc shapes and myopia
Retina		– Limited data for rare retinal diseases – Poor generalization across devices or image quality
Cataract	• Overestimation of severity in early cataract • Misidentification in dense lens	– No assessment of functional vision – Doesn't consider patient symptoms – Lacks lifestyle/contextual personalization
IOL Selection	• Inaccurate predictions in post-refractive eyes	

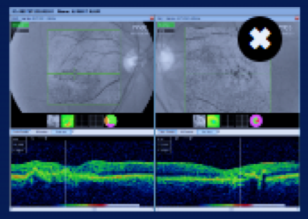
Legend: NPDR=Non-Proliferative Diabetic Retinopathy OCT: Optical Coherence Tomography

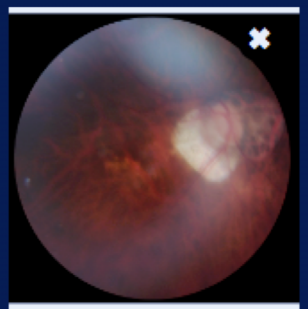
2 Upload retinas

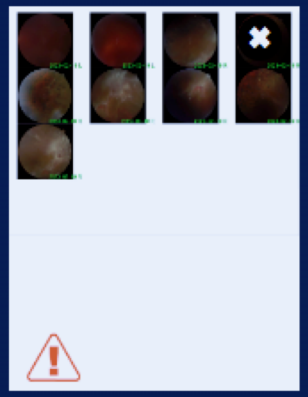
Drag and drop up to 6 retina image(s) in the area below or

SELECT FILES ON YOUR COMPUTER









3 Settings & Launch

View results

View / download PDF report

Do not analyze poor quality photos

Cost: 1 credit

CLEAR ALL
New patient

Errors Reported in Literature

Study / Case AI Tool Error :-

- DeepMind (2018) OCT AI Missed early AMD due to segmentation error
- IDx-DR (FDA-approved) Fundus DR detection False positives in high myopia due to peripapillary atrophy
- Google AI for DR Fundus AI Poor performance in low-light, real-world clinic images
- Visual Field AI Perimetry AI Mistook learning curve artifacts as glaucomatous loss

Ophthalmologists will be affected by A I ?

1. Enhanced Diagnostic Accuracy

AI tools (e.g., for **retinal imaging, OCT, fundus photos**) can detect diseases like **diabetic retinopathy, AMD, glaucoma** earlier than humans in some cases.

Ophthalmologists will **confirm or override AI suggestions**, acting as the final authority.

🔁 **Impact**: Less time on screening, more time on complex decisions and patient care.

🛠️ **2. Streamlined Workflow**

AI automates repetitive tasks like:

- **Image grading**
- **Visual field analysis**
- **Electronic medical record summarization**

⚙️ **Impact**: Faster clinic flow, fewer diagnostic bottlenecks.

👁️ **3. Precision in IOL and Surgical Planning**

AI improves **IOL selection**, **corneal topography analysis**, and **surgical simulation**.

Surgeons can plan with **greater accuracy**, reducing refractive surprises.

📊 **Impact**: Better outcomes, more personalized surgeries.

📉 **4. Reduced Human Error**

AI assists in minimizing oversight, especially in high-volume settings.

Can flag **missed diagnoses** or image abnormalities in time-limited consultations.

🛑 **Impact**: Patient safety and quality assurance improve.

Ophthalmologists will be affected by A I ?

5. Changing Training and Skill Sets

Future ophthalmologists will need:

- Understanding of **AI principles**
- Skills in **data interpretation**, not just image reading
- Ability to work with AI-integrated platforms

📖 **Impact**: Medical curricula will evolve to include **AI literacy**.

⍰ 6. Ethical and Legal Responsibility

AI may **suggest actions**, but the ophthalmologist is **legally responsible**.

Practitioners must **understand AI limitations** and document clinical decisions.

⚖️ **Impact**: Accountability shifts toward oversight and justification of AI use.

💬 **7. Enhanced Patient Communication**

With AI providing predictive models or image-based insights, doctors must:

- Explain findings in **plain language**
- Justify decisions when **AI and human opinions differ**

🗣️ **Impact**: Communication becomes a central skill.

⚠️ **Potential Challenges**

Over-reliance on AI may reduce skill in interpreting complex/rare cases.

Cost and training barriers for small clinics or rural ophthalmologists.

Bias in AI systems may affect patient care if not properly monitored.

🇮🇳 Legal and Regulatory Issues of AI in Eye Care (India Context)

⚖️ 1. Medical Negligence and Liability

Under Indian law, **clinicians are liable** if harm is caused due to reliance on AI tools.

Even if AI is used, **doctors cannot shift responsibility** for incorrect diagnosis or treatment.

Courts apply standards from:

- **Indian Medical Council Act, 1956**
- **Consumer Protection Act, 2019 (for medical negligence)**

✅ **Takeaway**: The **ophthalmologist or optometrist must verify AI output** before acting on it.

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ID	BESTEYE00220121
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First name	SHARMA
Date of birth	01.06.1955 DD.MM.YYYY
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Surgeon

Name	HANSPAL SINGH
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Calculation ID	

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Limitations on liability

Conclusion

- • AI is revolutionizing ophthalmology
- • Complements, not replaces, clinicians
- • Continued innovation.





Thank you!

Any questions?

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