

Glaucoma Care driven by Artificial Intelligence

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Commercial/Financial Disclosures

- I have the following disclosures
 - Stock: Visulytix Ltd, London, UK
 - Consultation/Honoraria:
 - Altacor Pharmaceuticals
 - Thea Pharmaceuticals
 - Alcon

The rising burden of glaucoma

- The global prevalence of glaucoma in people between 40-80 is 3.4%
- By the year 2040 it is projected there will be 112 million affected worldwide
- Current models of care are unsustainable and not scalable

ARTIFICIAL INTELLIGENCE

“Artificial intelligence (A.I.) provides computers with the ability to **learn without being explicitly programmed.**”

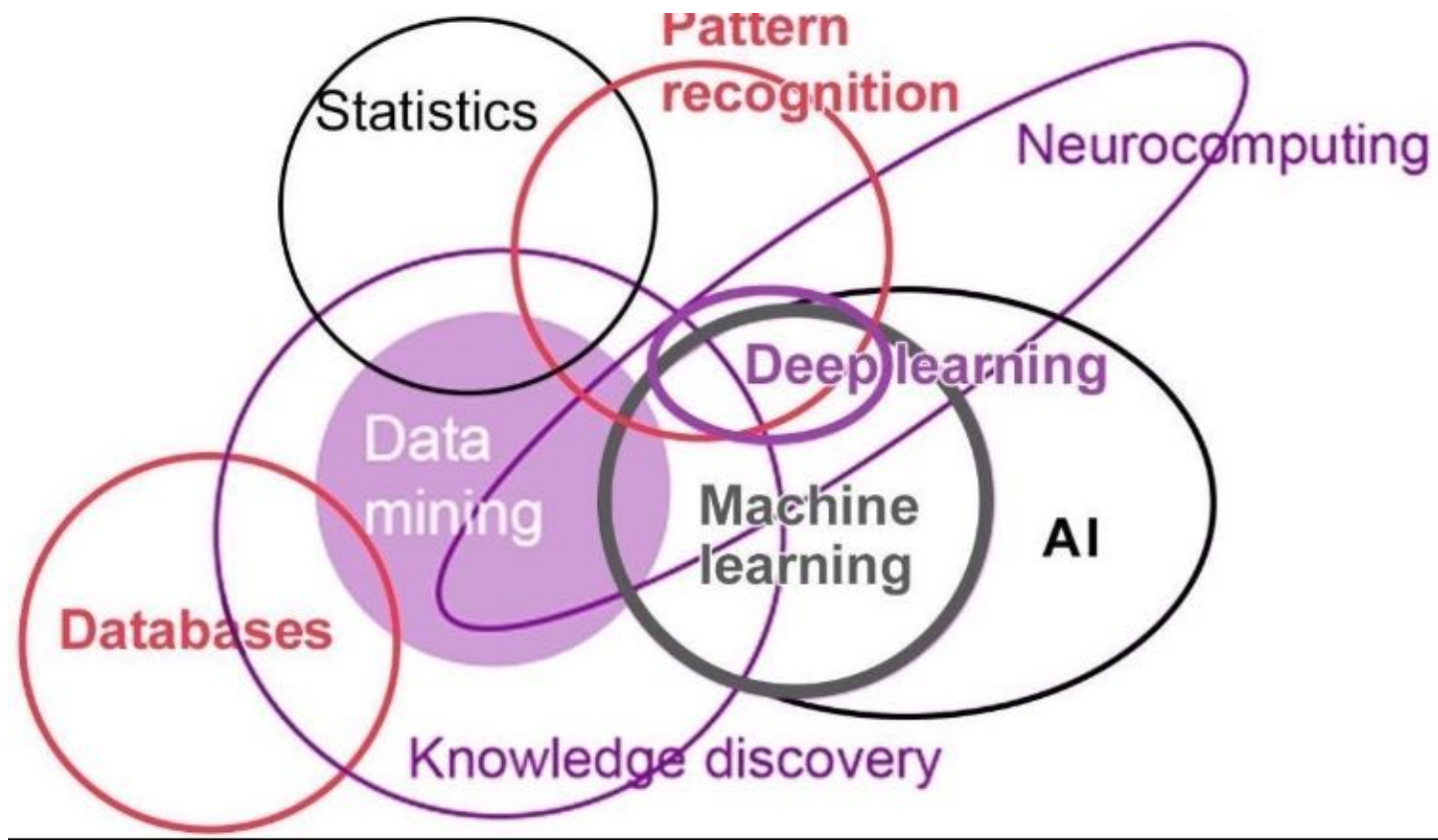


Learning to accomplish tasks (e.g. image classification)
based on being given examples

3 categories of AI

- **Narrow AI:**
 - Technologies that can solve or perform a particular task very well
- **Artificial General Intelligence (AGI):**
 - Computer software that is on a par with human performance across a range of abilities
- **Super Intelligent AI:**
 - A level of AI that encompasses creative thinking, general knowledge and scientific evaluation to an extent that computers could supersede humans as the most intelligent beings on Earth

What do the terms mean?



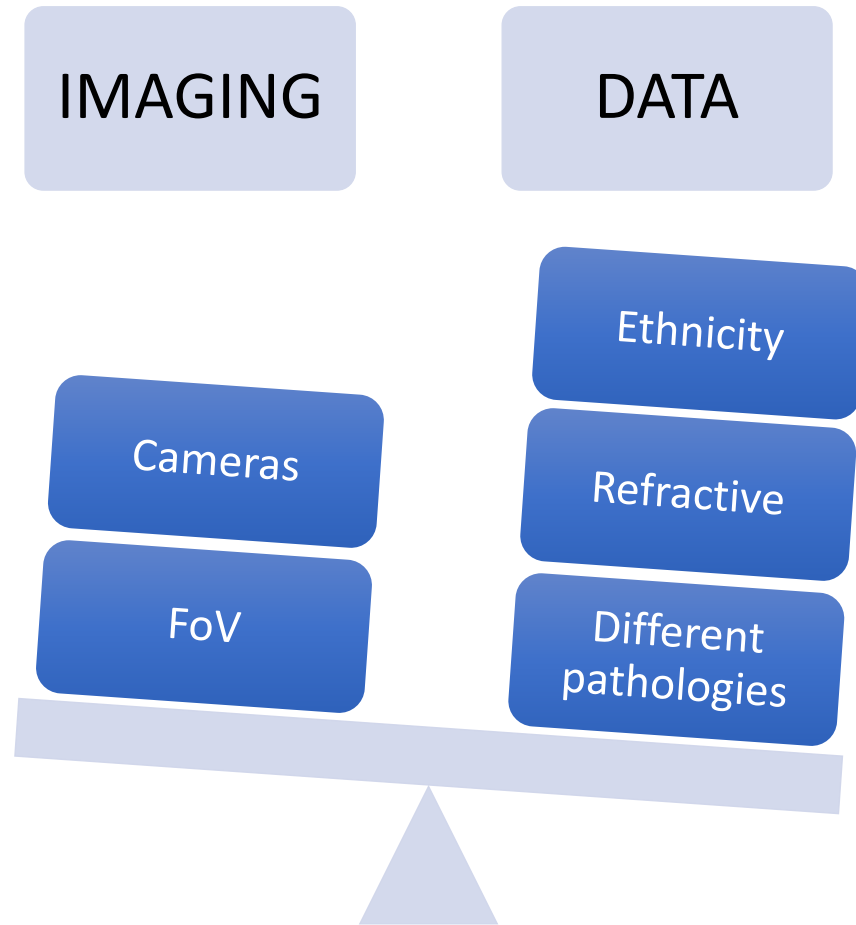
- ML is best envisaged as a subset of AI
- Basic principle is that ML algorithms use large volumes of data to detect patterns and then make decisions based on these patterns

OPTIC NERVE PATHOLOGY IS NOT A STRAIGHTFORWARD PROBLEM

- Specialists look at multiple features and add 'subconscious weights'
- Subjective for some features
- Binary feature identification
- Examples of features:
 - VCDR
 - RNFL defects
 - ISNT rule obeyed
 - Disc haemorrhages
 - Bayonetting, etc



MACHINE LEARNING MODELS ARE PRONE TO BIAS



- For a machine learning model to truly work
 - HETEROGENOUS DATA

- Visulytix – a UK based AI company
- Pegasus Disc – a retinal analysis decision support system*
 - Non-mydriatic or mydriatic cameras
 - FoV: 30-200 degrees
- Includes Optic Disc assessment
 - Disc Anomaly Score
 - VCDR
 - Combined Disc Anomaly Score

EUROPEAN OPTIC DISC ASSESSMENT STUDY

- N Reus et al, Ophthalmology, April 2010
 - Study to determine diagnostic accuracy of judging optic disc photographs for glaucoma by Ophthalmologists
 - 243 Ophthalmologists across 11 countries asked to grade 40 healthy eyes and 48 glaucomatous eyes with varying severity, on stereoscopic slides.
 - Duplicate slides were provided for determining intra-observer agreement
 - Overall diagnostic accuracy was 80.5% (range 61.4-94.3%)
 - Responder bias : those willing to perform the study
 - 'Perfect scenario' : no time limit to assess

PEGASUS versus OPTIC disc assessment study

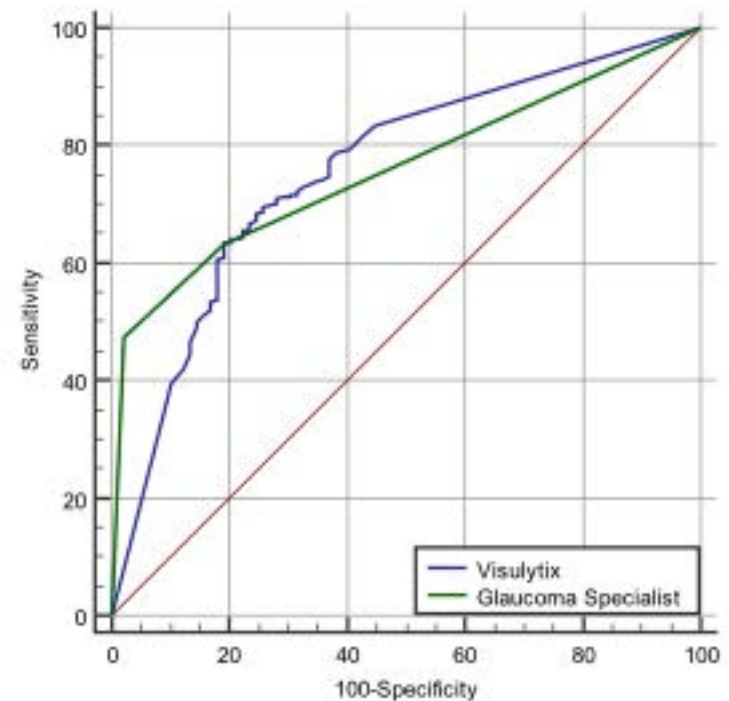
- Pegasus-Disc was tested “out of the box” versus a single image (not optimised for stereoscopic disc images)
- When comparing the combined disc anomaly output versus the ground truth labels:
 - AREA UNDER RECEIVING OPERATOR CHARACTERISTIC CURVE = 0.87

Table 1. Comparison of PEGASUS^{CF} results with those obtained by Ophthalmologists. PEGASUS^{CF} operating points were obtained by choosing a threshold value of 0.4.

	Accuracy	Specificity	Sensitivity
Ophthalmologists	80.5%	87.5%	74.7%
PEGASUS ^{CF}	83.0%	86.0%	81.0%

PEGASUS equivalent to glaucoma experts in the detection of glaucoma suspects/manifest glaucoma

- Recent Harvard University study (to be published)
 - Compared the consensus opinion of Glaucoma experts vs Pegasus
- Detection of optic disc photographs predictive of being a glaucoma suspect or manifest glaucoma
- 474 images
- AUROC consensus 0.759 vs 0.757 Pegasus ($p=0.93$)



AI in Glaucoma

Modality	Author	Journal	Headline
Fundus	Ting et al	JAMA, 2017	Detection of glaucoma with VCDR 0.7, AUC 0.942
	Phene S et al	ArXiv, 2018	AUROC 0.94 (A), 0.85 (B)
	Christopher M	Sci Rep, 2018	Detection GON, trained with 14k images
OCT	Muhammad H	J Glaucoma, 2017	NFL damage from macula OCT (12 x 9 mm) to identify glaucoma suspects better than traditional OCT metrics
Visual Fields	Yousefi et al	AJO, 2018	Detect earlier progression compared to traditional metrics such as PLR or global indices

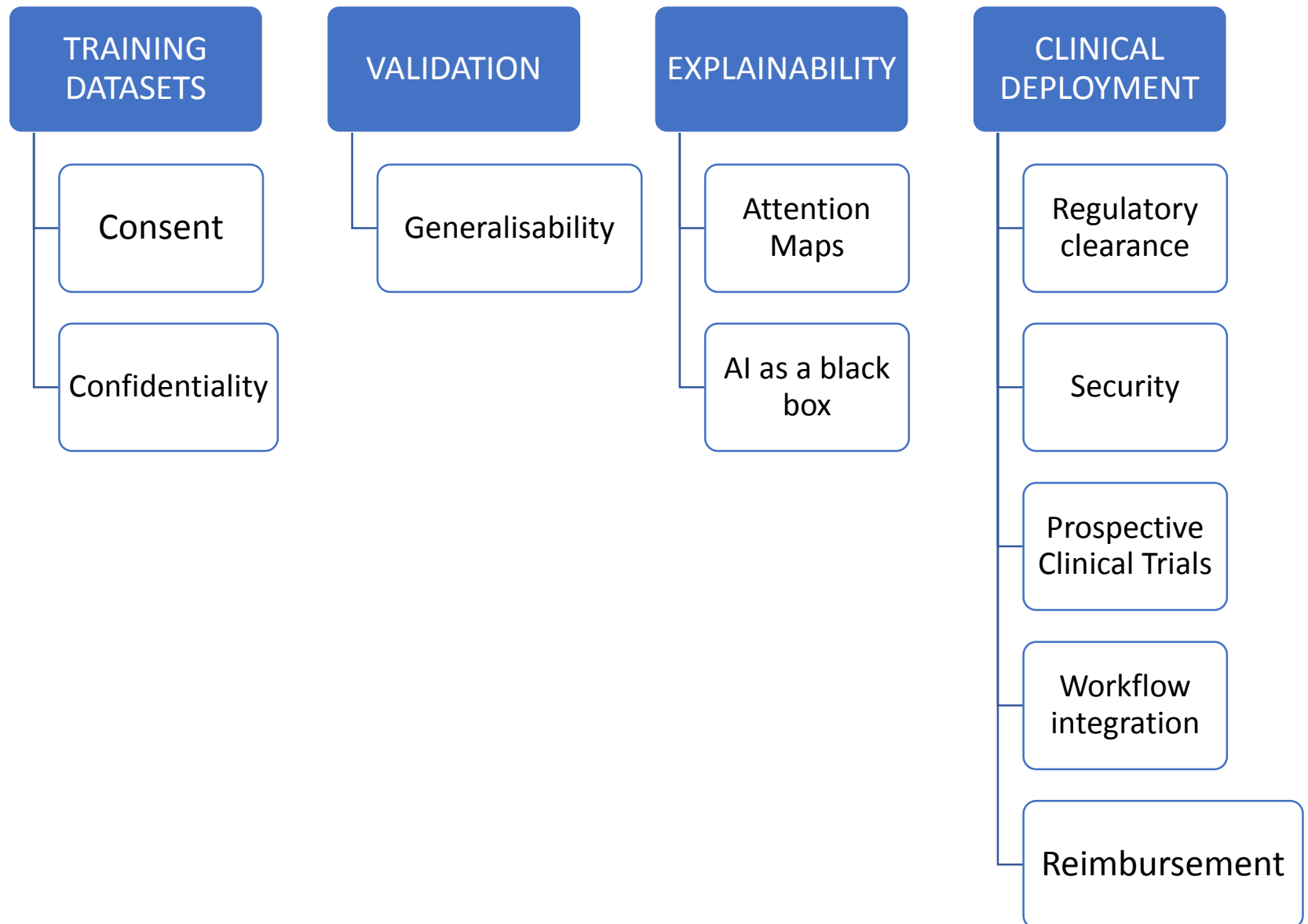
WHAT CAN AI/ML SYSTEMS DO FOR GLAUCOMA PRACTICE?

- Evidence is starting to emerge to suggest that ML based glaucoma software may be comparable to Ophthalmologists.
- Opens new possibilities for
 - Screening
 - Truly virtual clinics with ML systems using VF + OCT + IOP may allow remote monitoring
- Decision Support
 - “Like having an expert over your shoulder” = De-risk
 - Provide further confidence in making decisions
 - Aid learning and education

WHERE CAN AI SYSTEMS HELP?

- Eyecare professionals would welcome:
 - Improvements in disease detection
 - Assessment of progressive structural and functional damage
 - Treatment optimization
 - Accurate long term prognosis
 - Genetic data
 - Medical history

Challenges of deploying AI



KEY TRENDS MOVING FORWARD

- **AI = AUGMENTED INTELLIGENCE**

- AI/ML will generally support what human Ophthalmic care professionals do, not replace them

- **TRANSPARENCY = TRUST**

- Granularity in outputs to ensure Ophthalmic care professionals can understand the conclusions that AI/ML draws and can override it

- **SKILLS = SYMBIOTIC WITH AI**

- AI/ML systems trained by/supporting Healthcare professionals
- this will change the workforce and lead to 'new skills'

IN SUMMARY – ML BASED DECISION SUPPORT SYSTEMS ARE COMING

- AI and algorithms won't on their own deliver safe and effective Ophthalmic care, people and systems do.
- However ML-assisted Ophthalmic care professionals will improve care quality, and eventually replace Ophthalmic care professionals on their own.

Thank You

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