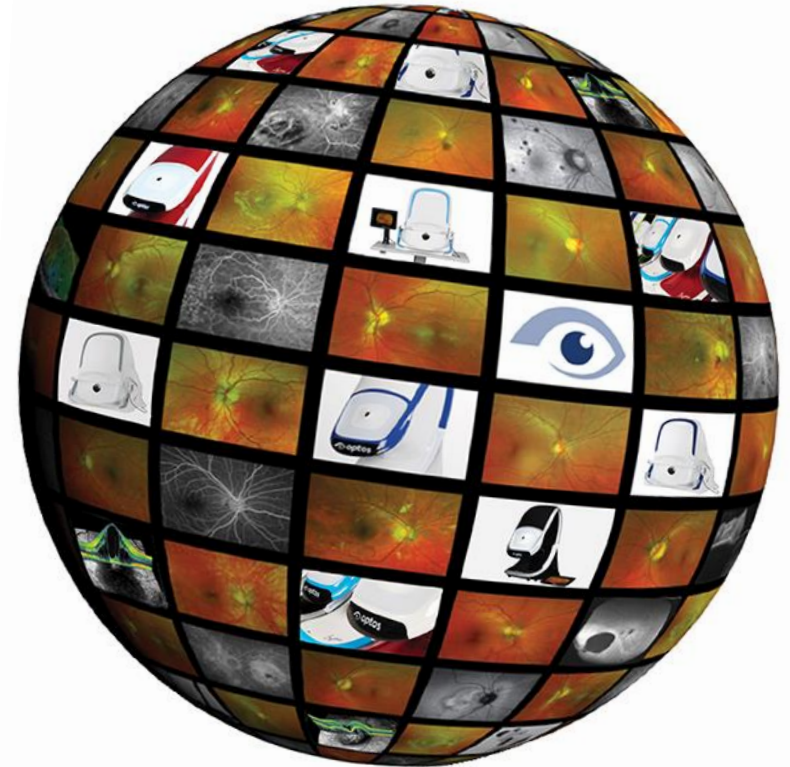


# Machine Learning applications to healthcare instrumentation



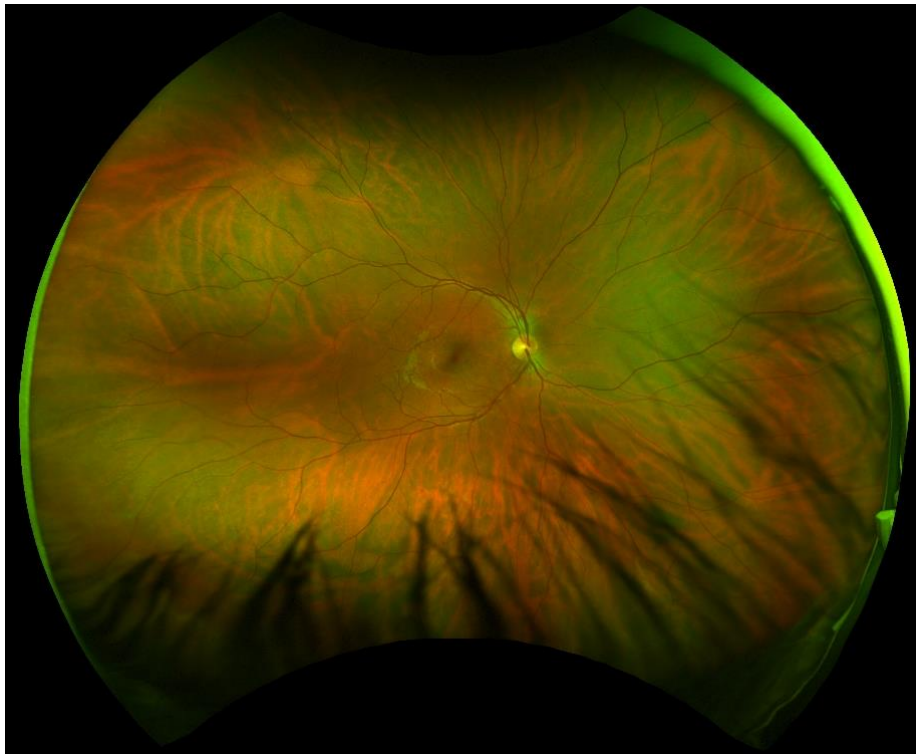
LIGO: India  
Peter Wakeford  
18<sup>th</sup> July 2018

---

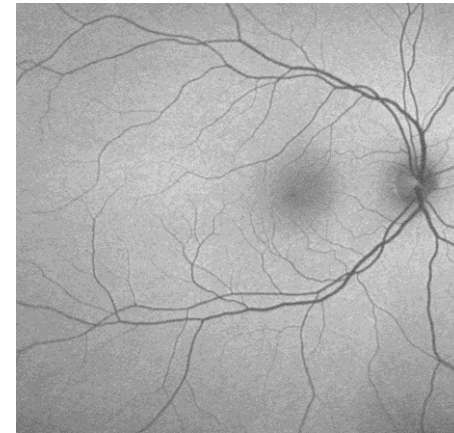
## Table of Contents

- Optos imaging system
- Machine learning overview
- Laterality determination
  - The problem
  - Neural network performance
  - Looking inside the neural network

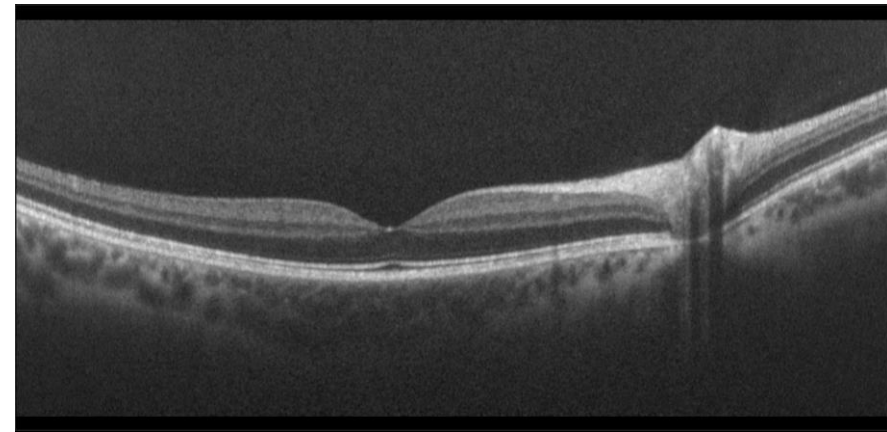
## Retinal images



Red / Green laser reflectance

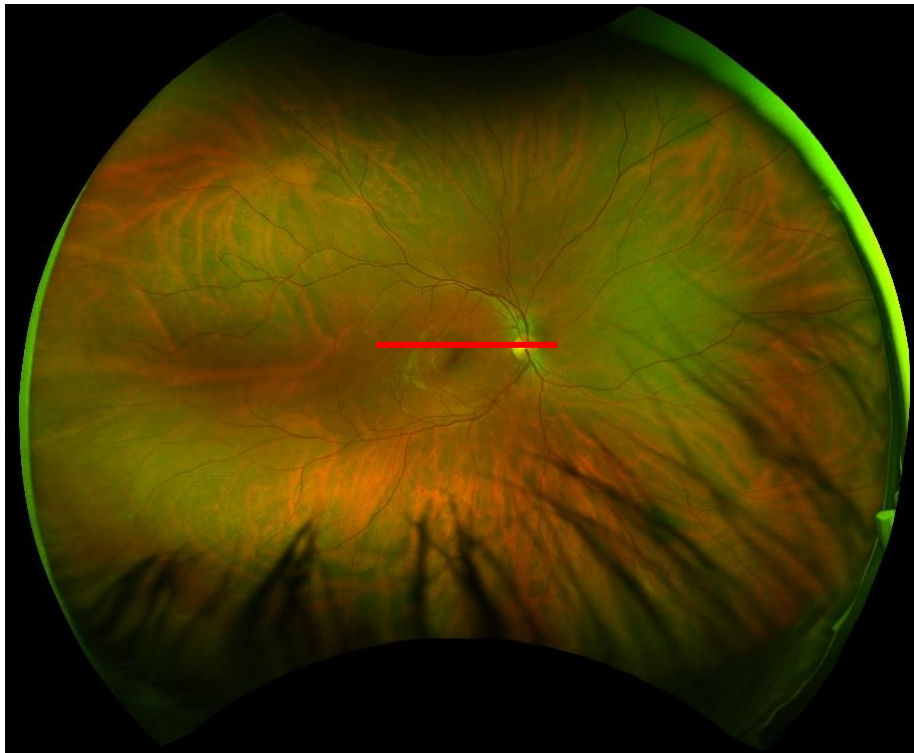


Autofluorescence

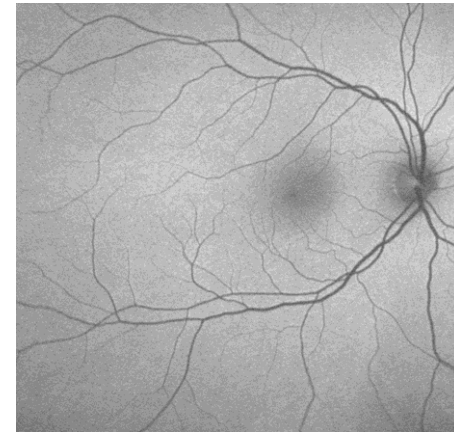


Optical coherence tomography

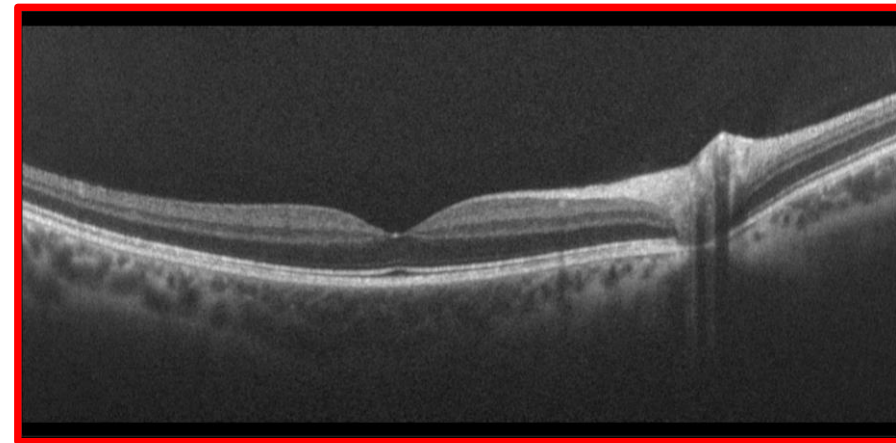
## Retinal images



Red / Green laser reflectance




Autofluorescence

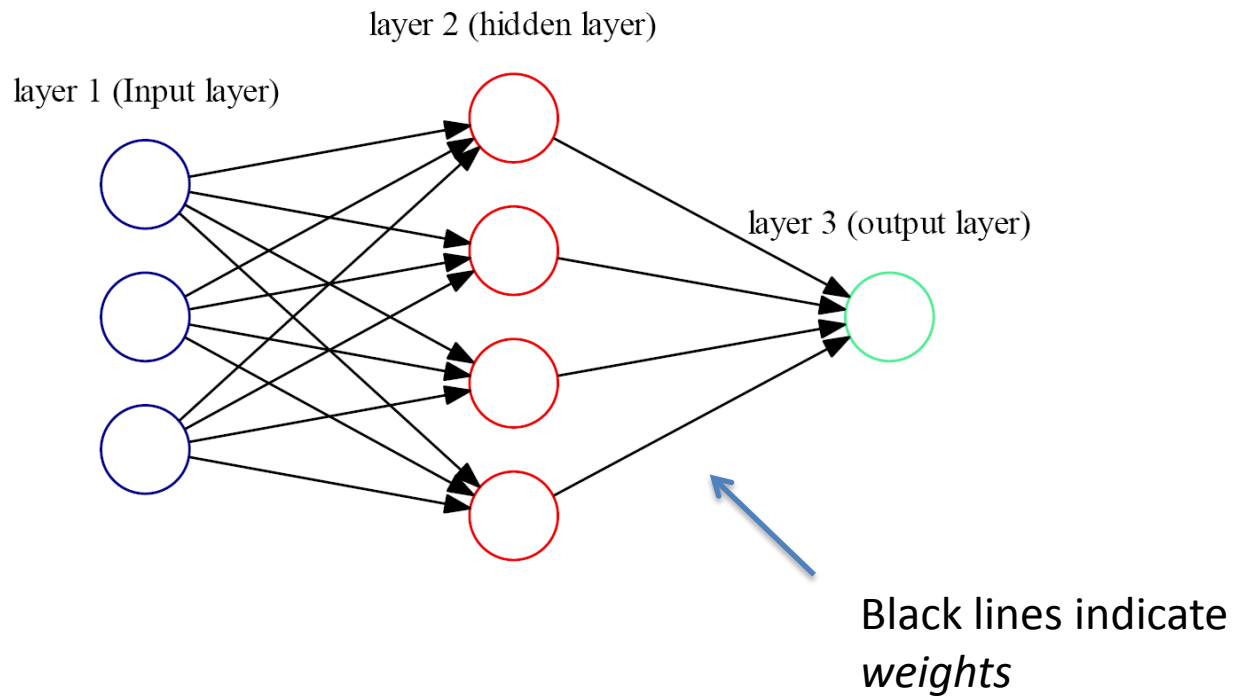


Optical coherence tomography

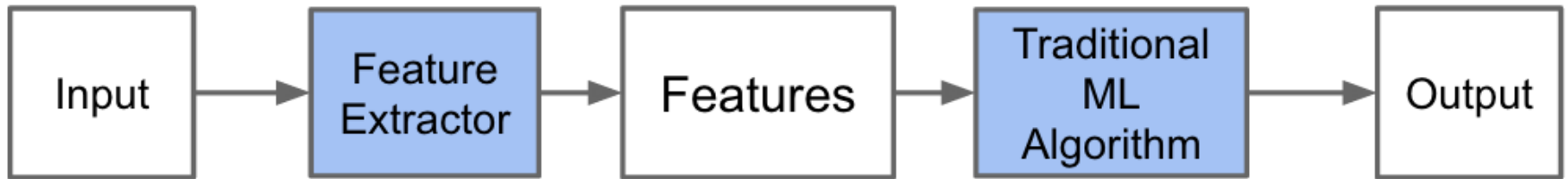
# Timeline – image quality assessment

Year	Duration	Title	Funder	Amount	Who
2014	6 months	<i>Automated Image Quality Assurance for Ophthalmoscopes</i>	S3C	£17k	Siong Heng, Matt Pitkin, Craig Lawrie
2014 – 2015	1 year 	<i>Automated artefact detection for scanning laser ophthalmoscopes</i>	CENSIS	£88k	Siong Heng Peter Wakeford
2015 – 2016	6 months	<i>Enhancing Optos quality assurance</i>	SU2P	£20k	Siong Heng Peter Wakeford
2016 – 2020	4 years	<i>Automated image quality measures for scanning ophthalmoscopes</i>	EPSRC / CDTAP	£140k	Siong Heng Peter Wakeford

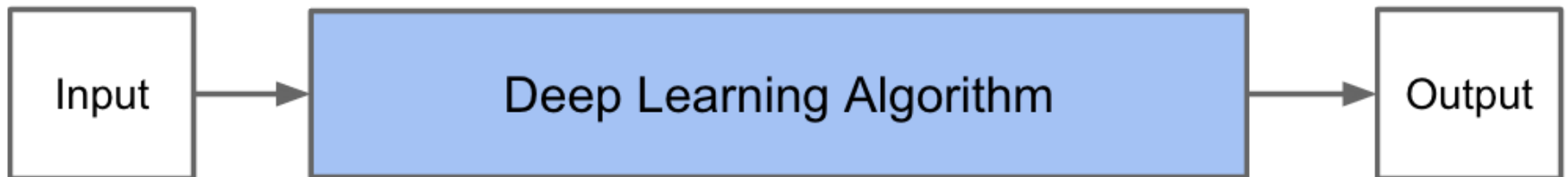
# Neural networks – ‘traditional’



## Deep Learning vs traditional Machine Learning



Traditional Machine Learning Flow



Deep Learning Flow

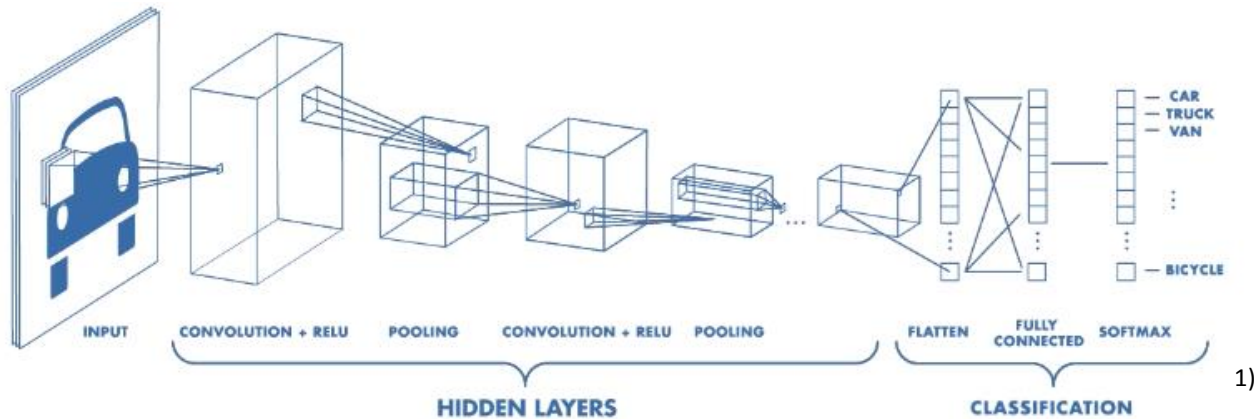
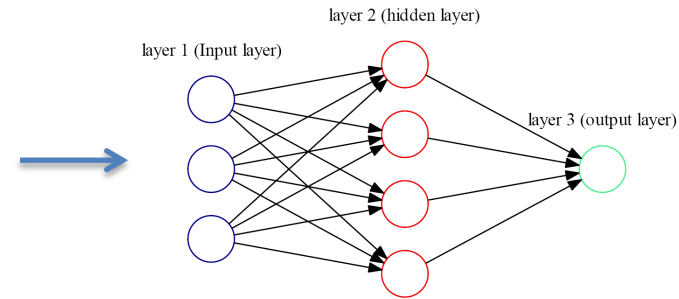
- No need to “hand-craft” features (domain knowledge, definition, detection).
  - This is especially important when dealing with images.

# Convolutional neural networks



$$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$$

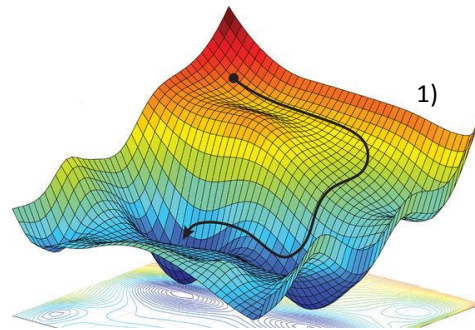
Convolve with kernel



1)



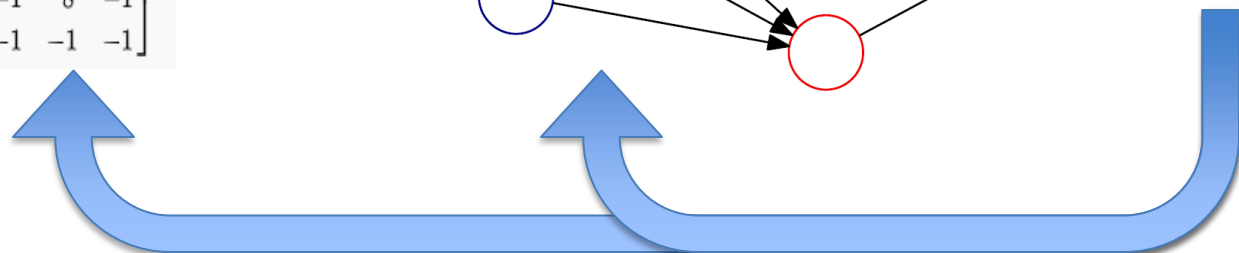
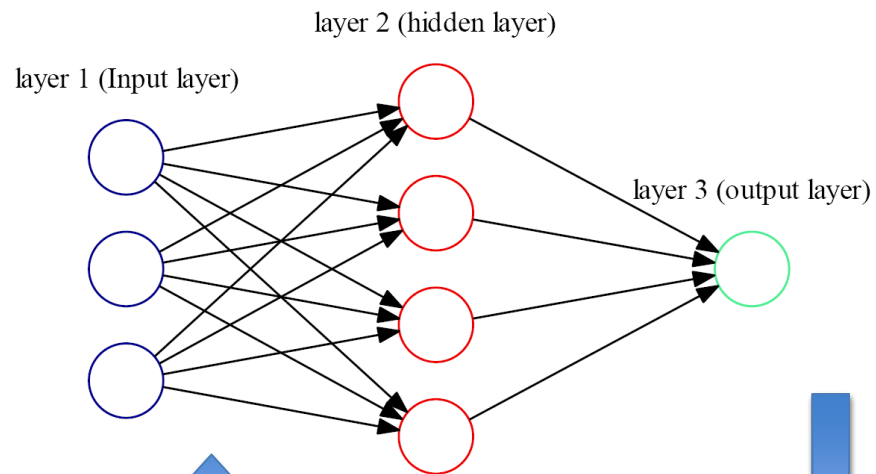
# The clever part?



Calculate mismatch

$$\begin{bmatrix} 1 & 0 & -1 \\ 0 & 0 & 0 \\ -1 & 0 & 1 \end{bmatrix}$$

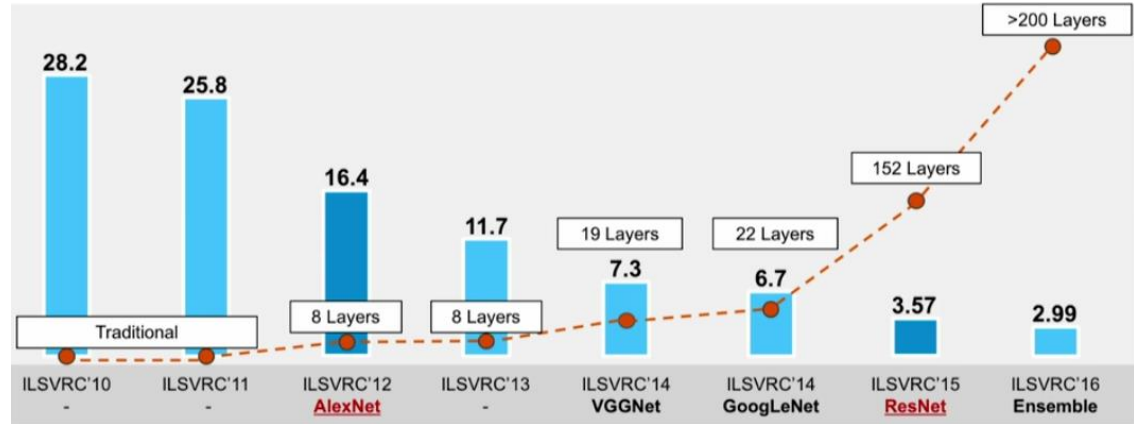
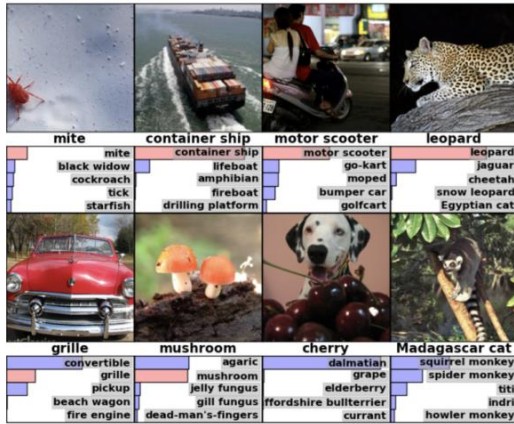
$$\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$$

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$


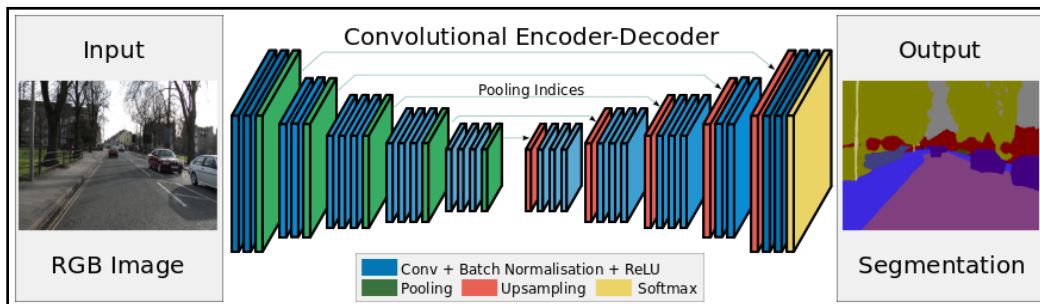
*Gradient descent, back propagation*

# Applications of Deep Learning

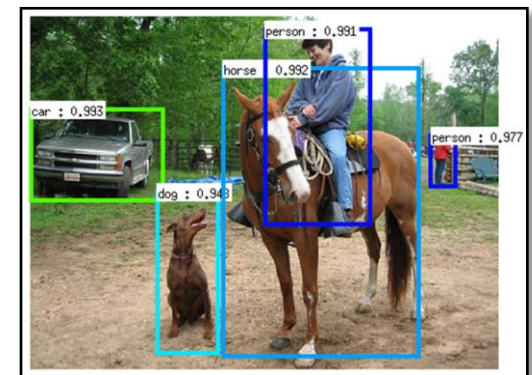
- Classification



- Segmentation



- Object detection



# Nikon's Optos, Google's Verily ink deal for machine learning in retinal imaging

DECEMBER 30, 2016 BY BRAD PERRIELLO — [LEAVE A COMMENT](#)



Nikon (TYO:7731) subsidiary Optos and Google (NSDQ:GOOG) unit Verily inked a deal this week to develop technologies for machine learning-enabled retinal imaging.

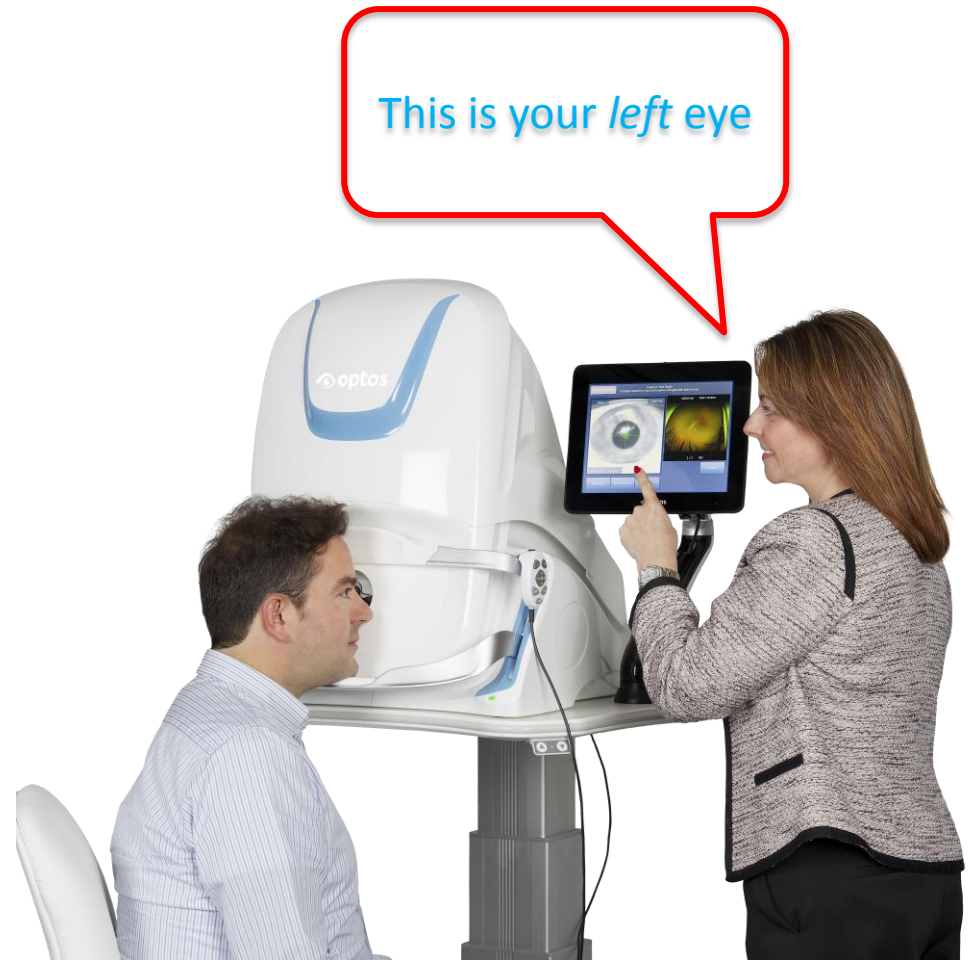
The deal calls for the companies will collaborate on improving the screening for diabetic retinopathy and diabetic macular edema, both among the leading causes of blindness worldwide.

The program combines Nikon's leadership in optical engineering and precision manufacturing and Verily's machine-learning technology to help healthcare providers diagnose the conditions, according to a [press release](#).

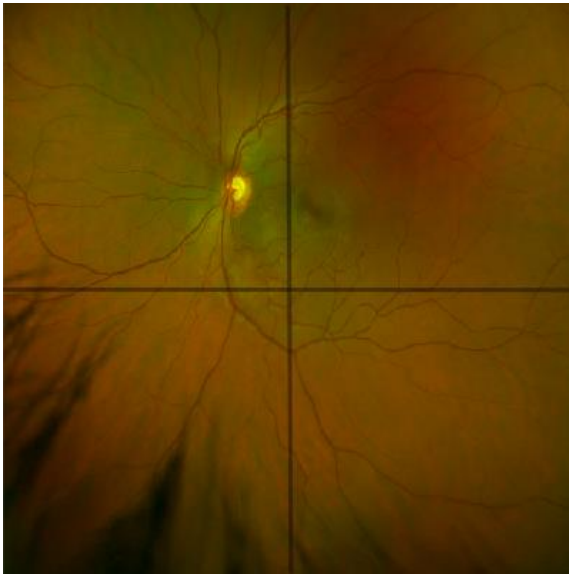
In February 2015, Nikon paid \$400 million to acquire Optos, marking the Japanese camera giant's 1st foray into the medical sector. Optos is the market leader in retinal imaging and its ultra-widefield technology produces images that cover more than 80% of the retina, which is greater than any other device.

## Clinical imaging session

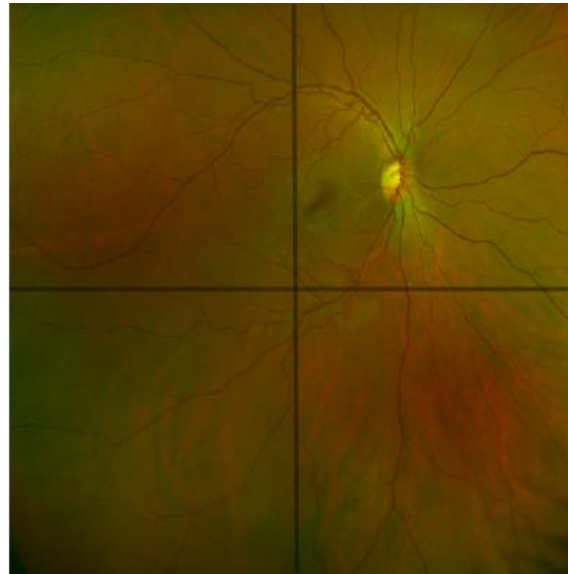
1. System **automatically** captures image when subject in position
2. Operator **manually** selects if left or right eye
3. Time consuming, error prone
4. Multimodal – important is correct!



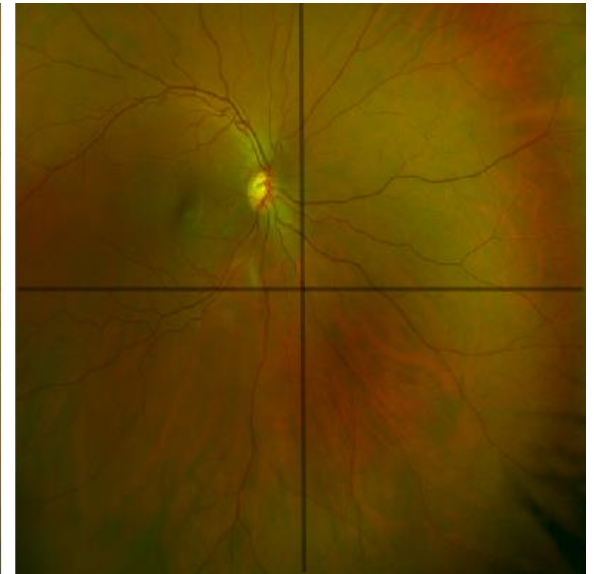
## Laterality determination (left or right eye)



LEFT EYE (CP)

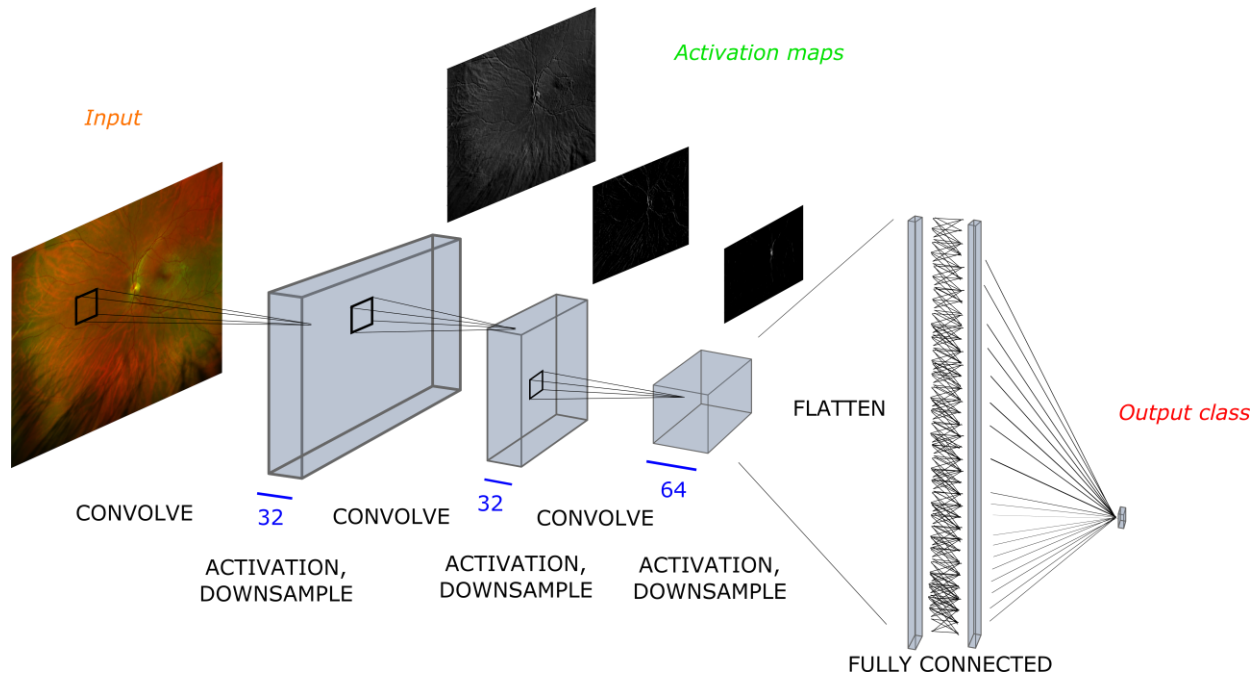


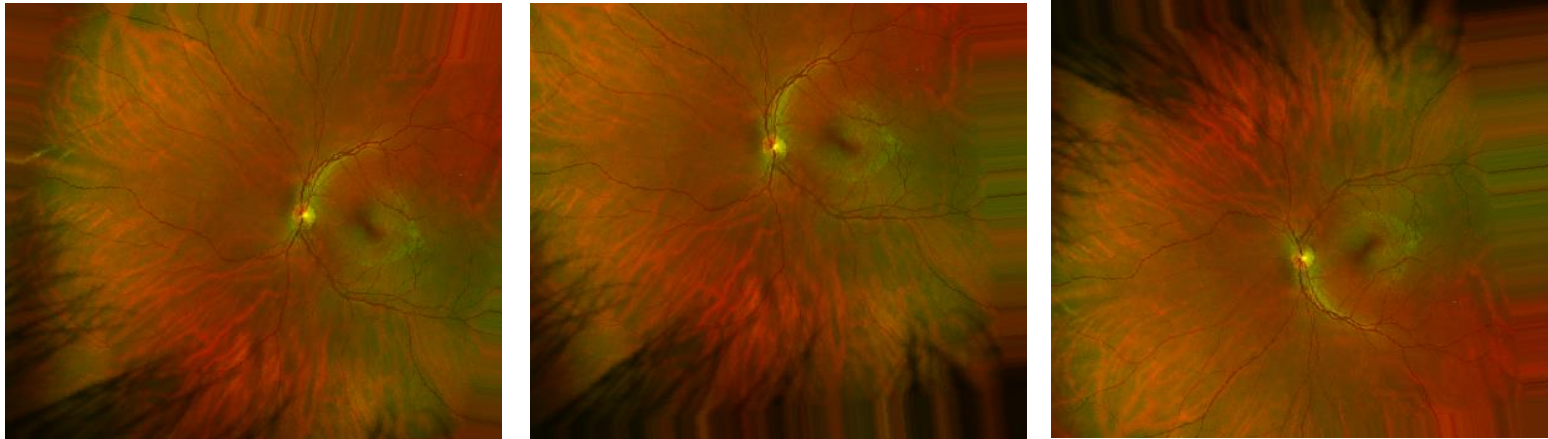
RIGHT EYE (CP)



RIGHT EYE (ES)

# The Network





*Examples of image augmentation by random shifts, rotation, zoom and vertical flipping*

## Results

- 822 test images

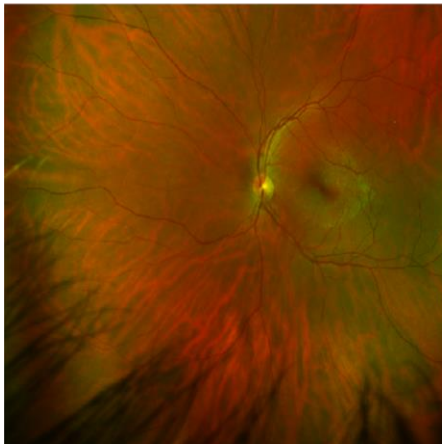
Image mode	Left accuracy	Right accuracy	Combined accuracy
Central-pole	98.9%	98.9%	98.9%
Eyesteered	98.6%	96.0%	97.3%
		<b>Total</b>	<b>98.3%</b>

- Not currently as good as the 'hand crafted' method
- But 70ms vs 2 seconds. Easy to integrate into system



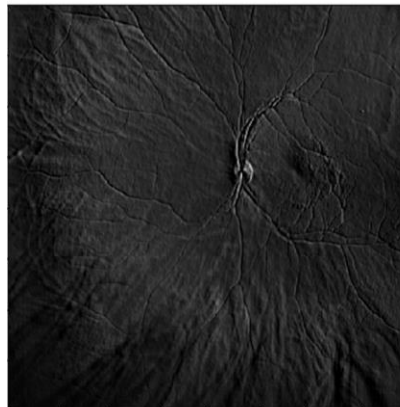
# Kernel activations

400 x 400



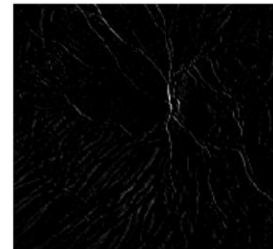
Input image

398 x 389



Activation 1  
Kernel 26

197 x 197



Activation 2  
Kernel 28

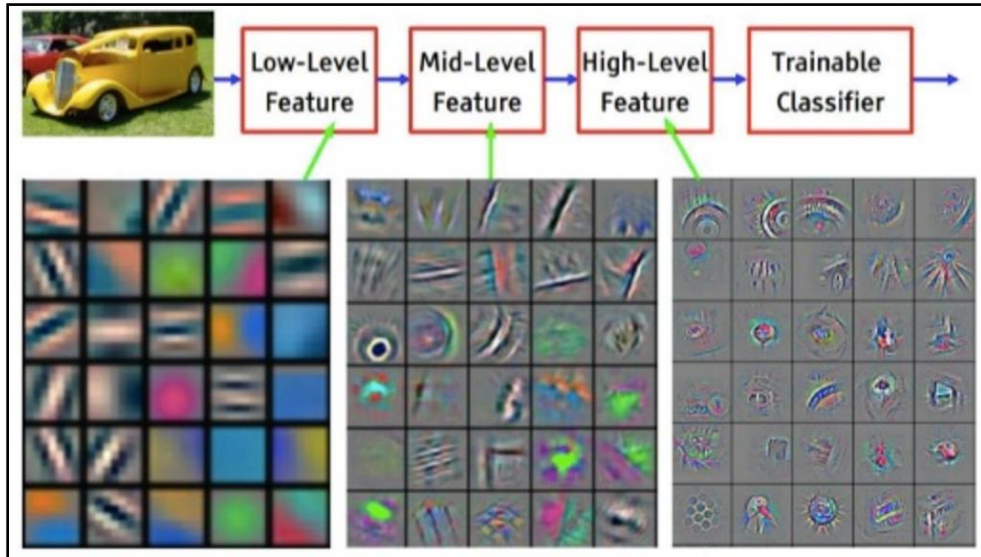
96 x 96



Activation 3  
Kernel 38

# Opening the box

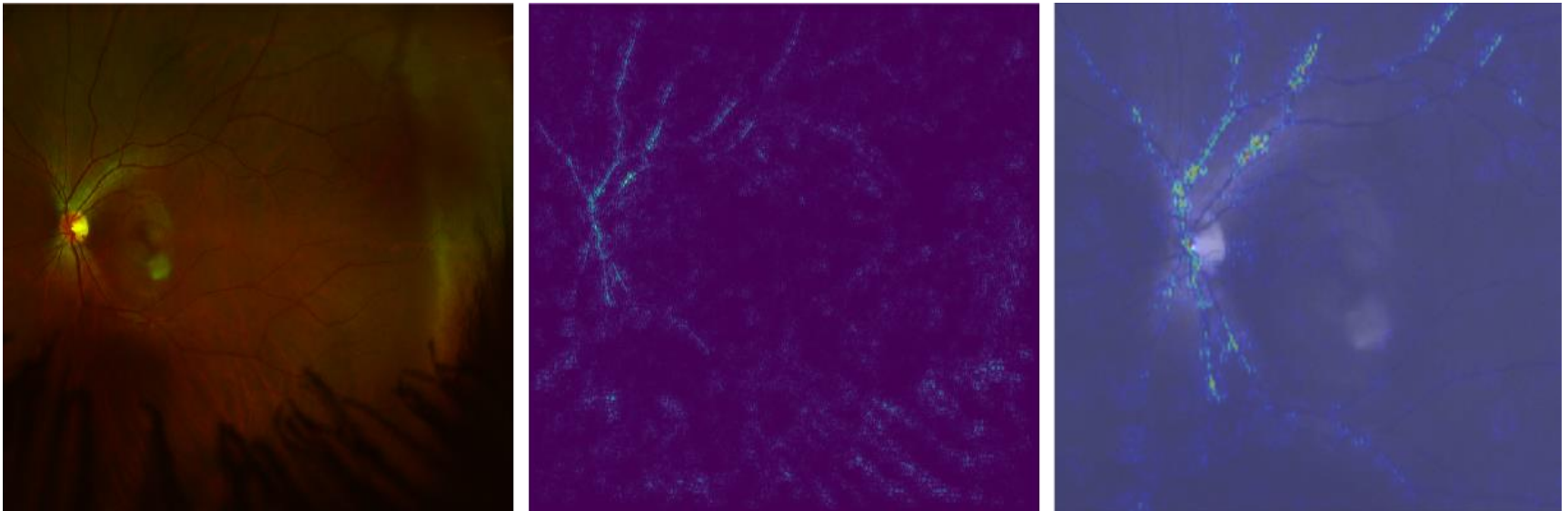
- Feature visualization



- Attention maps



# Attention maps – what is important to the network?



## Next steps

- Integrate into a system
- Test!
- Optimise
- Regulatory approval (problematic?)