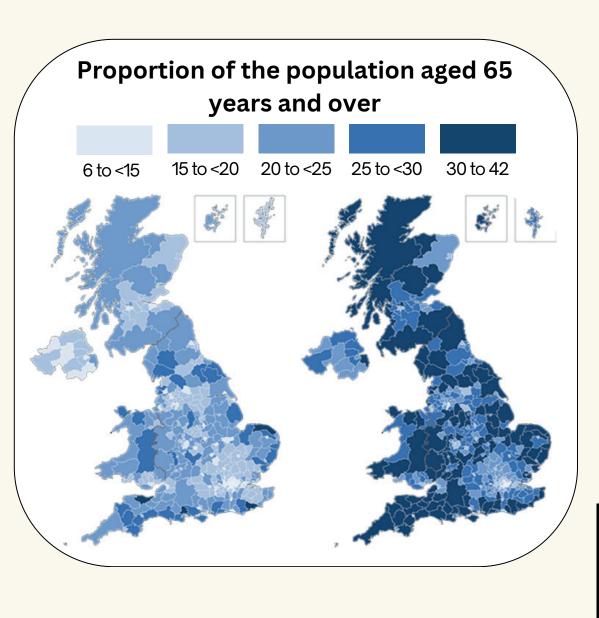
Digital Twins of the Retina: Augmenting healthcare data with maths and physics to improve outcomes

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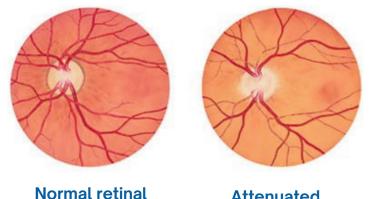
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The Threat A rapidly ageing population



- Over **2 million** people in the UK have visual impairment, 80% are over 65.
- By 2040, nearly 30% of the UK population will be 65 or older
- Vision loss costs an estimated £25 billion per year

Retinal vascular diseases



The Challenge

Time and resource constraints

• Little room for additional scans, measurements and appointments

Incomplete health records

• Large volumes of data not integrated in the decision making

Suboptimal patient outcome and large volume of unused data

Ageing population

 Increased demand for eye treatment

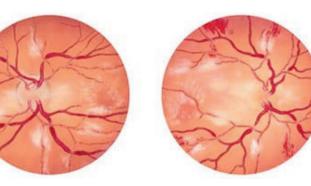




Engineering and Physical Sciences Research Council

- Treating age-related macular degeneration costs £0.5B per year in hospital prescriptions
- Many causes and symptoms stem from the retinal microcirculation
- Early detection is essential for preserving vision

Attenuated vasculature arterioles and venules



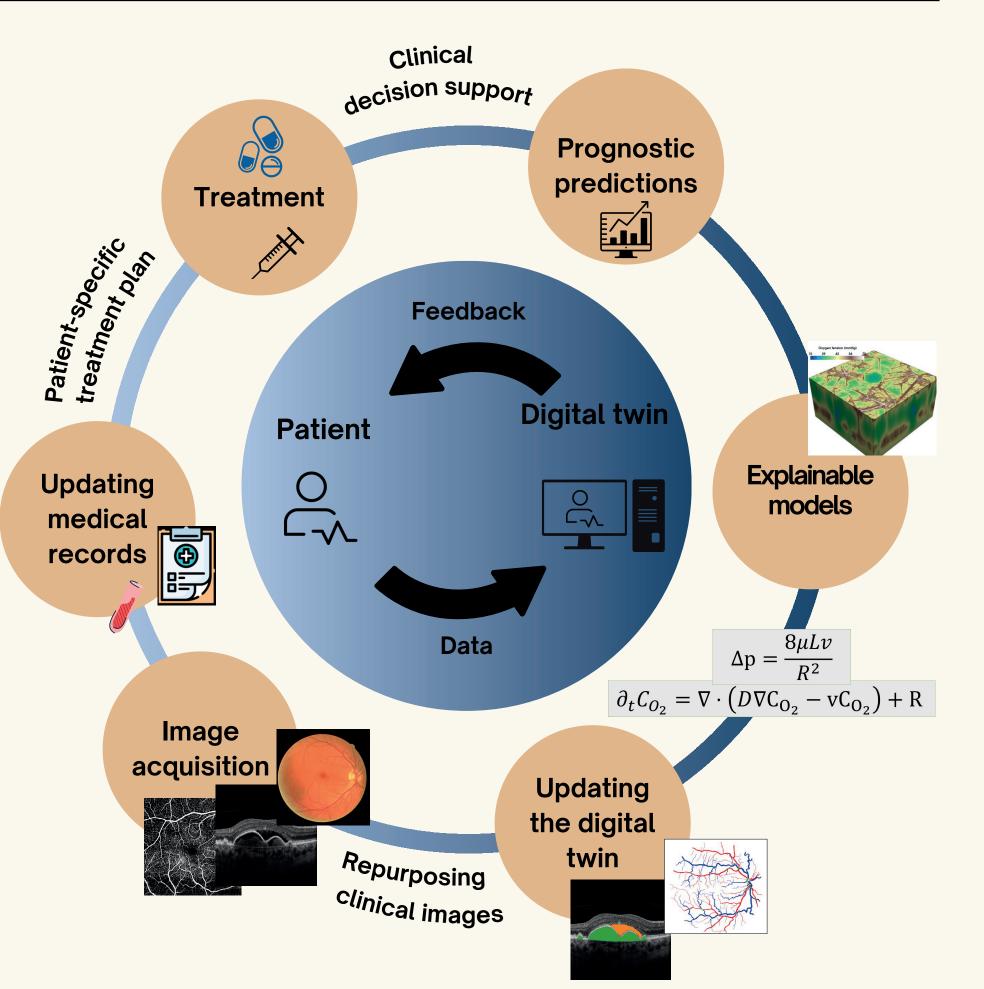
Decreased blood Haemorrhage, oedema, flow, lipid exudation occlusion, sight loss

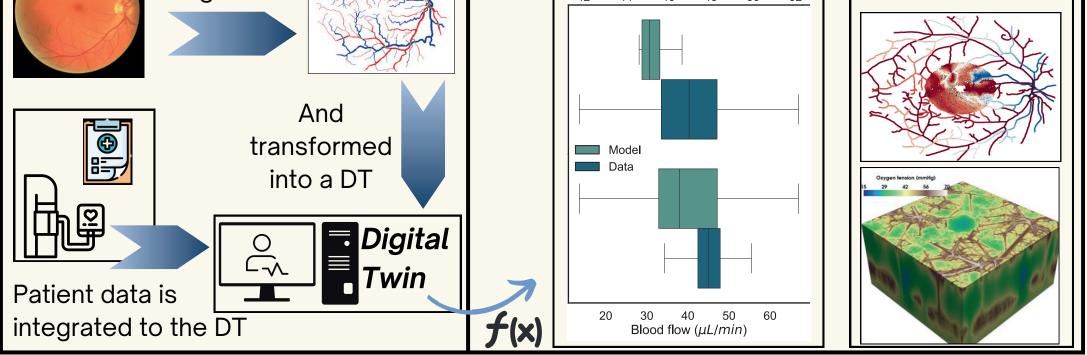
The Solution Digital Twins

- A **Digital Twin (DT)** is a digital counterpart of a patient's retina that:
 - Is created from existing images and data **Integration** into clinical practice
 - Makes predictions grounded in physics and mathematical concepts **Explainable**
 - Provide insight at a scale too small to observe
 - Can test 'what-if' scenarios **Personalised treatment**

| 1. Transform the images and add patient data | 2. Validate and make predictions | |
|--|--|--------------------------|
| Vessels are digitised | Validation Blood pressure (mmHg) 42 44 46 48 50 52 | Pressure and oxygen maps |

- Rising patient numbers generate **vast clinical data**, but resource constraints leave it underutilised
- Al technology can use this data but provides unexplainable prediction that do not integrate with clinical practice





- **Predictions** of blood flow and pressure align well with clinical data
- Our **DTs** are made from **non-invasive** routine retinal images and simple **blood pressure** readings
- We can look into **capillary** haemodynamics, derive **vascular risk** factors, identify high-risk patients
- We will be testing our model in real-world conditions with patient from the Royal Liverpool University Hospital



- The DT stays **up-to-date** with the patient
 - It incorporates comorbidities, test results **informing** future treatment plans
- DTs can be enrolled in 'virtual clinical trials' for quicker drug development
- With the 'eye as a window to the brain', DTs can be adapted to other vascular systemic disorders