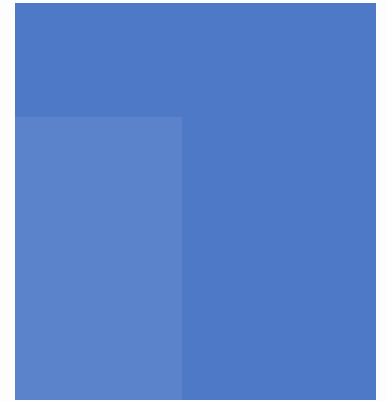# Developing a Lean Web-Based Visual Field Test

TM007

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Introduction

- Glaucoma is the 2nd leading cause of **blindness** worldwide
  - Chronic incurable disease → management is only option
- Glaucoma likely to become a **major healthcare issue** soon
  - 111.8 million Glaucoma patients by 2040 worldwide
  - Risk factors in Singapore
    - Aging Population
    - Diabetes
    - Hypertension
    - Early-age myopia

    } Possible Surge in cases in near future
- Disease onset is mild and gradual → often diagnosed **too late**
  - Earlier diagnosis → Better patient outcomes

Preliminaries   Engineering   Takeaways

Visual Field Testing

- Assess quality of patient's vision **regularly**
  - Monitor disease progression
  - Ascertain patient's response to treatment

- Humphrey **Visual Field Test** (VFT) is used in clinical practice
  1. Points are placed at various positions in field of view
  2. Lights at these points are flashed at different brightness values
  3. Determine minimum brightness for patient to see a light at particular point
  4. Repeat for many points → map of visual field quality

Visual Field Test Shortcomings

- **Inefficient**
  - Machine is costly and test is expensive
  - Patients spend time and money travelling to and from hospital
  - They have to return regularly as Glaucoma is chronic

- **Errors**

Type	Explanation	Indication
Fixation Loss	Patient responds to stimulus projected onto their blind spot.	Loss of attention
False Positives	Patient is "trigger-happy"; presses button even when there is no stimulus presented at that point in time.	Anxiety, Concern about getting a result indicating vision loss
False Negatives	Patient has responded to dimmer stimulus but fails to respond to brighter stimulus.	Fatigue, Inattentiveness, Malingering, Extreme vision loss

Preliminaries   Engineering   Takeaways

Engineering Goal

- Design **supplement** to clinical Humphrey VFT that is

- **Cheap**
    - Low equipment purchase cost
    - Low operating cost
    - Low cost per test

- **Convenient**
    - Test equipment is light and portable
    - Reduce number of retakes required to get reliable results
    - Reduce time taken per test

- **Reliable**
    - Results do not diverge significantly from clinical results

Engineering Roadmap

Phase 1: Minimum Viable Product (Completed)
- Digitise Humphrey VFT in Unity environment as proof-of-concept

Phase 2: Web-Based Minimum Viable Product (Current WIP)
- Physically realistic VR on the web using THREE.js library
- User authentication, Results persistence and management

Phase 3: Web-Based Feature Implementation (Future)
- Higher-order functionality ("Novel Product Features" & "Future Work")

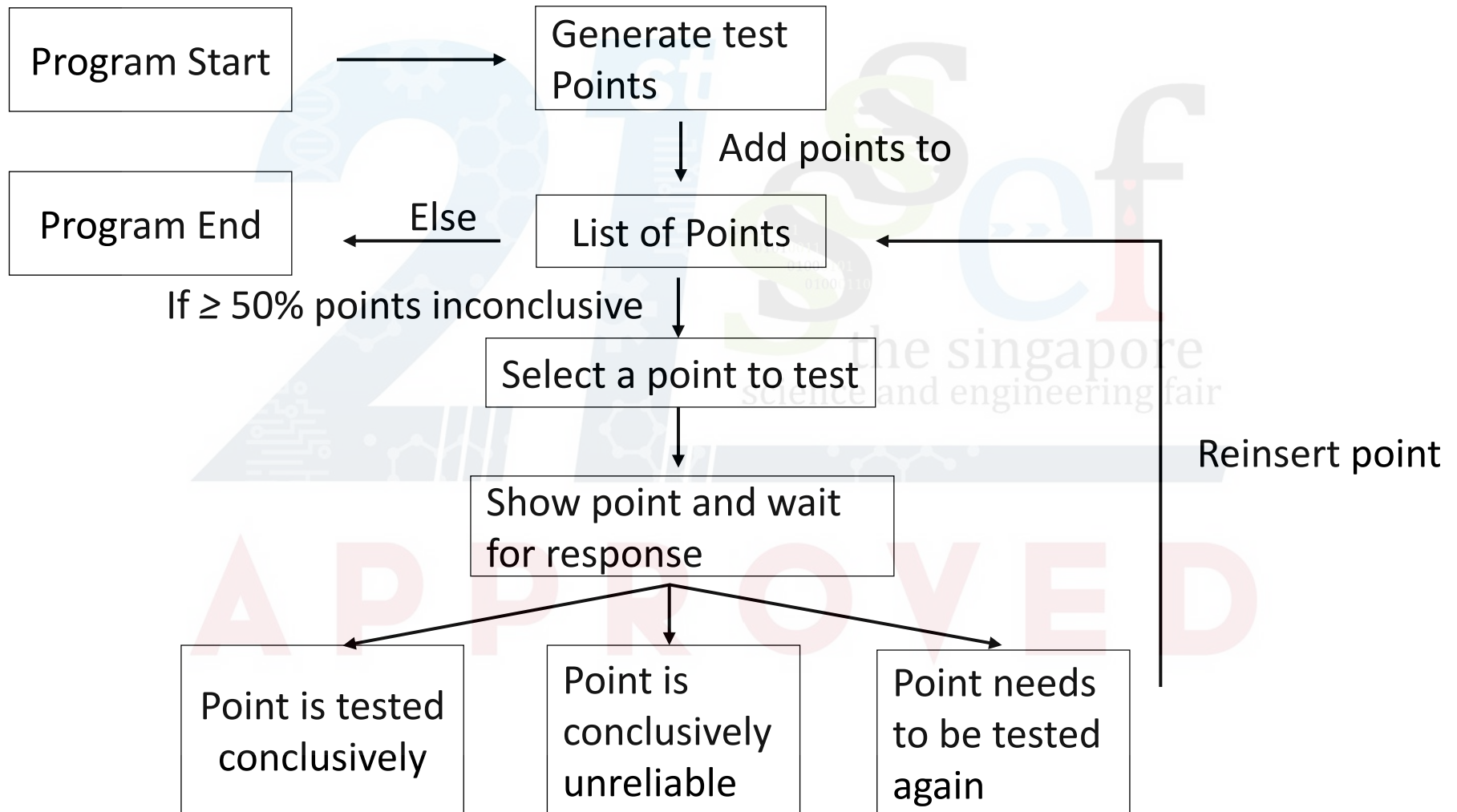**Phase 4: User Testing and Verification** (Proposed)
- If/when COVID-19 restrictions allow, product is tested

Product Overview

Client

Server

User Authentication
Serve Pages
Handle data

Database

User data
Past test results
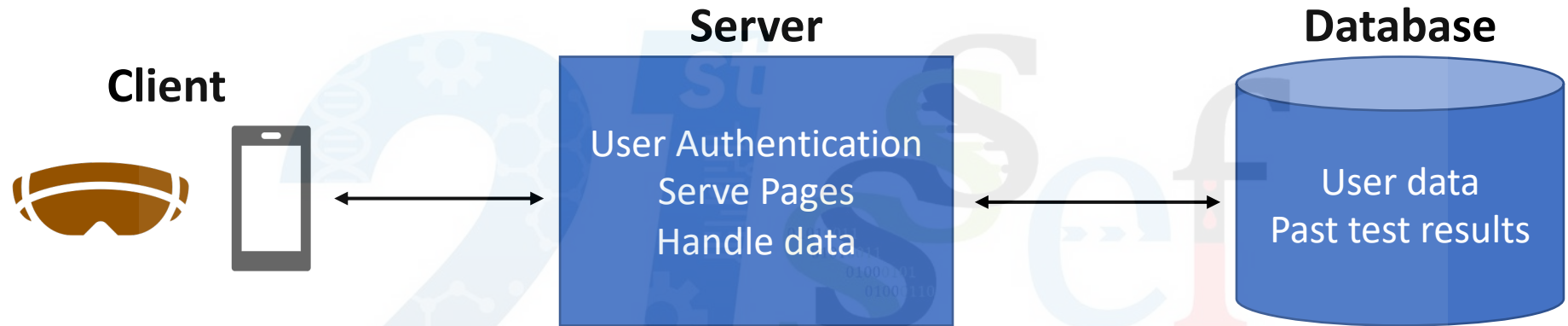
- **Homepage**
  - Shows information on test, instructions and links to other pages
- **About**
  - Shows rationale and explanation of test
- **Physician**
  - Shows dashboard with their patients' data
- **Patient**
  - Shows patient's past results in graphical form
  - Link to test page

Product Flowchart

Program Start → Generate test Points

Generate test Points →(Add points to) List of Points

List of Points → Else → Program End

If ≥ 50% points inconclusive

List of Points → Select a point to test

Select a point to test → Show point and wait for response

Show point and wait for response →
- Point is tested conclusively
- Point is conclusively unreliable
- Point needs to be tested again → Reinsert point → List of Points

Preliminaries   *Engineering*   Takeaways

Proposed Product Testing

Performance of Product vs Clinical Humphrey VFT

- Randomly sampled **20** persons **>65** years old
  - **10** diagnosed with Glaucoma   }
  - **10** diagnosed without Glaucoma   }   **50%** Male, **50%** Female
- Take test on product and then Humphrey VFT
  - (or vice versa, randomly decided)

1. Number of retakes required

2. Testing time each person took

3. Correlation between Product results and VFT results
   - Evaluated for statistical significance

Novel Product Features

- **Real-time** unreliability detection
  1. Patient does not see stimulus at certain brightness → reports seeing when stimulus at a dimmer brightness (or vice versa)
  2. Patient sees stimulus in natural blind spot (scotoma)
  - This flags results at that point as unreliable

- **Fixation Loss** Detection
  - Dead reckoning using phone accelerometer and gyroscope

- **Overpressing** Detection
  - Running average of presses/time → alert if significant change

- **Real-Time** Feedback
  - Provide audio-visual warnings in real-time if unreliability detected
  - Terminate test and restart if significant number of unreliable results

Future Work

- Physicians can **customise** testing points
  - Finer points distribution in smaller region of view
  - Personalised to each patient's disease progression

- **Data Processing** Algorithm
  - Compare patient's test results over time → indicate glaucoma progression severity

- **Diagnostic Algorithm**
  - Neural network trained on corpus of data → indicate probability of patient having Glaucoma as a cross-check for physicians

- **Eye Health Portal**
  - More tests can be consolidated into an eye health portal

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