Milestone 3:

LiDAR-assisted Wi-Fi Heatmap Generation

Group 106:

Austin He, Jian (Johnson) Gao, Jack Hou, Kevin Zhao, Victor Liang

Overview

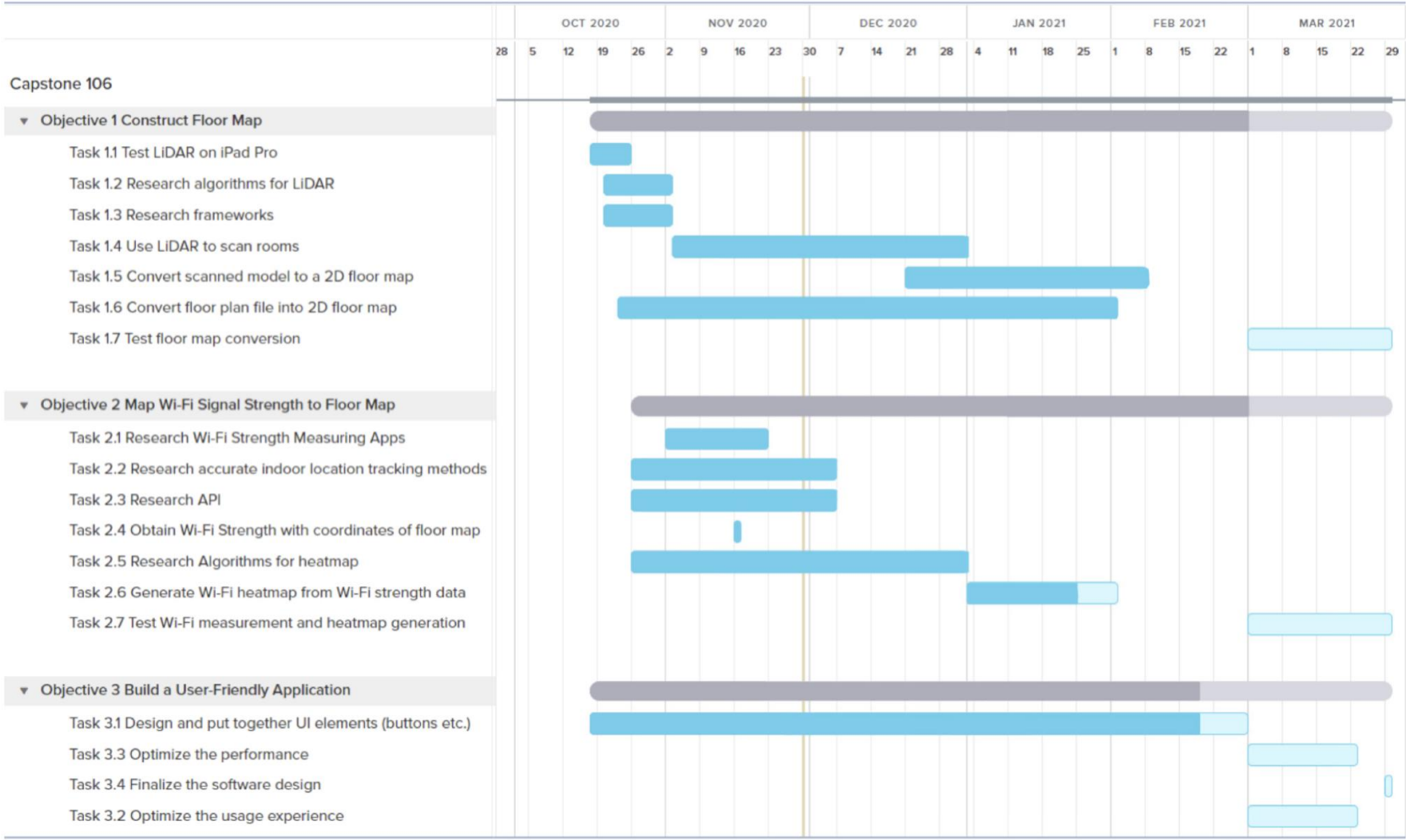
Project Management

LiDAR Sensing & Floor Map

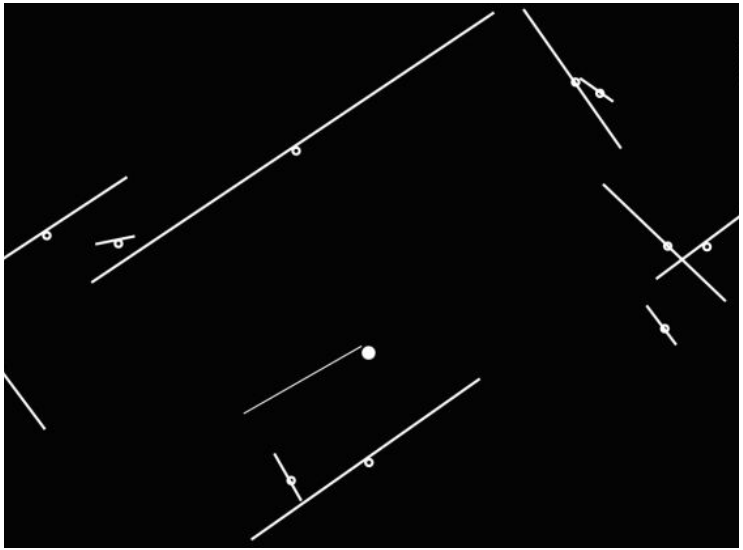
Wi-Fi Measurement & Heatmap

UI/UX

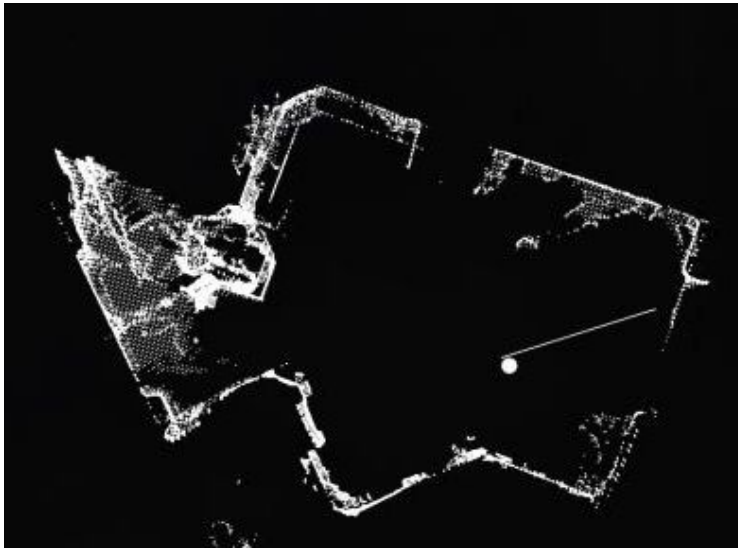
Verification & Validation


OCT 2020
NOV 2020
DEC 2020
JAN 2021
FEB 2021
MAR 2021
28 5 12 19 26 2 9 16 23 30 7 14 21 28 4 11 18 25 1 8 15 22 1 8 15 22 29
Capstone 106
Objective 1 Construct Floor Map
Task 1.1 Test LiDAR on iPad Pro
Task 1.2 Research algorithms for LiDAR
Task 1.3 Research frameworks
Task 1.4 Use LiDAR to scan rooms
Task 1.5 Convert scanned model to a 2D floor map
Task 1.6 Convert floor plan file into 2D floor map
Task 1.7 Test floor map conversion
Objective 2 Map Wi-Fi Signal Strength to Floor Map
Task 2.1 Research Wi-Fi Strength Measuring Apps
Task 2.2 Research accurate indoor location tracking methods
Task 2.3 Research API
Task 2.4 Obtain Wi-Fi Strength with coordinates of floor map
Task 2.5 Research Algorithms for heatmap
Task 2.6 Generate Wi-Fi heatmap from Wi-Fi strength data
Task 2.7 Test Wi-Fi measurement and heatmap generation
Objective 3 Build a User-Friendly Application
Task 3.1 Design and put together UI elements (buttons etc.)
Task 3.3 Optimize the performance
Task 3.4 Finalize the software design
Task 3.2 Optimize the usage experience

LiDAR Sensing — Floor Plan Preview



Approach 1: ARKit Plane Detection

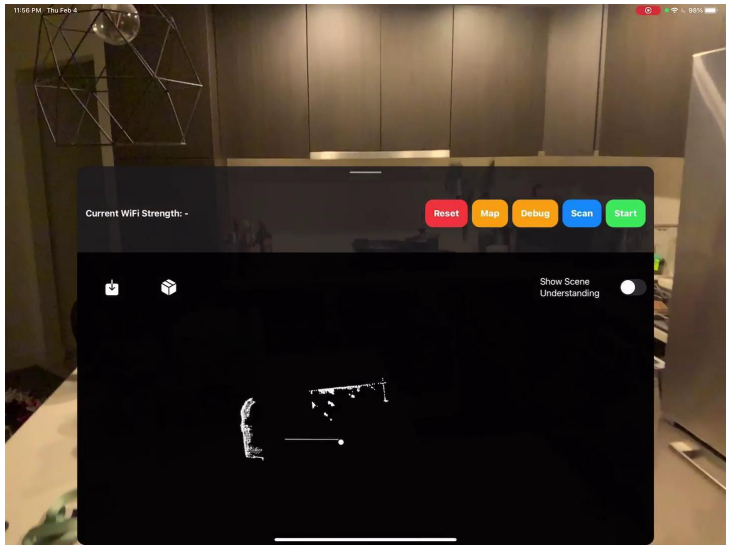


Approach 2: Raw Point Cloud

MetalKit — Floor Plan Preview Rendering

MetalKit is a low-level, hardware-accelerated 3D graphic and compute shader API.

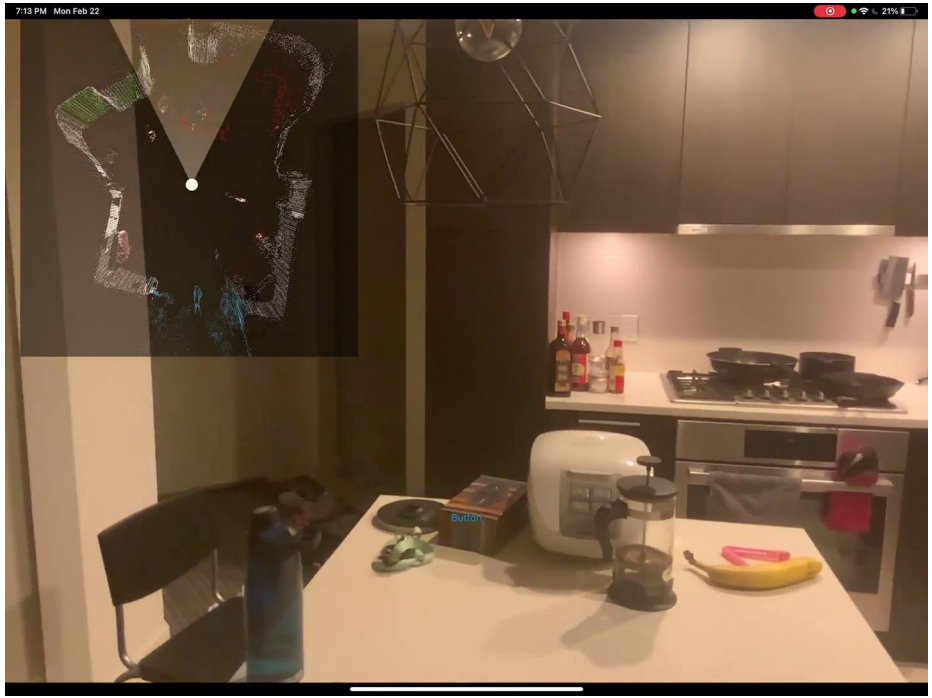
Without Metal:



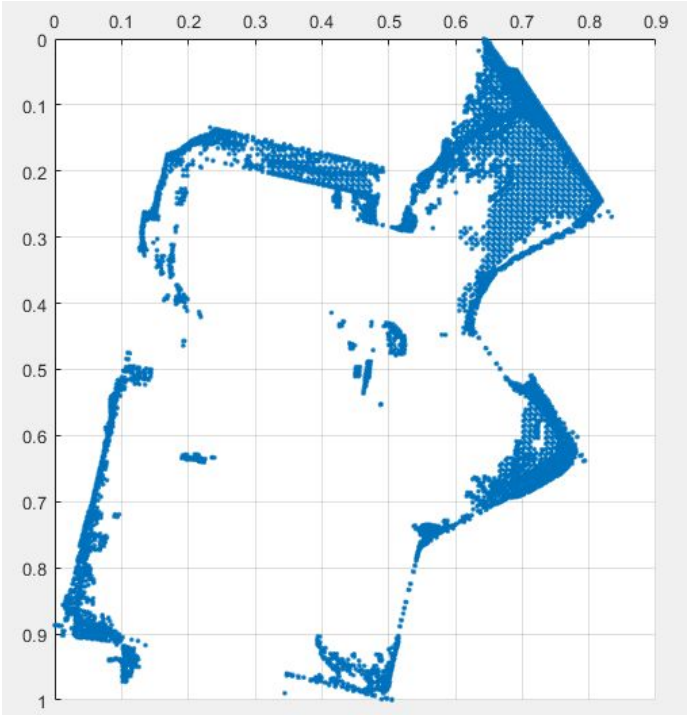
With Metal:

- Takes advantage of GPU
- Point cloud is now rendered smoothly

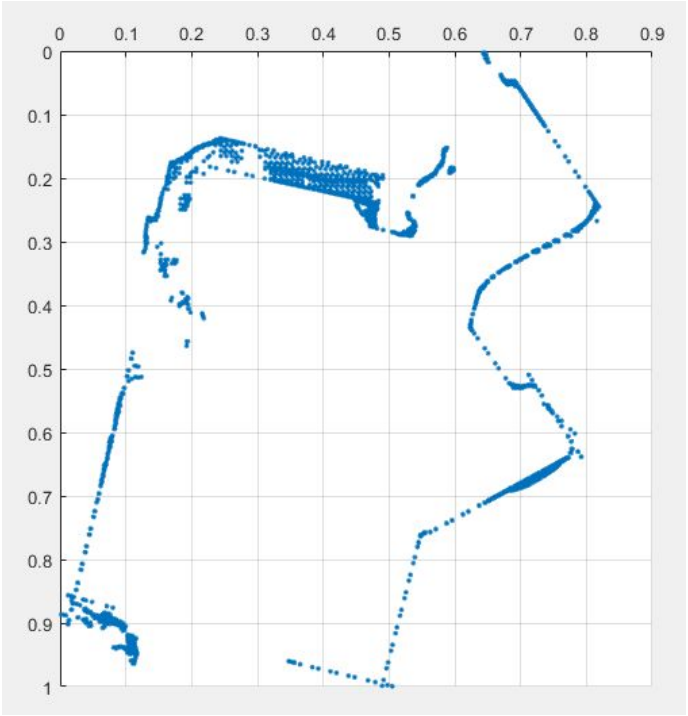
LiDAR Scanning - Demo Clips



LiDAR Sensing — Floor Plan Generation



Raw Point Cloud



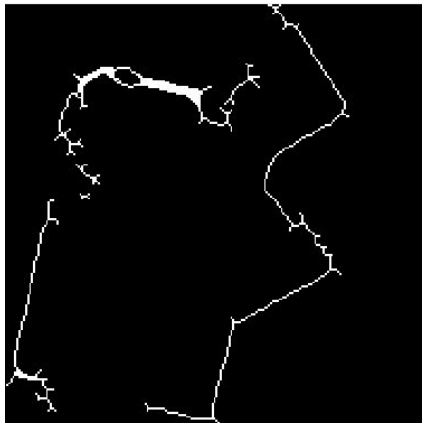
Truncated Point Cloud

LiDAR Sensing — Floor Plan Generation

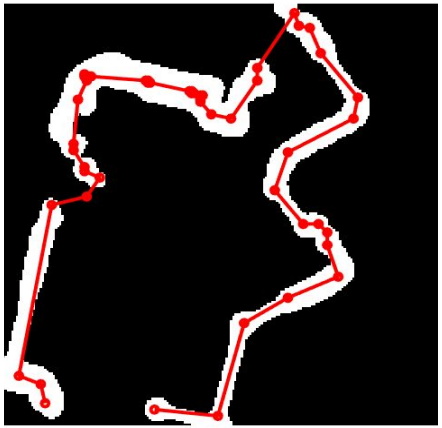
Hybrid of *discrete* data processing and *vector* conversion

1. Truncate the pointcloud to reduce workload
2. Use discrete space filters to “grow” points into blobs
3. Extract the corners using morphological operations
4. Apply exhaustive score-based search to generate a path

Discrete Render



Skeletonization

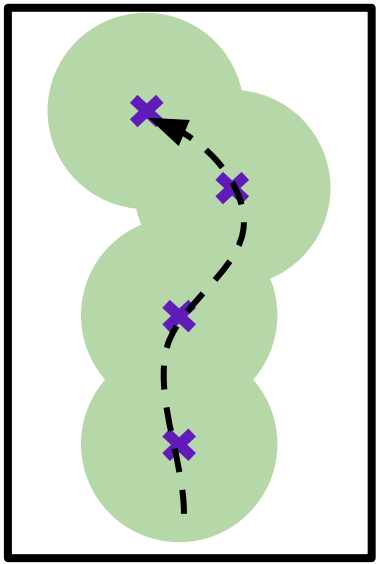


Graph Generation

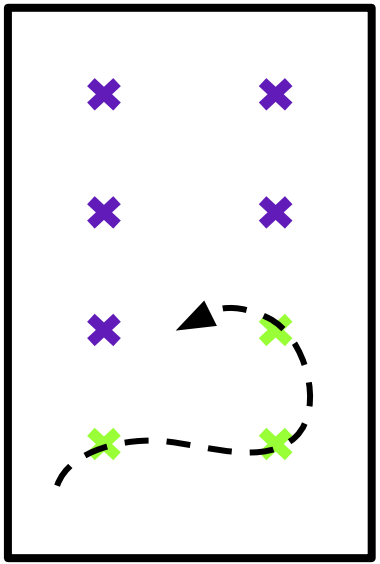
LiDAR Sensing — Pathing Assist

Trade-off between data quality and user experience

- Passive feedback (“one pass”)
  - Shows what the user has measured
  - Intuitive but more erratic
- **Preset Objectives** (“two pass”)
  - **Shows what the user needs to measure**
  - **Organized but less user friendly**



Passive Feedback

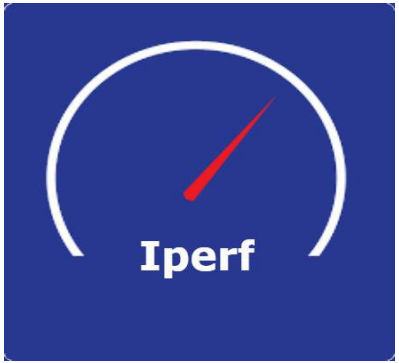


Preset Objectives

Wi-Fi Measurement

- Speedchecker SDK
  - Easy to integrate with iOS
  - Single measurement takes ~20 seconds

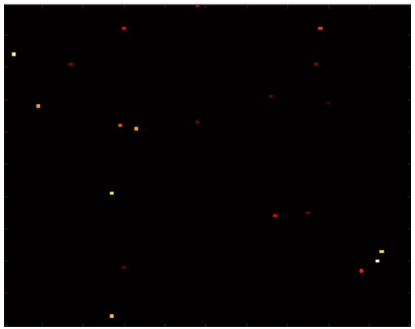
- **iPerf3**
  - **Used by Telus internally**
  - **High configurability**



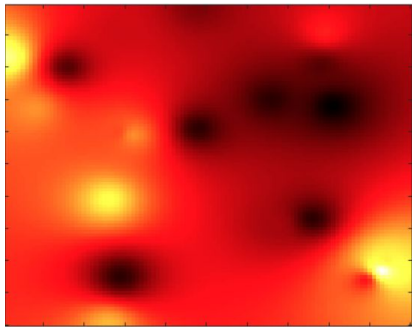
Data Processing and Heatmap Generation

Converting data points to heatmap:

- Interpolation is needed
- Works with sparse but accurate sets of data points
- Algorithm not too expensive to run

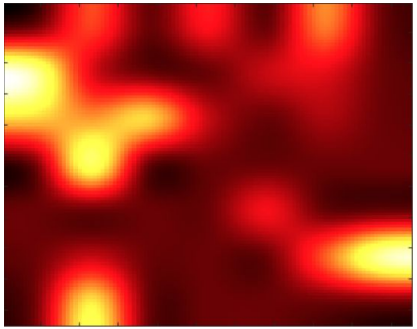


Input Dataset



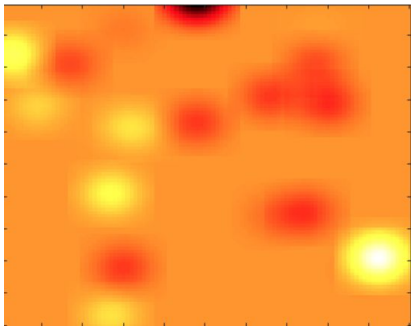
Weighted Nearest Neighbour

(k=10)



Bicubic Resampling

(N2 = 25)

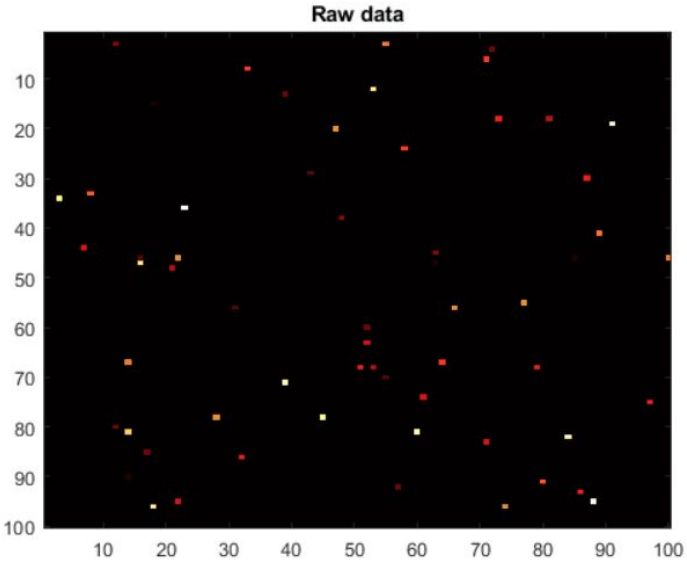


Gaussian Blur

(σ=7)

Heatmap Generation Demo

Measurements 60



k 20

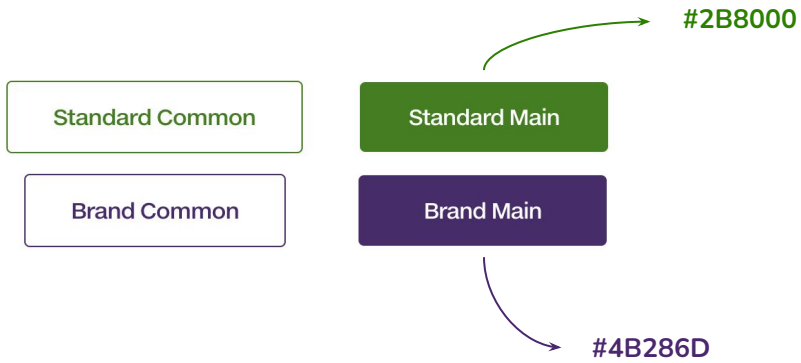
k = 20

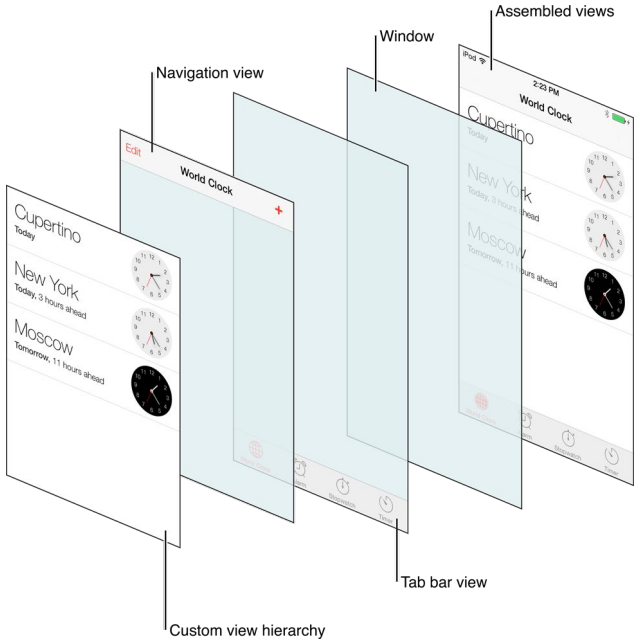
Wi-Fi Measurement — Next Steps

- Add coloured AR indicators
- Integrate heatmap generation into Swift
    - MATLAB coder -> C libraries -> Swift
- Iterate pathing method
- Test for accuracy

UI/UX

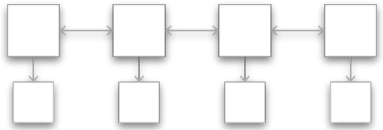
- TELUS Design System (TDS)
- Apple Human Interface Guidelines

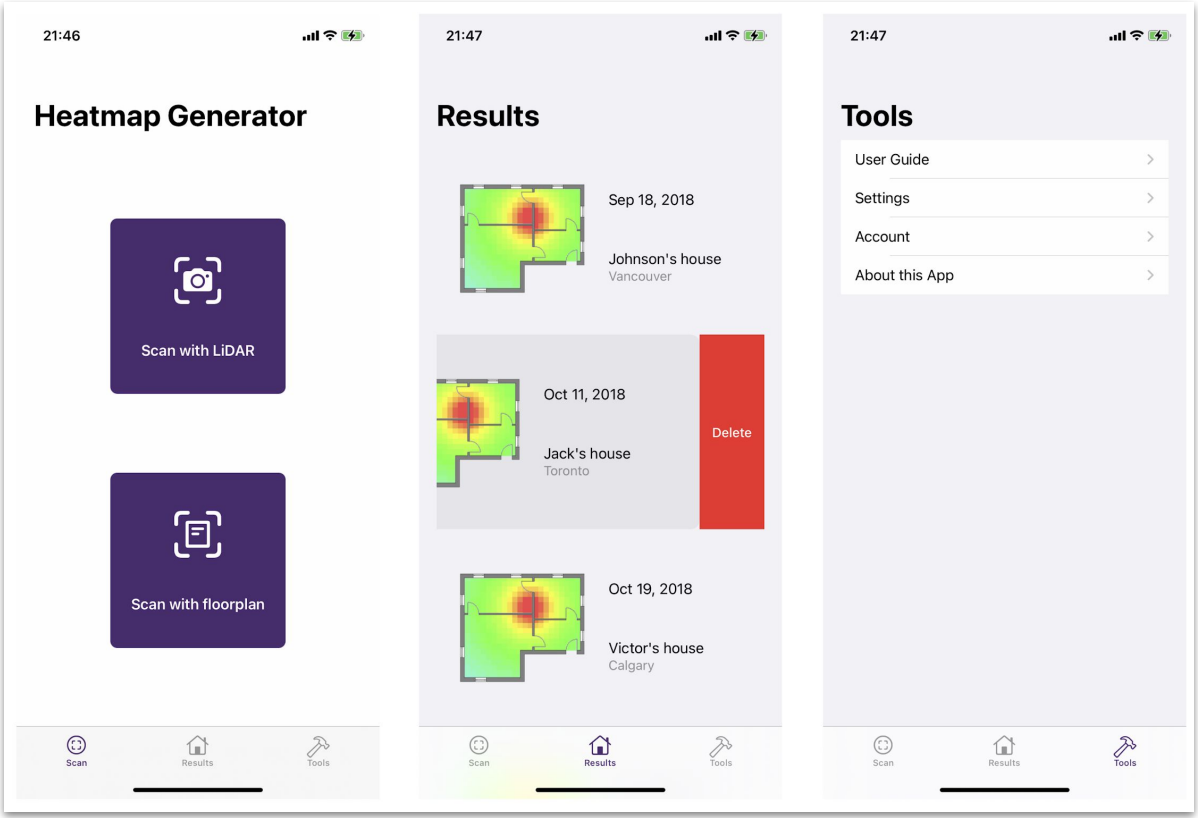




UI/UX

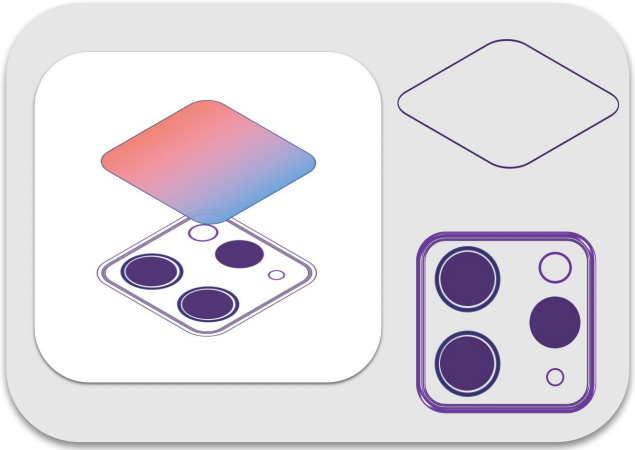
Flat Navigation

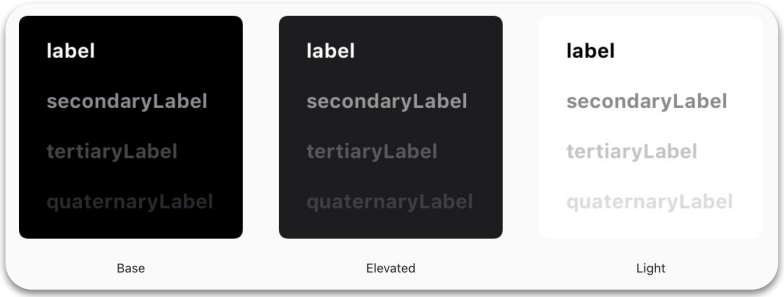




Other Visual Features

- App Icon
- Adaptive Layout
- Launch Screen
- Dark Mode





Verification

Objective	Requirement	Criteria
Obj1: Construct floor map	*Req1.1*: Convert LiDAR information to floor map	Compare generated floor map with rooms scanned
	Req1.2: Convert floor map file to floor map	
Obj2: Wi-Fi and Heatmap	*Req2.1*: Record strength of Wi-Fi with respect to coordinates on floor plan	Compare measured strength to a seperate Wi-Fi strength app
	Req2.2: Generate heatmap using Wi-Fi data and coordinates	How much of the floor plan is covered
	Req2.1N: Minimize scan time	User tests out scanning functionality
Obj3: Mobile App	*Req3.1*: Include intuitive and interactive instructions	User tests the whole user interface
	Req3.2: App should be well-optimized and responsive	Test app speeds
	Req3.1N: App should use appropriate visual components	Compare with other apps from TELUS

Validation

- Unit Testing
  - iPerf3 Module
  - LiDAR Floor Plan Generation
- GUI Testing
  - Button functionality
  - Extreme inputs ie. Repeated button inputs

Time (s)	Std Deviation (Mbits/s)
3	62.4448
5	42.5682
10	32.0953

Deliverables

1.0 Documentation

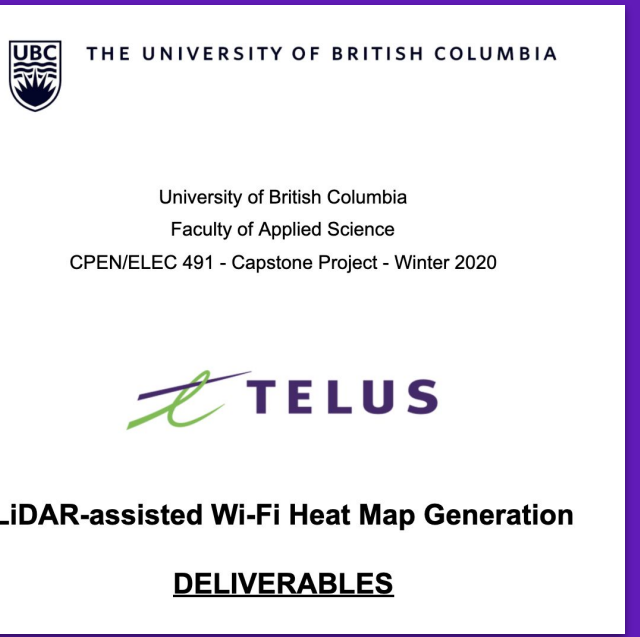
1) **Proposal**
2) **Requirements Document**
3) **Project Design**
4) **Management Plan**
5) **Validation & Verification**
6) **Retrospective**

2.0 Final Product

1) **iOS/iPadOS Application**
2) **Source Code**
3) **User Guide**
4) **Product Video**

3.0 Additional Specifications

1) **Presentation Slides**
2) **List of Purchases**
3) **Test Suites**



Next Steps

- ***Optimize*** *floor plan generation*
- ***Map*** *Wi-Fi data to generated floor plan*
- ***Integrate*** *UI/UX*

Questions