Engineering Problem

Dementia and memory loss patients can get lost inside buildings that they visit frequently because they cannot form memories of the building's layout. This requires a caregiver or another person to help them navigate at all times.

Engineering Goal

The aim of this project is to develop an app to lead people with memory loss through a building without needing the help of another person and will also remind the person that they can use it to navigate the building.

Project Direction Decision Matrix

- Used to determine which direction the project should head.
- Scores based off the average dementia patient.

	Prototype Design Concepts	Arduino/Attachable Device	Phone Application	Smart Watch Application	Recoded GPS Device
Criteria	Max Score	A	B	C	D
Feasible	10	6	9	8	4
Simple to Use	9	7	6	7	5
Cost-Effective	9	5	4	3	4
Accessible	8	5	7	6	5
Not Physically Demanding	8	7	6	6	4
Accurate	7	4	4	4	5
Reliable	7	7	5	5	6
Works in Variety of Buildings	5	4	5	5	4
Total		45	**46**	44	37

Indoor Location Decision Matrix

- Used to determine the best method to get the location of the user

	Indoor Location Systems	Google Geolocation	Accelerometer + Gyroscope	(TSARS) Time and Space Attributes of Received Signal	RSS (Radio Signal Strength)	WiFi RTT
Criteria	Max Score	A	B	C	D	E
Accuracy	10	7	3	5	7	10
Reliability in different buildings	9	7	9	7	8	8
Ease of use	8	5	4	3	4	7
Customization	7	6	7	6	5	5
Ease to implement	6	6	6	6	4	6
Total		31	26	26	29	**36**

Recorded Data

1 Router 2 Points

	Trial 1:	Trial 2:	Trial 3:	Trial 4:	Trial 5:	Average	SD	%RSD
Marker #	(m)	(m)	(m)	(m)	(m)	(m)	(m)	of Avg
1	0.873	1.013	0.916	0.978	1.061	0.968	0.075	7.732
2	0.213	0.207	0.215	0.213	0.233	0.216	0.010	4.613
3	1.747	1.862	1.847	2.019	1.815	1.858	0.100	5.387
4	1.415	1.336	1.268	1.353	1.238	1.322	0.070	5.325
5	1.302	1.382	1.320	1.452	1.322	1.356	0.062	4.566
6	1.432	1.348	1.555	1.693	1.323	1.470	0.154	10.480
					AVG	1.198	AVG	6.350

1 Router 3 Points

	Trial 1:	Trial 2:	Trial 3:	Trial 4:	Trial 5:	Average	SD	%RSD
Marker #	(m)	(m)	(m)	(m)	(m)	(m)	(m)	of Avg
1	0.875	0.888	0.882	0.958	0.835	0.887	0.044	5.005
2	0.217	0.212	0.214	0.203	0.218	0.213	0.006	2.718
3	1.178	1.061	1.114	1.069	1.180	1.120	0.057	5.088
4	1.253	1.388	1.255	1.323	1.462	1.336	0.090	6.720
5	1.207	1.434	1.251	1.257	1.353	1.300	0.091	7.028
6	1.262	1.276	1.386	1.366	1.253	1.309	0.063	4.780
					AVG	1.028	AVG	5.223

1 Router 4 Points

	Trial 1:	Trial 2:	Trial 3:	Trial 4:	Trial 5:	Average	SD	%RSD
Marker #	(m)	(m)	(m)	(m)	(m)	(m)	(m)	of Avg
1	0.868	0.790	0.810	0.840	0.872	0.836	0.036	4.289
2	0.191	0.201	0.201	0.200	0.190	0.197	0.006	2.878
3	1.040	1.064	1.040	1.105	1.184	1.087	0.060	5.564
4	1.230	1.335	1.318	1.352	1.183	1.283	0.073	5.705
5	1.284	1.376	1.363	1.402	1.312	1.347	0.048	3.564
6	1.354	1.366	1.454	1.358	1.466	1.400	0.056	3.984
					AVG	1.025	AVG	4.331

- Trials recorded inaccuracy (distance from theoretical)
- Average used to determine accuracy of the routers
- Standard Deviation (SD) and % Relative Standard Deviation (%RSD) used to determine precision of routers

Independent Indoor

Navigation for

Individuals With

Memory Loss

Introduction

Design

Testing

Results

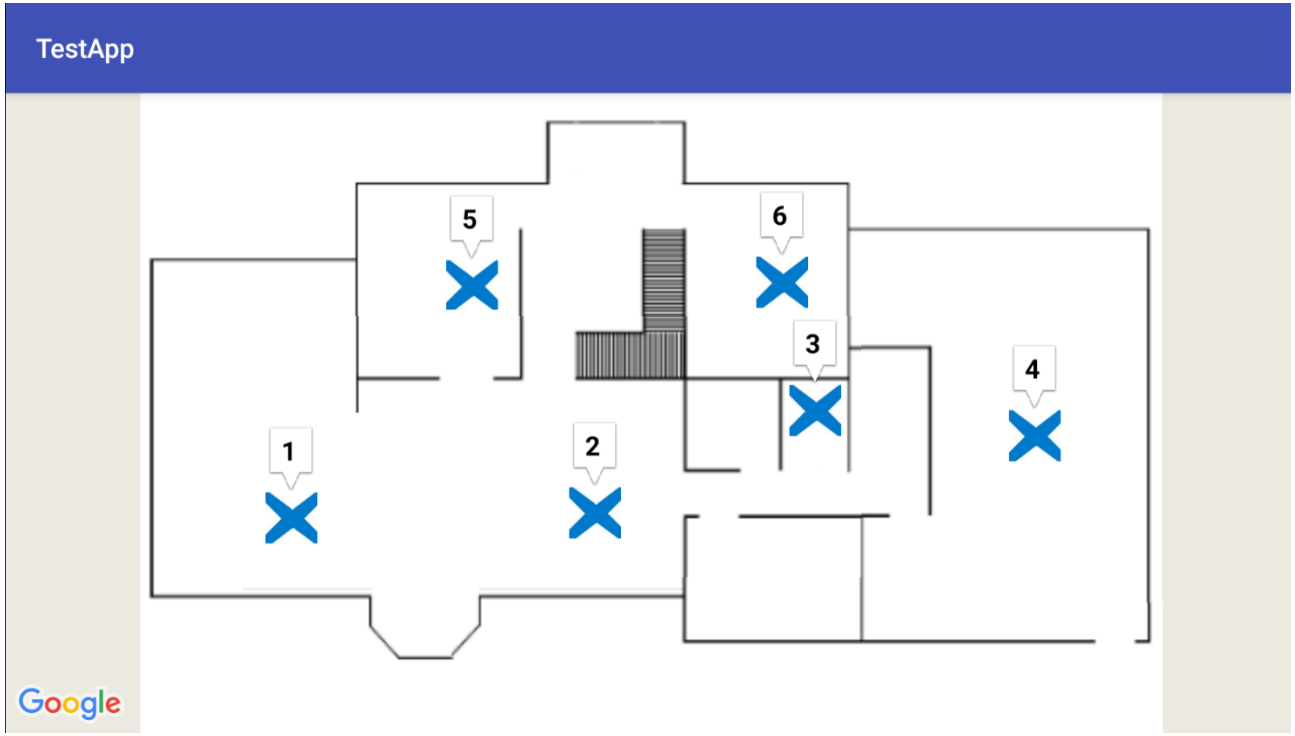
Average Marker Data

- Accuracy and precision significantly improved from 3 access points to 4
- Very minimal improvement from 4 to 5 access points

Average Marker Data

Access Points:	Average Inaccuracy (m)	Change in Accuracy (%)	%RSD of Avg	Change in Precision (%)
3	1.198	N/A	8.796	N/A
4	1.028	17.077	5.223	3.573
5	1.025	0.266	4.331	0.893

Marker Layout

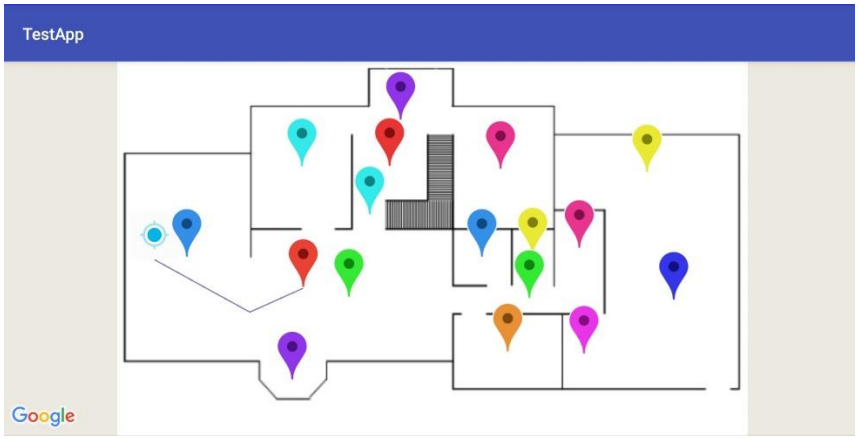


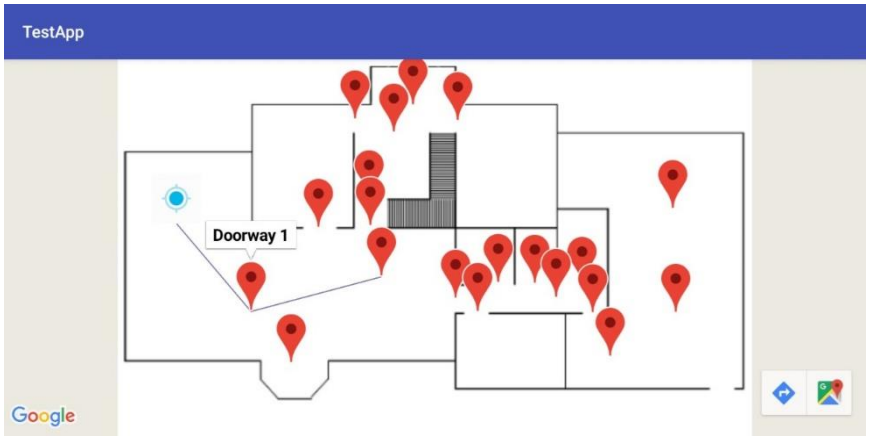
- Visual location of all the markers for the experiment
  - Marker 1 in open area and close to access point
  - Marker 2 close to the main router
  - Marker 3 behind thick concrete walls
  - Marker 4 in open area but not close to an access point
  - Markers 5 and 6 are in average rooms

Materials and Software Used

- Android Smart Phone
  - Held the code for the application and was used to test the app.
- Computer with Android Studio
  - Used to create the code for the application (in Java).
- Google's Maps SDK
  - Contains libraries and APIs with functionalities for creating and using maps.
  - Required an API Key from Google
- Google WiFi Routers and Points
  - WiFi RTT Compatible

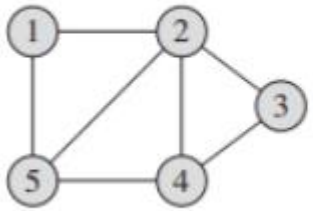
Navigation System





- Rooms (left image) are used to which doors the user can go through
- Doorways (right image) are used to calculate the best path from the user's position to the destination position.

How Position and Distance is Calculated



	1	2	3	4	5
1	0	1	0	0	1
2	1	0	1	1	1
3	0	1	0	1	0
4	0	1	1	0	1
5	1	1	0	1	0

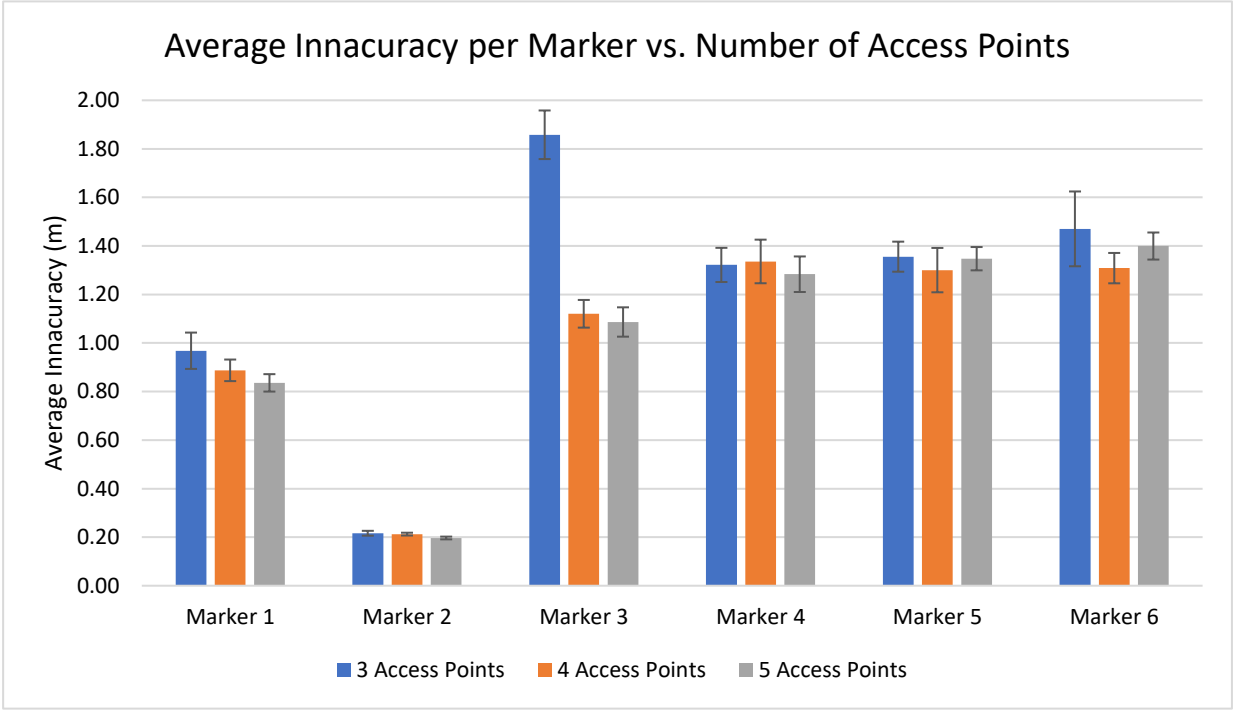
- Positions stored as Latitude-Longitude values using the Google Maps API.
- Distance between Lat-Lng positions stored in a matrix.
- Matrix value is 0 if the points are not connected, and the distance between the points if they are.

Testing Goal

The goal of the test is to determine the optimal amount of access points required for the application to function properly.

- Important due to every other aspect of the application being improvable with future extensions and the cost associated with WiFi RTT compatible routers.
- WiFi RTT is a fairly new technology, so only a limited amou
  - $265 for one Compulab WILD (1st RTT Enabled Access Point).
  - $169 for one Google Router and $80-$100 for additional Google Points.
  - Other compatible routers are around the same price.

Individual Marker Data



- Marker 2 (closest to main router) was constant throughout and had a significantly lower inaccuracy
- Marker 3 (inside a thick concrete walled room) significantly improved with an access point close by
- Other markers either slightly improved or remained constant

PROCEDURE

1 SETTING UP MARKERS

Markers were placed in different locations throughout the building. These markers would represent different conditions, such as close to the access point, behind a thick wall, etc. The markers would be constant throughout every experimental trial in order to make sure the results can be compared effectively. For this experiment, six markers were used.

2 DETERMINING THE THEORETICAL LOCATIONS

Because the application contains a scale model of the building's floor plan, it is possible to find the location in the application's map that corresponds to the exact location of the markers. These theoretical locations were used to calculate the distance between where the app thinks the user is and where they actually are.

3 RUNNING THE INITIAL TRIALS

The initial trials were run with the minimum amount of access points required to cover the entire area, which in the case of this experiment, was three access points. Each marker was visited in numerical order five times, with the inaccuracy being recorded each time.

4 ADDING ADDITIONAL ACCESS POINTS

After the initial trial, additional access points were placed in the locations that would most benefit from having an access point close by. The steps for the trials would then be repeated with the additional access point, and the results would be recorded. The same step of adding and additional access point and recording results would be done again.

5 INTERPRETING RESULTS

After all the data has been collected, it would be determined by a variety of factors, such as decrease in inaccuracy, improvement in precision, etc. These factors would be used to determine both individual marker improvement and average marker improvement

BACKGROUND

WHAT IS DEMENTIA?

Dementia is the overall term used to describe different diseases and conditions that cause progressive and irreversible changes to different mental functions. These changes can cause improper communication between brain cells, which causes many mental faculties, such as thinking, behavior, and feelings, to be affected abnormally.

IMPACTS OF DEMENTIA

Patients with dementia often have less control over their lives, and have to rely on caregivers or other people in general in order to live. Normal things, such as preparing meals, keeping track of items, such as keys, remembering appointments, and memorizing a building layout can be hard or even impossible for certain dementia patients.

PROBLEMS FACING CAREGIVERS

Caregivers for dementia patients are typically friends or family members of the patient, and they often have to provide 50 or more unpaid hours every week in order to take care of them. Because of this, when compared to caregivers for patients with other types of diseases, looking after someone with dementia takes more hours every week and has a larger impact on both the physical and mental health of the caregiver.

DIFFICULTIES WITH INDOOR NAVIGATION

Already established location systems, such as GPS, face problems in indoor spaces, such as walls that block/distort signals, multiple floors that overlap, and varying layouts for different buildings. These problems require other location systems to be used for accurate indoor location tracking.

WIFI RTT

WiFi Round Trip Time (RTT) is a feature on smartphones that allows enhanced location accuracy. It does this by not only sending information on the strength of the signal, but also the time it takes for the signal to reach the access point and return to the device. This time can be used to calculate a theoretical indoor accuracy of 1 to 2 meters.

SHORTEST PATH PROBLEM

The shortest path problem is the problem of finding the shortest path between one vertex and another. The shortest path problem is useful in situations where multiple paths from point A to point B are given, but a minimum distance is needed, such as with navigation.

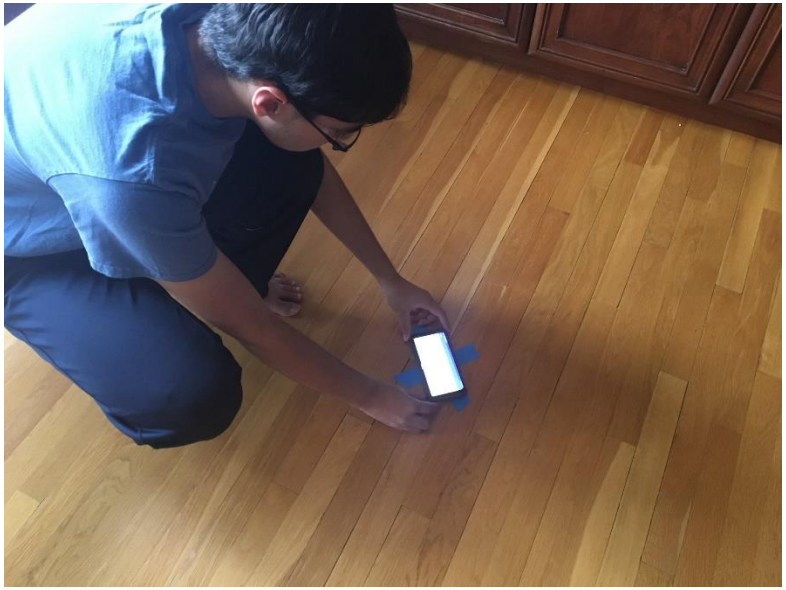
Conclusion

- Both memory loss patients and their caregivers suffer significantly due to memory loss patients not being able to navigate indoor areas.
- This application can help caregivers not have to worry about their patients constantly and memory loss patients gain more independence in their lives.
- Additional access points only required for locations with an already poor WiFi reach.

Future Extensions

- Create a simpler and more streamlined user interface
  - Minimal amount of clicking and settings for navigation to work
- Add functionality for multiple floors
- Add more customizability features for the user
  - Custom notifications for specific criteria, such as wanders too far from the path

Experiment Demonstration



- Marker is marked with a “x-mark” made from tape
- Phone is placed in center for consistency