Modelling and Displaying Optimal Placement of Automated External Defibrillators (AEDs) to Maximise Coverage of Out-of-Hospital Cardiac Arrest (OHCA) in Singapore

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Abstract: Out-of-Hospital Cardiac Arrests (OHCA) can occur at any time and currently the most practical solution is to adopt the use of Automated External Defibrillators (AED) in public areas. For every passing minute, the rate of survival of OHCA patients decreases by 7-10% . Thus, with limited AED resources, effective allocation of AEDs around Singapore is crucial as time is critical for OHCA patients. As of now there is no standard approach to best determine where to place AEDs around the country. This project aims to maximise existing and future AED coverage as well as provide simulation for optimal AED placements in Singapore. The project was conducted in consultation with experts at SingHealth.

Project Overview

Project Objectives

1. Develop User Interface for problem visualisation
2. Create mathematical models to select optimal positions to place AEDs
3. Maximise resource allocation based on geographical data analytics

Project Roadmap

Approaches For Maximising AED Coverage
- Maximal Coverage Location Problem (MCLP)
- Probabilistic Coverage Model (PCM)
- K-Means Clustering

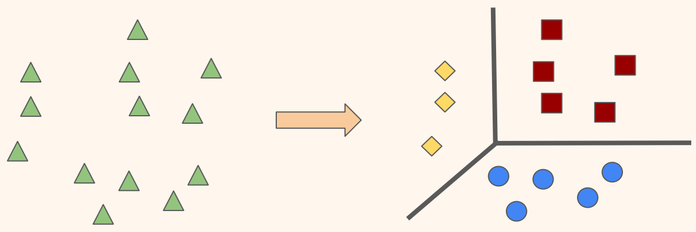
Building Dashboard For Visualisaion
- Data extraction and cleaning using python (OHCA and Population Data)
- Web Development with Data Science Implementation

Testing and Analysis of Implementations
- Evaluating against performance matrices of other approaches
- Usefulness and recommendations from SingHealth and MOH

Backend

K-Means Algorithm

A method to group data points into clusters based on minimisation of sum of squared Euclidean distances within clusters.



Application to this project

OHCA patients are clustered into groups and AEDs are represented by cluster centroids. This is an optimal placement given that the objective is to minimise total distance between OHCA patients to AEDs.

Reduce Execution Time and Memory Usage - Two layers of clustering

Given about 10000 AEDs and more than 100000 historical OHCA patients in Singapore, the large dimension distance matrices in K-means could not be computed. Two layers of clustering was used, for the dimension to be executable in programms.

Performance Metrics

Evaluates the performance of optimal addition of x number of AEDs.

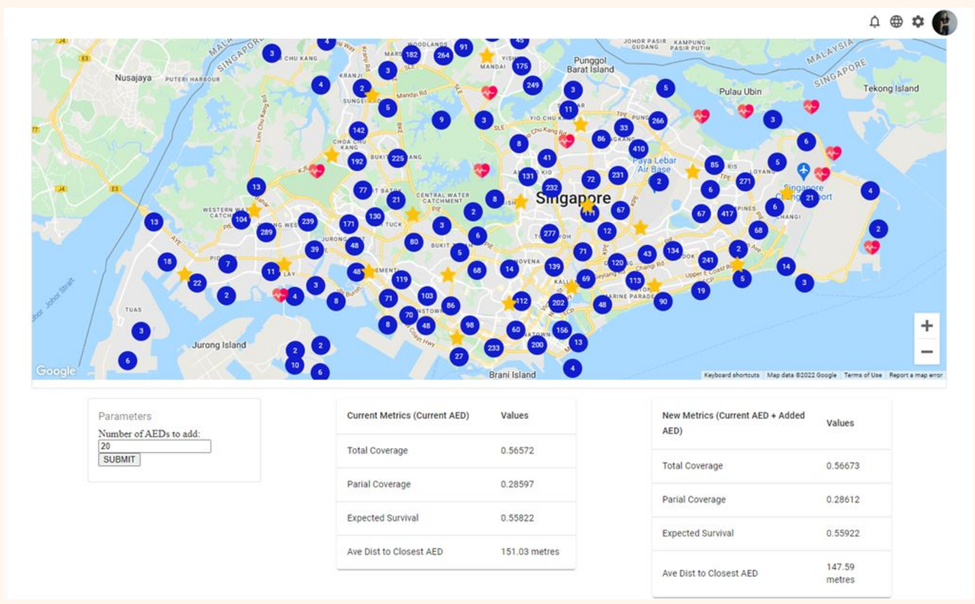
	Current placement	Add 500 new AEDs
Total coverage (Percentage of OHCAs covered)	0.56572	0.64645
Partial coverage (Percentage of OHCAs covered)	0.28597	0.33924
Expected Survival (Average chance of surviving)	0.55822	0.62038
Average distance (Average distance of OHCAs to AEDs)	151.03m	91.88m

Repositioning all AEDs VS Addition of AEDs

Repositioning of all AEDs utilises two datasets - “all available AEDs in Singapore” and “past OHCA occurrences”.
Addition of a fixed number of AEDs utilises one dataset, “uncovered OHCA patients under the current AED placement”. Optimal placement of auxiliary AEDs will be simulated.

Frontend

Web development/ User Interface

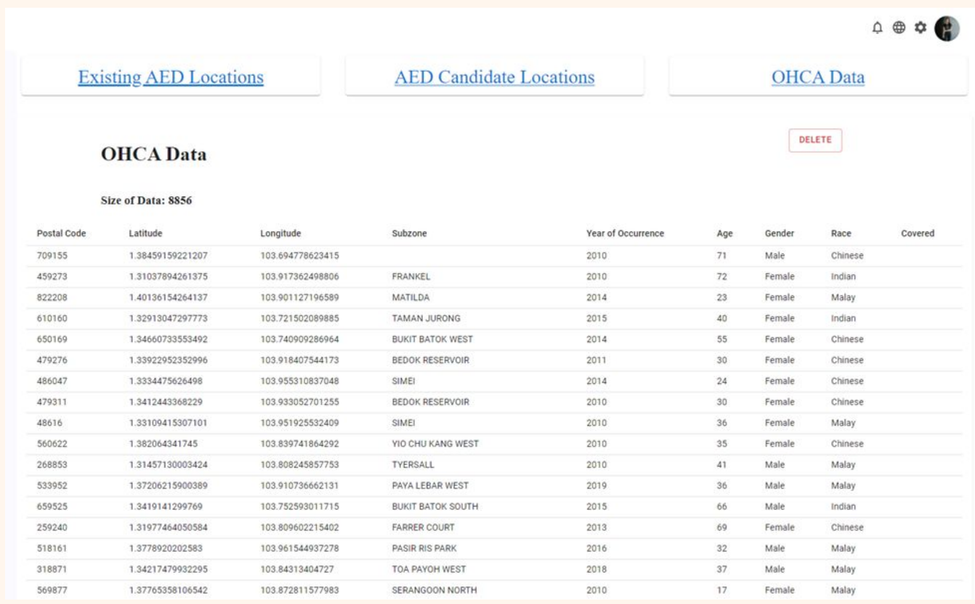


Simulating Optimal AED Placements with K Means Algorithm

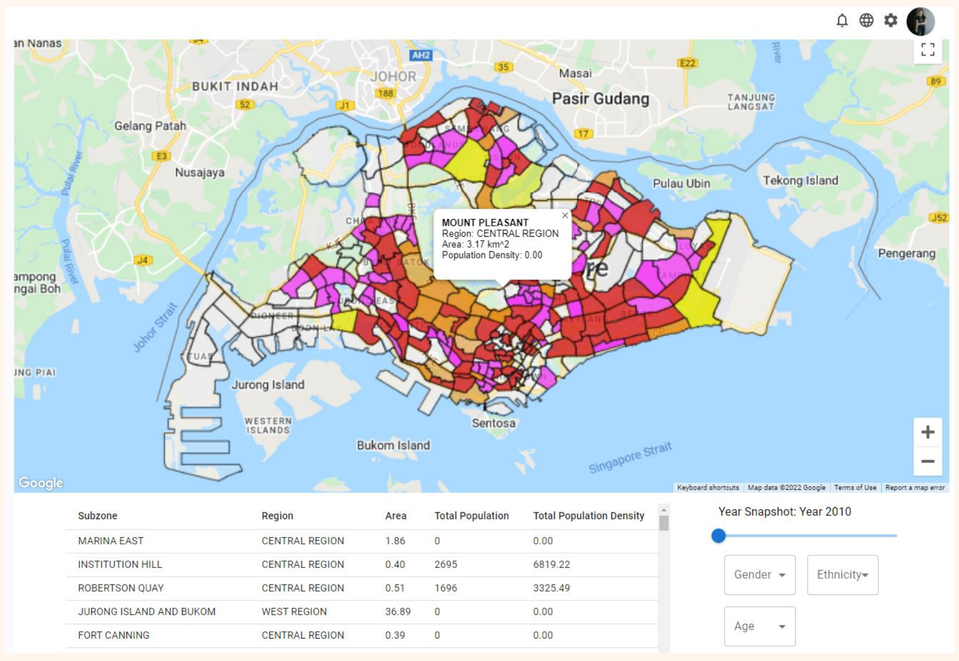
- Utilizes Google React Map Library
- Takes user input (number of additional AEDs to simulate)
- Plot optimal AED locations on Map
- Calculate existing and new metrics

Data Management

- Upload dashboard with most relevant data
- View uploaded datasets
- Interact with Django backend database through Object-Relational Mapper (ORM)



Population Density and OHCA Incidence Rate Heat Map



- Utilizes Google React Map Library
- Simulate population density and incidence rate (OHCA count / Population count) of each subzone
- Year, Gender, Ethnicity, Age filters

Key Skillsets

ISE Skillsets Applied:

Statistical Data Analytics | **Project Management** | **Optimization and Machine Learning**

Technical and Soft Skills Gained:

Human factor Engineering & Design Thinking | **Programming skills** | **Stakeholder Management**

Future Improvements

- Implementing OneMap API to include all specific address details
- Developing dashboard to include MCLP and PCM models
- Population forecasting for future undeveloped estates
- Mapping AEDs according to a ranked candidate AED list
- Mapping AED placements based on building levels and time taken