Optimal Placement of AEDs to Maximise Coverage of OHCAs in Singapore: Development of a Web Application for Policy Planners

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Background:
- Out-of-hospital cardiac arrest (OHCA) can happen suddenly and with high mortality rates.
- Early defibrillation to restart the heart can improve survival rates.
- Public Access Defibrillation (PAD) programs entail installing accessible automated external defibrillators (AED) in the community to allow quicker access by bystanders and supports early defibrillation.

Objectives:
- Develop an intelligent algorithm to identify the optimal installation locations for AEDs in Singapore -to reduce time taken to access AEDs, increase the rate of AEDs applied to OHCA victims, and thus help improve OHCA survival rate by using mathematical optimization techniques.
- Develop an interactive dashboard to support the decision making capabilities of AED planners.

Project Roadmap

Optimizing AED Coverage
- Maximal Coverage Location Problem (MCLP)
- Probabilistic Coverage Model (PCM)
- K-Means Clustering

Dashboard For Visualisaion
- Data extraction and cleaning using Python
- Web-based Frontend Development
- Model Implementation

Testing and User Feedback
- Evaluating against performance matrices
- User feedback from SingHealth and UPEC

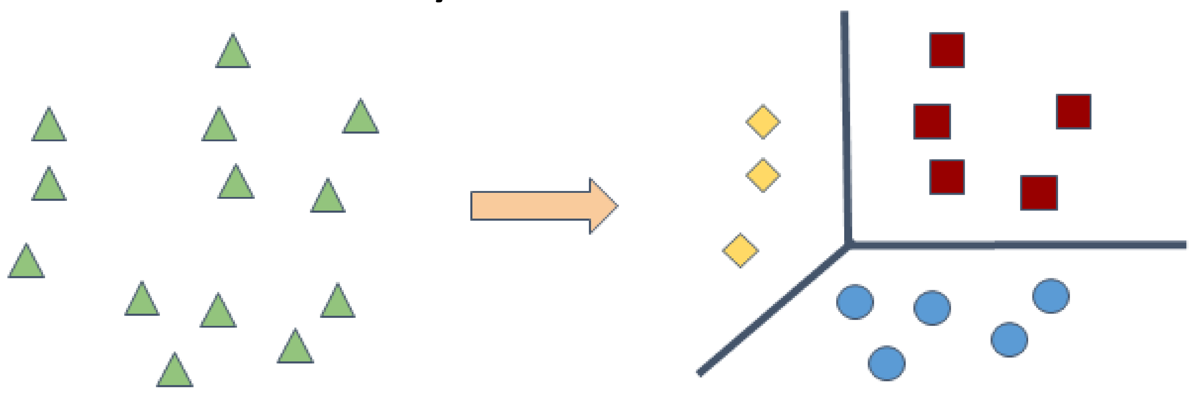
Data

- Ten years (2010-2019) of historical cardiac arrests data from the Pan-Asian Resuscitation Outcomes Study (PAROS) were first visualized and clustered by Python
- URA and Census data were gathered from web sources and merged with the PAROS dataset

Methods

K-Means Clustering:

- K-Means Algorithm was used to group data points into clusters based on minimization of sum of squared Euclidean distances within clusters.
- OHCA patients are clustered into groups and AEDs locations are identified by cluster centroids.



Maximal Coverage Location Problem (MCLP)

- Optimization model that maximizes the total number of demand points covered within distance limitations.

Probabilistic Coverage Model (PCM)

- PCM was modified with an exponentially decreasing coverage function that represents the gradual coverage of the AED.
- Overall coverage becomes the best-case probability of covering OHCA cases.

$$\text{Maximize } z = \sum_{i \in I} a_i y_i \quad (1)$$

subject to

$$\sum_{j \in N_i} X_j \geq y_i \quad \forall i \in I \quad (2)$$

$$\sum_{j \in J} X_j = P \quad (3)$$

$$X_j \cdot y_i \in \{0.1\} \quad \forall i \in I \ \forall j \in J \quad (4)$$

Figure 1: MCLP Model

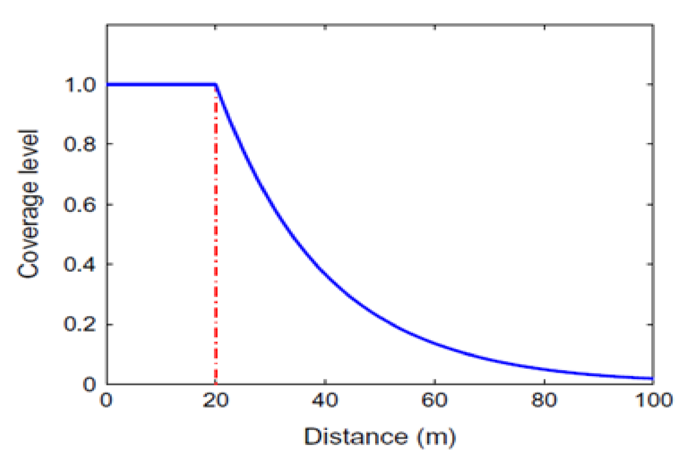


Figure 2: Coverage against distance (PCM Model)

Implementation

- Models were developed in Python scikit-learn and Gurobi optimization framework

Performance Metrics

	Original	Model
Total coverage (% OHCAs covered)	0.566	0.646
Partial coverage (% OHCAs covered)	0.286	0.339
Expected Survival	0.558	0.620
Average distance (OHCA to AED) (in m)	151	91.88

Full-stack Application

- A full stack web application implemented with a user-friendly interface for data refresh, model solving and visualization
- Implemented in Python Django.

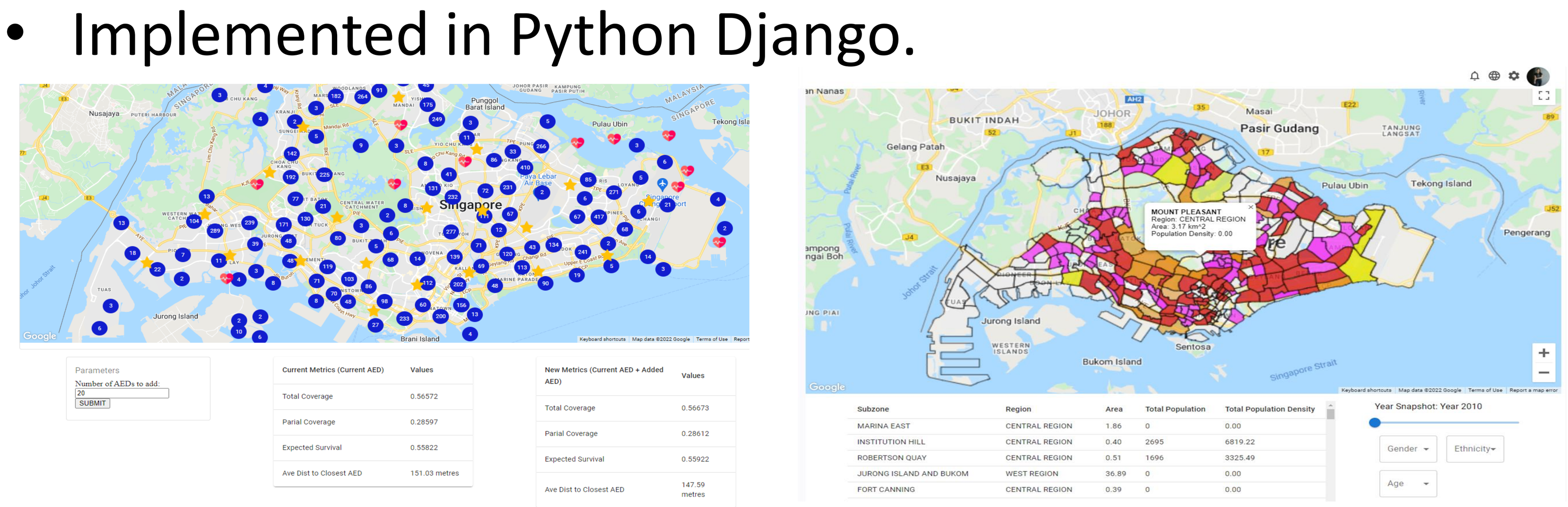


Figure 3: User Interface in web application

Technology Stack

python GUROBI OPTIMIZATION django

Conclusion

- Our dashboard visualizes OHCA heat maps in 332 Singapore subzones that can be filtered by age, gender and ethnicity
- Decisionmakers can utilize the dashboard to evaluate AED deployment policies with a user-friendly interface to facilitate data-driven decisions.