VECTOR-BASED GEOSIMULATION TRAVEL TIME MODEL FOR HEALTHCARE FACILITIES CATCHMENT

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ABSTRACT

Journey to healthcare facilities in most underdeveloped countries is characterised by bad road conditions and done mostly on foot.. Different impracticable methods to determine the travel time to facilities and catchment areas have yielded unreliable and unsuitable results, due to non-availability of spatial data and technical skills to understand the sophistication of the methods. Unfortunately, Geographic Information Systems (GIS) analysis only produces static results. These research uses GeoComputational method which integrates GIS with Agent Based Modeling (ABM) to create a simple, dynamic and flexible model to overcome these challenges. Geographic locations of public healthcare facilities are combined with road-network map to determine catchment area of healthcare facilities based on travel-time agent simulation.

Objectives

- Develop a simple and interactive GeoComputational travel time model
- Use the travel time to define catchment area of healthcare facilities

- GeoComputation: Using computational techniques to solve spatial problems, including collecting, storing, visualizing, and analyzing spatial data, and of modeling spatial system dynamics.
- Agent-Based Modeling (ABM): A powerful simulation modelling technique where individual agents and their interaction with each other and their environment are explicitly represented in a program.
- Geographic Information Systems (GIS): A computer system for capturing, storing, manipulating, analysing, managing, and displaying spatial data.

Existing travel-time measures assume:

- A structured transport system with good road condition.
- A larger percentage of the population have private cars.
- Availability of input data and technical skills to understand the complexity of the models and analysis.

Methodology

Data
- Road network vector map
- Boundary vector map
- GPS (X, Y) locations of healthcare facilities

Procedure
- Create GIS maps as shapefiles
- Import GIS dataset into ABM
- Simulate agents
- Create travel-time model in ABM (Agent chooses the shortest path)
- Export data to GIS

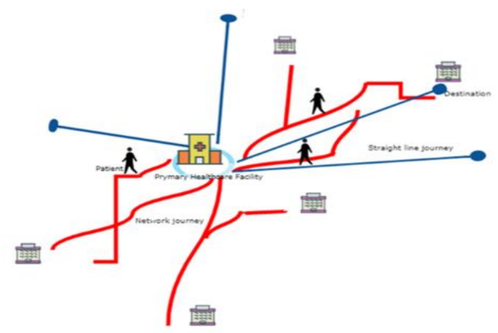

Figure 1. Road network and straight-line travel pattern

Results

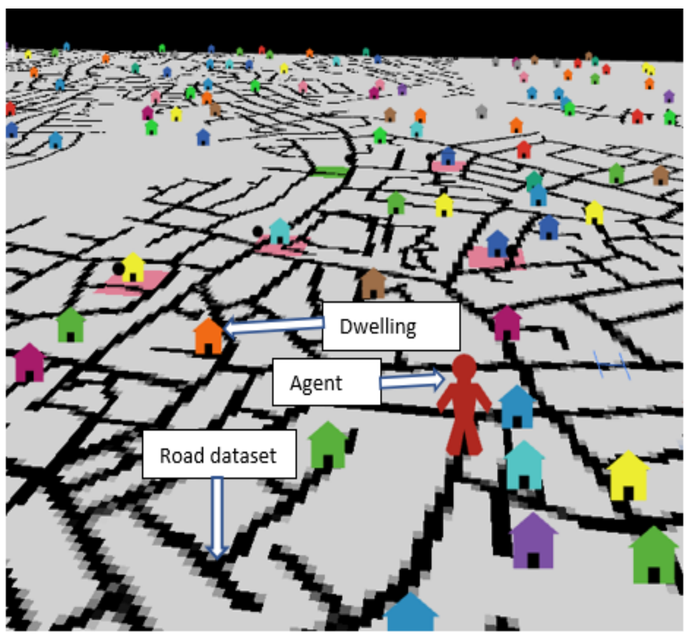

Figure 2. ABM simulation
Simulated agent moving along road dataset (black lines) imported from GIS, towards a dwelling

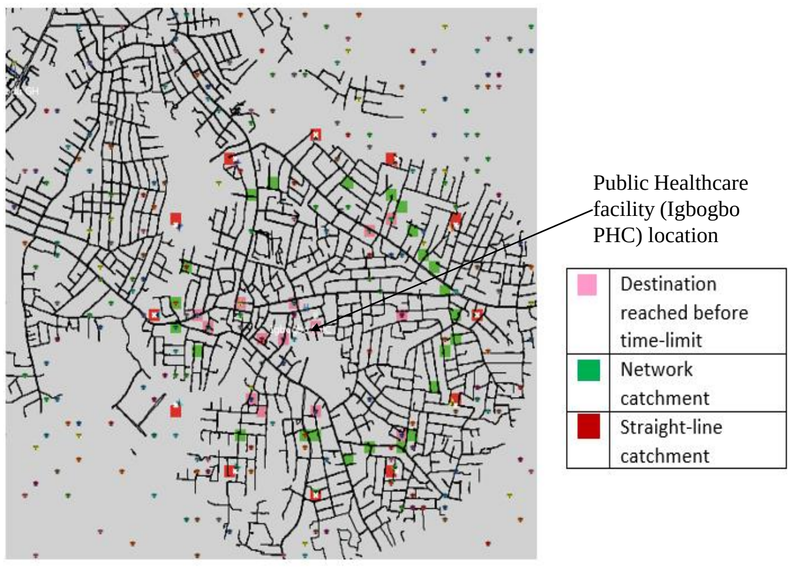

Figure 3. Catchment area definition
Catchment defined by agents' journey at 30 minutes travel time and 48 minutes/metre travel speed using network and straight-line methods centred at healthcare facility location.
Pink patch is destination reached before time-limit on network

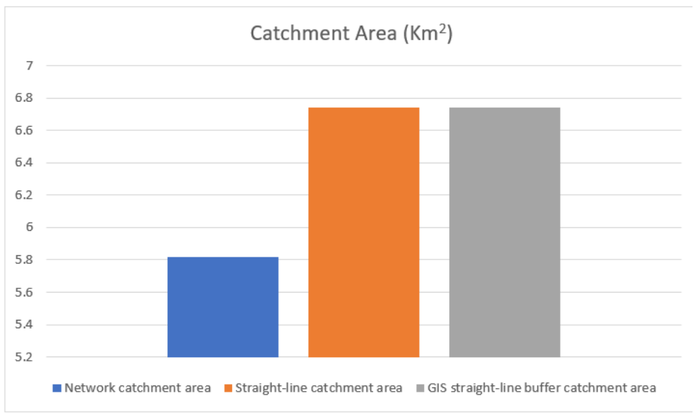

Figure 4. Comparison of catchment area using network, straight-line and GIS buffer methods

Discussion

Network Analysis
- Produces more accurate travel time estimates
- Provides actual road network travelled between two locations
- Better represents travel times and/or distances

Straight-line
- Does not reflect different direction and pattern of travel
- Assumes uniform utilization rates of facilities within the catchments
- Exaggerates catchment area

ABM
- Input data variability
- Flexible capability
- Interactive analysis

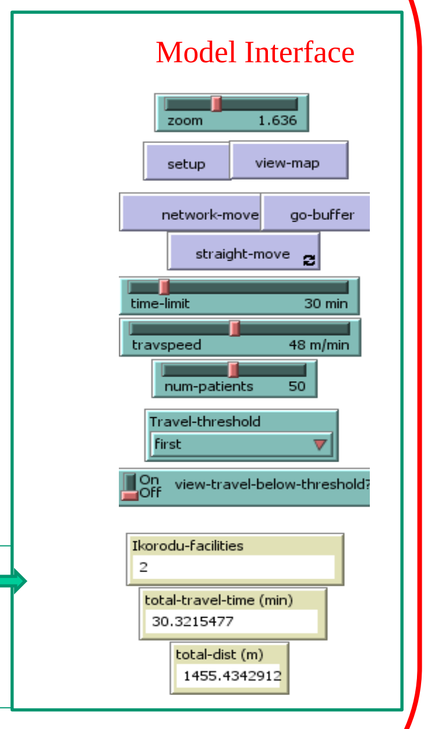

Figure 5. Simulation model interface

Conclusions

Non-availability of input data and technical skills for complex and sophisticated travel-time measures can be a draw-back to healthcare planning.

Simple GeoComputational model can produce realistic result that is comparable with expensive tools.

Integrating GIS with ABM in spatial analysis provides flexibility and ability to vary input parameters.

Future Work:
This is an on-going PhD research which aims at optimizing healthcare facilities locations.