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RESEARCH QUESTION

How does women's greater fear of crime and propensity to stay on main roads influence their overall travel time in relation to their male counterparts? This study focuses on accessibility of spaces by foot within a virtual urban environment, accounting for traffic, lighting, and the gendered behaviour of residents due the real or perceived risk of crime.

ODD DESCRIPTION

Purpose and patterns

The purpose of this model is to illustrate and explain how gender, safety preferences, household responsibilities, traffic and the urban landscape produce inequality in access in local areas. A concept driving this model is urban threats (perceived or actual) against women result in a higher propensity to stay on busier, well-lit roads, resulting in slower travel due to inefficiencies and bottlenecks in populated streets.

The model is evaluated by its ability to reproduce one pattern, which is the average duration for agents with different genders and caring responsibilities to reach a destination.

Entities, state variables, and scales

Entity types: The following are the key entities included in the model:

- Agents representing individuals of either sex (male or female)
- Locations are spatial units representing homes and commute destination.
- Grid cells, also spatial units representing a generic gridded urban environment of buildings and roads (primary, secondary and generic road), on which roads agents can interact.

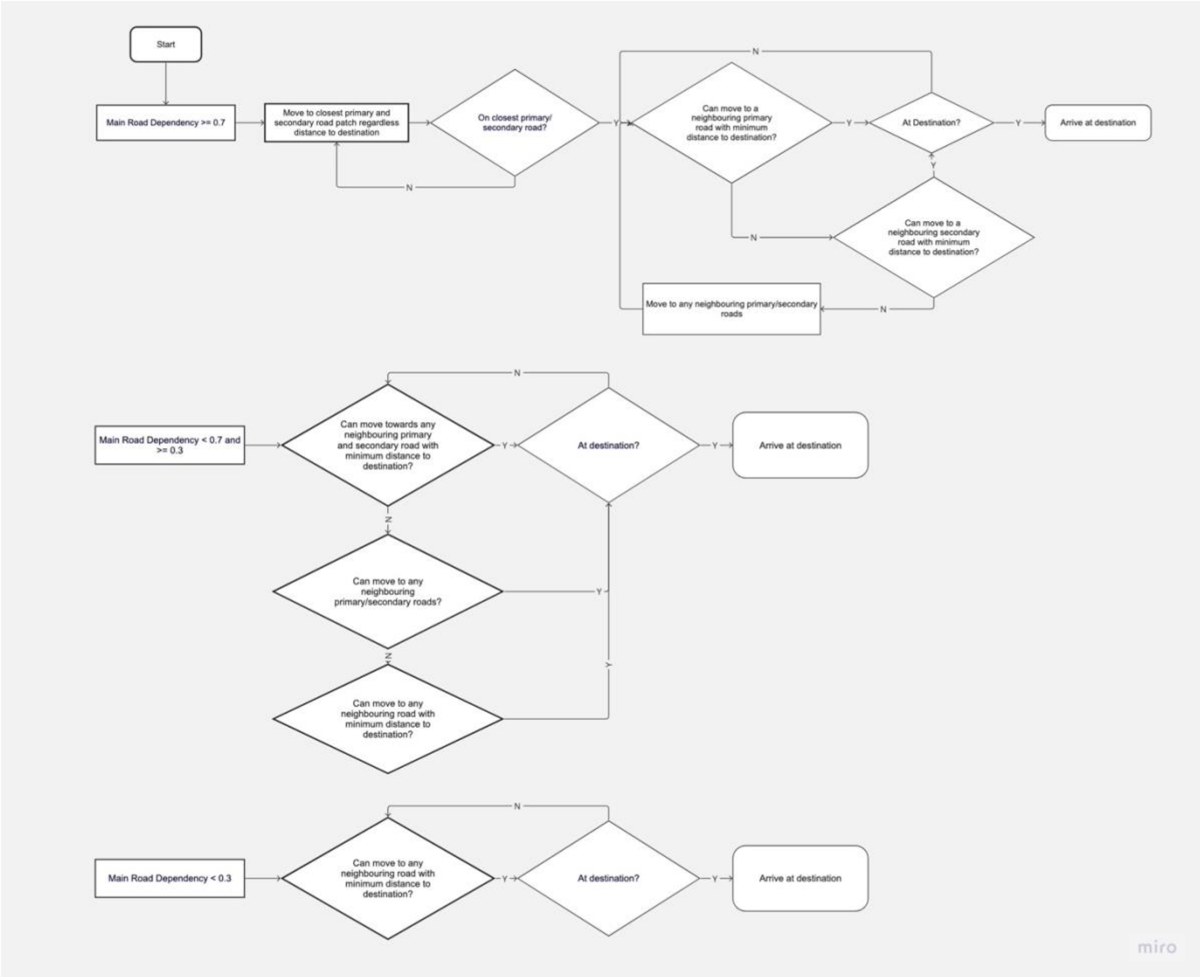
State variables:

Entity	State variables	Status	Type	Rationale
Individual	Gender	static	Breed, male or female	
	Number of male or female	static	Integer	Reporter variable
	Child-care responsibilities	static	Boolean	Whether or not a woman has childcare responsibilities
	Male dependency on main road	static	Probability equally distributed float range between 0.1 – 0.5	Depending on agent's dependency-on-main-road value, agents will have different movement strategies described in submodels.
	Female dependency on main road	static	Probability equally distributed float range between 0.5 – 0.8	

	Traffic	static	Probability equally distributed float range	High traffic probability means individuals are highly unlikely to able to travel neighbouring roads.
	Number of individuals (male, female, mothers) who have reached destination	dynamic	Non-negative integers	Reporter variable. Set as 0 upon initialisation, values will be updated at each time-step.
	Number of time steps individuals (male, female, women) took to reach destination	dynamic	Non-negative integers	
Location and grid	Number of individual homes	static	integer	Randomly allocated across environment
	destination	static	NetLogo coordinates	
	Primary, secondary and generic road types	static	NetLogo coordinates, distinguished by different patch colours	
	Buildings	static	Netlogo coordinates in a gridded structure	
	Luminated streets	static	Netlogo coordinates	

Scales: 1 time step is 9 seconds. Simulations run until all agents have reached the destination. Each grid cell represent 15m, the model landscape is 1200 x 1200m, 1,400 km2. This equals average walking speeds of 15 metres in 9 seconds. A fine resolution was chosen to visualise a journey from homes to the destination. Space is bounded, not toroidal. It is assumed to be night, where concern for safety is higher, and addition of luminated streets are beneficial.

Process overview and scheduling:



Design concepts

Objective: Average travel time to reach the destination.

Adaptation: Agents have variations of a key adaptive behaviour: whether and where to move, depending on the agents' state variables, location and environment. The decisions are modelled as both direct and indirect objective seeking. Agents within a certain threshold of dependency on main roads are allocated to execute a set of decision flows. Within that flow, agents make decisions to prioritise their objectives. Paydar et al. (2017) highlighted the fear of crime often leads to route-paths along key roads.

Interaction: Indirect interaction occurs in a 15m radius of an individual, representing traffic. An individual is to move through the space depending on the level of traffic, based on evidence showing the higher the pedestrian flow in a bottleneck, the greater the wait-time due to cascading and stochastic movement patterns (Daamen & Hoogendoorn, 2003).

Initialisation

Environment: A generic urban environment, applicable to multiple sites. Grid cells establish a base gridded road network separated by infrastructure blocks, with a network of primary and secondary roads, and the destination place can be at any connected point. Homes are generated randomly upon infrastructure blocks; the number can be adjusted to the experiment.

Agent: State variables of individual agents are initialised according to population distribution. An equal number of men and women are introduced. 20% of women population are randomly allocated child-care responsibilities (mothers). Women are randomly and evenly allocated a dependency-on-main-road probability between 0.4 to 0.8; men's ranges between 0.1 to 0.5, assuming that 50% of women and 15% of men feel unsafe on side-streets at night (sustrans, 2022). A mother's probability is multiplied by a factor of 1.3. Agents randomly spawn from homes.

Submodels: The distance/route-path to the destination from a variation of 15m road patches is calculated at the start of the simulation, where one submodel calculates the distance/route-path accounting for primary, secondary and general roads, while another accounts for only primary roads.

The closest 15m primary/secondary road patch to agents with dependency-on-main-road probability > 7 are identified and labelled.

Reporters: the number of individuals reaching the destination (male, female, mothers) are set as 0.

Scenarios: A choice of introducing additional luminated roads into the network is available.

Input data

No input data is required for this model.

Submodels

a) **identify shortest route to destination (All roads, just primary roads)**: The destination patch is initially given a distance variable of 0, and neighbouring patches (that satisfy patch requirements [type of roads]) are allocated a distance of 1. Their neighbouring patches are then given a distance of an additional +1, and so on until all patches within patch requirements have a distance variable.
b) **Identify and move to closest primary/secondary road patch:** Detect and identify the closest primary or secondary road patch within a 1km radius, and move towards this target until the current location of the individual is the same as the identified target.
c) **Move to different patches**: Variations of this submodel are built based on the objective prioritisation, be it safety or minimum time-spent to destination. These sub models are then fed into another submodel (*move-to-destination*) to customise prioritisation flow. Refer to process overview and scheduling for prioritisation flow for each dependency-on-main-road category.

Submodels	**Function**	**Rationale**
move-to-anyroad-min-dist	Move to any neighbouring primary, secondary and luminated road patch that has the minimum distance to destination.	Key priority for people with medium dependency-on-main-road. Safety and minimum travel time are both priorities for this individual/

move-to-mainroad-min-dist	Move to neighbouring primary road patch that has the minimum distance to destination.	Key priority for people with high dependency-on-main-road thus high concern for safety. Individuals prioritise on being on primary roads more than minimum travel time.
move-to-secondary-road-min-dist	Move to neighbouring secondary road patch that has the minimum distance to destination.	Second alternative for high dependency-on-main-road population if there are not neighbouring primary roads
move-to-mainroad	Move to any neighbouring primary, secondary and luminated road patch regardless of distance from destination	This model allows individuals to move to any neighbouring road patch if there are no desired routes they could take.
move-to-shortest-path	Move to any neighbouring primary, secondary luminated and general road patch that has the minimum distance to destination.	Key priority for people with low dependency-on-main-road. Individuals prioritise minimum travel time.
Each submodel has an inbuilt waiting function, where if immediate neighbouring areas have 3 or more individuals, depending on the traffic probability, it may be able to move forward to these areas. If there are less than 3 individuals, the agent may move freely to any patch that satisfy the road parameters given the chosen patch does not have any other individuals on it. This waiting function is to stimulate the bottleneck nature of roads. Although it provides higher levels of safety, it drastically increases travel time. Whereas for people with lower road dependency with less concern for safety, individuals may be able to choose less crowded routes to reach destination.		

d) **Reach-destination**: Individuals who have reached the destination area will be removed through the [die] command. At each time-step the number of individuals removed from simulation are added to the count-individual variable, computed as output.

BRIEF METHODOLOGY

In order to address the feasibility of the 15-minute-city for women with generally higher concern for safety and propensity to stay on main roads, the model will be systematically use test combination of different variable values.

Experiment 1: Total Population Population: 100 to 1000 at 100 increments Traffic: 0.5 Lights: off
Experiment 2: Traffic Traffic: 0.1 to 0.9 at 0.1 increments Population: 300 Lights: off
Experiment 3: Luminated streets. Lights: on Population: 300 Traffic: 0.5

This approach identifies variables that are the most important in influencing individual's travel time and identifies variable optimisation for a minimum gender difference in travel time.

References:

Daamen, W. and Hoogendoorn, S.P., 2003. Experimental research of pedestrian walking behavior. Transportation research record, 1828(1), pp.20-30.

Paydar, M., Kamani-Fard, A. and Etminani-Ghasrodashti, R., 2017. Perceived security of women in relation to their path choice toward sustainable neighborhood in Santiago, Chile. Cities, 60, pp.289-300.

Sustrans. (2022) Personal safety: Women's experiences of being alone after dark, Sustrans. Available at: https://www.sustrans.org.uk/our-blog/opinion/2022/march/personal-safety-women-s-experiences-of-being-alone-after-dark/ (Accessed: 12 May 2023).