Situated Cellular Agents Approach to Crowd Modeling and Simulation

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Agenda

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Introduction

MAS = Multi-Agent Systems
MABS = Multi-Agent based Simulation

Difficulties:

- No general framework describing roles, phases, goals, intermediate steps and sub-products based on MAS exists.
- Lack of methodoligies supporting the development of MABS
- Difficulties in forming a simulation project team
- role of the model is unclear
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Introduction

CA = Cellular Automata

Serveral Models are based on an analytical approach, representing pedestrian as particles subject to forces, modeling the interaction between pedestrian and the environment.

CA is different - the cellular space includes both a representation of the environment and an indication of its state.

- Example: formation of lanes in biderectional pedestrian flows

Situated Cellular Agent Model

Limitations:

- single layered spatial structure for agents environment
- an agent can only emit fields consisting of a subset of its own state.

The Situated Cellular Agent is defined by the triple
<Space, F, A>

- Space models the environement where the
- set A of agents is situated and interacts through the
- set F of fields

Situated Cellular Agent Model

The SCA agent is defined by the 3 tuple $\langle s,p,t \rangle$ where

- t is the agent type
- s denotes the agent state
- p is the site of the space where the agent is situated

Agent type is defined by the 3 tuple $\langle \Sigma_T, \text{Perception}_T, \text{Action}_T \rangle$

- defines the set of states that agents of type t can assume
- perceptive capabilities
- behaviour

PerceptionT is a function associating to each agent state a vector of pairs representing the

- receptiveness coefficient and
- sensitivity thresholds

Situated Cellular Agent Model

Action represents the behaviour for agents of type t

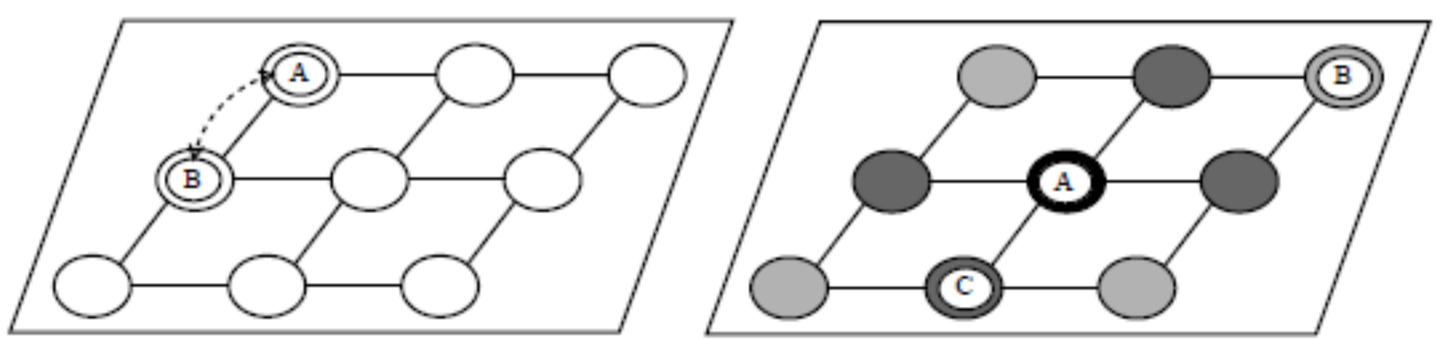
Following can be used:

- emit(s, f, p): the emit primitive allows an agent to start the diffusion of field f on p, that is the site it is placed on
- react(s, ap1 , ap2 , . . . , apn, s′): this kind of primitive allows the specification of a coordinated change of state among adjacent agents
- transport(p, q): the transport primitive allows to define agent movement from site p to site q
- trigger(s, s′): this primitive specifies that an agent must change its state

Situated Cellular Agent Model

Formally, a field type t is defined by
<W t,Diffusion t,Compare t, Compose t>

- W t denotes the set of values that fields of type t can assume
- Diffusion f: diffusion function taking into account in which site and with which value it has been generated
- Compare t: is the function that compares values of the same field type
- Compose t: expresses how fields of the same type have to be combined



Spatial Infrastructure

In SCA agents' actions take place in a discrete and finite space

A discrete abstraction of the actual space in which the simulation will take place must be defined.

- The abstraction is constituted of notes
- Nodes represent the positions that can be occupied by pedestrians once per time

SCA space represents thus an abstraction of a walking pavement

- Usually a cell dimension of 40 × 40 cm2 is adequate to represent the typical space occupied by a pedestrian in a dense crowd.

Active Elements of the Environment

Active elements of the environment influence the movement of pedestrians.

- constraint agent movement (gateways, doors)
- provide information (exit signs, indicators)

diffusion–perception–action mechanism is used to generate attraction or repulsion effects

1. space discretization
2. selection of agents (presence field)
3. specific type needs to be defined (for diffusion and composition function for that type of signal)
4. define emission intensity

only a few parameters must be defined (position in the env., specific field type, emission intensity)

Pedestrian Modeling

Pedestrain modelling is the behaviour of the agent, and the way in which they achieve there goals and the impact the surrounding environment has on them.

- Agent are used to represent pedestrians
- Behavior of agent subdivided into “attitude”.
- Different fields have different effect agents on agents movement.
- Impact of fields on agents needs to be specified
- Agents goals and attitude change

Discussion

- Three elements make up the model:-
  - Spatial abstraction of the environment
  - Active elements
  - Mobile agents

- To run the simulation the number of agent is inputted and there starting location and state.

- Some activities can be ignored to create specific situations.

<u>Take into consideration</u>

- Agents are a simple respresentation of humans.
- Pedestrians travel as individuals and groups.

The Scenario

- Many types of crowd behavior takes place.
- Hard to predict because of the number of different sinarios is unlimited.
- Crowd are difficult to predict and individuals behave differently depending on their priority and goals.
- Most complex crowd behavior happens when a passenger that are waiting to get on the train are directly facing passengers waiting to get off the train.

The Modeling Assumptions

For the simulation to work some behavioral assumptions need to be made

- Passengers that do not have to get off at a train stop tend to remain still

Passengers will move

- to give way to descending passenger
- to reach some seat that has became available
- or to reach a better position like places at the side of the doors
- or close to the handles

Agents are forced to move off the train to allow others off if there is no other way of getting around

Passengers move towards the door of the train as it is stopping.

The Environment

Environment space needs to be specified for the simulation to run in.

Scale of the environment and location of fields (doors, handles seats) is important to gain accurate data.

Layout need to be precised and accurate.

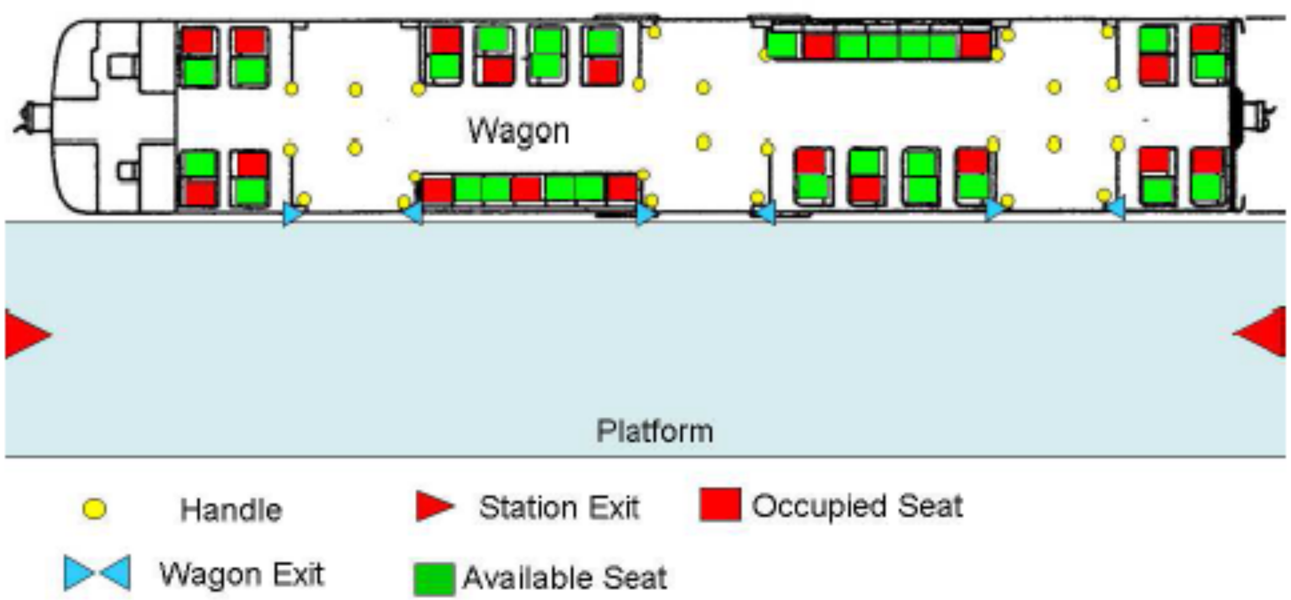
Station exits emit fixed fields, constant in intensity and in emission.

Agent-doors emit another type of field.

- Guide passengers to get off the wagon, towards the platform.
- Guide passengers that are on the platform and are bound to get in the wagon

The Environment continue

- Seats may have two states: occupied and free
- Handles also emit a field type very similar to the one emitted by seats, whose attractive effect is however less intense

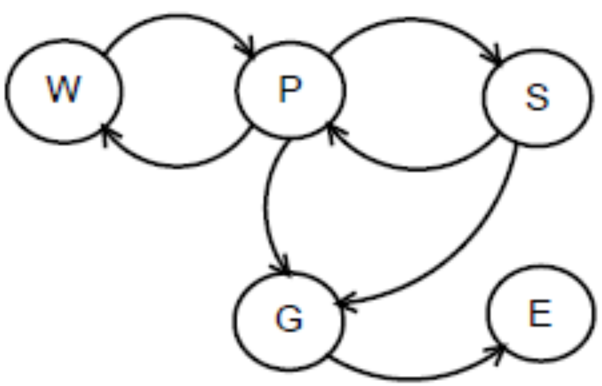


Passengers

Attitudes for agent:-
Waiting (W), Passenger (P), Get-off (G), Seated (S), Exiting (E)

Agents attitude will determin attractiveness or discussed towards fields.

Change of attitude change of priority change of reaction towards fields.



State	Exits	Doors	Seats	Handles	Presence	Exit press.
W (getting on)	not perc.	attr. (2)	not perc.	not perc.	rep. (3)	rep. (1)
P (on board)	not perc.	not perc.	attr. (1)	attr. (2)	rep. (3)	rep. (2)
G (getting off)	not perc.	attr. (1)	not perc.	not perc.	rep. (2)	not perc.
S (seated)	not perc.	attr. (1)*	not perc.	not perc.	not perc.	not perc.
E (exiting)	attr. (1)	not perc.	not perc.	not perc.	rep. (2)	not perc.

* = The door signal also conveys the current stop indication.

Test and Results

State "S" was ignored to allow greater focus on agent in state "W" and "G". Passengers getting on and off the train.

Synchronous. Every agent performs one action per turn

100 times simulation was run,
6 passengers wanting to get off the train, "G".
8 wanting to get on, "W".

All agent completed there goals between 40 and 80 turns.
Average 55 turns.

Consistence finding with realistic scenario, and fits with expectations.

Test and Results, Errors

- Agents performed back and forth movements.
- Groups facing themselves for a few turn
- Problem could be even great with a highter number of agents performing the same task.

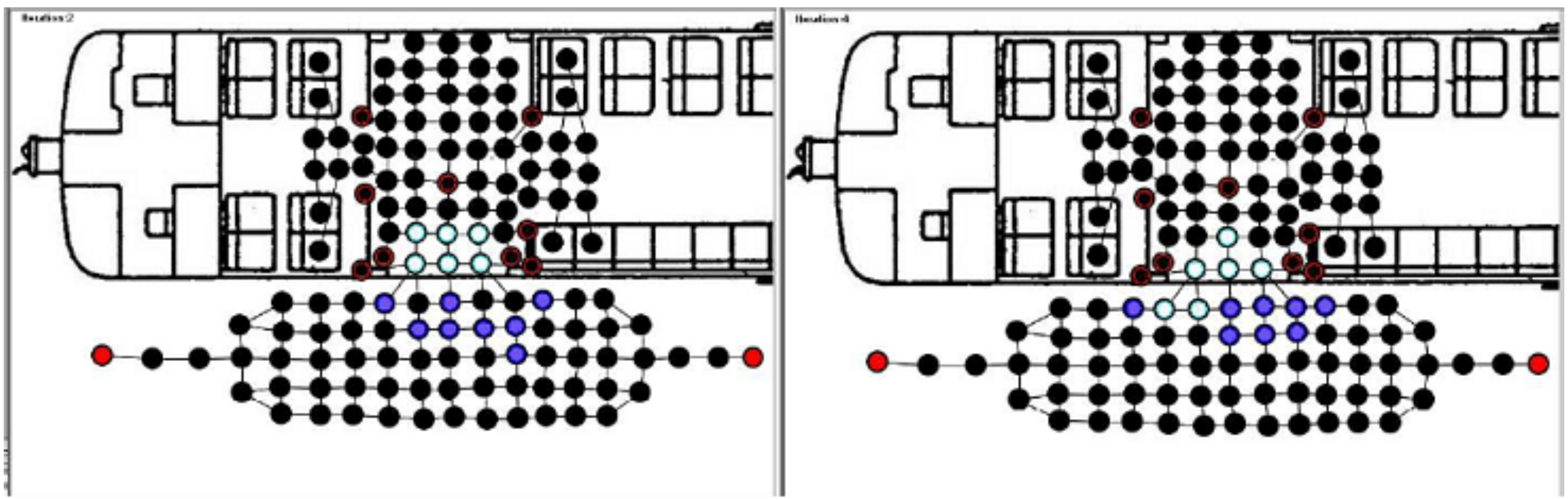
<u>Prevention of errors</u>

- Allow agents to keep track of their previous position. "Step Back". Forcing the agent to take a different route.

Test and Results with improvements

Results with Improvements

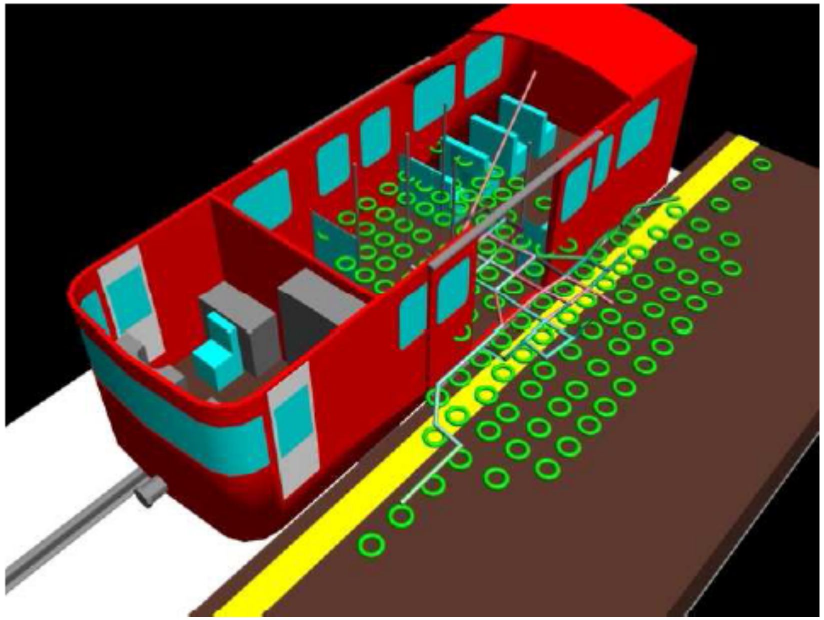
- Oscillating agent movement was drastically reduced.
- All agent completed there goals between 28 and 60 movements. Average around 35 turns.



Screenshot of simulation. Left diagram without alowing agents to track there movemnets. Right hand screen shot show the agents makig room for other agent to get off the train

The Role of 3D Envisioning

- Developer simulator can be Intergrated into a 3D model
- Simplify its understanding to non experts
- Make it easier to compare results and findings
- Agent movement can be made smooth instead of jumping from place to place.



Any Questions?