The smart police men
Conceptual Design Multi-Agent Systems

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1   Introduction

Imagine being in a giant Dutch warehouse. Times are not going well. The parent company of the warehouse is bankrupted. So the only thing that is still left to do for the warehouse is to organise a big shopping sale. And well, the Dutch like good prices, so once the sale has started the warehouse is suddenly filled with customers like it never was. But, as we all know, life is not so lovely as we would want: some people take advantage, also in the course of a shopping sale at a giant Dutch warehouse. Fortunately we know what to do with these thieves: arrest them! The question is, how do we monitor all the items to prevent theft? How do we divide our attention properly to handle everything that is going on? And once we are informed a theft has occurred, how do we handle the situation best and catch all the thieves? This (and other questions, that are specified below) will be simulated in `Netlogo`. In what follows we describe our simulation in more detail. We discuss the environment, the agents and their beliefs, desires and intentions, as well as the way they communicate with each other.

2   Simulation

Before the start of the simulation, the user has to define several things: how many items will be placed in the environment, and what kind of agents will be placed where?

The user should select a number of cops and add them manually to the environment if the user want to decide where the cops start out. The same holds for the items.

2.1   Environment

The environment of the simulation will consist of one floor of a giant warehouse building. This floor contains several rooms and corridors between them. Obviously, agents can only go through doors

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to switch rooms. Doors on the borders of the floor can also be used to escape from the building. For every room will be globally saved which doors are part of which rooms.

After the user has decided how many items will be placed in the environment and where, they will be placed in the allotted locations. Items can be stolen by thieves, after which they will disappear from the environment and into the virtual pocket of the thief. When a thief puts an item back in the environment for reasons that will be explained later, the item will appear again at the position where the thief dropped them.

2.2   Agents

The simulation contains three types of agents: customers, cops and thieves. At the beginning, the user has to decide how many customers, cops and thieves are placed in the environment. For the cops and thieves, the user also needs to decide what their starting position will be. This will not have to be done for customers; they will be placed randomly.

In the basic version of the model, customers are simply agents walking around. They have no beliefs or desires, and walk around to fill the environment and make it harder for thieves and cops to navigate and be seen by each other. (See the section on possible extensions for how this can be made more complex.) Cops and thieves, however, are more complex.

2.2.1   Cops

Cops have some characteristics, beliefs, desires and intentions that will influence their actions.

- **Characteristics:** Cops have a certain speed which can be set by a slider in the interface to chase after thieves. Cops also have a certain strength which can be set by a slider in the interface, which determines if they can overpower a thief when they catch him. Next to that, cops have a particular view area. This area can be adjusted by the user with the use of a slider, to set how far a cop can see. The view is a semicircle. This means that the agents can only see that what is in range with what they face.

  Important to note is that agents can not walk on the same patch (as usual), so they have to move around each other.

- **Beliefs:** Cops have beliefs about other agents and about the environment. First of all the beliefs about the agents: when a cop sees a colleague, that colleague and its position are stored in his believes. This location is only valid for a number of ticks till when it is out of sight, as it is not likely that an agent will stay in the same place for a long time. The same holds for seeing a thief. Cops will have a belief about how strong or fast a thief is, once they get close enough to observe this. This belief corresponds to the real speed and strength of the thief. For as far as the environment is concerned, cops hold beliefs about in which room they are, which doors are connected to it, and which doors lead outside (i.e. out of the building). They add a room and the corresponding doors to their belief the moment they enter a new room they have not been before.

- **Desires:** Cops have three desires: checking the environment for thieves, talking to colleagues and catching thieves.

- **Intentions:** Cops have six intentions: walking around the environment, observing the environment, approaching a colleague, talking to a colleague, following a thief and arresting a

thief. If a cop has the desire 'checking environment for thieves' its intention is either 'walking around the environment' or 'observing the environment'. This changes every tick. If a thief is observed during the observation of the environment, the cops desire changes to 'catching thieves'. Once the cop has this desire, its intention is first 'talking to colleagues' to inform its colleagues about the location of the thief. If the colleagues do not have anything better to do than catching this particular thief (for example, catching another thief) their beliefs and intentions change in order to be able to catch the thief. Once the colleagues are informed the cop's intention changes to 'following a thief'. Once the cop is close enough to the thief, the cop's beliefs about the strengths and speed of the thief are updated and it communicates this to the other cops (if this has not been done before), again by changing beliefs and intentions. According to the strength and speed of the thief a decision is made whether a cop can arrest the thief alone or needs help. The cops that are finally chosen to catch the thief are the closest cops that together have enough strength to catch the thief. Once the cop is close enough to the thief to capture him the cop's intention changes to 'arresting thief' after which he can arrest the thief (possibly together with his colleagues). Once the thief is arrested, the cop's desire changes to again to 'checking the environment' and it's intention to 'walking around the environment', continuing as described above.

Finally, when the shop closes (after a number of ticks), the agents will stop.

The cops can be informed that they need to catch a thief in two ways. Either they see that a thief picks up an item or they hear an alarm. As we simulate the floor only and assume the thief has escaped once its outside, we build in a method that turns on an alarm with a certain probability once a thief has stolen an item.

2.2.2 Thieves

- **Characteristics:** Thieves have a certain speed which can be set by a slider in the interface to chase after thieves. They also have a certain strength which can be set by a slider in the interface, which determines if they can be overpower by a cop when they are caught. Thieves also have a particular view area. This area can be adjusted by the user with the use of a slider. Also the thief's view is a semicircle, which means that the persons can only see that what is in range with what they face.

- **Beliefs:** When a thief sees another thief, he does not care. Every shoplifter for himself. Cops on the other hand are interesting: their identity and location are saved as a belief of the thief once they are spotted by the thief. This location is only valid for a number of ticks till when a cop is out of sight: it is not likely that an agent will stay in the same place for long. Thieves will also have a belief about how strong or fast a cop is, once they get close enough to observe. Thieves also hold beliefs about in which room they are, which doors are connected to it, and which doors lead outside.

- **Desires:** Thieves have three desires: try to steal something, drop an item, and escape.

- **Intentions:** Thieves have a number of intentions: walk around, observe the environment, steal an item, drop an item and escape. When they do not have found anything to steal, they will walk around and observe for items to steal. When they found an item, and the circumstances are right, e.g. no cops close to them, the thief will steal the item. Once it has an item, it will try to escape, or drop the item if it feels like it will get caught soon, for

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example when a cop is very close and the door to escape is very far away. For trying to escape several strategies can be used. E.g. the thief can just run as fast as he can to the exit, he can move around as if he were a normal customer, he can or cannot adapt his behaviour according to the number of cops around, etc. In the most basic version of the model the thief moves to the exit once he has stolen an item (but see the section on possible extensions at the end of this report). If the thief has already seen an exit on his way to the theft, he still has this exit in his belief base and can simply move to this exit. If not, he will have to move around through rooms he has not been into yet (so he needs to check his belief base again), looking for a possible exit. Rooms he enters and the corresponding doors are again added to his belief base, to prevent him from visiting the same room over and over again. Finally, thieves have three ways of stopping: they have no more time because the shop is closing, they have stolen something and gotten away safely, or they were caught by the police and escorted outside.

2.2.3 Communication between agents

Cop have various types of information that they can share with their colleagues over their intercoms: the identity and location of a thief, and if known its strength and speed. More details have already been presented above. In the most basic model we only deal with one thief. In an extended model (see the section on possible extensions) communication between multiple thieves could be added, if thieves operate in groups.

2.3 Research questions

The described scenario can be used to answer the following research questions:

1. What is the best place for the agents to be in the environment to deal with the situation at hand?

2. What cop to thief ratio will help the cops prevail?

3. To what extent is a higher speed an improvement? I.e. is there a moment that having a higher speed does not matter anymore?

4. What is the best strategy for the thieves? Just running away and trying to escape?

2.4 Possible extensions

When developing a simulation like this, many extensions are possible. Due to time limitation, we are not sure if we are able to implement all of the ideas for extending this simulation. However, we would like to mention the following ideas:

1. An option to enable cops and/or thieves to work in teams. Does this result in quicker arrests?

2. Adding a strategy for the thieves, run away as fast as possible or is it better to hide sometimes?

3. Introducing terrorists. Now the cops are not aware of what kind of criminal activity is taken place.

4. Introducing panic of the customers. How do they respond when seeing many cops?

5. When a thief is seen by a customer, the customer could help by communicate this knowledge to the cops.

6. Thieves and cops get a running speed, which is higher than their usual speed. They can start running once they spot each other, where the thief wants to escape and the cop wants to catch the thief. However, they can only maintain this speed for a number of ticks, before they get tired and return to their original speed.

7. When thieves drop items at different locations than where they were from, cops have to return them to their original position.

8. Customers can pick up items too, if they want to buy them legally, after which they are removed from the environment.

9. Thieves will not only attempt to go outside, but also find the shortest route to the exit that they know.

10. Cops can work in shifts. Then they can watch the warehouse also outside opening hours. This is interesting if different types of crimes can take place.

11. We can introduce several types of items that are stolen. E.g. a watch may be more important than an eraser.

12. In the basic version of the model the normal customers do not have a BDI framework. We can introduce one, so that they can also interact with the police.

13. Cops and thiefs can have predefined strengths and speeds. In the basic framework they get a strength or speed between a certain range, but in an extended version the strength and speed can be set as a value in the code.