

Conceptual design final assignment.

Maurits Bleeker, Jörg Sander & David Zomerdijk

Introduction:

Even though efforts are made to mitigate green house gasses the increase of the sea level seems to be inevitable. For the Dutch this is great news since our reputation on building embankments is unparalleled. However, to stay in the race we need stay on top of our game. Although the TU delft builds beautiful embankments they take a lot of time and need heavy machinery to build. Therefore, this approach is not suitable when the need for protection is acute. We propose that instead of using machinery that takes weeks to transport, we use a swarm of relatively small robots that work together to build an embankment. Due to their limited size they can be flown in right before a flood is about to happen, potentially saving lives and billions of euros on damages.

Before we commercialize this idea, we intend to build a simple prototype in NetLogo. In this prototype we will visualize the task at hand and implement multiple building strategies in order to find the most optimal strategy to build an embankment along a coastline. Before the agents start building they will have to first explore the world in order to determine where they have to build the embankment. In the following sections we will discuss their environment, way of reasoning, communication and the research goals of this prototype.

Environment

The agents will be situated on a coastline. The water will be represented by blue patches and the land will be represented by yellow patches. On the land there will be multiple “depots” where they will be able to find “construction material” which they will use to build the embankment. *figure 1* is a schematic sketch of the environment in which the red squares depict the depots and the gray circles depict the agents. The environment will be a limited area and the agents will not be able to go beyond the borders of this environment and are only able to ‘drive’ on the land.

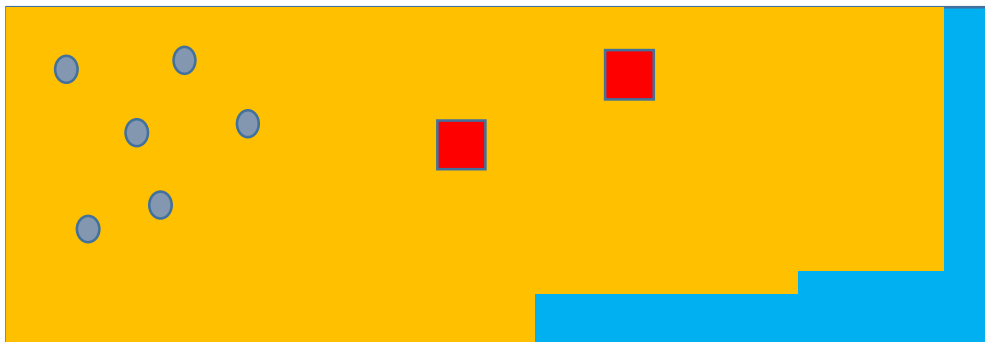


Figure 1 Environment

The embankment that the agents need to build will be made up of ‘construction material’ from the depot. One piece of building material will cover one patch and heighten the

embankment by one level. The ultimate goal is to build an embankment of height X . The agents will only be able to move to areas that are one level higher than the height of their location. Also they can only place construction material around them on patches of the same height as their own. The challenge is to make the embankment in such a way that multiple agents are able to cooperate and not interfere with each other. In the next section we will go in how the agents will accomplish this.

Agents

The agents will reason by using the beliefs, desires and intention model. They will have three possible desires:

- Explore the world
- Build an embankment of height x along all coastlines in the area.
- Drink beer with its fellow workers when embankment is done at the depots.

When they start they know nothing about their environment and start by exploring their environment. They will only know the size of their environment and will work together to explore this environment as fast as possible. They will share every new patch they explore with the rest of the team such that every agent will have the same beliefs. For exploring they will have the following beliefs:

- Location of the patches that represent the shoreline (place where the embankment has to be build)
- Location of the depots
- Explored patches (if it can be deduced that an area is water, this will be added to the explored patches)

To explore they will have the following intentions:

- Observe within a certain radius
- Walk around (for this we need to find an optimal solution for the agents to work together)

The agents will be able to carry only one piece of 'construction material' at the time. And as soon as they are done exploring the area their beliefs shift to building the embankment. For this they will have the following intentions:

- Go to depot.
- Get construction material from depot.
- Heighten certain location on the embankment; consists of:
 - Go to location
 - Drop construction material

Obviously there will be conflicts between the agents, the agents will probably want to move along the same paths but also they might have the same intention to construct. To prevent this they will share information on what their intention is and they will resolve this conflict such that agents don't try to build on the same location. The conflict will be resolved by

estimating who will be able to construct the location fastest. For this the following beliefs are necessary:

- Own intention
- Others intentions

One of the biggest challenges is to find an effective way to build an embankment. This because 'stairs' need to be made from construction material to be able to build the higher locations of the embankment. Building stairs will take time, therefore, we need to come up with a strategy to minimize the stairs we need to build. On the other hand, if there is only one stairs to build the embankment, the agents will have to wait a long time to utilize the stairs because other agents are making use of it. For this we will look into the research done by Werfel et al (2011) that had a team of robots make predefined structures with no supervision. In this research they were faced with the same problem.

Research goals

To conclude, the goal of this prototype is to not only show that this idea is possible, but also to find the best ways to explore the environment and build the embankment. For exploring the environment, we are interested in finding the strategy that minimizes the combined distance traveled by all the agents to explore the entire environment. There are many facets of building a structure that we can research. For example: what is the building strategy that minimizes the time to build, uses least the least amount of material, that minimizes the distance traveled. In our prototype we will first focus on minimizing the time to build because this will be most important when a potential flood is on its way.

References

Werfel, J. Petersen, W. Nagpal, R. 2011. *Distributed Multi-Robot Algorithms for the Terres 3d collective construction system*. Modular Robotics workshop, Intl. Conference on Robots and Systems (IROS)

Link to paper: <http://www.eecs.harvard.edu/ssr/papers/iros11wksp-werfel.pdf>

A more extensive thesis on the Terres project:

<http://www.eecs.harvard.edu/ssr/papers/phd14-petersen.pdf>