MS-E2177 - Seminar on Case Studies in Operations Research, Assessment of design options for border control

Finnish Defence Research Agency - Project Group

Interim Report

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1 Changes in project scope and objectives

Our project scope and objectives have remained relatively unchanged. There have, however, been minor changes. First, the scope has changed to include possibilities of further developments: we will first make a minimum viable product of the model, and use the remaining time to update the model to be realistic as possible. The objectives have remained unchanged after taking into account the changes in the project scope.

In the initial assignment, we were given a task to determine the "effectiveness" that we want to maximize in our model. Currently, we are considering the ratio of $\frac{\text{immigrants captured}}{\text{number of immigrants}}$ as our main metric of the "effectiveness" of our design options. The second metric is the ratio of $\frac{\text{immigrants not detected}}{\text{number of immigrants}}$. This second metric can be used to compare combinations that perform closely according to the first metric, since people that cross the border undetected are seen as the most unwanted outcome.

2 Project status

Originally, our project plan tasks regarding the implementation were introduced at a quite general level. Now that we have implemented the architecture and worked with the implementation for four weeks, we have a more refined view of the tasks. Since presenting our project plan, we have worked on the project 2-3 times a week by holding project meetings on campus. In addition, we met our client at a project update meeting last week and received positive feedback and good insights. We also met with Dr. Ali Abbas who is a visiting professor from the University of Southern California. Dr. Abbas had experience on the border control topic and we had an insightful brainstorming session. Next, we will present our project status by the required tasks for the implementation.

2.1 Completed tasks

After presenting our project plan, we completed the implementation architecture the following week. This was completed one week earlier than in the initial project schedule giving us one extra week to work on the implementation.

We decided that running the simulations should be divided into a main loop and a simulation core. The main loop sets up and runs simulations and gathers the results, while the simulation core contains the actual simulation logic and calculations. To implement the simulation core, we took an object-oriented approach, in which the objects and people in the simulation are implemented as classes, that move in a two-dimensional world.

Implementation efforts have mostly been focused on different parts of the simulation core. The movement logic of border control personnel and the border-crossing immi-

grants have both been implemented, as well as a simple camera that passes information of the immigrants' movements to border control. Some progress has also been made in implementing the main loop, specifically, reading some setup parameters into a convenient parameter-structure for initializing a simulation.

2.2 Ongoing tasks

Currently, we are finishing the parametrization of the implementation. Parameters are pulled from a CSV-file into a dictionary and then moved to a data class containing all parameters. At the moment, these data classes are working and the last micro task is to switch hard-coded parameters in the simulation to connect with these parameters. When we add more equipment/features into our model later, we add the corresponding new parameters using this style.

We are also working on finishing the necessary tasks to have a minimum viable product simulation, in which there would be a group of immigrants, a group of border-control personnel and some cameras that can spot the immigrants, then getting some output out of the simulation. These tasks include initializing the simulation according to a set of parameters and outputting the outcome of one simulation iteration.

2.3 Future tasks

After implementing a minimum viable simulation, we will add more resources and objects to the simulation in order to expand the choices of possible resources and to get the simulation closer to a real-world scenario. The next two implementation objectives are drones, which would patrol and scan an area and follow a group of immigrants if it would spot one, and dogs, which would be implemented as a change in border control movement logic for every border control group that utilizes dogs.

The last task before getting viable results is to create a function that determines possible combinations of border safety equipment. This is done inside the main function and it will take equipment prices and a budget as inputs. We are currently considering some greedy algorithm-styled ways to calculate these combinations, i.e., we consider combinations that fill or nearly fill the budget. Deterministic calculation of the whole combination space will probably not be realistic and therefore we will likely simulate these combinations with some heuristics (over 90% budget is used).

After we can fully run simulations with our model, we build a visualization front for our software. Due to a high amount of simulation runs, we are not building a video game-styled visualization where the immigrant paths, border guard movement, etc., are shown. Instead, we are focusing on presenting performance metrics of the different combinations of border safety equipment. In addition, we will present some summary statics of our simulations.

Finally, we run the simulations and gather results. Since we run simulations with multiple sets of parameters and resource allocations, this can take a long time computation-wise and might even require some re-implementations to make the simulations computationally lighter. Finally, we analyze the results and write the final report.

3 Changes in risk management

Below, in Table 1, are the updated risks for the project. The largest changes concern lowering the probabilities of the risks, as the remaining time is shorter now and the risks have not yet realized.

Table 1: List of updated risks for the project

Risk	Effect	Probability	Impact	Prevention
Poorly defined scope	Too much work to do, client is unhappy about results	Very low	High	Regularly discuss with client on results thus far and possible improvements and/or other areas of research
Insufficient public data	Model does not accurately reflect reality	Medium	Medium	Spend sufficient time in searching for data, make otherwise robust model
Team member inactivity	Increased workload for other team members to stay on schedule	Very low	Medium	Communicate within the group, project leader communicates with course personnel if challenges arise
Comm. issues towards client	No feedback for model, harder to update	Very low	Medium	Communicate actively, leave sufficient time before deadlines to allow for delays caused by communication issues
Model is too complicated	Issues in computational tractability	Low	Medium	Simplify model, use supercomputers to assist in calculations
Lack of capabilities	We are not able to complete the model	Very low	High	Have a clear schedule and scope, ask for help from course personnel or client if issues arise