Project Application Development

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Abstract

This research report explores the development of an application that results from a possible solution, to a problem taken from an existing ecological system, by using a mathematical model to show the predicted effects of the proposed measure on the ecosystem.

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# Introduction

An important application of mathematical engineering is building a model of a real-life situation in order to make predictions and find desirable solutions to a problem. Several major challenges exist in this approach however.

One problem is that it can be difficult to determine what the correct model is, even for a simple real-life situation. Usually, one needs to have observations to collect data, then fit the data to a mathematical formula to create a model. The observations can be difficult and / or tedious however, and fitting data points to a formula is challenging as soon as the formula becomes more complicated than a simple n-th degree equation.

A problem underlying the previous one is that it might not even be clear what variables to use in the first place. When predicting how fast trees grow, what is relevant? Temperature and humidity spring to mind, amount of sun might very well be a factor, but nutrients in the soil could be as well, and if so, which ones?

The first step in getting rid of those complications is simplifying. In the example of tree growth, keep temperature and humidity, but the complication of nutrients will be evaded by ignoring it, and hoping a fit can be made between data and formula anyway. Parameters like nutrients can be added after understanding the influence of the other factors to improve the model.

Of course, one does not always need to start from scratch. For often encountered cases like ecological systems, models have been constructed before. Using this knowledge, one already knows what the formula being sought might look like, greatly reducing the amount of data necessary to create a fit.

Another challenge pops up when the system under consideration has multiple subsystems influencing each other. Then, the individual subsystems might be fit for gathering data and constructing a model, but due to the interactions, the whole becomes too complicated very quickly. Again using the tree as an example, we’ll add fern to the underground. The amount of light the fern receive depends on the growth of the tree, so the formula describing the fern growth will include the whole formula describing the tree. And that’s only one-way; image the situation with the fern also draining moisture away from the tree, thereby influencing it in turn!

Again, the solution here lies in simplifying: converting complex formula to a simpler one describing the situation ‘well enough’, splitting into separate formulae.

In all these possible solutions, the problem arises that quite often the calculations are tedious and error-prone, while the meaning of the results might still be hard to visualize. That’s why it is a good idea to, after setting up the model(s), implement these in an application which gives the output not only as numbers, but also graphically.

In this project, a real-life situation will be examined using several of those techniqes. In the end, you will have gained insight in the way a combination of mathematics and software engineering can be used to make predictions for complication systems. You will also have a better understanding of how to choose between methods available in an applied research.

# The Project Goal

In this project, we work as a team on a possible solution to a problem taken from an existing ecological system. The problem has already been identified, but is completely unclear whether the proposed solution is feasible.

The idea is pretty complicated, so it is necessary to define a structured approach to solving it early on, removing from the goals all those elements we cannot achieve in the time allotted. The client does not need a highly accurate prediction of the effects in this stage; an indication whether it will help solving the situation is good enough.

At the end of the project, we will have a mathematical model for the system and an application doing the number crunching to show the predicted effects of the proposed measure.

# Context and Research Questions

# Context

In the nature preserve called Oostvaardersplassen, three large herbivores are living: wild horses, wild cattle, and deer. Other major species are geese and birds of prey. As one can surmise from this, there are no major predators present. The ecological system has been unbalanced from the beginning, partly due to the absence of a top predator, partly due to the closed nature of the preserve (it’s fenced of), meaning the herbivores cannot migrate.  
Seeing that the balance can hardly be improved by the most natural way – releasing a top predator – and that doing nothing will probably lead to a drastic change in the populations, another approach is looked for. One factor quite relevant, but not yet examined, is the geese. There are a lot of geese, especially during winter, eating the same grass as the large herbivores do. The geese also do not have a real enemy in the preserve; there are some foxes, but not that many.

Our project is built out of two groups which work on different parts of the project, our group is focusing on the competition between the herbivores and the geese for food (Grass), how do they interact between them and how much grass do they consume, we came up with a main question to our part of the project and some sub-questions for it, after answering those questions we will have a much more clear vision of what is going on in Oostvaardersplassen.

# Main Research Question

**Main Research Question of the whole project will be:**

* *What will happen to the populations of deer, cattle, cow and geese if releasing a number of foxes in the preserve (with the number of foxes being the free variable.)*

**Our Group Main Research Question will be:**

* *How do the herbivores and the geese compete for the grass in an enclosed area?*

# Research Sub-Questions

**Our Group Sub-Questions:**

* *What is the rate of grass consumption of each animal?*
* *How do animal populations change as a result of grass availability?*

# Research Strategy

# Methods

# Back-End Work Development

# Front-End Work Development

# Results

# Conclusion

# Recommendations

# Bibliographies

# Appendices