Chapter 1

Introduction

Throughout the history great epidemic diseases have spread across the world, leading to catastrophic consequences for human populations. Millions of lives have been taken. The Black Death and Cholera are epidemics that have moved over large distances into Europe Ref.[2, p. 315]. An important aspect in the current spread of diseases is the displacement of human populations. About a million people cross international borders daily. The growth of human population, especially in underdeveloped countries, is another factor that affects the spread. These developments played a key role in the spread of HIV in the 1980's. The World Health Organization has estimated that around 32.6 million people are infected with the HIV virus today Ref.[3]. Knowledge about the spread and severity of epidemic diseases is valuable for the human population in preventing major damages. The current outbreak of Ebola in West Africa in March 2014, has shown that epidemics will occur repeatedly. Mathematical models can help us understand the severity and prepare the population in the best way possible.

This thesis will study and compare three different models which simulate epidemic diseases. The three models that will be used are: the ODE model, the PDE model and Random walk. Each model will be presented and studied. The threshold value for an epidemic disease will be examined in the first chapter, **??**. The second chapter, **??**, focuses on how a travelling wave of infected disperse in an area. The third chapter, **??**, will look into Monte Carlo methods, which will later be used for the Random walk simulations. The results from the different models will be compared and analysed throughout the paper.

A couple of choices have been done for this thesis. First, the systems will be modeled for a short period of time. The length of the longest simulations is a month, while the third chapter only consists of simulations with the length of half an hour. This is done to study variations of human and zombie behavior in a zombiefication. Second, all models are simulated as closed systems. The amount in each simulation never exceeds 763 humans and the time aspect is short. Therefore the birth and death rate is close to negligible, and are set to zero.

Two different examples will be used for all three models. The first case is based on an influenza outbreak which occurred at an English boarding school in 1978. A basic SIR system will be used to model the epidemic trough 15 days. This example shows the effect of varying the parameter values in the system. This will be done in chapter **??**. The maximum concentration of infected humans will be compared, to see if the results between the models differ. The effect from the two spatial models in chapter **??** and chapter **??** will be compared to the ODE model. The second case is based on the TV series *Walking Dead*. Here, a SEIR model will be used to simulate a zombie outbreak. The model is based on the paper *Escaping the Zombie Threat by Mathematics* by Langtangen, Mardal and Røtnes Ref.[1]. The simulations will be done for different phases, and the parameter values in each phase will be changed and studied. Differences in behavior will be used to vary the simulations. Restricted areas will be used in the simulations of the PDE model, while Random walk also adds altered behavior.

Bibliography

[1] Hans Petter Langtangen, Kent-Andre Mardal, and Pål Røtnes. Escaping the zombie threat by mathematics. Technical report, Simula Research Laboratory, 2012.

[2] J.D. Murray. *Mathematical Biology: I. an Introduction*. Interdisciplinary Applied Mathematics. Springer, 2002.

[3] World Health Organization. 10 facts on hiv/aids. http://www.who.int/features/factfiles/hiv/en/, 2014.