Fighting the pandemic: Rapid detection of SarsCov-2

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Introduction

This year mankind is facing a new threat, SarsCov-2 virus, affecting the entire population of the planet, disrupting economies world-wide and costing hundreds of thousands of human lives. This is a global challenge rapidly spreading through transport networks and developed urban societies; it is highly uncertain as we do not have a full understanding of what we face, and no cures and vaccines exists to date. There are growing concerns that it would not be possible to fully eradicate the virus from the population in the near future. In view of the absence of cure, many countries adapted a strategy imposing severe social distancing as a possible defensive measure. Whilst these strategies have shown great success in restricting the spread of infection whilst in full lockdown and quarantine, these strategies are not sustainable economically in the longer term. Hence alternative solutions are urgently needed.

One of the possible measures to ease economical and social impact of the lockdown as well as a possible quarantine exit strategy is to enable rapid, cheap, and efficient testing for SarsCov-2 throughout the entire population. If such a test would be available, it would allow the governments to isolate sources of SarsCov-2 infections within the communities and inhibit the spread of infection to levels at which the infection naturally burns out. The problem, however, is that global testing capacities are limited world-wide, and the virus is changing dynamically through continuous mutations, as more people get infected. The main research context of this task is the challenge of developing rapid tests to help fighting SarsCov-2 pandemic.

Specific problem

The aims and goals of the task is to develop computationally efficient and accessible tools for rapid detection of SarsCov-2 using existing testing and computational infrastructure; the tools should be available for large-scale deployment in both developed and developing countries with different funding models of their health systems. A possible approach would be to consider SarsCov-2 detection using the so-called Full Blood Count test – a standard analysis that is routinely performed in hospitals and haematological laboratories world-wide. This test can be performed in under 5 minutes for a single patient, and the technology is accessible to countries with different economic backgrounds and populational profiles. The task, therefore, is to investigate this possibility for develop an algorithm for rapid assessment of SarsCov-2 infection using the Full Blood Count test.

Approach and work plan

On the first day, participating students will be provided with a tutorial on the computational and mathematical background supporting epidemiological modelling; we will discuss and analyse the classical Susceptible-Infected-Removed (SIR) model and will investigate different scenarios capturing the spread of infection. We will determine major parameters affecting the spread of infection and investigate how the current SarsCov-2 pandemic can be controlled by efficient testing and targeted isolation. In the remaining days of the Modelling Week, we will be building algorithms for SarsCov-2 detection from the Full Blood Count data. The tasks will include cleaning the data and determining its major parameters such as dimension. The students will be provided with an opportunity to learn about several different ways the data dimension can be defined. This will be followed by building a classifier using agnostic Machine Learning techniques, including linear classifiers with exhaustive feature selection and, time permitting, nonlinear models. The group will learn how to rigorously assess provable accuracy of their model and apply this knowledge to determine accuracy of the classifier for SarsCov-2 detection. Based on the test's accuracy, the group will investigate, derive, model and report a testing strategy and scenarios in which the new test could be used to help managing the spread of SarsCov-2.

Recommended Literature

[1] R. O. Duda, G. Stork, P. E. Hart. Pattern classification and scene analysis, Wiley, 2000.
[2] V. Vapnik. The Nature of Statistical Learning Theory, Springer, 2000.

Pre-requisites

No specific prior knowledge is assumed in addition to standard undergraduate modules on linear algebra, basic probability and statistics, and modelling (numerical integration of systems of ordinary differential equations).