Machine Learning II: Assignments #1
14 performance points (max),
email: PDF+code to jan.nagler@gmail.com
due: as announced in lecture

1. Covid-19 Disasters

   The SIR model is a 3-compartment model. Extend this model to 4 compartments, where the 4th compartment is for deaths (D). Mortality is modelled by new transitions from $I \to D$ defined by the mortality rate μ. Susceptible and Recovered do not die.

   (a) Derive the corresponding system of equations for S, I, R and D. E.g., $\frac{\mathrm{d}D}{\mathrm{d}t} = \mu I$ but this is not the only difference to SIR. In addition, the basic reproduction number may now depend on μ as well, how?

   (b) Assume that the basic reproduction number R_0 for B.1.1.7 is not exactly known but only the range $R_0 \in [3.0, 4.0]$. Assume that the mortality rate μ is also not exactly known but only the range $\mu \in [0.4\%, 4\%]$. Study how these parameter uncertainties affect the prediction of D at $t = 365d$. What about the cumulative number of deaths after a year?

   (c) Study numerically the effects of a hard versus soft lockdown (by two for you reasonable values of β), in terms of $D(365d)$. What about the cumulative number of deaths after a year? Assume $\mu = 1\%$ and a γ compatible with $R_0 = 4$.

   (b,c) Can you find a way to derive and plot the effective reproduction number, R, as a function of time, given otherwise fixed parameters ?

   (a-d) Free choice for the initial conditions $S(t = 0)$ and initial prevalence, $I(t = 0)$. Assume $R(0) = D(0) = 0$. If you choose $N = 1$, the compartments become fractions of the population number and you can remove N from the entire system of equations. Start with more than 1% of infected individuals (but not exactly 1%). Every plot must have a title and must display what parameters are fixed, and a legend. Every plot must be followed by a small take home message.

2. Principal Component Disasters

   Create labeled surrogate data sets. Perform a PCA/Class prediction with ovr logistic regression analysis as developed in the lecture.

   (a) 4 blobs: Create clearly separable 4-blobs in 3d but also a 'disaster' realization with strong overlaps. Study, show and compare elbow plots and prediction boundaries.

   (b) 2 touching parabola spreads as shown in the lecture, but in 3d (not 2d). Study and show elbow plot and prediction boundaries.

   (a,b) Every plot must be followed by a small take home message.