Modelling the Spread of COVID-19 Cases

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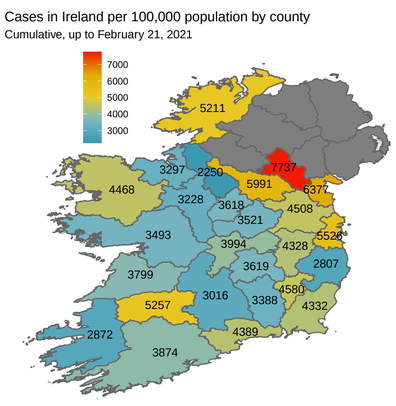
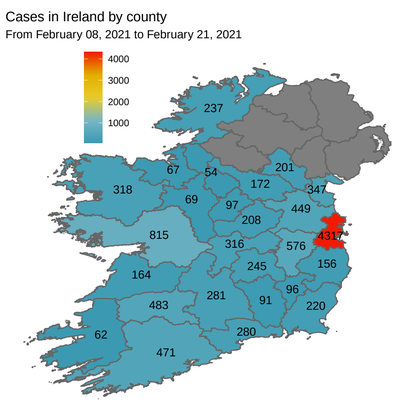
INTRODUCTION

The Coronavirus disease (COVID-19) was first characterized by the World Health Organisation as a pandemic on 11th March 2020. The outbreak has affected almost every aspect of human life throughout 2020, and is expected to continue for much of 2021.
Situation in Ireland up to early 2021:





MATHEMATICAL MODELS

Based on methods derived in [1].
Model Assumptions

(I) Any infected person becomes ill (symptomatic) and infectious on the q-th day after infection.

(A) During each day, each ill person unconfined infects on average a other persons.

(B) During each day, a proportion $b \in (0,1)$ of ill people loose gets isolated and withdrawn from a further spread of the epidemic.

We derive the recurrence relation

$$x_{n+1} = (1-b)x_n + ax_{n-q}, \quad x_n = x_n^* \text{ for } n = 0, 1, \ldots, q. \quad (1)$$

The recurrence equation has limiting behavior:

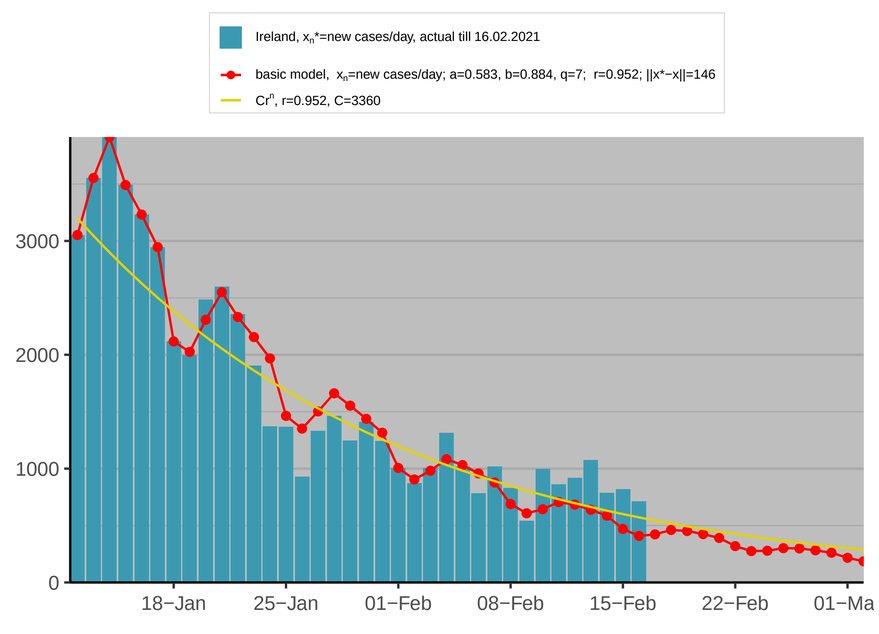
$$x_n \sim Cr^n \text{ as } n \to \infty. \quad (2)$$

For the periodic model, we allow for some oscillation of the parameters a and b:

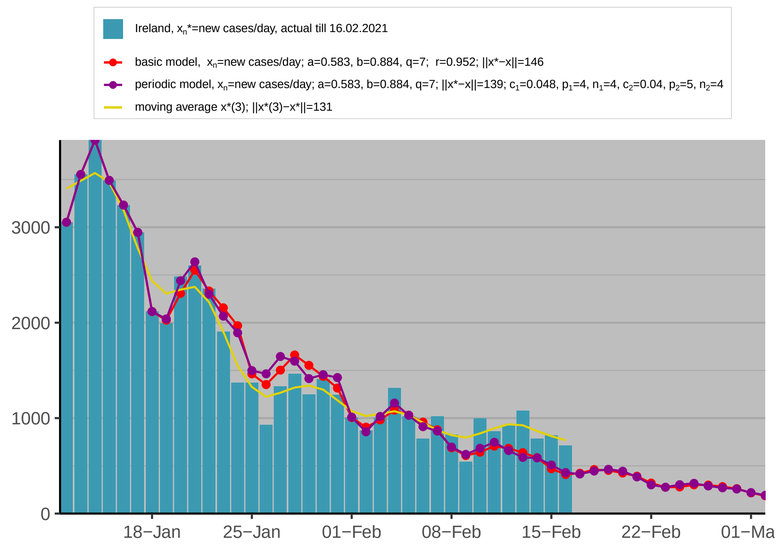
$$a_n := a\left(1 + c_1\left(\sin\left(\frac{2\pi}{p_1}(n - n_1)\right)\right)\right) \quad (3)$$

$$b_n := b\left(1 + c_2\left(\sin\left(\frac{2\pi}{p_2}(n - n_2)\right)\right)\right) \quad (4)$$

LIMITING CURVE



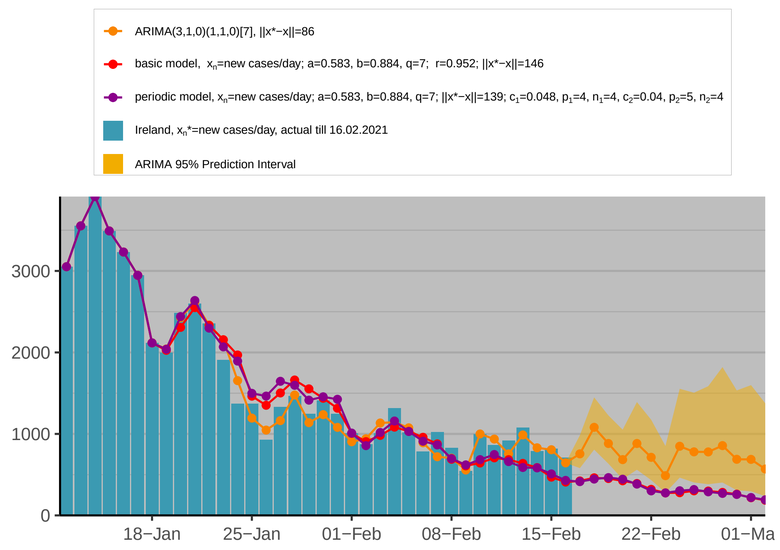
BASE AND PERIODIC MODELS



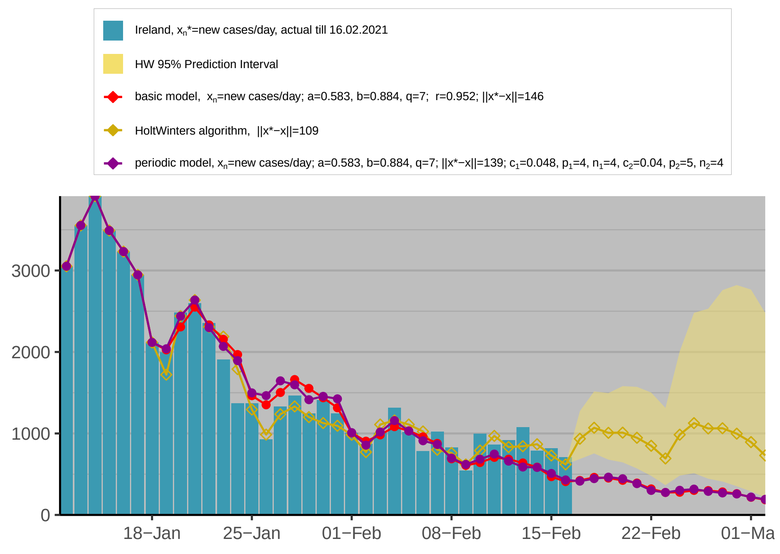
STATISTICAL MODELS

Based on time series forecasting methods discussed in [2]. Statistical models give us some more information to work with in the form of confidence intervals for the forecast period.

SEASONAL ARIMA MODEL



SEASONAL HOLT-WINTERS' MODEL



REFERENCES

[1] Alexander Grigorian. *Mathematical riddles of COVID-19*. June 2020. URL: https://www.math.uni-bielefeld.de/~grigor/corv.pdf.

[2] R.J. Hyndman and G. Athanasopoulos. *Forecasting: principles and practice, 2nd edition*. OTexts.com/fpp2. OTexts, 2018.