

NLSIG-COVID19Lab: A modern logistic-growth tool (nlogistic-sigmoid) for modelling the dynamics of the COVID-19 pandemic process

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Software

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Summary

The growth (flow or trend) dynamics in any direction for most natural phenomena such as: epidemic spreads, population growths, adoption of new ideas, and many more, can be approximately modelled by the logistic-sigmoid curve. In particular, the logistic-sigmoid function with time-varying parameters is the core trend model in Facebook's Prophet model for time-series growth-forecasting at scale ([Taylor & Letham, 2018](#)) on big data. The scientific basis for this prevalence is given in ([Bejan & Lorente, 2011](#)). Such growth-processes can be viewed as complex input-output systems that involve multiple peak inflection phases with respect to time. An idea that can be traced back in the crudest sense to ([Reed & Pearl, 1927](#)). A modern definition for the logistic-sigmoid growth which considers restricted growth from a two-dimensional perspective is the nlogistic-sigmoid function (NLSIG) ([Somefun et al., 2020](#)) or logistic neural-network (LNN) pipeline.

In this context, NLSIG-COVID19Lab functions as a NLSIG playground for modelling the COVID-19 epidemic growth in each affected country of the world and the world as a whole.

Statement of need

Admittedly, epidemiological models such as the SEIRD variants ([Lee et al., 2020](#); [Okabe & Shudo, 2020](#)) are just another form of representing sigmoidal growth ([Xs et al., 2012](#)). It has been noted in ([Christopoulos, 2020](#)) that the SEIRD-variant models yield largely exaggerated forecasts. Observing the current state of the COVID-19 pandemic, this is also true, as regards, the results of various applications of logistic modelling ([Batista, 2020](#); [Wu et al., 2020](#)) which have largely resulted in erroneous identification of the epidemic's progress and its future projection, hence leading policymakers astray ([Matthew, 2020](#)).

Notably, two recurring limitations of the logistic definitions in the literature and other software packages exist. A trend that has continued since the first logistic-sigmoid function introduction ([Bacaër, 2011](#)).

First is that, the co-domain of logistic function is assumed to be infinite. This assumption violates the natural principle of finite growth. Second is that, during optimization, estimation of the logistic hyper-parameters for the individual logistic-sigmoids that make the multiple logistic-sigmoid sum is computed separately, instead of as a unified function. The effect of this, is that, as the number of logistic-sigmoids considered in the sum increases, regression analysis

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becomes more cumbersome and complicated as can be observed in these works (Batista, 2020; Chowell et al., 2019; Hsieh & Cheng, 2006; Lee et al., 2020; Taylor & Letham, 2018; Wu et al., 2020).

These limitations are efficiently overcome by the nlogistic-sigmoid function (or logistic neural-network pipeline) NLSIG for describing logistic growth. The NLSIG is a logistic neural-network machine-learning tool under active development. The benefits it provides at a functional level:

- unified function definition
- functional simplicity and efficient computation
- improved nonlinear modelling power

Ultimately, the development of the NLSIG-COVID19Lab was motivated by research needs, in that, it illustrates the power of the nlogistic-sigmoid neural pipeline. NLSIG-COVID19Lab provides an optimization workflow with functions to make modelling and monitoring the COVID-19 pandemic easier and reliable. Notably, instead of engaging in false prophecy or predictions on the cumulative growth of an ongoing growth phenomena, whose source is both uncertain and complex to be encoded in current mathematical models (Christopoulos, 2016; Matthew, 2020), on the contrary, this software package makes projections by means of:

- two-dimensional perspective metrics (YIR and XIR) for robust monitoring of the growth-process being modelled in an area or locale of interest.
- adaptation of the Dvoretzky–Kiefer–Wolfowitz (DKW) inequality for the Kolmogorov–Smirnov (KS) test to construct a non-parametric confidence interval of uncertainty on the nlogistic-sigmoid model with a 99% probability ($\alpha = 0.01$) by default.

NLSIG-COVID19Lab is useful as a quick real-time monitoring tool for the COVID-19 pandemic. It was designed to be used by humans, both researchers and non-researchers.

NLSIG-COVID19Lab is currently written in MATLAB but will be implemented in other languages in the future.

The user-client end (both user application scripts and graphical user interface) of the NLSIG-COVID19Lab is designed to provide a friendly interface demonstrating the NLSIG modelling power for time-series growth processes from data. In this case, the growth-process is the time-series COVID-19 pandemic growth from official datasets (see Figure 1 and Figure 2).

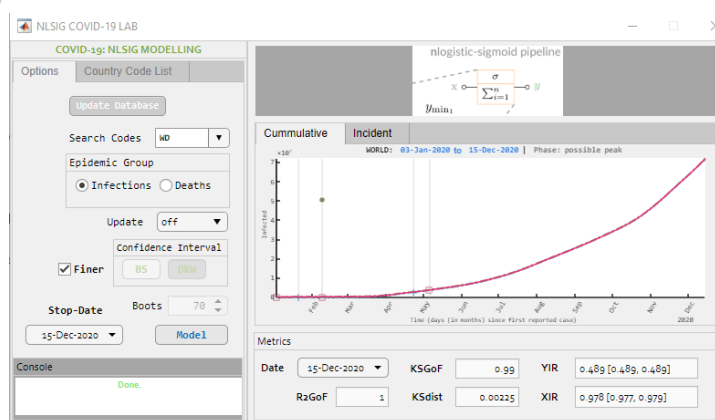


Figure 1: GUI Layout showing the Total Cumulative COVID-19 Infections in the World.

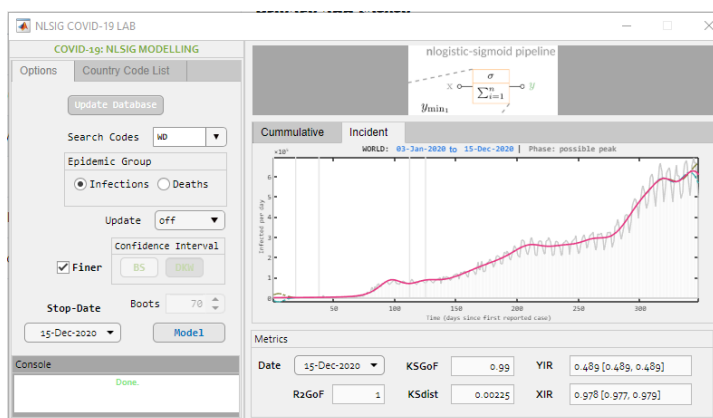


Figure 2: GUI Layout showing the Total Incident COVID-19 Infections in the World.

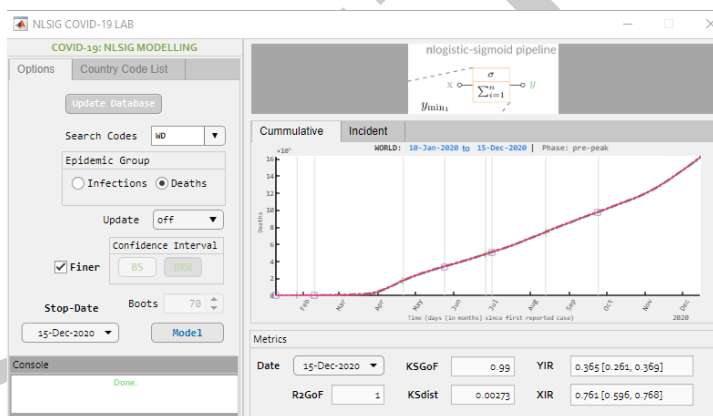


Figure 3: GUI Layout showing the Total Cumulative COVID-19 Deaths in the World.

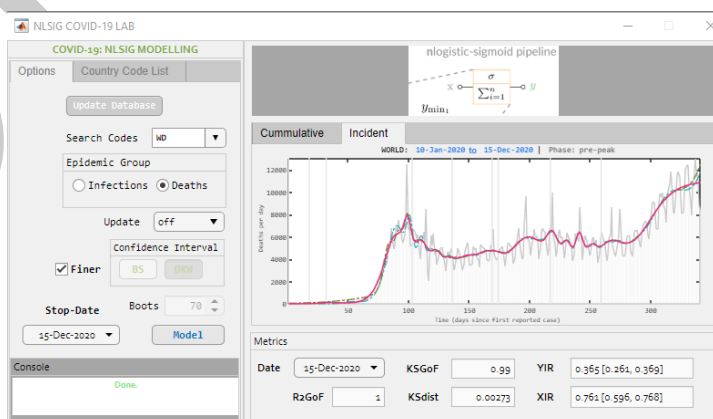


Figure 4: GUI Layout showing the Total Incident COVID-19 Deaths in the World.

66 Core Data Source

67 As at the time of writing. The COVID-19 Database of NLSIG-COVID19Lab is sourced from
68 the:

- 69 ▪ World Health Organization
- 70 ▪ Johns Hopkins University Center for Systems Science and Engineering

71 Related research and software

72 To the best of knowledge, we are unaware of any other software packages or tool providing a
73 similar purpose or functionality for describing the logistic growth of the COVID-19 pandemic
74 from a realistic finite two-dimensional perspective of natural growth.

75 This application of the NLSIG to modelling the COVID-19 pandemic was selected as the best
76 paper at the *2nd African Symposium on Big Data, Analytics and Machine Intelligence and*
77 *6th TYAN International Thematic Workshop, December 3-4, 2020.*

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