Response to COVID-19 with Probabilistic Programming

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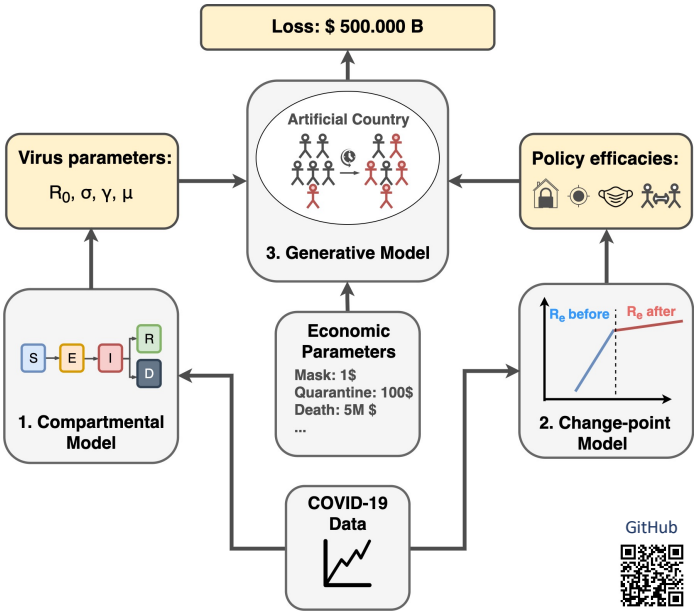
Motivation

This work proposes a probabilistic programming method to quantify the efficiency of major non-pharmaceutical interventions. We present a generative simulation model that accounts for the economic and human capital cost of adopting such strategies, and provide an end-to-end pipeline to simulate the virus spread and the incurred loss of various policy combinations.

Method



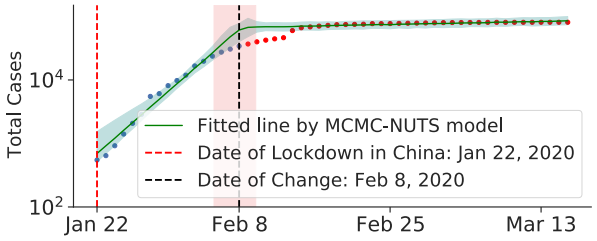
1. Infer COVID-19 parameters using the compartmental model.
2. Apply the change-point model to infer policy efficiencies.
3. Run the generative model in artificial country simulation to estimate the economic cost for different policy combinations.

Virus Statistics

Parameter	Value
Recovery time	16.33 days
Incubation time	5.27 days
Basic reproduction number	2.64
Case-fatality rate	2.5%

Policy Efficiency

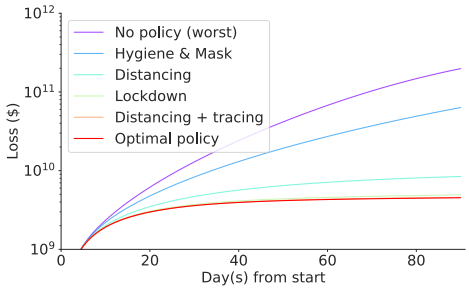
$$\text{Policy efficiency} = 1 - \frac{\text{slope}_{\text{after change-point}}}{\text{slope}_{\text{before change-point}}}$$



Policy	Efficiency
Lockdown	96%
Contact tracing and distancing	96%
Social distancing	74%
Mask and hygiene	30%

Cost Estimation

The best policy identified so far is contact tracing with social distancing, with a loss of around $ 2 billion for 1 million population size. Without intervention, the loss in the imaginary nation is $197.9 billion.



Policy Combination	Total Cases	Total Deaths	Total Loss (billion $)
Optimal policy	10,734	577	4.526
Contact tracing and distancing	11,003	591	4.569
Lockdown	11,003	591	4.933
Social distancing	22,478	1,138	8.437
Mask and hygiene mandate	201,929	8,941	63.400
No policy	592,136	28,018	197.927

Conclusion

In the present study, we gauge the efficacy of the early-stage policy to respond to the pandemic, with economic factors related to the policy itself and its benefits of slowing down the virus. Sophisticated analysis from 10 countries suggests that social distancing, coupled with contact tracing, is the most efficient policy among major interventions.

Our full paper is available at http://arxiv.org/abs/2106.00192.

References

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