PanCommunity: Non-Monolithic Complex Epidemic and Pandemic Modeling

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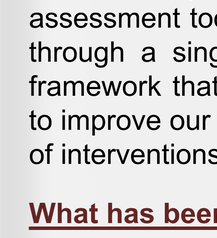


Introduction

PanCommunity project looks at communities at local, federal, and international scales and investigates the impact of testing, preventative measures and vaccines, when used in combination, to improve community response and resilience. It aims to assess outbreak risks as well as community response (to the epidemic as well as to the intervention strategies) and account for socio-economic impacts of different strategies on community response and epidemic outcomes.

Motivation and Background

Dynamics of complex interconnected systems are extremely difficult with the data technologies available today. Several simulation software have been developed within epidemics as well as bio-surveillance and threat assessment tools. Yet, a complex epidemic process cannot be simulated through a single monolithic model and an integrated data and model framework that supports complex, coupled system simulation ensembles to improve our ability to forecast infectious disease spread, and the effects of interventions, across heterogeneous communities is lacking.

What has been achieved so far?

- DataStorm/PanCommunity integration – highly modular, non-monolithic modeling and ensemble simulation of pandemics through cloud-based reusable components
- A new high-dimensional optimization framework
- A SIRTEM COVID-19 model integrating testing, quarantine, and hospitalization with spatial context
- A novel ensemble sub-epidemic modelling framework which can be used to forecast biological and social growth processes

Sample workflow

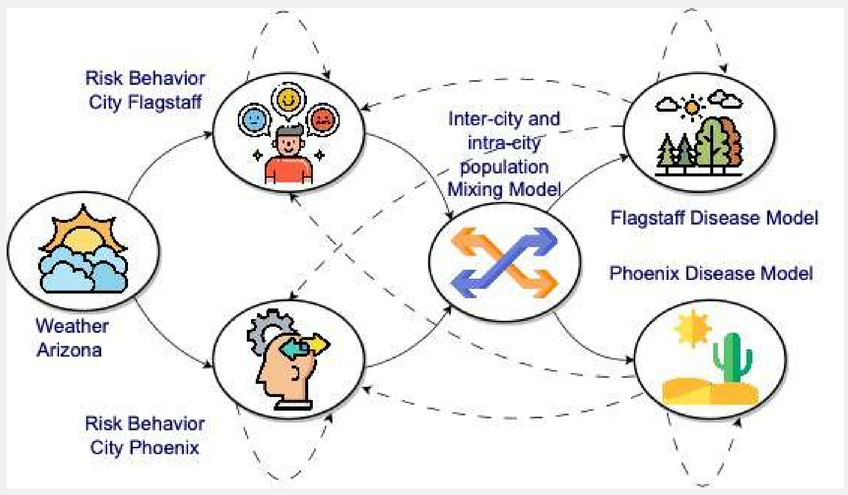


Figure 1: This workflow takes into account disease models, external impactors (such as weather), differences in local behaviors (such as risk averseness), and intra- and inter-city mixing patterns impacted by these behaviors

Interface

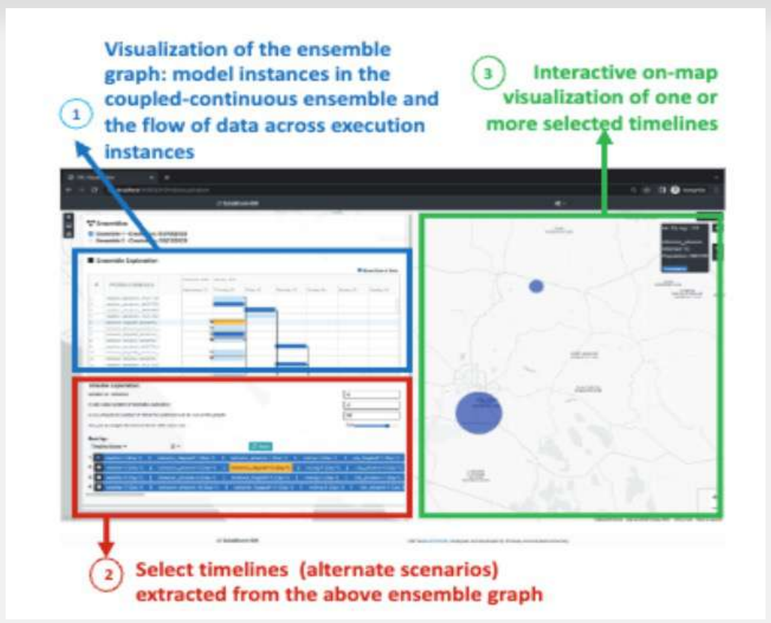


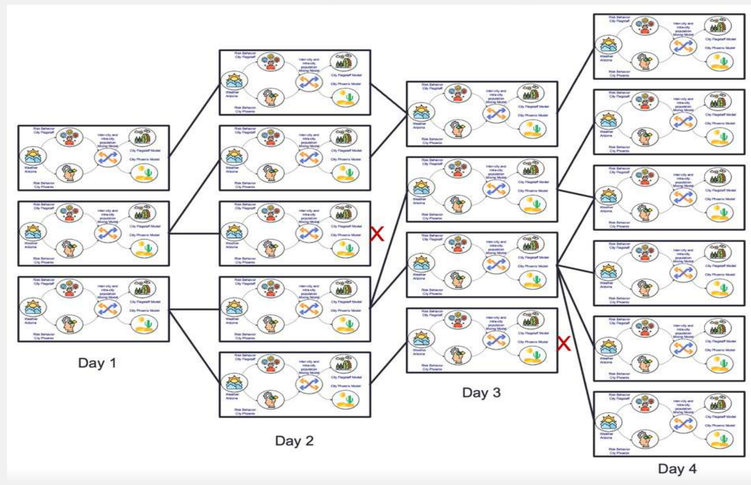
Figure 2: DataStorm-EM timeline exploration interface

Timeline Generation

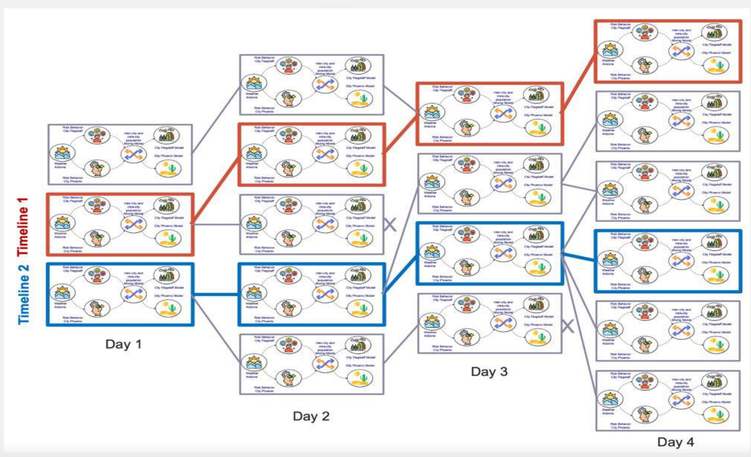
Given a large simulation ensemble, consisting of DataStorm adaptive continuous coupled simulation ensembles, the goal of the system is to enable decision makers to explore the alternative (consistent, yet diverse) timelines.

- Which Simulation to Execute
- Efficient Ensemble Execution
- Ensemble Exploration and Interpretation

Provenance graph



Different timelines



Recent Developments

- Added global pruning instead of local pruning to introduce diversity in the timeline
- Optimized for I/O overhead to reduce the runtime
- Lag of varying lengths can exist among different models
- Different gap filling strategies are used to fill the gaps

Future Directions

- Development of an efficient sampling algorithm based on gradients and tensor decomposition
- The best strategy to determine the values of the parameters to be sampled in each successive iteration is chosen considering the information so far
- It only requires a fixed budget much smaller than the size of the parameter space to estimate the behavior of the function
- The samples are dynamically allocated as the time advances

Conclusion

PanCommunity framework enables practitioners to explore alternative (consistent, yet diverse) timelines weaved within ensemble simulations and make causal inferences regarding the interplay between various factors impacting a pandemic spanning multiple communities at varying scales.

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