Dynamic functional data analysis for “flattening the curve” by Thomas Sun

Abstract: There is urgent demand for robust statistical models that can predict the outlook of the COVID-19 pandemic in cities and estimate the impact that certain social measures and policies have on the trajectory of the incidence curves. In the distinct array of outbreaks across the country, two major sources of variability arise: vertical differences in the peaks of the curves through amplitude variability, and horizontal shifts in the timing of the peaks through phase variability. We use functional data analysis to jointly model both phase and amplitude variation in the disease curves across various locations. Many existing statistical models including the few existing FDA models for COVID-19 focus only on the amplitude variation, or size of the outbreaks. The ongoing and uncertain nature of the pandemic also creates a challenging setting for separating the two components. However, incorporating both sources of variation are critical to understanding the timing and severity of the outbreaks and how our efforts impact flattening the curve. We build upon novel frameworks that decouple the two sources of variability through alignment and fitting of sparse functional data, which are then incorporated into a dynamic functional model that links these features to important covariates. Our methods provide a better understanding and visualization of how disparities in social distancing metrics and demographic differences influence the trajectories of COVID-19 outbreaks across US cities.