COVID Information Commons (CIC) Research Lightning Talk

Transcript of a Presentation by Michel Boufadel (New Jersey Institute of Technology), January 13, 2021

Title: RAPID: Scaling, causality, and modulation of the spread of COVID19

Michel Boufadel CIC Database Profile

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Transcript

Michel Boufadel:

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My name is Michel Boufadel. I'm the PI and Dr. Xiaolong (Leo) Geng is Co-PI. We collaborated with various researchers in the nation. You can see their list here at Princeton, Duke, Rutgers, Hopkins, University of Pittsburgh, and the University of Cincinnati.

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The first part of the talk is going to focus on the number of cases in the U.S. So, you obtain these data from Johns Hopkins University and you know they provided them daily. And then so we analyzed the special distribution of the number of cases and then you can see here in March 2020 and then in May. And then like if you zoom in on the certain region, let's say this is the Washington D.C. area, we noticed that the number of observed cases you know they are spiky. So, you have like the high number, maybe this is D.C. or Baltimore, and then you move and then there's nothing in between. You do the smaller population and then you have a higher number. So, for us that's reminiscent of what's observed in, you know, in turbulence and then so we thought okay that the number of cases would be something known as multifractal.

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And so, we, you know, we got to investigate that. So, the conclusion is that the number of COVID-19 cases is what you call scaling, and then, but it's not totally random. It is correlated and we analyze the correlation using what we call the Fourier spectrum. So first because it is scaling, so the- you can find a direct relation between what's happening at 10 kilometers up to 2,600 kilometers. So initially, during the early phase of the disease, the correlation was small you know- as you can- as one could deduce from the slope. As the slope gets, you know, steeper, then it means the correlation increases and then we notice that the spatial correlation of the disease converges towards the correlation- the spatial correlation of the population. And these are other multi-factor properties that you know- they are in the paper. I'm not going to discuss them now.

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And then for our investigation, we used a relatively simple model developed, you know, more than 120 years ago. It is called SIR model. Susceptible these are the people who could be infected- the infected ones, infectious and then removed. These could be removed due to recover or by death.

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So, we are- we use this model to try to capture what is happening and you know if you recall that spectral slope figure, this is here shown as a time series using also our model which is the line. And then one could note that we were able to produce the spatial correlation using that model. This is just an illustration of how our model functions. So, we start with a population that is multifractal and then we assign, you know, the model for infection and then you can see these are the number of new cases of course with time- the number of new cases with the subsides.

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The conclusion of this is that, you know- the first thing was the major finding for us was the population- the special distribution of population is multifractal, so which allows us to explain why the COVID-19 spatial distribution is multifractal. You know, there are major work where they use big data to model the spread of the disease using number of people, using their phones, so our approach, you know, provide a compromise between the big approach- the big data approach and, you know, fitting models at small towns say at the scale, say, of Newark. And there's always issues of privacy using big data. And the other, you know, again this is maybe pure modeling but we believe that paying attention to special correlation would constrain the model so it doesn't go wild.

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The next part of my talk is about the movement of virion you know or you know just call them particles in the supermarket. Imagine this is a supermarket that is 40 meters long, you know, 20-25 meter wide.

And then you have the doors here. The red in the arrows these are the- where the air comes from- vents. And then the white arrows are the return vents. This is hypothetical.

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And so, we use CFD [Computational Fluid Dynamics] simulation, we call it RANS, to model the movement of air in the supermarket.

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And I want to show here the results. Our focus was on the attachment of the particles. There are a lot of studies that deal with the transport, but for us we say, okay, you know, what happened? You know because we do know that the part you know the virus or the particles they do attach to surfaces. So here you can see them attaching to the ceiling the orange. They attached to shelves you know blue, attached on the floor which is yellow. Whereas if you don't allow for attachment, you know even after 20 minutes you see them spread all over the place. So therefore, the attachment on services is important when you want to predict the indoor transport of viruses.

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This is one curve here where you have one graph. You have the concentration at 5 meters from the source. This is without attachment of 5-micron droplets, so it is 20 percent the strength of the source. With 25 percent attachment, you can see this is like maybe 12 percent and then with 100 percent attachment is like 10 percent. So, we conclude that the attachment doesn't play a role which means the type of surfaces in the supermarket is not going to be- it's not going to play a major role because there were discussions like oh should we use you know metal or glass or plastic? We- based on these simulations, it seems it doesn't make a big difference.

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One thing we investigated is also, you know, when they said, okay, there's one way in the supermarket so people could walk one way- one-way isles. And then we said okay well one of the things that you could reduce you know the number of air particles the virus particles in the air, is maybe you can create "Baffles". This is- as an environmental engineer we're used to using- to this concept for plug flow reactors. And then we conclude that if you place these baffles in the system, you are going to reduce the concentration of particles in the air. And the other thing that- from the study is that the narrower the aisles, the better the air quality, which is kind of counterintuitive because every- you know whenever you look at a supermarket you know you look at large aisles and then it gives you the feeling that it is healthier. Thank you.