COVID Information Commons (CIC) Research Lightning Talk

Transcript of a Presentation by Massood Tabib-Azar (University of Utah), August 18, 2021

Title: RAPID: Colorimetric COVID-19 Detection Using Aptamers

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Transcript

Lauren Close:

I'd like to now introduce our next speaker professor Tabib-Azar of The University of Utah.

Florence Hudson:

Massood, I think you're muted.

Massood Tabib-Azar:

Sorry.

Florence:

That's okay. We can hear you now. Thank you.

Massood:

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Thank you very much for the opportunity and thanks for the introduction. This- my talk is slightly different than the ones we have seen so far. It is about developing some electronic sensors to detect COVID-19 from the environment and from saliva and bodily fluids. Dr. Elizabeth Middleton from the University Hospitals of University of Utah has provided the saliva samples and without her help this wouldn't have been possible. And this work is supported by partially supported by an NSF CMMI [National Science Foundation Civil, Mechanical and Manufacturing Innovation] RAPID grant.

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So, as I mentioned the objective was to develop something a sensor that is very fast. So, in order to be able to do that, the idea came across to develop a sensor that detects the whole virus and not decompose it to its constituents like proteins RNAs and whatnot. And we wanted to be able to detect these viruses in less than five minutes. So, the sensor that I'm describing today is as does it in about a minute. And also, it was desirable to have reusable sensors for a resource limited area so that you can reuse- reset the sensor and reuse it. Although there are some issues regarding contamination and cross contaminations that prevents this from happening readily unless you have some elaborate techniques to reset them without contaminating others. So, if anybody's interested in the stuff that I'm talking about, I sent in the chat a link to all the news clips and stuff that cover this sensor development and also Dr. Aaron Duffy from our commercialization office can be contacted for commercialization discussions. There are five companies that have started commercializing this.

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So, saliva is actually pretty complex fluid. 99 percent of it is water. That one percent remaining has lots of nanoparticles in it and I didn't know that before I started- like most of the stuff that we do. And there are nanoparticles that are completely different size than COVID-19. They're okay because they don't really contribute to this signal as long as they are much smaller than COVID-19 or much larger. So COVID-19 it takes different sizes in saliva it's about 125 nanometer in diameter and directly competing with it are the exosomes in saliva. They're about 100 nanometers in diameter so similar in size and they're also spherical but they do not have any spiking proteins that we are familiar with in COVID-19.

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So, our sensor basically relies on three different things. This is the schematic of the sensor structure. These are optical microscope images of the sensor. Essentially, there are two electrodes that are separated from each other by a distance corresponding to the size of the COVID and the bottom gold electrode and the top gold electrode, they are- they have surface molecules on them that are called aptamers. These are singular strand DNA synthetically designed to bind with these spiking proteins on the surface of the COVID-19. And they bind with s1 and s2 these are surface type 1 proteins and surface type 2 proteins. So, size is important. If it is too small or if it is too large, it won't really fit the sensor space in there. The spiking proteins are important. If they don't have it, you can wipe them out without too much difficulty. And also, the electrical properties of these wires are also important because we measure the impedance of this junction where you can call it the capacitor or whatever you want to call it. And if it does not COVID-19, then the impedance that you would measure would be different. So, these three different things should come together for us to recognize something as the virus that we are interested in.

Slide 5

COVID-19 is also electrically charged. This is well known about viruses in different pH environment. They acquire different residual charge. In the case of COVID-19 and saliva, it is slightly negatively charged. You can see that if you perform these current versus voltage measurements very carefully with electrodes. One side functionalized with aptamer and the other side not. You can see that this asymmetry and to explain this asymmetry you have to assume that COVID is slightly negatively charged. We take advantage of that and put positive charge at the bottom electrode in our sensor in order to attract actively the virus to the sensor.

Slide 6

So, once you have the sensor in place and all the aptamers and so on and so forth, you can choose different ways of measuring the response of the sensor to the presence of the COVID-19. You can do current versus voltage measurement. Those are DC measurements. Or you can look at the capacitance and resistance of the sensor and then try to see if the presence of COVID-19 significantly contributes to the behavior of capacitance and resistance over certain range of frequencies. And at five kilohertz, the difference is largest between saliva that's infected and saliva that's not infected that are deposited on the sensor.

Slide 7

Of course, the inductor capacitance resistance measurement units are 50k or so and you can't really do that in a handheld device that you want to basically give people something like this to carry with themselves to detect the COVID in the environment, and we replaced all that equipment with a microprocessor that applies these square pulses. And then we developed a technique to just look at the response of the of the sensor to this output voltage that you have. And we have a reference capacitance that is comparable to the capacitance of the sensor. And if the VR kind of looks like the red one that I show in there, then we decide that it is- the saliva is infected. And you can see the response of the negative and pulse. There are a few samples that are kind of in the no man's land and those are the false positives and false negatives that we account for.

Slide 8

Now the system is a standalone. There is a LED that turns red when the saliva is infected or it remains green. And this system is also paired- can be paired with your smartphone, and the output of the sensor can be displayed. There is also a mapping capability that enables you to see where in the world the sensor has been used and if there are infections detected then there is this you know COVID-19 schematic or whatever cartoon shows up. And there was one in Provo in Utah, and you can see that it is being tested in many different places: Japan and Thailand and all over the world.

Slide 9

Now detecting things from airborne kind of version of the- detecting the airborne version of the COVID-19 is a little bit more challenging. The false positivity rates and negative rates are slightly higher because when you do it from airborne samples, there are super particles in the air and so on and so forth that are similar in size, and one has to be careful about that. But still, we can detect it from airborne samples without too much difficulty although it needs more development to be able- so that you can use it in the air rather than putting some saliva samples on it.

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So, these are some of the statistics or the characteristics of the sensor. Our false positivity and negativity rates are between four and ten. It is better on the four percent side when you do it in the laboratory environment again because the sensor interacts with the environment and less stuff you have in the air better it works. And it detects the variants, but if the variants have s1 and s2 proteins that are more than few percent different than the original one, then we have to change our aptamers. These are synthetically produced so they're easy to get and employ and use it in our sensor. Our sensor system also has an oximeter, a thermometer, and walk sensor so it can enable you to look at the toxic gases in the air: CO, CO2, stuff like that are also become larger in infected people. That's basically it. Thank you very much.