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Detecting Coronavirus in Real Time by Analyzing Particles Emissions

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Detecting Coronavirus in Real Time by Analyzing Particles Emissions

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Abstract. New techiques COVID-19 diagnostics based on innovative mathematical theories are suggested

Keywords: infection diagnostics,COVID-19, detection, prevention, hypernumber

1. Introduction

The ability of Coronavirus screening in real time is critical for minimizing the chance of the infection transmission. The suggested previously and used approaches of measuring body temperature have multiple limitations. One of the major limitations is that the temperature symptom may appear in average 4-6 days after getting the infection (Groth, 2020).Researchers at the European Centre for Disease Prevention and Control found that as a result, three-quarters of passengers leaving Chinese cities with COVID-19 would not be detected by entry screening (Rauhala, 2020).

Another approach to real time diagnostics reveals to analyzing signature of the particles exhaling per breaching by ill person.The importance of particle count testing is to provide screening of individuals for isolation with symptoms or potentially even before symptoms arise (Zhu at el, 2020). Challenges to developing a distinctive signature include individual variability in particle size distributions (Papineni and Rosenthal, 1997). Nevertheless, distinctive features may be identified at least with higher resolution observations.

The major challenge in screening by counting particles from person’s exhaling breath reveals to preventing cross contamination. One of the approaches in obtaining samples of breathed air without direct contact suggests taking a portion of individual breath into a plastic bag, and suctioning the air into the device. The disadvantage of this proposal is its operation complexity as well as inability of the real time screening.

This work provides distinctive features of the development based on the authors results that support the proposal. The details will be covered in utility patent and scientific publications.

The advantage of the suggested method includes such things as:

1. Rapid recognition of the health abnormality prior to appear such symptoms as temperature, coughing, etc.
2. Secure patients cross contamination by entailing viruses from the previous tested person.
3. Detecting and preventing air test flow conditions that may cause viruses back flash with real time monitoring and artificial intelligence modeling.
4. Using low costs sensors and computational device that will make it affordable for regular customer.

2. Safe method of coronavirus detection by particle count from the persons exhaling breath

The method of detecting coronavirus that prevents cross contamination (transmission viruses from infected to healthy person) during screening is illustrated at figure 1. The exhaled from the mouse air-particles mix is sucked by the fan through the test tube. Particles count is performed by PM 2.5 sensor. There are multiple sensors on the market that determine particle amount of size from 0.3 to 10 microns. We selected ADAFRUIT PM 2.5 due to the data reading accuracy and simplicity in connecting to the analyzer – Raspberry PI mini-computer. The device functionalities include:

a) Using one time breathing tube that manually or automatically attached to the screening device.
b) Preventing virus aerosol streaming to the mouse at the moment when person is not exhaling breath to the tube with aerodynamics design.
c) Recognizing particles exhaled from screening person. The exhaled particles should be differentiated from phone particles. The algorithm for such recognition is imbedded in real time monitoring program.
d) Preventing aerosol moving to the screening person mouth due to the accidental air flow abnormality by applying intelligent engine – model to calculate the probability of the particles reach the person's mouse. Such probability depends on air flow inside of the tube, temperature, test tube geometry and can be defined with methods covered in (Dantsker et al, 2002, 2003; Burgin and Dantsker, 2013). The model would allow detect event of aerosol streaming to the mouse in milliseconds and alarm or stop such particles movement by isolating person from the flow.
e) Defining abnormal particulate signature per exhaled breathing. One of the approach in defining virus signature reveals to estimating amount of the particles exhaled per unit of the air. According to research (Fabian et al, 2011) healthy subjects exhaled less than 100 particles per liter. An international team of researchers reports (EarchSky Voices in

Human World, 2020) show that patients with coronavirus disease 2019 (COVID-19) release thousands of viral particles directly into the air simply though breathing. The researchers say the patients in the study exhaled severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) at an estimated rate of up to 100,000 particles per minute. Considering that person exhaling 7-8 liters per minute, the amount of exhaled particle per minute approximately 12,500. Since the amount of exhaled particle from infected by coronavirus person in significantly higher than the number of particles exhaled by healthy person, such characteristic is very distinctive signature for coronavirus recognition

The aerosol size that exhaled per infected person breath is covered in (EarchSky Voices, 2020) the post. Aerosols produced by people when they breathe, talk and cough are generally between about 0.7microns to around 10 microns. The aerosol with such size range can be counted by PM 2.5 sensors.

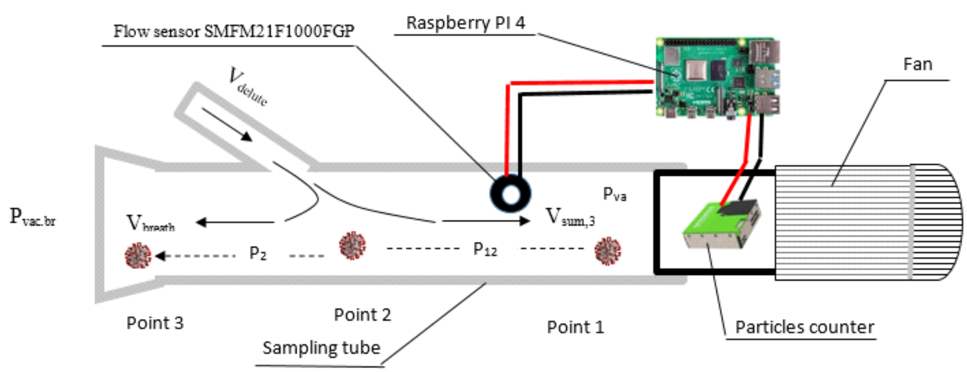


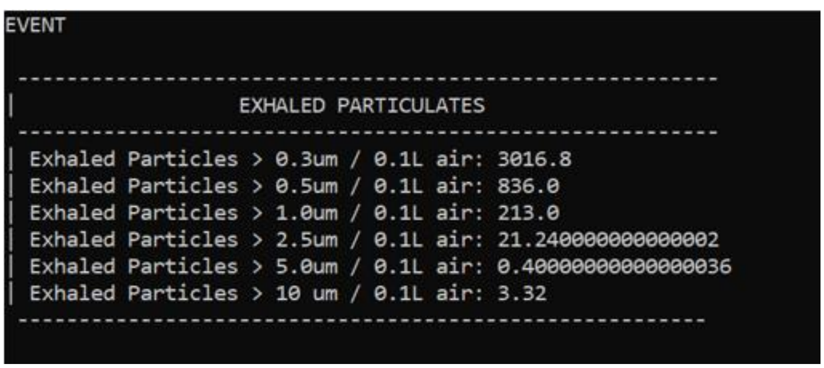
Figure 1 Particulate count when person is breathing with configuration to avoid cross-contamination

3. Testing detection exhaling particles

The test device and remotely connected through WIFI to the Raspberry PI laptop computer are presented in Figure 2.

Figure 2 Coronavirus screening test device

The output from continuous particulate monitoring that covers exhaling event recognition is shown on Figure 3.



```
EVENT

 -------------------------------------------------------
|                  EXHALED PARTICULATES
 -------------------------------------------------------
| Exhaled Particles > 0.3um / 0.1L air: 3016.8
| Exhaled Particles > 0.5um / 0.1L air: 836.0
| Exhaled Particles > 1.0um / 0.1L air: 213.0
| Exhaled Particles > 2.5um / 0.1L air: 21.240000000000002
| Exhaled Particles > 5.0um / 0.1L air: 0.40000000000000036
| Exhaled Particles > 10 um / 0.1L air: 3.32
 ------------------------------------------------------
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Figure 3 Output to the console of the exhaling particles count

4. Mathematical foundations

The suggested methods of COVID detection are based on the advanced mathematical theory of hypernumbers and extrafunctions (Burgin, 2010; 2012).

The theory of hypernumbers is a novel approach in functional analysis aimed at the development of such mathematically correct technique, which allows consistent operation with dynamic and in particular, divergent integrals and series. Real hypernumbers are constructed from real or rational numbers using the technique, which is similar to the method of constructing real numbers from rational numbers using their topological properties. Complex hypernumbers are constructed in the same way from complex numbers. Real hypernumbers, as well as complex hypernumbers, have the structure of semitopological spaces.

Hypernumbers are dynamic numbers, that is, numbers that can asymptotically characterize the dynamics of different processes, for example, limit computations or processes utilized in numerical analysis. For instance, in addition to converging finite hypernumbers, which coincide with conventional real or complex numbers, there are oscillating hypernumbers, infinitely increasing hypernumbers and infinitely decreasing hypernumbers. This property allows ascribing hyperprobability taking values in real hypernumbers between 0 and 1 to any process while conventional probability is assigned only to random processes whereas randomness does not have a comprising definition (Burgin and Krinik 2009).

Hypernumbers essentially increase the capacity of the calculus allowing researchers and engineers performing summation of any series of real or complex numbers (Burgin 2008), integrating any real function (Burgin 2012), building a rigorous construction of the Feynman path integral (Burgin 2008a; 2012a), solving various operator equations (Burgin and Dantsker 1995), mathematically grounding different regularization techniques used in physics (Collins, 1984) and solving some open problems in probability theory (Burgin and Krinik 2009; 2012). For instance, mathematicians have been searching for various conditions of series summability in the classical sense (cf., for example, (Jolley, 1961; Sofo, 2003)), while hypernumbers allow one to find the sum of any series of real or complex numbers (Burgin 2008a; 2012).

The theory of hypernumbers is complemented by the theory of extrafunctions, hyperfunctionals and hyperoperators, which for a far-reaching extension of distribution theory. It continues the same line of reasoning, extensively extending the scope of distribution theory and providing far-reaching means for improving exactness and capability of physical theories. Indeed, on the one hand, as it is demonstrated here and in (Burgin 2012), distributions are particular cases of such extrafunctions as generalized distribution. On the other hand, provide more powerful means for differentiation and integration. For instance, while distributions allow one to differentiate any continuous real function, extrafunctions permit one to differentiate any real function (Burgin 2012). In addition, extrafunctions make available integration of any real function (Burgin 2012).

There are two basic types of extrafunctions - general extrafunctions and norm-based extrafunctions, which include conventional distributions, hyperdistributions, restricted pointwise extrafunctions, and compactwise extrafunctions. General extrafunctions are arbitrary mappings of hypernumbers. Norm-based extrafunctions are constructed based on norms in function spaces with the help of sequences of functions and factorization of normed spaces. Norm-based extrafunctions have the structure of semitopological spaces.

Similar to the theory of hypernumbers, the theory of extrafunctions, hyperfunctionals and hyperoperators provide extremely powerful means for differentiation and integration. For instance, while distributions allow one to differentiate any continuous real function (Schwartz, 1950/1951), extrafunctions permit one to differentiate any real function (Burgin 2012). In addition, extrafunctions make available integration of any real function, as well as summation of any functional series (Burgin 2012). This feature of extrafunctions allows to be exceedingly useful for differential equations allowing solving such equations for which it is proved that they are not solvable even in distributions not speaking about conventional functions (Lewy, 1957; Burgin and Ralston 2004; Burgin 2010). In addition, functional hyperintegrals, which are a kind of hyperfunctionals, provide a rigorous mathematical foundation for the Feynman path integral (Burgin, 2004), which has become one of the primary key tools in contemporary physics (Feynman and Hibbs, 1965) finding applications in information theory, stochastic analysis, control theory, chemistry, statistics and financial mathematics, stochastic differential equations and biology.

Important parts of the theory of extrafunctions, hyperfunctionals and hyperoperators are the theory of hyperdifferentiation, which is also called the extended differential calculus essentially extending the conventional differential calculus, and the theory of hyperintegration, which is also called the extended integral calculus essentially extending the conventional integral calculus.

5. Conclusion

The direction covered in this work is the first step in screening coronavirus infection by providing a secure method of delivering inhaling aerosol to the particle sensor(s) and recognizing infection by using analytical methods. The analytical methods are based on multiple discoveries related to the medical aspects of the inhaled aerosol (Edwards et al, 2021; Stohner, 2021) as well as on advanced theories of aerosol transport and non-classical mathematics (Burgin, 2010; 2012; Burgin and Dantsker, 2015) that allow rapidly solving diagnostics problems.

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