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PREFACE

PREFACE on the Special Issue 'Technologies for Fighting COVID-19'

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The ongoing COVID-19 pandemic due to the SARS-CoV-2 virus has already infected more than 10 million people and accounted for death of more than half-a-million worldwide, with no sign of abating in near future. Given the scale of its spread, it is obvious that everyone has to contribute to contain the damage caused by the pandemic. The engineers and technologists have a very critical role to play by conducting innovative research and harnessing their ideas into successful products in a very short period so that the virus attack in a person can be identified at a nascent stage and contained without infecting general public, doctors, healthcare workers, the security personals, media people, and many others engaged in transport, manufacturing and entertainment industries. It is a difficult task to develop new technologies within a short span but many of the existing technologies can be deployed with subtle changes to meet the immediate needs challenged by COVID-19. Realizing the grave concern caused by COVID-19, Indian National Academy of Engineering has rightly decided to bring in a special issue of the Transactions of INAE on 'Technologies for Fighting COVID-19' in cooperation with Springer Nature. We feel fortunate that we have been entrusted to bring in this special issue in a record time of 10 weeks as its Guest Editors.

We were overwhelmed by the response received from various institutes and organizations across the country for quick realization of this SI. Reviewers provided constructive and rigorous assessment of submitted papers and many of the papers have undergone multiple revisions to ensure the quality of papers. We are very grateful to the reviewers for providing meaningful comments that helped in raising the standard of the original submissions. We are presenting 49 accepted papers in this SI. The accepted papers were posted "Online First" and these have been very well received by scientists, technologists and engineers concerned with COVID-19.

The papers appearing in the SI can be broadly categorized as:

1. development of computer models and Apps for managing the pandemic,
2. development of microdevices for detection/diagnosis of the disease,
3. systems for Containment of the virus and for Disinfecting surfaces and objects, and
4. development of ventilators, face masks, and drugs.

A summary of the salient points from the papers incorporated in SI is provided in the following paragraphs:

the article by Podile and Basu (2020) addressed very briefly about the recent advances and developments in understanding the etiology and epidemiology of Covid-19 pandemic and various factors influencing the transmission of disease and the measures that are being undertaken to curtail further spread of the disease. The authors have elucidated the structural and genetic make-ups of the SARS-CoV-2 virus, and the mechanism of entry of corona viruses into cells.

Development of Computer Models and Apps for Managing the Pandemic

Verma et al. (2020) conducted a comprehensive data analysis of nine major countries, and showed the existence of successive power laws in between exponential regime and flattening of Covid-19 epidemic. Several factors contributing to successive power laws have been discussed in detail. Ranjan (2020) proposed two data-driven models to forecast the decay phase of the epidemic, as the epidemic

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in the decay phase is different from its growth phase. Chandak et al. (2020) described a machine learning based application to compute the lock-down schedules, while taking health and economic related activities into consideration. Khadilkar et al. (2020) examined the lock-down policies, using an AI-driven approach, which can simultaneously control the spread of the disease while balancing it with both health and economic costs. The approach dealt with imperfect lockdowns and has potential to explore a range of policies employing tunable parameters. Bhardwaj (2020) proposed a logistic model, which predicts the number of infections at the end of the outbreak, and also the period when the peak of infection would arrive. Anand et al. (2020) developed a model that accounts for the number of infected and quarantined patients while predicting the spread of the disease. Suman et al. (2020) came up with a model to address the gap between the demand and supply of public transport, which is invariably going to arise given that an additional constraint of physical distancing needs to be met during transport in the currently prevailing conditions.

Jhunjhunwala (2020) explained the role of telecommunication network in managing the epidemic. He has narrated the way telecom has been leveraged for developing Arogya Setu App and described its functioning and how it helps a user to figure out the risk of being infected. The functioning of the App on both Smartphones and Feature Phones has been explained. Arogya Setu App is being up-dated regularly and is being used by several millions of people with confidence to bolster efforts to fight the COVID-19 pandemic. Mallik et al. (2020b) presented an App that can inform people of the containment zones, so as to prevent trespassing into these zones. A list of 40 relevant Apps currently available in the country has also been documented in their paper. Mallik et al. (2020a) developed an App for tracking the movement of ambulances with infected patients and for helping the traffic police to trace the movement of such ambulances. Shah and Patel (2020) described the use of geospatial technology for mapping open spaces, such that these could be turned into quarantine centers if required. The tool can be useful for tracking supplies to an infected center. Sarfo and Karuppannan (2020) employed the geospatial technologies to fight against COVID-19 in Ghana. The tempo and trend of the epidemic was modeled using Universal Kriging and Inverse Distance Weighted Interpolation algorithms. The modeling took into account the mobility dynamics, the current COVID-19 cases reported, population dynamics in different zones and the rate of SARS-CoV-2 infection in Ghana. This study provided a basis for devising containment measures to reduce the rate/prevention of spread of the pandemic and utilize the very scarce resources more efficiently.

Development of Microdevices for Detection/ Diagnosis of the Disease

Tripathy and Singh (2020) described a method for detection of the SARS-CoV-2 virus using a device that is hand-held and affordable. The proposed method based on electrochemical transduction is label-free. Murugan et al. (2020) proposed a portable plasmonic fiber-optic absorbance biosensor (P-FAB) platform for detection of SARS-CoV-2 virus in saliva samples with a very little effort in the sample pre-processing. Tripathi and Agrawal (2020) proposed engineering of the blood plasma separation microdevice for detecting relevant anti-bodies in blood. Duryodhan et al. (2020) aimed at developing a diverging microchannel based micro-PCR, by utilizing the unique distribution of heat in a suitable geometry. Chatterjee and Bandyopadhyay (2020) developed a technique for detecting taste-contributing agents that is envisaged to have application in the detection of COVID-19. Paul et al. (2020) proposed a diagnostic test based on a paper fluidic device. The device could diagnose bacterial infections through molecular tests. Nag et al. (2020) provided an overview of evanescent wave absorbance and localized surface plasmon resonance-based optic fiber platform for potential screening of COVID-19.

Since one of the symptoms for identification of COVID-19 seems to be inability to smell, Gandhi et al. (2020) developed a device based on olfactory sense detection for detecting the disease. The device generates precise level of smell digitally and repeatedly in a contactless manner. Roy et al. (2020) came up with an idea of using a lung-on-chip platform to study the SARS-CoV-2 pathogenesis in humans, with drug toxicity testing claimed to have potential in providing meaningful insights into antigen–antibody interactions. Jain and Muralidhar (2020) proposed an electrowetting-on-dielectric based technology to merge a liquid drop of possibly infected sample with another drop of a reagent for the purpose of testing.

Systems for Containment of the Virus and for Disinfecting Surfaces and Objects

Diwan et al. (2020) described a numerical tool for simulating the cloud of fluid ejected during coughing and sneezing. The authors considered coughing and sneezing flows as a problem of fluid dynamics of a transient turbulent jet/puff with buoyancy, laden with evaporating droplets carrying the pathogen. They have developed a direct numerical simulation code and arrived at the time duration over which the cough flow can persist after the coughing has ceased. These simulations claimed to have

potential in devising accurate guidelines for separation distances between neighbors within a group, design better masks, and minimize the spread of the disease. Singh and Tripathi (2020) proposed to study ventilation design of a room for effective transportation of coughing- and sneezing-generated pathogen aerosols. Joshi (2020) developed an innovative chamber christened as COVid SAmple Collection Kiosk (COVSACK) to protect the healthcare provider from getting infected while collecting samples. COVSACK has been designed based on CFD simulations for effective spread of disinfectant in fine droplet form. The kiosk was built using lightweight composite that is capable of sustaining extreme weather conditions and can be sanitized in three minutes after sample collection. After its deployment in hospitals and diagnostic centers, it has changed the way that testing is being done in the country with a drastic reduction in the use of personal protection equipment. Rao and Rao (2020) developed a 'Aerosol Containment Box' for safeguarding health care providers against infection during intubation procedure and sample collection. Maurya et al. (2020) developed a tunnel for disinfecting objects employing three different disinfectant strategies. The tunnel is fully automatic, modular and portable. Krishnan et al. (2020) described the design and construction of 'Chitra Disinfection Gateway', a walkthrough tunnel, meant to be installed in public places for disinfecting personnel passing through it. Murthy (2020) elaborated a tunnel-based system for disinfecting luggages and packages, which can be installed in airports and bus/train stations. Kumar et al. (2020) demonstrated a portable disinfectant device developed under Industry-Academia collaboration. The device effectively combined two disinfection strategies: spraying of sanitizing liquid and UV light. Neelakandan et al. (2020) proposed a system for disinfecting face masks, with emphasis on utilization of local resources. Rao (2020) has clearly explained the development of a mobile virology research and diagnostic laboratory. This unique mobile laboratory helps in conducting real-time reverse polymerase chain reaction (rRT-PCR) test for diagnosing Covid-19, virus culturing for drug screening, convalescent plasma-derived therapy, and will aid in the development of vaccine and diagnostic kits. This mobile laboratory has been developed as per WHO and ICMR bio-safety standard BSL-3. It is heartening to learn that the technology developed for containerization of ground support equipment and clean rooms technology adopted for integration of high precision missile components with high safety standards has been utilized very effectively for establishing COVID-19 diagnostic laboratory.

Sharma and Sharma (2020) narrated a plasma sterilization system employing UV, ozone and short-lived molecules produced during discharges. The system is portable and can be used for sterilization and treatment of garments and used disposable protective gears. Kar et al. (2020) tweaked two different cold plasma devices for the purpose of pathogenic inactivation. Mahapatra et al. (2020) proposed to combine anti-viral action with liquid-repelling properties to enhance the functionality of personal protective equipments (PPEs). Kashyap and Saha (2020) came up with novel idea of employing a high voltage charge generator from a very low DC source to eliminate the virus from the surface of PPE, with the aim of sanitizing it before and after use. Siddiquie et al. (2020) proposed reduction in contact of viruses with surfaces by employing hydrophobic surfaces by texturing them. Alternatively, fullerene-coated surfaces could be employed for this purpose. Sarada et al. (2020) also employed a combination of strategies for disinfecting places and surfaces effectively. Towards this, they combined physical, thermal and chemical processes to design a UVC based disinfection trolley. The trolley comprises honeycomb air heater and a fogging chamber using UVC germicidal lamps, dry heat sterilization, and hypochlorous acid based chemical disinfectant to provide rapid and effective inactivation of microorganisms.

Development of Ventilators, Face Masks, and Drugs

Indian Space Research Organization (ISRO) team (Design and Development Team 2020) developed three low cost ventilators, with unique characteristics. Tests were carried out on prototypes of these ventilators and critical mechanical and electronic parameters were established to ensure satisfactory performance of the developed systems. Contributions from VSSC/ISRO are well received and commendable. Johar and Kuldeep 2020) developed micro-controller operated solenoid valve based ventilator for stand-alone and hospital-use. Their ventilator has been successfully demonstrated to various hospitals. Tharion et al. (2020) designed a ventilator using readily available materials, which can be assembled in a short time. An offset slider-crank mechanism is employed in their design. Hirani (2020) described a motorized bellow-based ventilator with inbuilt intelligence, for providing assistance in breathing. The developed prototype has further been tested in a hospital. Singh and Sardana (2020) designed a BiPAP, which is a mode of ventilation whereby positive pressure is maintained for air intake, and a low pressure for expiration. Sarkar et al. (2020) proposed a novel three-layered face mask with a hydrophilic layer sandwiched between two hydrophobic layers. Simple tests on the developed mask show a better performance than commercial surgical masks in arresting droplet transmission, thereby reducing the chances of infection.

Singh and Vijayan (2020) conducted a review on the use of chloroquine as a potential drug for the treatment of COVID-19. They explain how chloroquine and

hydroxychloroquine mediates anti-viral effect in both prophylactic and therapeutic settings. Madhavan and Mustafa (2020) suggested the existence of antigenic mimicry between SARS-CoV-2 and host proteins, which could have therapeutic applications. Biswas et al. (2020) developed a risk assessment score to predict the severity of the disease of suspected patients. This helps in providing early attention and management before the availability of the RT-PCR test for confirmation. Patel et al. (2020) proposed a unique five-layer body bag for the deceased. The body bag is leak-proof, strong enough for handling and transport, and has provision to view the face of the dead body by family members before cremation/burial.

The scale of the pandemic has increased manifold between conceiving of this SI to its appearance. This should lend additional justification for bringing out this SI. We hope that the readers would agree that the SI has been able to compile several different technologies at a single place. Several of us were not even aware that such alternate approaches exist, and that somebody else is already trying to use the other approaches for fighting the biggest danger posed to mankind.

We therefore hope that the articles in the SI will enrich the readers, and provide them with additional ideas and tools. As the President, INAE said in his Foreword (Mishra 2020), we will consider the SI a success only when teams having novel ideas, proposed and partial/full solutions come together and quickly work out collaborations to produce a marketable product at a reasonable cost and reliability which is of utmost importance in diagnosis and treatment.

Prof. K. Bhanu Sankara Rao, Editor-in-Chief of Transactions of INAE showed unabated interest and rendered much needed support and invaluable guidance at all the stages for realizing this rare and timely issue. The keen interest and encouragement of Dr. Sanak Mishra, President INAE for this SI is gratefully acknowledged. We are thankful to him for penning down a concise and excellent foreword for the SI. We sincerely thank all the authors for their excellent contributions, and the reviewers for thorough and timely reviews. Sincere and special thanks to the Springer Nature team comprising Ms. Nidhi Chandhoke, Ms. Esha Mutreja, Mr. Mohammed Imran, and Ms. Barakah Sharmeen for their timely decisions at various stages. Without their cooperation bringing this issue would not have happened within 10 weeks.

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