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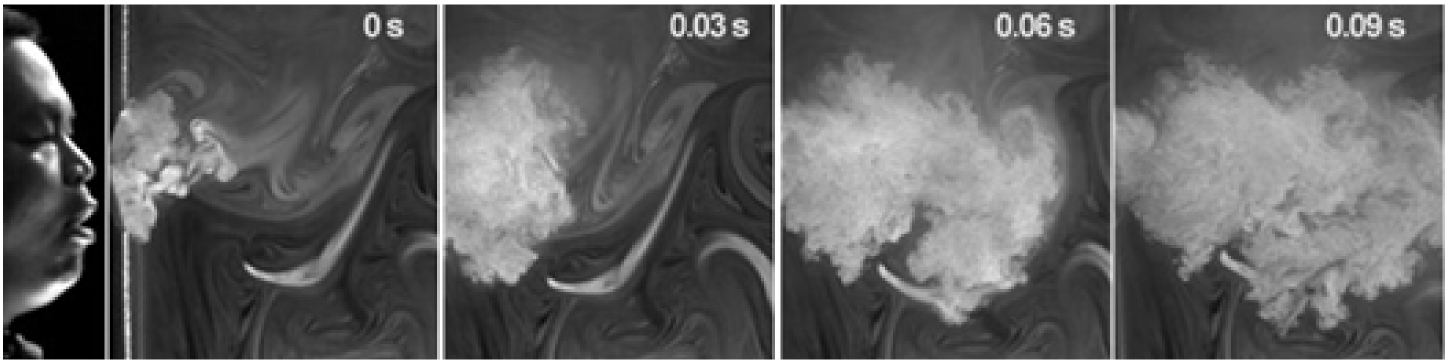
IAQVEC NEWSLETTER

ISSUE 2 • NOVEMBER 2021

*ASSOCIATION FOR INDOOR AIR QUALITY, VENTILATION AND ENERGY CONSERVATION IN BUILDINGS



particles movement trajectory during cough period taken by PIV

(***see the featured article*** • *P.2*)

PRESIDENT'S MESSAGE

It's been almost a year since IAQVEC Newsletter First Issue was published. At that time, I expected COVID-19 to be over by now, but it's still raging worldwide. I hope that you and your family are fine and in good health. COVID-19 has changed much of our lives. Of course, there are many negative aspects, but there is also the aspect of accelerating things that should change in the built environment. For example, progress of online, review of work-life balance, promotion of Digital Transformation, etc. Perhaps, even if COVID-19 ends, society will not completely return to its pre-pandemic state. Some of these changes will continue in the future. Under such changes, we should consider making a better built environment. In the First Issue, we announced that the next IAQVEC conference would be held in Dalian, China in June 2022, but the time and venue of the conference have changed due to the influence of COVID-19. The next IAQ VEC conference will be held in May 2023 in Tokyo, Japan. We look forward to your active participation. We hope to have a face-to-face meeting, but since the impact of COVID-19 is expected to remain also in the future, we need to consider various possibilities simultaneously. We hope that this will be a new conference model after COVID-19.

FEATURED ARTICLE

Newsletter Production Team

- *Leila Rafati Sokhangoo*
- *Rafaela Orenga Panizza*
- *Arash Hosseini Gourabpasi*

Concordia University, Montreal

Send your comments and questions to:
Dr. Mazdak Nik-Bakhkt, *Journal & Newsletter chair*

MEASUREMENTS OF EXHALED AIRFLOW VELOCITY THROUGH HUMAN COUGHS USING PARTICLE IMAGE VELOCIMETRY

BY:
Mengtao Han
Ryozo Ooka

Preamble

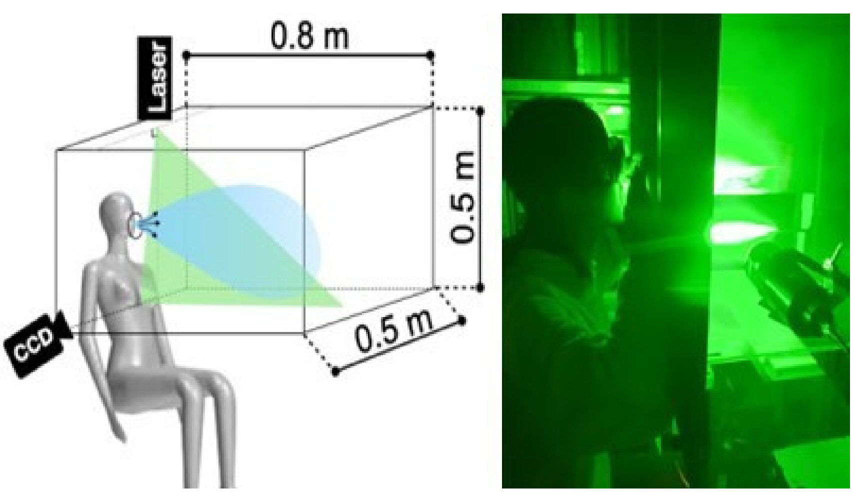
The coronavirus disease suddenly broke out at the end of 2019 and quickly swept the world (COVID-19). It has infected over 210 million people and caused over 4.5 million deaths by August 2021, leading to a major global public health disaster. As a potential carrier of the novel coronavirus SARS-CoV-2, the exhaled airflow of infected individuals through coughs is considered significant in virus transmission. Thus, elucidation of the characteristics and distribution of cough airflow and droplets / droplet nuclei is essential for the study of viral infection and the control of prevention. With the development and widespread application of computational fluid dynamic (CFD) technology, it is possible to utilize CFD to simulate and study the propagation process of droplets exhaled from infected people and the accessibility of viruses in the architectural space. This will be of great significance in controlling the virus's transmission and subsequently providing precaution and control methods against infection in the building. It can even provide the design basis for the architectural space from the perspective of environmental health. Therefore, it is essential to elucidate the characteristics of cough and the distribution of its initial velocity, which provides the boundary condition and a validation database for CFD simulation.

Research gap

During the last two years, numerous studies analyzed the coughing mechanism, coughing respiratory droplets, and more directly, the exhaled virus information to understand the mechanisms of airborne infection. These studies revealed some of the cough airflow characteristics. However, there are mainly two deficiencies in the previous cough airflow measurements, making it difficult to form an effective boundary condition and validation database for the CFD simulation of droplet propagation. One is that the time series data of initial magnitude and directions of cough airflow exhaled from the mouth have not been reported, which is indispensable for simulating a complete unsteady cough airflow process. It is challenging to utilize the limited data to provide a validation database and boundary conditions for cough CFD simulation. The other is that the frequency of particle image velocimetry (PIV) was low due to equipment limitation, leading to the missing airflow characteristics related to the small time scale. It is essential to employ a high PIV frequency to capture some detailed cough airflow features because several important characteristics were at the time scale of millisecond level. The temporal and spatial resolution will also be rough when utilizing low frequency, and fine turbulence structure caused by large initial velocity near the mouth cannot be captured.

Experimental Method

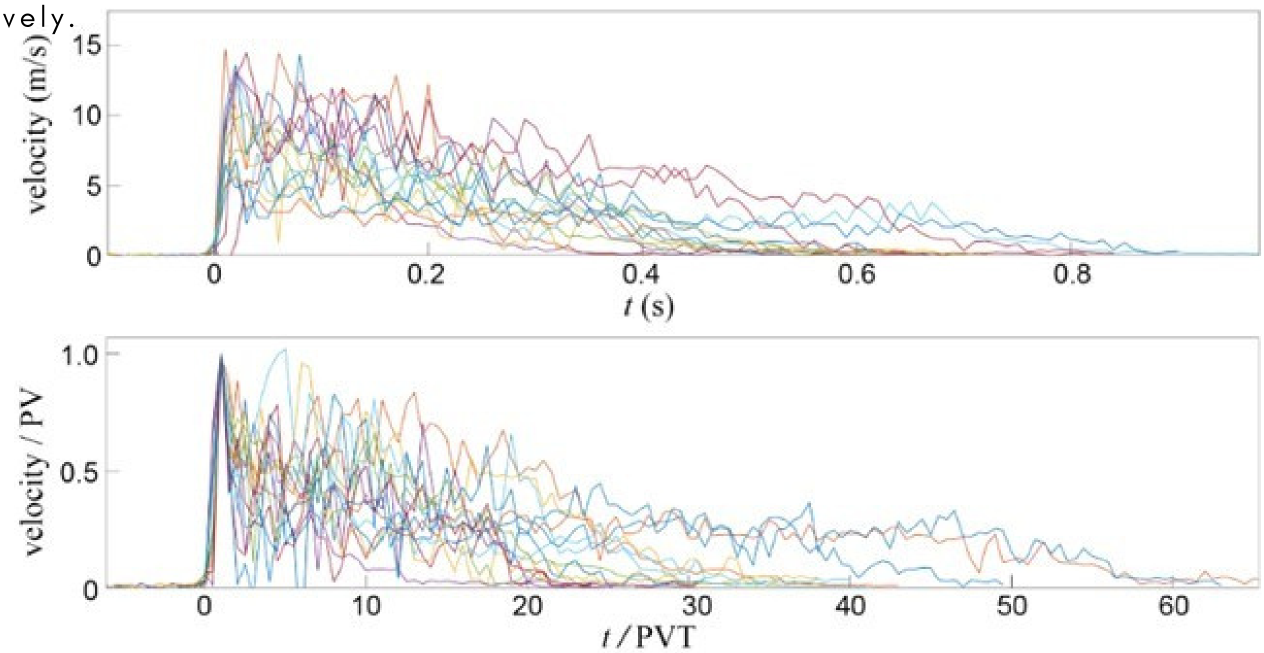
In this study, we carried out experiments to elucidate the kinetic characteristics of the airflow ejected by human cough as the basis for research on the effects of human cough on virus transmission. This experiment used high frequency particle image velocimetry (PIV) with high frequency (interval: 1/2986 s) to measure the initial velocity of cough flow for a total of 60 coughs in 10 healthy non-smoker subjects (5 males + 5 females) (figure on the right side). We considered the basic characteristics of cough airflow such as cough duration, maximum wind speed, and cough diffusion angle.



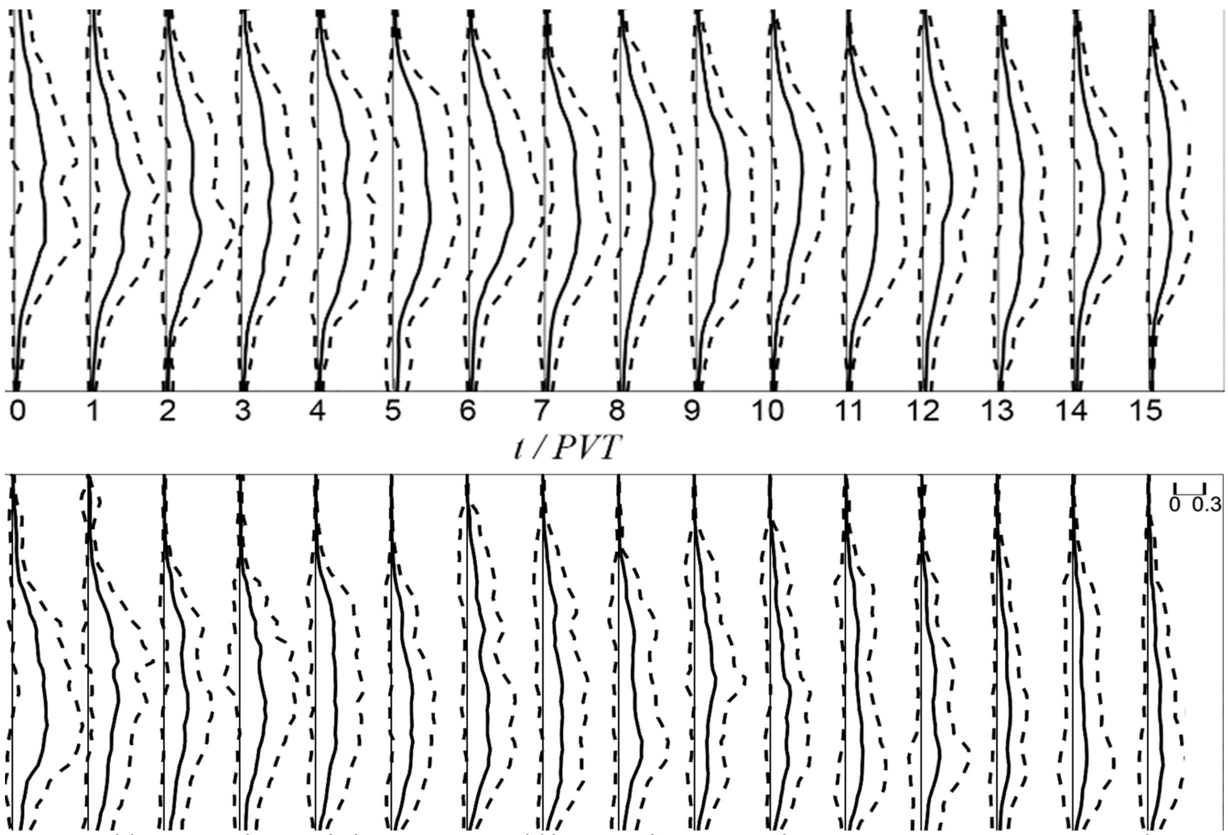
Experimental settings

Results

It became clear that the cough airflow velocity suddenly reached its peak wind velocity at the maximum acceleration and then gradually attenuated (the first figure below). This is a typical change with time of maximum velocity of cough airflow in all cases. We found that the duration of the cough was 520-560 ms and the vertical and horizontal cough diffusion angles were approximately 15° and 13° respectively. After performing the ensemble average operation and eliminating individual differences among the subjects, a general cough air velocity distribution was obtained (the second figure below). Averaged air velocities for men and women were measured at 11.8 m/s and 10.13 m/s, respectively. Maximum air velocities for men and women were measured at 15.2 m/s and 13.1 m / s, respectively.



Raw (upper) and dimensionless (lower) maximum velocity variations with time (PVT: Peak Velocity time)



Vertical(upper) and horizontal(lower) air velocity variations with time

Planned future research works

The obtained velocity distributions can provide a detailed database for further investigations into the mechanism of droplet/virus transmission through cough airflows and for validating the transmission via CFD simulations. Furthermore, the results of this study can provide the potential boundary conditions for transmission simulations (e.g., the temporal variation function, spread angles, etc.). In the future, we plan to simulate cough airflow utilizing these data obtained to confirm the experimental data's applicability as simulation boundary conditions and validation basis.

The simulation can help determine the propagation features of droplets (e.g., propagation distances, propagation routes, and concentration distributions), which is essential for the design and research of building space sensitive to social distance such as hospitals and sanatoriums.

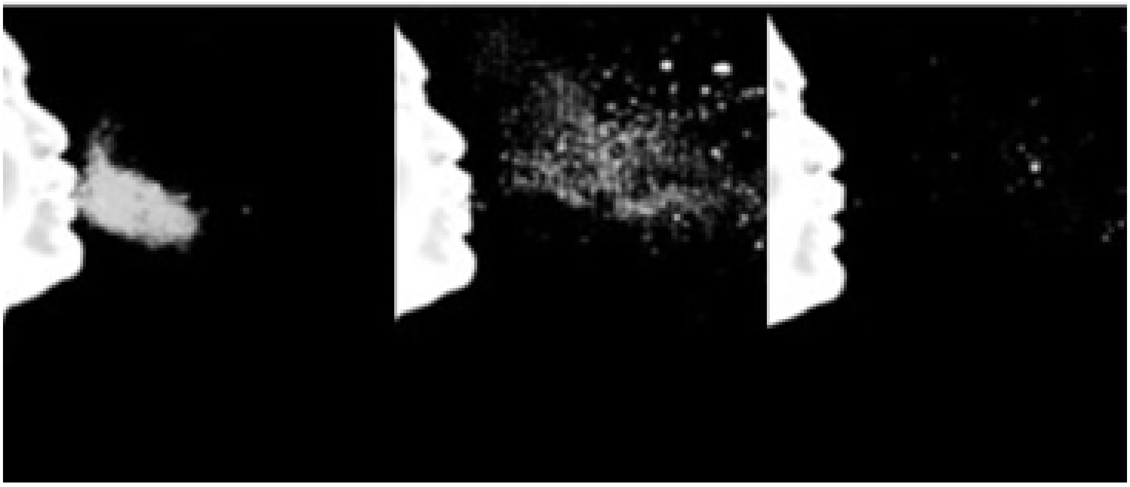


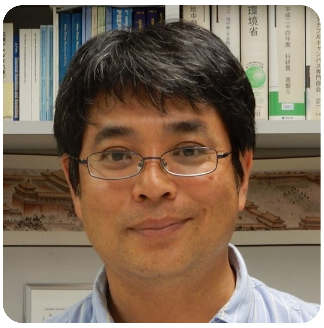
Image of droplets movement during cough period taken by PIV

More details on the experiment setup, cough airflow overall characteristics, initial velocity distributions, and open research data can be found HERE: (https://linkinghub.elsevier.com/retrieve/pii/S0360132321004236)

ABOUT THE AUTHORS

Mengtao Han

Mengtao Han, Male, Ph.D., Associate Professor of the School of Architecture and Urban Planning, Huazhong University of Science and Technology, P.R. China. He obtained his Ph.D. from the Architecture Department at the University of Tokyo in 2019 and worked as a postdoctoral researcher at the Institute of Industrial Science, University of Tokyo, Japan, from 2019 to 2020. He also worked as a young scientists research fellow of the Japan Society for the Promotion of Science (JSPS) from 2018 to 2020. He works on the development and application of airflow simulation methods in the building environment, and building energy-saving technologies. He made achievements in the application of the lattice Boltzmann method to the built environment.



Ryozo Ooka

Ryozo Ooka is a Professor in Institute of Industrial Science, The University of Tokyo, Tokyo, Japan. Prof. Ooka received his BS, MS from Kyoto University and Ph.D. from The University of Tokyo. Prof. Ooka is now President of IAQVEC association and also President of ASHRAE Japan Chapter. His research includes urban climate, CFD, indoor air quality, thermal comfort, optimization of building energy design and operation based on artificial intelligence. He has published over 300 pear reviewed journal papers, and has received several awards from Architectural Institute of Japan (AIJ) Society of Heating, Air-conditioning and Sanitary Engineers of Japan (SHASE), and Building and Environment Journal etc. Prof. Ooka serves as an associate editor of Sustainable Cities and Society Journal.

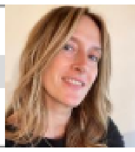
IAQVEC SEMINARS

The IAQVEC Technical Program (Chaired by Dr. Joon-Ho Choi, University of Southern California) has organized a series of online technical seminars from September 2021 to May 2022 as part of the first round of the seminar series. It will be a monthly seminar featuring a diverse range of topics and speakers. Each seminar will be held on the third Thursday of each month. IAQVEC members and anybody else who is interested will be welcome to hear 16 distinguished experts present their cutting-edge research. Two speakers will be featured at each monthly meeting. The third seminar will be held on November 11, 2 PM (Greenwich Mean Time) via ZOOM (" the link information will be sent via email to the IAQVEC members a week before the schedule). Dr. Menghao Qin (Technical University of Denmark) will give a talk about his recent work, entitled "Novel functional materials for energy-efficient indoor moisture control," and Dr. Lavinia Chiara Tagliabue (University of Turin, Italy) will share her study, entitled "BIM for sustainability and Green Digital Twin."

For questions and further information, please contact:
***Dr. Joon-Ho Choi**, Technical Program chair*

November 11th
02:00 PM (GMT)

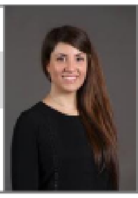
Menghao Qin
Professor, Technical University of Denmark
Novel functional materials for energy-efficient indoor moisture control



Lavinia Chiara Tagliabue
Associate Professor, University of Turin
BIM for sustainability and Green Digital Twin

January 13th
02:00 PM (GMT)

Sarah Crosby
PhD candidate and research assistant, University of British Columbia
Towards improved thermal comfort predictions: Hierarchical Bayesian modelling of indoor environmental design conditions



Gloria Pignatta
Scientia Lecturer, UNSW Sydney
Solar pre-cooling: pros, cons, and opportunities

February 17th
02:00 PM (GMT)

Masanori Shukuya
Professor Emeritus, Tokyo City University
Exergetic understanding of the built environment - the insights so far obtained

Junseok Park
Professor, Hanyang University
Occupant behaviour for natural ventilation in buildings

March 10th
01:30 PM (GMT)

Kazuhide Ito
Professor, Kyushu University
In Silico Modeling for Airborne Transmission Analysis in Indoor Environment

Parham Mirzaei
Assistant Professor, University of Nottingham
Holistic strategies for natural ventilation in response to the warming urban climate

April 14th
01:30 PM (GMT)

Ulrike Passe
Professor, Iowa State University
Holistic strategies for natural ventilation in a warming urban climate

Jeehee Lee
Assistant Professor, University of Nevada
DATA-CENTRIC BUILT ENVIRONMENT

May 12th
01:30 PM (GMT)

Christos Markides
Professor, Imperial College London
A review of hybrid solar technologies and systems

Wonseok Oh
Research Fellow, University of Tokyo
Evaluation of thermal sensation in outdoor environment under mist spraying condition

IAQVEC 2023
THE 11TH INTERNATIONAL IAQVEC CONFERENCE
MAY 2023, JAPAN

STAY TUNED FOR DETAILS!

2019 IAQVEC - BARI, ITALY

Best paper award: Lingkai Cen

Paper Title: A Personal Visual Comfort Model: Predict Individual's Visual Comfort Using Occupant Eye Pupil Size and Machine Learning

☞

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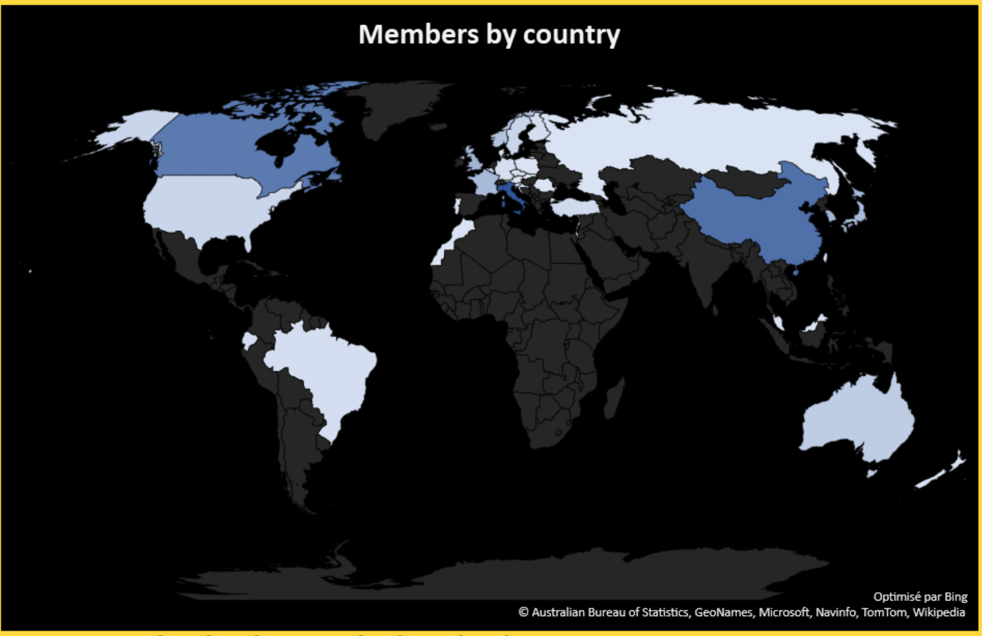
and subscription to the newsletter

CONTACT MOHAMED EL MANKIBI AT:

patrice.blondeau@univ-lr.fr

ASSOCIATION'S GOALS:

- PROMOTE SCIENTIFIC, TECHNOLOGICAL AND TECHNICAL ADVANCES RELATED TO IAQVEC FIELDS AT AN INTERNATIONAL LEVEL
- DEVELOP AND DISSEMINATE KNOWLEDGE AND SPREAD INFORMATION RELATED TO IAQVEC
- PROMOTE AND ORGANIZE IAQVEC CONFERENCES



Current membership demographic based on location

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