Deterministic Pathogen Transmission via Coupled Computational Fluid and Crowd Dynamics

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ABSTRACT

Advances in computational fluid and crowd dynamics (CFD, CCD), as well as computer hardware and software, have enabled fast and reliable simulations in both disciplines. A natural next step is the coupling of both disciplines. This would be of high importance for evacuation studies where fire, smoke, visibility and inhalation of toxic materials influence the motion of people, and where a large crowd can block or influence the flow in turn. The same capability could also be used to simulate with high fidelity the transmission of pathogens in the presence of moving pedestrians, enabling a much needed extension of current simulation technologies [1].
The present work considers a tight, bi-directional coupling, whereby the flow (and any pathogens in it) and the motion of the crowd (and any in- and exhalation) are computed concurrently and with mutual influences. Enabling technologies that made this tight coupling feasible include:

a) Development of immersed boundary methods;

b) Implementation of fast search techniques for information transfer between codes; and

c) Strong scaling to tens of thousands of cores for CFD codes.

The talk will begin with a quick overview of pathogen, and in particular virus transmission. This will define the relevant physical phenomena, which in turn define the ordinary and partial differential equations that describe the flow and the particles. Thereafter, the models used for pedestrian motion are considered. The description of the numerical methodologies conclude with the coupling methodology employed. Several examples illustrate the influence of pedestrian motion on air motion, and hence aerosol and pathogen transport, and show the potential of the proposed methodology.
We believe that this is the first time that a deterministic, high fidelity simulation capability for pathogen transmission with moving pedestrians has been developed.

REFERENCES

[1] R. Löhner and H. Antil - High Fidelity Modeling of Aerosol Pathogen Propagation in Built Environments With Moving Pedestrians; *Int. J. Num. Meth. Biomed. Engng.* (2021) **37**:3