Analytical Model to Quantify the Effect of Facial Feature and Mask's Peripheral Leakage for Large Population

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Acknowledgment: Supported by NSF Grants CBET-2034992, CBET-2034983, and CBET-2035002

Abstract:

With the outbreak of the COVID-19 pandemic, the use of face masks has been widely recommended by public health organizations. A mask with the proper fit on the wearer's face can significantly reduce airborne transmission. Mask fit, its resulting peripheral leakage, and face mask efficacy depend on the wearer's facial topology and the type of face mask. However, the effect of facial topology on mask's leakage has not been quantified to date. Here, we propose an analytical integral boundary layer solution to quantify the flow field in the interface region between face and mask. The mask deployment study is conducted for more than 1000 distinct morphable faces and different mask shapes. Face and mask are connected by a series of many linearly interconnected channels. Each channel has a porous top boundary and extends from the inner mouth/nose high-pressure region to the mask's outer edge. The compatibility condition of inlet pressure is used to determine the flow distribution in each channel. An analytical model is validated with a detailed flow simulation. The inward and outward protection levels of masks are explored for a large virtual cohort of the population. The outcomes of the simulation demonstrate a relation between breathability and filtration performance of the mask as a function of the mask's permeability coefficient and fit. Furthermore, we discuss the statistics of peripheral leakage patterns in a large cohort of faces obtained from the model.