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Evaluation of manikin simplification methods for CFD simulations in occupied indoor environments

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ABSTRACT

While simplified computational thermal manikins (CTMs) are widely employed in CFD models of occupied indoor spaces in order to save the computational cost, a criterion of simplification is still absent and the effects of CTM simplification are yet not clear. In this study, six CTMs including a 3D scanned CTM and five simplified CTMs generated from various simplification approaches were employed to analyse the impact of CTM simplification on the prediction of airflow field and contaminant transport. Comparison of the predicted airflow field against the published data in the literature demonstrated that CTM simplification has a strong effect on the thermal airflow field prediction in the vicinity of manikin surfaces. For densely occupied indoor spaces such as a train cabin, the error induced by CTM simplification could be enlarged and further cause significant global error to the prediction of contaminant transport. This is especially true when contaminants are released from the CTMs. This study demonstrated that the mesh decimating algorithm is promising to simply CTMs that is not only able to reduce considerable computational cost but capable of maintaining an acceptable predictive error.

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Brief summary

Five simplified manikin models were developed in this study for evaluating the effects of manikin simplification methods on the CFD predictions in indoor environments. The deviation between the numerical results and published data were largely affected by the simplification approaches, especially under densely occupied building environments. This study found that the mesh decimating algorithm is promising to reduce computational costs while retaining acceptable predictive error and thereby recommended for future applications. The recommended method can be further utilised to study thermal comfort or infectious disease transport in a cost-efficient way under complicated indoor environments with a large number of occupants, such as classrooms, hospitals and airliner cabins.

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1. Introduction

When designing the heating, ventilating and air conditioning (HVAC) system and assessing the indoor air quality (IAQ), the occupational comfort, health and safety are and will always be the most crucial criteria. In order to assess the thermal comfort and to estimate the health risks associated with contaminant exposures, thermal manikins (CTMs) representing the human occupants have been widely employed in the Computational Fluid Dynamics (CFD) investigations of various indoor and built environments

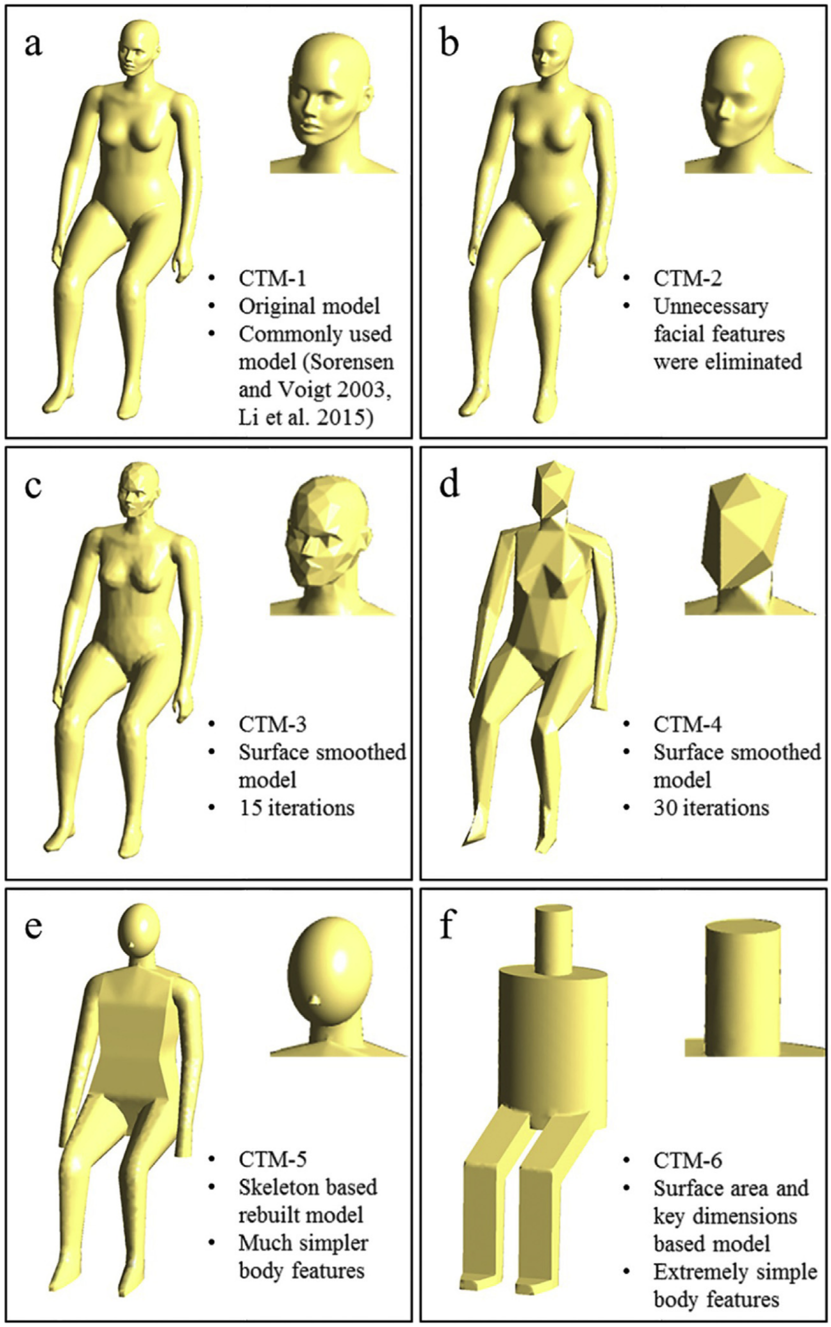

Fig. 1. Geometric information of CTMs.

Table 1
Body surface areas and segment weighting factors of CTM models.

	CTM-1		CTM-2		CTM-3		CTM-4		CTM-5		CTM-6	
	Area (m^2)	Weighting factor (%)	Area (m^2)	Weighting factor (%)	Area (m^2)	Weighting factor (%)	Area (m^2)	Weighting factor (%)	Area (m^2)	Weighting factor (%)	Area (m^2)	Weighting factor (%)
HEAD	0.101	6.3	0.097	6.2	0.100	6.3	0.097	6.3	0.096	6.1	0.122	7.4
NECK	0.022	1.4	0.022	1.4	0.021	1.4	0.021	1.4	0.022	1.4		
UPPER BODY	0.450	28.2	0.448	28.6	0.445	28.2	0.432	28.2	0.482	30.5	0.798	48.7
Arm L	0.159	10.0	0.151	9.7	0.157	10.0	0.152	10.0	0.157	9.9		
Arm R	0.160	10.0	0.151	9.7	0.158	10.0	0.153	10.0	0.158	10.0		
Leg L	0.352	22.1	0.349	22.3	0.348	22.1	0.337	22.1	0.333	21.1	0.359	21.9
Leg R	0.351	22.0	0.348	22.2	0.347	22.0	0.337	22.0	0.333	21.1	0.359	21.9
Total area	1.596		1.566		1.577		1.530		1.580		1.638	