INPLASY PROTOCOL

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Support: None.

Review Stage at time of this submission: Completed but not published.

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Digital human modeling in automotive engineering applications: a systematic review and bibliometric mapping

Li, J[1]; Li, PJ[2]; Hu, JW[3].

Review question / Objective: The aim of this systematic review is to investigate the state of the art of digital human models (DHMs) applied in the field of transportation and automotive engineering, to better inform the development of new models for such use cases. To this end, the proposed systematic review will address the following questions: What is the general trend of research in this field? Which specific use cases, methodologies, and human models are being more widely studied or utilized than others? How can we describe such study characteristics in a structured and quantitative manner?

Eligibility criteria: Eligible publications included in the review are screened according to the following criteria: (a) The publication must be a full-text article published in an academic journal or in the proceedings of an academic conference, (b) The publication must be final and the article must be in press, (c) The language of the publication must be English, (d) The publication must apply digital human models in a transportation or automotive engineering context, (e) No particular restrictions are placed on the country and/or region of origin of the publication.

INPLASY registration number: This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 24 October 2022 and was last updated on 24 October 2022 (registration number INPLASY2022100094).

INTRODUCTION

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studied or utilized than others? How can we describe such study characteristics in a structured and quantitative manner?

Rationale: The field of design, development, and application of Digital Human Modeling (DHM) in the context of transportation and automotive engineering has advanced rapidly over recent years. However, a systematic bibliometric analysis of this ever-expanding field of DHMs is still lacking. Even though several narrative reviews of this field have been published, these reviews are often criticized for lack of reproducible article search and acquisition procedures, comprehensive criteria for study inclusion, and quantitative metrics of study bias. As such, there is an urgent need for a systematic synthesis of studies in this field as well as the evidence they present. Such synthesis would ideally utilize the latest iterations of protocols for systematic review and meta-analysis, and should also describe the developments, focuses, and trends in the field from a bibliometric and descriptive statistics point of view.

Condition being studied: None.

METHODS

Search strategy: We are to perform a systematic literature search on eight major databases (i.e., ScienceDirect, PubMed, SpringerLink, Google Scholar, Scopus, and Web of Science) over 20 years between January 1, 2000, and August 31, 2022. The search terms are as follows: `(Digital human model OR DHM*) AND (vehicle OR automatic* OR virtual ergonomics OR automotive OR car*)`. The reference lists of selected studies are also to be indexed, and expert opinion is to be sought to identify further eligible publications.

Participant or population: This review places no limit on the human participants involved in each of the individual publications included. However, typical participants in research studies of digital human modeling (DHM) applications in transportation and automotive engineering would be either of the three following

types: (a) Vehicle operators or passengers; (b) Pedestrians or cyclists involved in physical contact and/or impacts with automobiles; (c) Mechanics actively involved in the manufacture and/or servicing of automobiles.

Intervention: The primary interventions considered in this systematic review involves the digital human models that are utilized in individual studies. Only studies that provide nontrivial details on the construction, mechanisms, and use cases of DHMs that directly emulate and provide substantial insight on human interactions with automobiles are to be included.

Comparator: None.

Study designs to be included: No inherent restriction on the study design of individual publications is in place, as long as the publication fits the eligibility criteria described in Item 16 of this form and the quality assessment described in Item 21.

Eligibility criteria: Eligible publications included in the review are screened according to the following criteria: (a) The publication must be a full-text article published in an academic journal or in the proceedings of an academic conference, (b) The publication must be final and the article must be in press, (c) The language of the publication must be English, (d) The publication must apply digital human models in a transportation or automotive engineering context, (e) No particular restrictions are placed on the country and/or region of origin of the publication.

Information sources: ScienceDirect, PubMed, SpringerLink, Google Scholar, Scopus, and Web of Science.

Main outcome(s): The following data fields were extracted from eligible publications:
1. The title of the publication
2. The journal of the publication
3. The last name of the first author of the publication
4. The year of the publication
5. The country of the first author's institution. The first institution was

selected for analysis if a first author is affiliated with more than one institution.

6. The area of research of the publication, e.g., proposition and/or validation of new model, reconstruction of existing accident, ergonomics assessment

7. The objective and/or stated implications of the research

8. The name of the digital human model (DHM) involved in the research, if provided

9. The digital construction method involved in the DHM, e.g., finite element analysis or multi-body system

10. The subject population that the DHM models

11. The body part(s) modeled by the DHM

12. The posture(s) modeled by the DHM

13. The validation methods of the DHM, if provided

14. The characteristics of the DHM, in terms of the human body properties or functions being modeled, e.g., anthropometric, biomechanical, and physiological/clinical

Additional outcome(s): None.

Data management: Datasets were analyzed using Microsoft Excel 2019 (Microsoft Corp, USA) and visualized using GraphPad Prism 9 (GraphPad Software Inc., San Diego, California, USA). The R-bibliometrix (https://www.bibliometrix.org/home/) was also used to analyze and visualize the data as a supplemental method. CiteSpace (version 6.1R3) was used for the bibliometric visualization and analysis of the reported studies.

Quality assessment / Risk of bias analysis: We included five criteria of a study's qualities in our assessment:

1. The objective(s) of the study should be clearly and concisely described and should be relevant to the experimental application of DHMs in automotive engineering and/or research.

2. The area of research and methodology of the study should be logically and clearly summarized.

3. The origins, constructions, type, characteristics, and use cases of the DHMs involved in the study should be provided.

4. The DHMs involved in the study should be verified, either independently by the investigator or by appropriately citing peer sources.

5. The results of any DHM simulation(s) in the study should be reported in detail, should be relevant to any research objective(s), and should justify any further conclusions drawn.

For each criterion listed above, a study would receive one (1) point if the criterion is fully met, half (0.5) of a point if the criterion is partially met while certain details and/or justifications are absent, and zero (0) points if the study shows a minimal attempt to meet the criterion. The final quality index (out of five(5) possible points) was calculated by summing the scores of questions, and the following qualitative assessments are provided for different score ranges: 0-1.0 (very bad), 1.5-2.0 (bad), 2.5-3.0 (good), 3.5-4.0 (very good) and 4.5-5.0 (excellent).

Strategy of data synthesis: The literature metrology characteristics were analyzed using Microsoft Excel 2019, GraphPad Prism 9, and R-bibliometrix. Aggregate counts and percentages for all publications for different values in each of the data fields described in Item 18 are produced, described, and visualized. Meanwhile, relevant keywords, stratified by the frequency of occurrence across all included publications, are counted and visualized as a word cloud distribution and a bibliographic data map.

Subgroup analysis: None.

Sensitivity analysis: None.

Language restriction: English.

Country(ies) involved: United States, China.

Other relevant information: For the three authors listed in item 30 of this form, the first author, Jian Li, is affiliated with the College of Fashion and Design of Donghua University in Shanghai, China (Address: 1882 Yan'an Road, Shanghai 200051, China); the second and corresponding author, Peijing Li, is affiliated with the

Electrical and Computer Engineering Department at the University of Michigan in Ann Arbor, Michigan (Address: Bob and Betty Beyster Building, 2260 Hayward Street, Ann Arbor, MI 48109-2121, United States); the third author, Jingwen Hu, is affiliated with the University of Michigan Transportation Research Institute in Ann Arbor, Michigan (Address: 2901 Baxter Road, Ann Arbor, MI 48109-2150, United States).

Dissemination plans: We intend to draft and publish a paper detailing our results in a peer-reviewed journal.

Contributions of each author:
Author 1 - Jian Li - This author is involved in the following research activities: determining protocol for systematic review, searching for publications, acquisition of documents, initial screening of documents, identification and aggregation of study characteristics, quantification of bias and further screening, bibliometric and statistical analysis, and drafting of paper manuscript.
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Author 2 - Peijing Li - This author is involved in the following research activities: searching for publications, acquisition of documents, initial screening of documents, identification and aggregation of study characteristics, quantification of bias and further screening, drafting and proofreading of paper manuscript, correspondence during registration of review protocol and further dissemination of research results.
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Author 3 - Jingwen Hu - This author contributed to the validation of document screening, evaluation, and analysis results, and the drafting and proofreading of the paper manuscript.
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