NOUVELLE GAGNANTE

CATÉGORIE : SCIENCES NATURELLES ET GÉNIE

Who wouldn't want to have a digital twin?

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Have you ever dreamed of having a digital twin that could replace you whenever you encounter undesired issues? Wouldn't it be beneficial if someone got an illness on your behalf and found the most effective treatment for you? Is it even possible? No, not that much anymore... However, at least I am aware of a validated human thorax digital twin who can be adept at exploring frequency ranges in acoustic pulmonary therapy to ascertain the most optimal one for you, stemming from the collaborative efforts between the Acoustic-Signal-Human Research Center of Université de Sherbrooke (CRASH-UdeS) and École Polytechnique de Montréal (PolyMtl).

Representing multiple internal organs

The proliferation of the digital twin concept is gaining traction, standing out as one of the most prominent technological trends. In this landscape, computational biomechanics, an enthralling domain, plays a vital role by aiding digital twins through mathematical modeling, computer simulations, and sophisticated imaging techniques. The utilization of the Computed Tomography-based Finite Element Model (CT-FEM) further enhances precision in analyzing the mechanical attributes of living organisms.

Muco-obstructive lung diseases pose a significant worldwide public health issue and are associated with high rates of mortality. Respiratory therapy with vibro-acoustic devices helps patients who are having trouble breathing, however, there is inconsistency in the operating conditions.

The aforementioned study emphasized the imperative of accurately simulating the vibro-acoustic effect on the human thorax for respiratory therapy to roll out this inconsistency and optimize the operating conditions of acoustic devices. The highlighted work in the study advocates the most developed and validated CT-FEM multiple internal organs inclusive methodology and it contributes to the development and the accuracy of target-based multiple organ inclusive studies.

Proposed methodology

The developed methodology comprises four different main steps: segmentation, reducing surface, generating surface meshes and finite element analysis. Further, these steps were enriched with the decision-making strategies for multiple internal organs.

To facilitate respiratory therapy, a human thorax consisting of soft tissues, rib cage, lungs, trachea, and bronchioles were segmented to represent each internal organ (Figure 1). Then, the surface number was diminished to create smooth surface meshes and obtain a realistic geometry from the CT-based image. These surface meshes were then utilized to generate high-quality meshes for the engineering analysis.

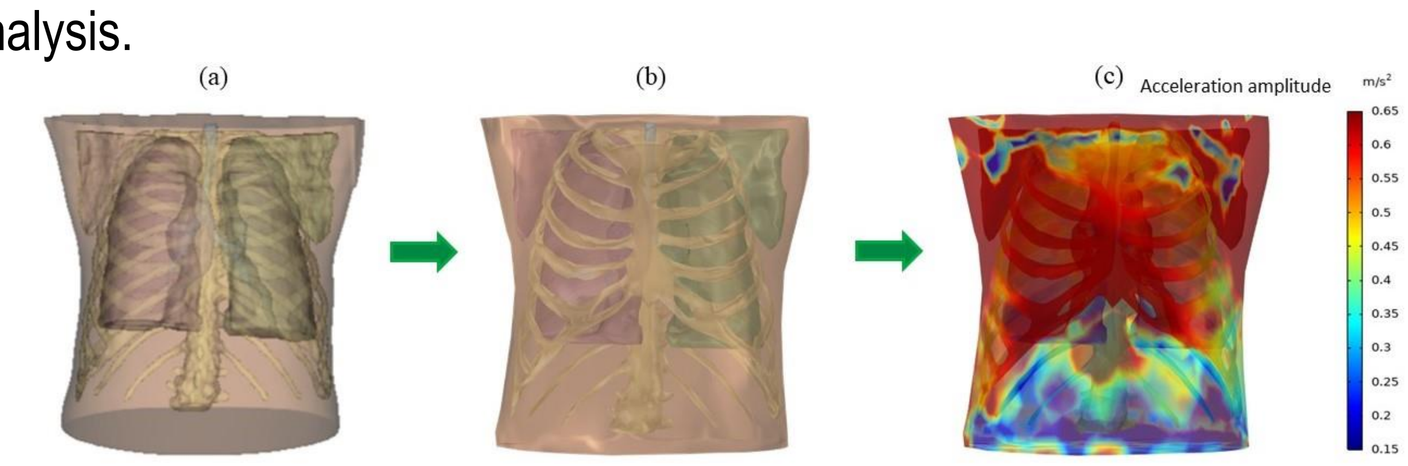

Figure 1. Representation of the human thorax twin after (a) the segmentation process, (b) the CT-FEM generation, and (c) the analysis results of the therapy (Adapted from the aforementioned article)

Challenges and validation of the human thorax model

Representing the physical properties of biological tissues poses substantial challenges, considering diverse patient conditions and integrating scales from the cellular level to macro organ geometries.

Consequently, they made it necessary for the modelling to be validated before using it as an instrumental tool for medicine. CT-FEM of the human thorax was validated by two independent experimental studies for resonance frequency in both male and female subjects by considering the following factors:

- The nature of the physics of the applied therapy
- The diversity in the biological and physical properties of each organ
- The interactions between internal organs

Future of the study

Generating a realistic CT-FEM appears ground-breaking in crafting a digital twin, yet limitations persist in adding more internal organs to the thorax twin for respiratory therapy. Hence, forthcoming studies aim to identify and include additional internal organs to augment biomechanical investigations across diverse fields such as medicine, engineering, sports, and beyond.

Consequently, thanks to groundbreaking collaborative research from CRASH-UdeS and PolyMtl, digital twins are emerging not just as a buzzword but as a tangible paradigm shift, poised to become a technological reality in the near future.

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