Contribution ID: **38** Type: **Talk**

Numerical Models of Human Brain and the Development of Machine Learning Algorithms to Analyse Weather Conditions for the Prediction of Cerebrovascular Accidents

Understanding the pathomechanism behind brain structure destruction is crucial for effective prevention and treatment strategies. The aHEAD project addresses this by continually enhancing diagnostic techniques and simulating the impact on brain structures resulting from road accidents, sports injuries, and head protection device efficacy, such as ski, bicycle, and motorcycle helmets. Through collaboration with neurosurgeons and neurobiologists, the project synthesizes extensive knowledge of brain structure properties and utilizes experimental studies to obtain precise input data for numerical head models. This interdisciplinary endeavor integrates medical imaging processing, advanced material processing, biomechanics, computer science, and neurosurgery to develop state-of-the-art models representing different age groups. Following rigorous validation, numerical brain tissue structural destruction simulations under mechanical loading are achieved using LS-DYNA and Abaqus codes. These simulations enable a deeper understanding of injury mechanisms and facilitate the refinement of protective measures.

In parallel, a study investigates the influence of environmental conditions on vascular incidents, aiming to develop a predictive model. Interestingly, the aHEAD models feature advanced cerebrovascular systems (such as pressured bridging veins), which enabled the authors to verify some research hypotheses connected with weather conditions. Leveraging machine learning algorithms and medical data, a recursive neural network architecture is tailored to analyze weather-related risk factors for vascular events across different diagnostic groups. Results suggest a significant association between environmental conditions and vascular incidents, particularly for spontaneous hemorrhages. Despite challenges such as incomplete medical data, the developed model demonstrates promising predictive capabilities, offering insights for enhanced patient care and hospital preparedness. Future efforts will focus on obtaining more comprehensive data and refining anomaly detection methods to improve model accuracy and applicability. These initiatives underline the importance of interdisciplinary collaboration and advanced technological solutions in advancing medical research, diagnosis, and patient care.

References

DOI: 10.1007/978-3-031-34884-6_16; DOI: 10.1007/s43452-023-00758-9

Acknowledgement of financial support

I extend my gratitude to the dedicated members of the aHEAD project team whose expertise and collaborative efforts have been instrumental in the success of this research endeavor.

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Session Classification: AI & Simulation, Big Data & Analytics