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Machine Learning Enhanced Scalable Finite Element Simulation of Head Injury

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Traumatic brain injury (TBI) is considered a leading cause of death under 40 [1]. In the EU, it is estimated that 2.5 million people suffer annually from TBI [2]. Finite element simulations of head impact are often used to evaluate the degree of tissue damage associated with an injuring mechanical load. Such approach often requires complex constitutive models and large meshes, in turn leading to computationally intensive simulations. To this end, this work aims at modelling a brain injury in silico by leveraging machine learning techniques to scale finite element simulations to the level of complexity required for TBI modelling. Abaqus was used to simulate multiple head injuries using a detailed finite element head model built from patient medical images including both structural and axonal information. The position, velocity and angle of impact as well as different impactor geometry and mechanical properties were varied to create a library of precalculated accidents. Tissue damage following different criteria and thresholds were evaluated for each simulation. Model reduction was then implemented via a machine learning layer, significantly reducing the time required to produce an estimation of damage. Given that the model focuses on continuous data, supervised learning techniques such as artificial neural networks, support vector regressors, statistical models, instance-based methods and decision tree variants were considered. The resulting software will allow for quasi-immediate prediction of tissue injury for any new set of impact parameters. The final aim of this work is to provide on-the-fly, time efficient, pre-admission assessments of patient condition informed by paramedical information. The model presents the advantage of improving over time as more simulations are inputted, providing more training information to the system.

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