Numerical simulation of non-lethal projectiles on human thorax

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These last decades have seen the development of a new type of weapons, the non-lethal weapons. Unlike the conventional weapons which may cause severe or fatal injuries and whose injury mechanisms are well documented, the non-lethal weapons are designed for temporary incapacitation with reversible consequences or minor damage to the human body. They try therefore to fill the gap wherever the use of excessive force is not necessary and the use of verbal commands not effective. There are various non-lethal technologies but here we will focus on kinetic energy non-lethal weapons (KENLW), as they’re commonly used nowadays.

The non-penetrating characteristics of non-lethal projectiles lead to different injury mechanisms than those related to conventional lethal projectiles. In order to better understand these effects and assess the injury severity, experiments are carried out on Post Mortem Human Surrogates (PMHS), animals and mechanical anthropomorphic systems. Nevertheless, with the development of high performance computing systems, numerical simulations based on finite element method are increasingly used because of their cost-effectiveness, their predictive capabilities and their adaptability.

Physical injury is a consequence of the interaction between the projectile and the human body. To assess the severity of injury, criteria are defined, such as the viscous criterion for the thorax. Practically, these criteria are difficult to measure experimentally, making the numerical simulation an efficient alternative solution.

To investigate and predict the human thorax response to the impact of the usual KENLW, a finite element thorax model has been developed from thorax CT-scan images. In this paper, we focus on the model validation using open literature results (force-time and deflection-time characteristics of the thorax) from experiments on PHMS.

Keywords: non-lethal, injury mechanism, projectile, thorax, CT-scan, viscous criterion