Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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PhD information	
Title	Development of a biomechanical finite element model to simulate the dynamic fracture of bone organs

Main topics regards to CSC list (3 topics at maximum)	Life sciences and public health: Biomechanical Engineering
Required skills in science and engineering	Solid Mechanics, Finite element, Material science

Subject description (two pages maximum)

Human bone organs may be subjected to dynamics impacts under different conditions. For example, rib fractures are frequent thoracic injuries, which are the principal causative factors in 30% of road traffic accidents. Also, femur and vertebral fractures are the greatest risks facing patients with osteoporosis when they fall, reducing their physical mobility, quality of life, and life expectancy.

Today, advanced modeling and simulation technologies are allowing biomechanical researchers to create computer models of complex human organs.

Despite a large number of previously developed finite element models in published literature dealing with the bone fracture, there is still a lack of relevant biomechanical dynamic modeling approaches to predict the fracture conditions (force at fracture and fracture profile) of bones.

The previously developed numerical models to simulate the bone organs fracture were developed and validated under quasi-static conditions based on linear and non-linear approaches. Different fracture criteria were applied in the previous studies in order to predict the onset of the bone fracture under excessive load without coupling the effect of the progressive damage during fracturing process and the mechanical behaviour of bone. Such criteria are (i) suitable in general for ductile material and (ii) allow the simulation bone fracture from initial loading, to the start of local bone failure without considering the loss of bone material stiffness generated by the progressive damage accumulation prior fracture.

Several experiments showed that bone exhibits a quasi-brittle stress-strain relation with visco-plastic effects and rate-dependent fracture strain. However, a shortcoming of these models is that the damage growth and cracks propagation within bone leading to complete fracture are not simulated.

Novel generations of non-linear finite element models suitable to simulate the dynamic loading coupled to damage and fracture criteria are still needed to allow a better comprehension of the mechanical behaviour of bone such as the force provoking the fracture and the fracture profile under dynamic impact environments (falls, impacts, accidents, …).

The PhD work aims to develop a biomechanical finite element model describing the dynamic behavior of bone considering its complete fracture under the impacts of dynamic loads. An elasto-visco-plastic behavior law coupled to damage and fracture will be developed and implemented into the finite element code Abaqus/Explicit.

The validation of the model will be performed by comparing predicted and existing experimental results (developed previously in our Lab) performed on more than 30 femurs and ribs tested under dynamic impacts.