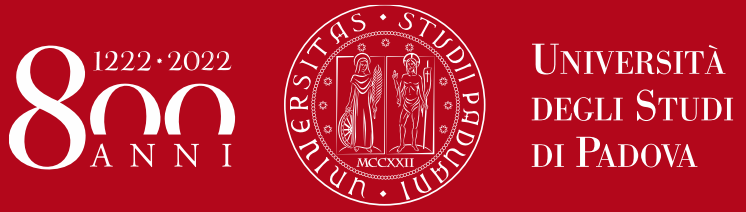


New approaches to protect the human body from impacts

Karan Gupta - 37th Cycle

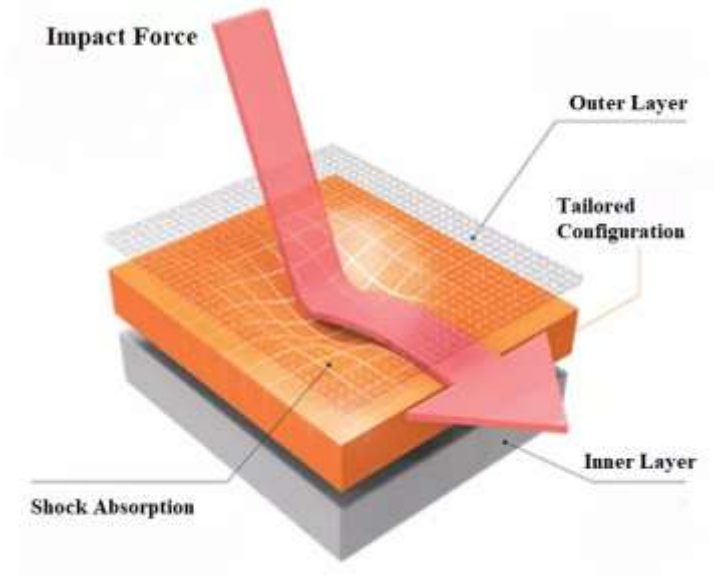
Supervisor: Prof./Dr. Ugo Galvanetto

Admission to the first year - 15/12/2021

Research Motivation

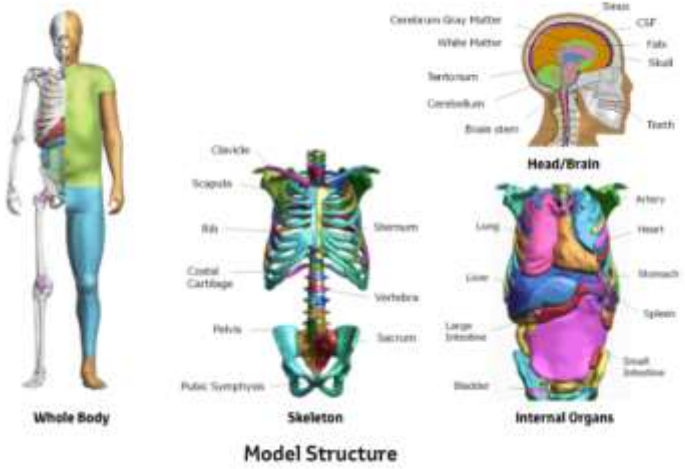
- Energy absorbing material
- Human body response during impact forces
- Advanced protective system to prevent injuries during:

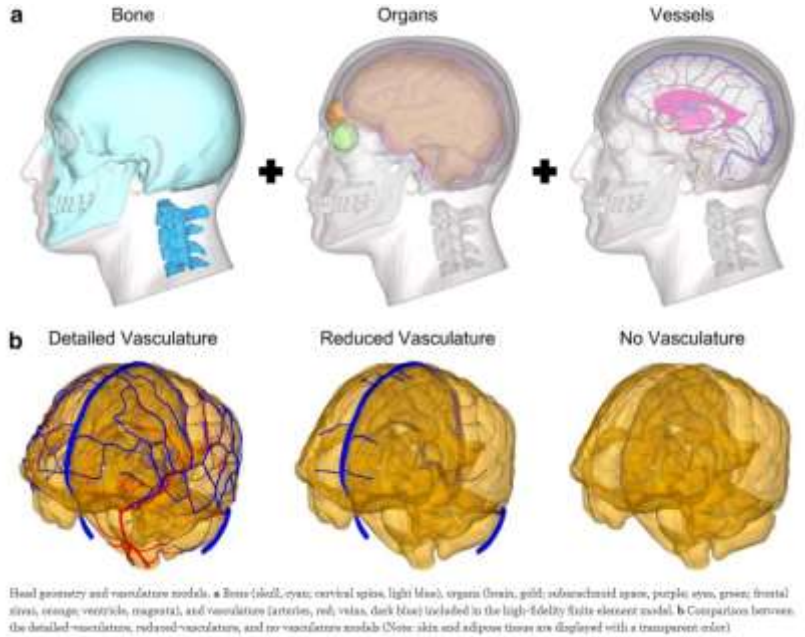
  - Air crashes
  - High impact forces
  - Interplanetary space vehicles
  - Supersonic transport
  - Military operation
  - Crash Impact



Research Motivation

- This research will be focused on the safety of human body parts, particularly the most crucial component, the head.





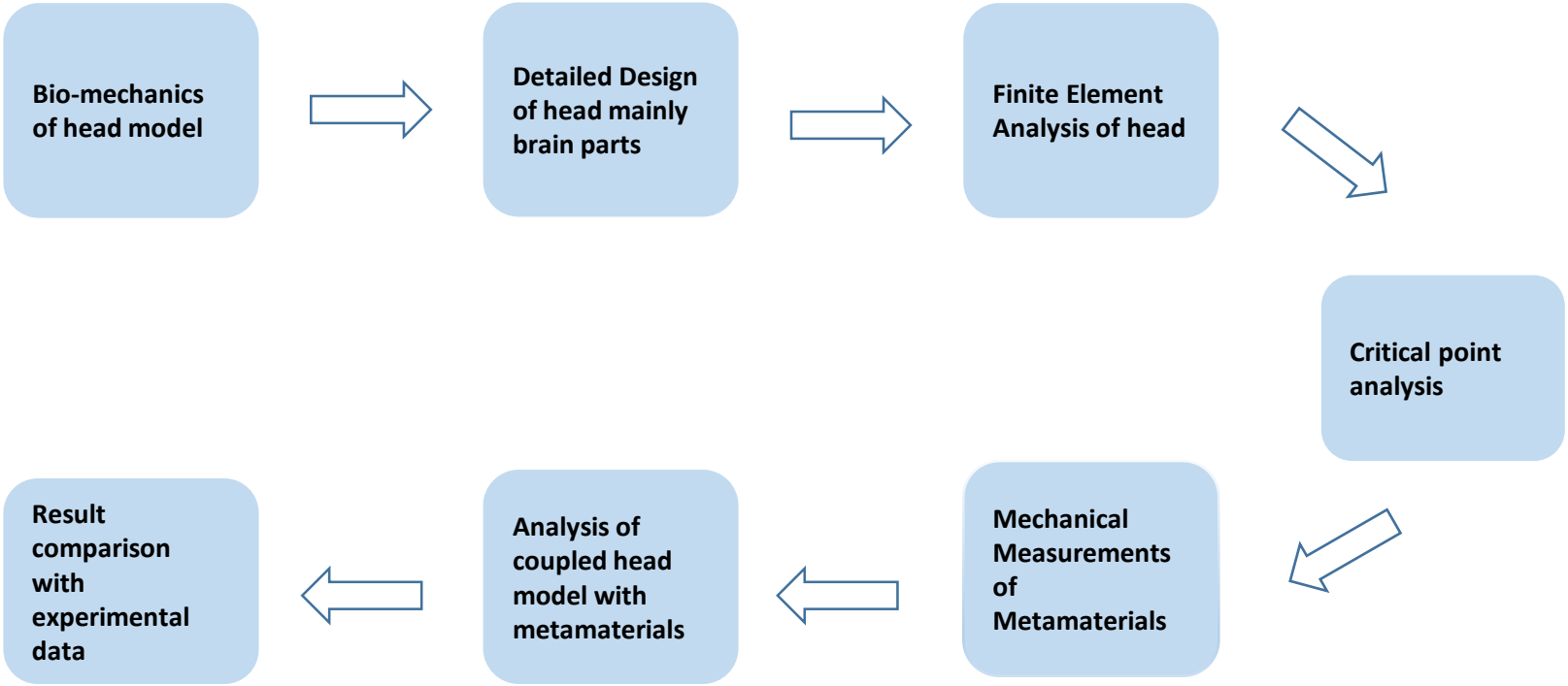
Head geometry and vasculature models. **a** Bone (skull, cyan; cervical spine, light blue), organs (brain, gold; subarachnoid space, purple; eyes, green; frontal sinus, orange; ventricle, magenta), and vasculature (arteries, red; veins, dark blue) included in the high-fidelity finite element model. **b** Comparison between the detailed-vasculature, reduced-vasculature, and no-vasculature models (Note: skin and adipose tissue are displayed with a transparent color)

Problem Statement

- Tissue level biomechanical responses of human brain during impact with the detailed FE model.

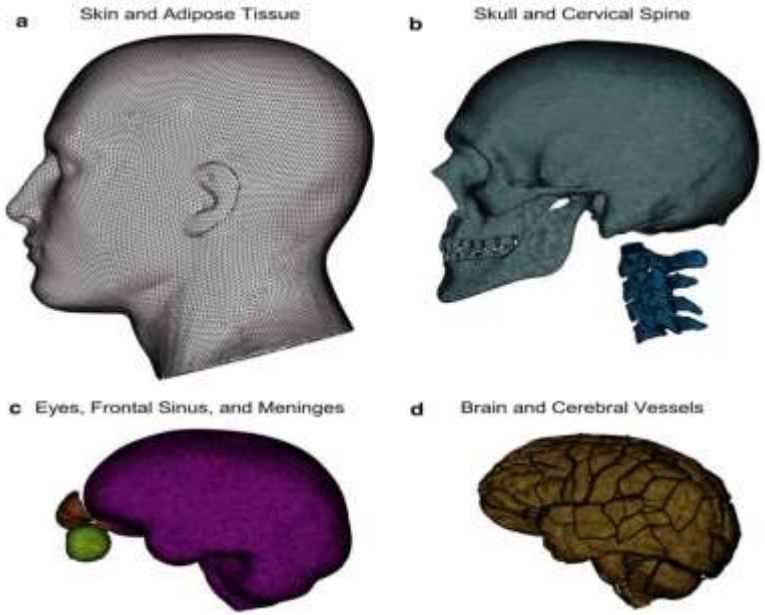
- To investigate unique tailored-made materials for human protection under diverse loading and off-nominal condition.

Research Workflow



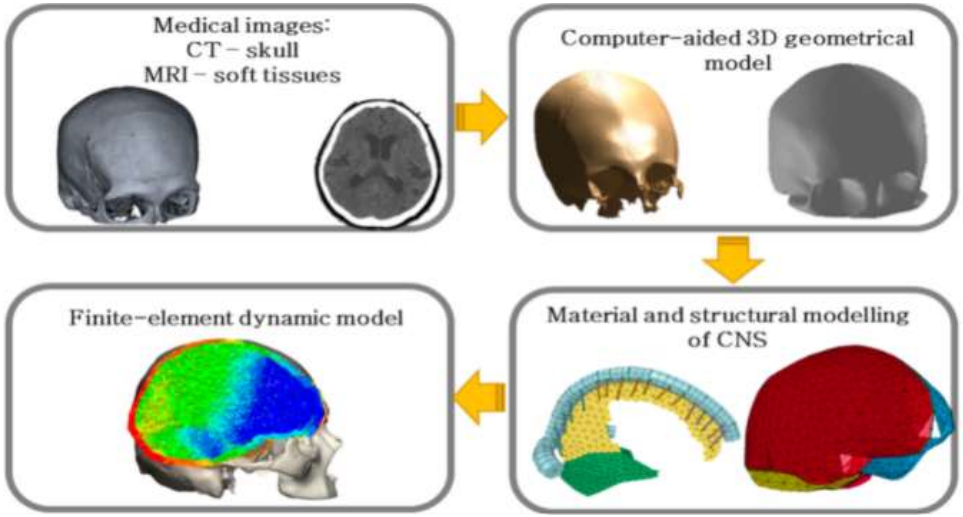
Study of human head model:

- Detailed network of cerebral vasculature, including the major veins and arteries as well as their branch vessels.



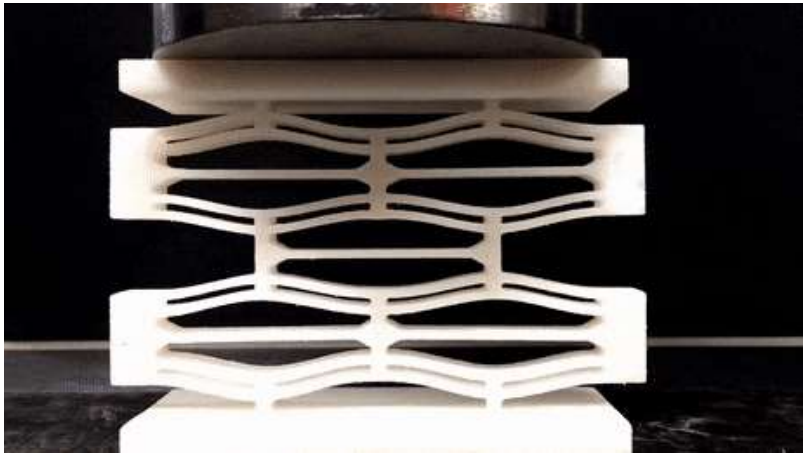
Head Design and Simulation:

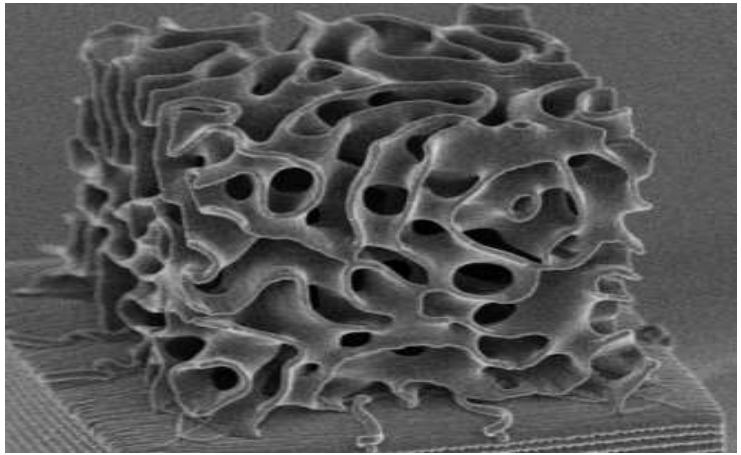
- To develop high-fidelity detailed design network of cerebral vasculature, including the major veins and arteries as well as their branch vessels.
- To conduct trauma simulations at different attacking angle to determine the intracranial pressure (ICP), the relative displacement (RD), the von Mises stress, and the maximum principal strain and its validation with experimental data.



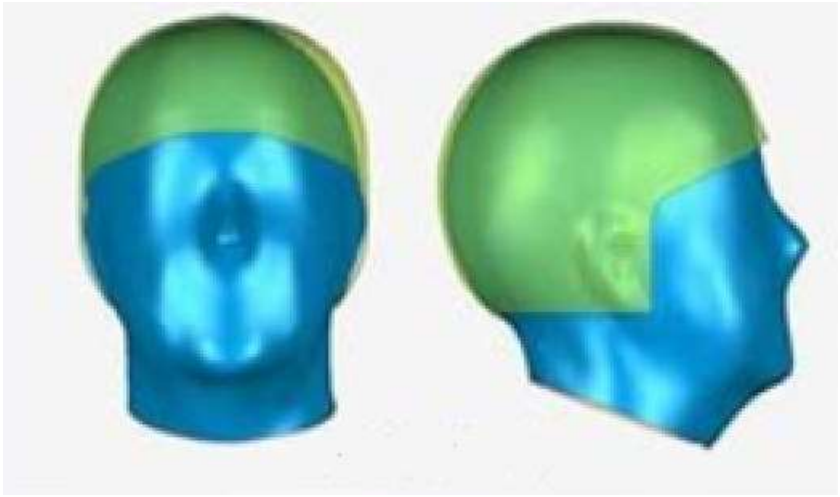
Energy Absorbing Material (Metamaterials):

- Negative stiffness-based cellular materials.
- Carbon nanolattices with spinodal topologies.





Simulation of coupled system and its comparison with experimental data



Outcomes

- ✓ FE modeling of brain tissue that influence the assessment of the actual biomechanical response of the brain during dynamic analysis.
- ✓ Novel energy absorbing material for the sole purpose to minimize TBI during off-nominal conditions and protection of human from micro-meteroids.
- ✓ Further implementation of state of the art to other vital parts of body for protection either on space, land and water.

Applications: Military Equipment's

Aerospace Structure's

Sports Equipment's

Gantt Chart

WBS NUMBER	TASK TITLE	% OF TASK COMPLETE
1	Study of the State of the art	
1.1	Impact corelation with human	0%
1.2	Bio-mechanical responses of head anatomy	0%
1.3	Head injuries and its evaluation	0%
1.4	Human head FE model	0%
1.5	Energy absorobing material	0%
2	Head Design and Simulation	
2.1	3-D Design of head	0%
2.2	Impact Simulation	0%
2.3	Post-Processing of results	0%
2.4	Critical point detection	0%
3	New Material Inclusion	
3.1	New state of art concept & its comparison	0%
3.2	Design of material	0%
3.3	Coupled head model with material	
3.4	Post-Processing of results	0%
3.5	Result comparison with experimental data	0%
4	Thesis and Reports	
4.1	Reports	0%
4.2	Thesis writing	0%
4.3	Confrences participation	0%
5	Educational Activities	
5.1	Courses	0%

Thanks for the attention