**Research Topic for the ParisTech/CSC PhD Program**

***Subfield***: Mechanical Engineering, Materials Science and Thermodynamics.

***ParisTech School***: ENSTA ParisTech

***Title***: **Development of fatigue-resistant shape memory alloys by microstructure optimization**

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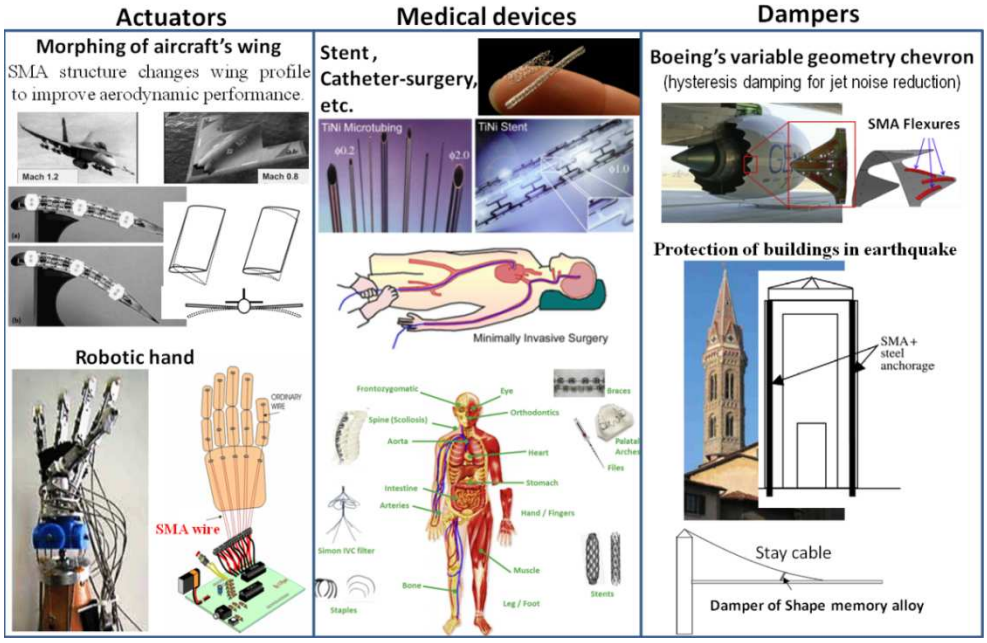
***Short description of possible research topics for a PhD***:

Shape memory alloy (SMA) is a multi-functional material which can "remember" its original shape even after complicated thermo-mechanical loadings. Its properties—shape memory and superelasticity enable many applications in automotive, aerospace, robotic and biomedical devices (see figure). The superior properties are due to a solid-solid phase transition (Martensitic phase transformation) which triggers large recoverable deformation and leads to various microstructures—distributions of different phases and orientations, their compatibility and the associated dissipative evolution. The variety of the microstructures makes possible a wide range of applications, for example, SMA earthquake dampers of a large hysteresis (large energy absorption/dissipation) and robotic SMA actuators of a small hysteresis (small dissipation). Recent researches show that the fatigue life of the material under cyclic thermo-mechanical loadings can't meet the requirements (e.g., a medical "stent" requires at least $10^7$ cycles). To improve the resistance to fatigue, this research is to modify the material microstructure by theoretical optimization methods (with micromechanics, homogenization methods, phase-field model, etc.) and/or experimental tests/fabrication (with modification of chemical compositions, thermo-mechanical treatments, composite structures, etc.).




***A list of 5 (max.) representative publications of the group:*** (Related to the research topic)

[1] **Y.J. He**, Q.P. Sun. "On non-monotonic rate dependence of stress hysteresis of superelastic shape memory alloy bars". *International Journal of Solids and Structures* 48, 1688-1695 (2011).

[2] H. Yin, **Y.J. He**, Q.P. Sun, "Effect of deformation frequency on temperature and stress oscillations in cyclic phase transition of NiTi shape memory alloy", *Journal of the Mechanics and Physics of Solids* 67, 100–128(2014).

[3] L. Zheng, **Y.J. He**, Z. Moumni "Lüders-like band front motion and fatigue life of pseudoelastic polycrystalline NiTi shape memory alloy" *Scripta Materialia* 123, 46–50 (2016).

[4] H. Yin, **Y.J. He**, Z. Moumni, Q.P. Sun "Effects of grain size on tensile fatigue life of nanostructured NiTi shape memory alloy" *International Journal of Fatigue* 88, 166–177 (2016).

[5] S. Zhang and **Y.J. He** "Fatigue resistance of branching phase-transformation fronts in pseudoelastic NiTi polycrystalline strips" *International Journal of Solids and Structures* 135, 233–244 (2018).