Design and evaluation of SMA-activated structural smart fabrics

Smart fabrics are textile-like structures capable of responding to environmental stimuli. An emerging and innovative class of these fabrics are the so called Structural Smart Fabrics (SSFs), that are smart fabrics with tunable mechanical properties [1]. SSFs can be geometrically and functionally optimised thanks to the advent of 3D additive manufacturing which enables to produce chainmail-like fabrics. One of the main potentials of these structures is the possibility to adopt interlocked discrete cells (see Figure 1.a), opening new possibilities in creating stiffness-tailored fabrics. To enhance these properties, functional materials such as Shape Memory Alloys (SMAs) can be used thanks to their capability to mechanically react under external stimuli. The SMARTEX project (Structural sMARt fabric with TunablE properties), recently started at Politecnico di Milano, aims to advance the current state of the art on smart fabrics by designing, manufacturing and testing an SSF actuated by SMAs (see Figure 1.b). The result would be chainmail like structures that can tune their stiffness based on environmental stimuli (temperature) or external signals (electric current).

The objective of this thesis is to develop, design and prototype a new concept of SSFs activated by devices extracted by 2D SMA sheets. Several preliminary solutions will be developed and assessed via numerical analyses. These will include the SMA material behaviour studied earlier by the SMARTEX research group. Once one or two potential solutions are identified, these will be 3D printed with polymeric cells. The student will then assembly the SSF, implementing the SMA device in the polymeric fabric, and testing at both low and high temperature.

The following tasks are expected to be performed:

- Develop several potential concepts of both the activation devices and the relative fabric cells to integrate them, and assess their performance via FE analyses.
- Assemble and test the SSF at low temperature (soft configuration) and high temperature (stiff configuration);
- Analyse the obtained experimental and numerical results to suggest potential improvement in the SSF design.

Expected duration: 6 months
Type: full thesis, with examiner (controrelatore)
Experimental activity: yes

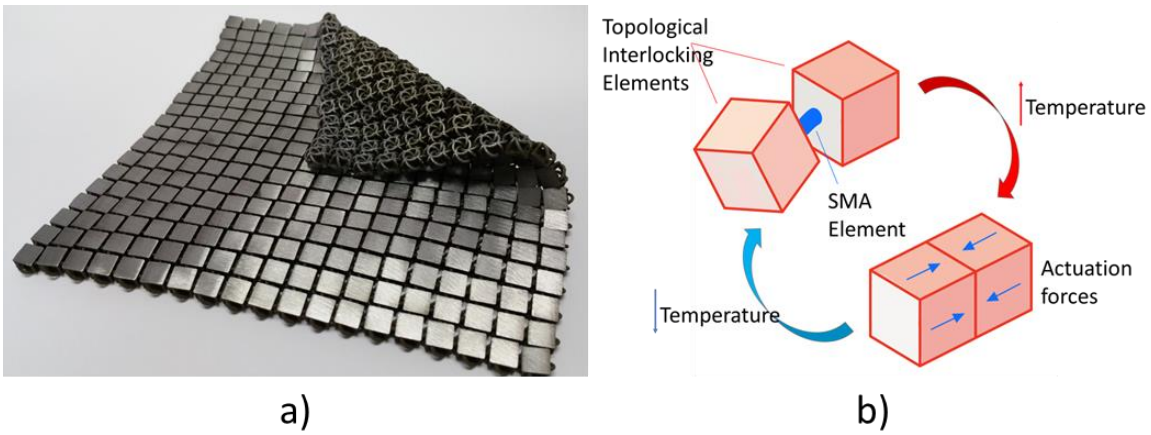

Figure 1: a) Passive chainmail-like fabric developed by NASA [2]. b) The SMARTEX concept.

[1] Wang Y, Li L, Hofmann D, Andrade JE, Daraio C. Structured fabrics with tunable mechanical properties. Nature 2021;596:238–43.

[2] Landau E. “Space Fabric” Links Fashion and Engineering. NASA-JPL 2017. https://www.jpl.nasa.gov/news/space-fabric-links-fashion-and-engineering.