Design and performance of SMA-activated tubular 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. 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 tubular SSFs activated by SMA devices like wires or sheets (see Figure 1.b). New cells geometries will be designed to adapt the planar SMARTEX SSFs to a tubular configuration. These designs will be assessed via simulations to identify the best configuration. This will be then 3D printed and assembled with its SMA actuation device. The tubular SSFs will thus be tested to prove its functionality and evaluate its performance at low and high temperature.

The following tasks are expected to be performed:

- Develop several cells geometries and SMA activation devices for the tubular SSF and assess their performance via FE analyses.
- Design, via FE analysis, an experiment to evaluate the functionality and performance of the tubular SSF at low temperature (soft configuration) and high temperature (stiff configuration);
- Perform the designed experiment and compare it with the numerical results to suggest potential improvement in the SSF design.

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

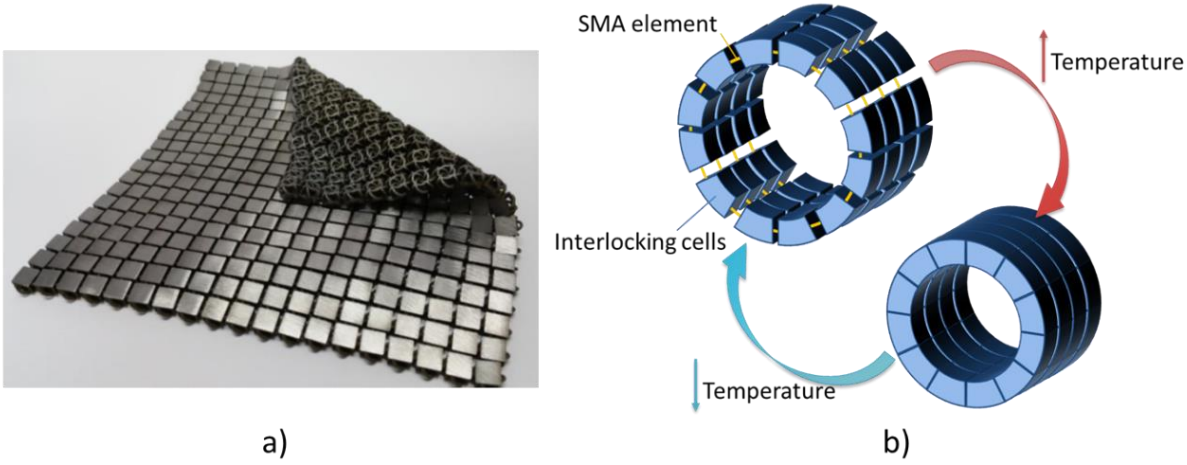

Figure 2: a) Passive chainmail-like fabric developed by NASA [2]. b) A tubular SMARTEX SSF.

[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.