Simulation of Adaptive Structures Made of Textile and Shape Memory Alloy

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Introduction
Medical textiles are widely used as bandages for diverse purposes. Usually textiles have a certain stiffness depending on the passive material and the manufacturing technique. To improve and extend the applications by making the stress-strain characteristic adaptive, hybrid structures made of textile with integrated shape memory alloys (SMA) are investigated and evaluated regarding its capability. This article focuses the benefits given by the numerical simulation of smart textiles using the finite element method (FEM).

Methods
Three different approaches of textile modelling were compared concerning the mechanical behaviour and the computational effort. With the objective of simulating the interaction of woven fabrics and SMA wires, solid, beam and membrane shell elements were taken into account resulting in microscopic and macroscopic models. A structural characterization of the components with a materials testing machine led to the required model parameters. Next to the implementation of the anisotropic hyperelastic textile properties, the temperature dependant stress-strain hysteresis of the SMA was applied.

Results
Describing the textile on filament scale every junction needs to be represented by a contact definition. In this way the numerical solving process becomes very complex. A sufficient accuracy and adequate computation time was reached by using membrane shell elements for textile and solid elements for SMA. Based on this choice the compound model was loaded and its displacements and actuator forces were determined and validated by experimental data.

Conclusion
In this article it is shown that the finite element analysis is suitable to simulate adaptive interacting structures made of textile and SMA. Based on the developed simulation model, the design of hybrid textile structures like patient-customized bandages is possible.