# AI-supported Sensor Networks on Fiber and Fabric Level for Smart Textile with Real-Time Physiology Monitoring Capabilities

Mathis Bruns*[1], Mareen Warncke[1], Hanna Kahne[1], Sina Schwingshackl[1], Benjamin Waschilewski[1], Hung Le Xuan[1], Johannes Mersch[1], and Chokri Cherif[1]

[1]Institute of Textile Machinery and High Performance Material Technology (ITM), TUD Dresden University of Technology Dresden, Germany – Germany

**Abstract**

Smart textiles are emerging as a versatile platform for continuous, unobtrusive physiological monitoring, bridging the gap between conventional wearable electronics and the comfort of everyday garments. Achieving this vision requires the integration of real-time and locally resolved sensing functionality at multiple hierarchical levels of textile construction, from the individual fiber and yarn up to the final knitted or braided fabric.
At the yarn level, PEDOT-based conductive and functional yarns enable multi-parameter real-time monitoring, including pH, temperature, and humidity. The intrinsic electrochemical and electrical properties of PEDOT, combined with its processability into fiber and yarn form, allow these sensing yarns to be directly incorporated into textile structures while retaining flexibility and washability, making them suitable candidates for continuous, skin-conformal chemical and physical sensing based on physics-informed artificial intelligence. To expand the range of achievable textile architectures, braiding technology is explored as a complementary manufacturing route for introducing functional yarns. A cobot-assisted braiding manipulator has been implemented to automate and precisely control the placement of functional yarns during the braiding process, enabling reproducible integration of sensing elements while maintaining mechanical integrity and scalability of production. This approach is demonstrated through the development of braided temperature or spatially resolved humidity sensors, showcasing how braiding can be leveraged to embed real-time sensing capability with high spatial resolution directly within the textile architecture.

Building on functionalized yarns, fabric-level integration is demonstrated through several application-driven prototypes. Knitted smart gloves incorporating strain- and motion-sensitive yarns enable real-time monitoring of hand and finger movements, supporting applications in rehabilitation, human-machine interaction, and activity tracking. Knitted textile electrodes have further been developed for electromyography monitoring of pelvic floor muscle activity, offering a comfortable and discreet alternative to conventional rigid electrodes for assessing muscle function in clinical and home-monitoring settings.
Together, these developments illustrate a multi-level strategy for smart textile design, spanning material synthesis, yarn functionalization, and fabric formation through both knitting and cobot-assisted braiding. By combining chemical, mechanical, and electrophysiological sensing modalities within textile substrates, this work contributes toward the realization of comfortable, integrated, and scalable smart textile systems capable of comprehensive physiological monitoring for next-generation wearable healthcare applications.

*Speaker

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