Politecnico di Torino

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CHEMICAL ENGINEERING

PNRR/MICS - Design of technical fabrics based on numerical modelling and AI

Funded By	MINISTERO DELL'UNIVERSITA' E DELLA RICERCA [P.iva/CF:97429780584] Politecnico di TORINO [P.iva/CF:00518460019]

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Context of the research activity	The research activity of the Doctoral Candidate will be mainly in the field of computational modelling of heat and mass transport phenomena in porous media, with the specific application to the investigation of moisture (i.e. sweat) transport in clothing, focused on the design of multi-layer sportswear with optimized features of moisture transport and heat dissipation. A series of numerical and modelling tools will be used in this research project: the various structures of the fabrics (to be investigated at the scale of the yarns) will be modelled in-silico with geometry reconstruction algorithms, and the resulting CAD models will be used in computational fluid dynamics simulations which will be performed to investigate heat and mass transfer in each different configuration. Finally, the obtained results will be used to train AI-based tools (i.e. classical and convolutional neural networks) to obtain fast and accurate surrogate models to be used in a wide exploration of the geometry-material-conditions space leading to proposal of optimized multi-layer sportswear fabrics. Progetto finanziato nell'ambito del PNRR - PNRR M4C2, Investimento 1.3 - Avviso n. 341 del 15/03/2022 - PE0000004 MICS-Made in Italy Circolare e Sostenibile - E13C22001900001

	The research activity of the Doctoral Candidate will be in the wide context of the MuSyChEn research group and it will be guided especially by the framework of the Extended Partnership PE11 “Made in Italy circolare e sostenibile”. The objective of the research activities is the development of AIbased models for the estimation of heat transfer in sportswear fabrics, and specifically focusing on the migration of sweat through the fabric layers, which will be modelled as an anisotropic porous medium. In high metabolic rate conditions, the main mechanism of heat transfer (i.e. dissipation) is latent heat exchange due to sweat evaporation, which makes it a prime focus on investigation for this application. The activity will start from the development of

Objectives	CAD computer models of various fabrics and yarns, with the goal of evaluating their permeability and transport via capillarity. Dual-layer fabrics, body-facing plus air-facing, will be considered in order to maximize the oneway transport of sweat from skin to the environment. Using CAD reconstructions of these fabrics, computational fluid dynamics (CFD) simulations will be performed on the different porous structures to evaluate their transport properties, and eventually be validated by experimental data. The very wide geometrical variety arising from different dimensions and geometrical arrangements of the fibers result in a parameter space whose dimensionality is too big to be tackled by “classical” optimization studies based on repeated, full-order, CFD simulations. Then, as a first step a preliminary campaign of numerical simulations will be performed. The results obtained from this activity will be employed in the construction of a training set of an AI-based model (read: deep-learning). Specifically, at the beginning simpler and more classical deep learning models will be built (i.e. fullyconnected neural networks) to be used as input-output models for the prediction of metrics describing transport effectiveness starting from numerical descriptors of the porous medium (e.g. porosity, surface area, et c.). Then, more innovative deep learning models (based on convolutional neural networks) will be developed in order to predict these same metrics with increased accuracy as these models will be able to ingest as their input the complete, local structure of the porous medium (in the form of a CAD model) instead of being limited to a description based on integral parameters. These surrogate models, able to reproduce the full-order CFD results in a fraction of the computational cost (i.e. a few seconds) will eventually be employed to predict and optimize the management of moisture transport in sportswear.

Skills and competencies for the development of the activity	Knowledge of mass and heat transport phenomena and numerical modeling tools