FabAgent: An Agentic Optimization Framework for the Design of Sustainable Fabric Blends Using Large Language Models and Evolutionary Algorithms

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The fashion industry emits an estimated four billion tons of CO2 annually. Nearly one-third of this is due to the choice of fibers used in clothing. Despite the critical role of fiber selection in overall GHG emissions, limited research exists on the design of optimal fiber blends because of a lack of comprehensive, easily accessible datasets on fiber properties. This paper introduces FabAgent, the first large language model (LLM) based agentic optimization framework to discover novel sustainable fabric blends. FabAgent provides a scalable way to extract information from scientific publications and the Internet, compiling a structured data set of 101 fabric materials with 24 attributes each, making this one of the most comprehensive raw material data sets for sustainable clothing design. Next, FabAgent uses multi-objective evolutionary optimization to explore Pareto optimal solutions over a large design space of possible blends, balancing sustainability, durability, comfort, and cost, while accommodating constraints on allowable yarn compositions. The optimal blend found by FabAgent outperforms many commercially available blends in leading fashion brands such as Banana Republic, Giorgio Armani, GAP, and Nike: a 30.46–52.71% improvement in environmental sustainability, 15.40–92.21% improvement in cost efficiency, and 68.29-83.49% improvement in comfort.

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