Surface Pattern Design using the Boundary Element Method and Bayesian Optimisation

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Contact interactions, ubiquitous in engineering systems, drive energy dissipation through friction and adhesion. One of the main methods of controlling these phenomena is through surface topography. Nevertheless, manufacturing surfaces with highly controlled surface roughness and performing experimental testing are both difficult and costly. Hence, computational design and testing is a very cost-effective alternative, which allows focusing real-world production and validation efforts on the most promising designs.

Recently, patterned surfaces have emerged as a transformative approach to tunable contact, not only due to growing application demand, validated proofs-of-concept, and ease of manufacturing. The control of friction through surface design is also being actively investigated, targeting friction coefficient tuning, bio-inspired designs, or fully imposing a friction law [1]. These studies open new avenues for the development of systematic design frameworks in this emerging research field. In this context, the present work introduces a computational framework for automatic design of patterned surfaces, integrating the open-source boundary element code Tamaas with the in-house optimization tool, Piglot [2, 3].

In this initial stage, the focus is on designing deterministic surface patterns parametrized by a small number of variables. The objective is to enforce a prescribed contact area evolution for a given applied pressure. One of the investigated patterns consists of a grid of spherical asperities, similar to that used in [1]. The proposed strategy is evaluated using a range of objective functions, from single-value targets to full functional prescriptions. The results obtained in this first study lay the groundwork for more advanced applications, involving adhesive and frictional contact, as well as stochastic surface patterns.

References

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