Researchers identify best algorithms to optimize performance of functionally graded materials

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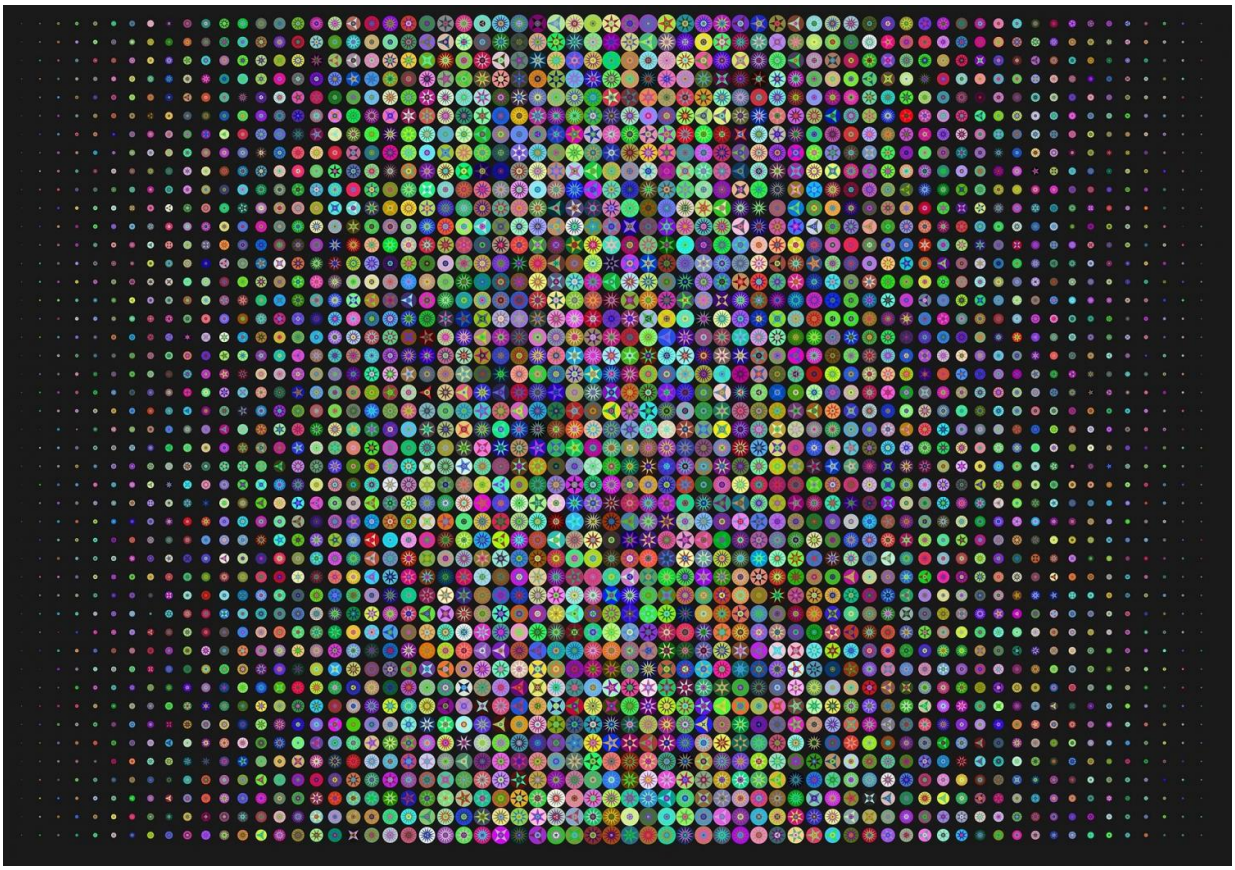

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A study from Japan published in the *International Journal of Computer Aided Engineering and Technology* reveals a way to optimize the composition of functionally graded materials (FGMs). FGMs are advanced composite materials with a gradual variation in composition and properties across their volume, designed to optimize performance under specific loading conditions.

The work could be used to mitigate residual thermal stress in uniformly cooled, multi-layered FGM plates, allowing them to cope better with the significant thermal cycles found in aerospace applications and in the power generation industry.

Ryoichi Chiba of the Department of Mechanical Engineering at Sanyo-Onoda City University has used what are referred to as black-box optimization (BBO) techniques within the open-source framework Optuna to carry out the investigation. Optuna is known as a user-friendly interface, ideal for complex optimization tasks.

Chiba has used three Optuna algorithms: the tree-structured Parzen estimator (TPE), the covariance matrix adaptation evolutionary strategy (CMA-ES), and the non-dominated sorting genetic algorithm II (NSGA-II). Each of these algorithms offers a unique approach to optimization, with TPE focusing on rapid convergence, and CMA-ES and NSGA-II on evolutionary strategies.

The optimization of FGMs has always proved a tough task as there are so many variables at play in their design and production, any one of which might have a significant positive or negative impact on their properties.

Chiba explains that the CMA-ES algorithm worked best. While TPE

converged quickly on a solution, its optimization quality was not as high as the more thorough evolutionary approaches of CMA-ES and NSGA-II. There were, the work shows, problems that can arise in attempting to account for interactions between design variables that were sometimes counterproductive, leading to a more complicated optimization rather than an enhanced process.

More information: Ryoichi Chiba, Comparing open-source optimisation algorithms for functionally graded material design: a thermoelastic case study, *International Journal of Computer Aided Engineering and Technology* (2024). DOI: 10.1504/IJCAET.2024.138652

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