INNOVATION PARTNERSHIPS
UNIVERSITY OF MICHIGAN

Neural Particle Swarm Optimization for Material-Aware Inverse Design of Optical Structures

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OVERVIEW

AI and optimization-based optical structure design algorithm for structural color

- Uses a material screening model, a structural parameters prediction model, and particle swarm optimization
- An environmental-friendly alternative to chrome coatings and reconstructing pictures

BACKGROUND

Structural color refers to the color generated through the light interaction with patterned or layered optical structures. Designing optical structures to obtain user-specified properties such as color targets is not a trivial task due to the complex relationship between the optical structures and the perceived color by human eyes. The human visual system is sensitive to variations in light and color, creating challenges when attempting to engineer optical structures to achieve desired colors. Though machine learning-based inverse design methods have previously been developed for obtaining optical structure designs given specific color targets, most of these approaches do not consider the potential for searching from a variety of materials to achieve the best color targets. The inability to search and select the best materials leads to sub-optimal design performance or makes it impossible to obtain colors specific to the materials' fixed reflection and absorption properties. So, a need exists to improve our understanding of color perception, to develop reliable design methods, and to create efficient means by which to manage the complex relationship between structures and generated colors.

INNOVATION

Researchers have developed a hybrid inverse design method termed Neural Particle Swarm Optimization that combines a material screening model, a structural parameters prediction model, and particle swarm optimization to obtain structural color designs with appropriate

materials. Mixture Density Networks (MDN), a class of neural network models that returns multimodal conditional probability distributions, assesses materials and associated design parameter values to fine-tune the predicted design parameter values. The Particle Swarm Optimization (PSO) involves a type of optimization that solves a problem by having a group of candidate solutions moving in the search space influenced by local solutions. This method demonstrates exceptional design accuracy and efficiency on designing environmental-friendly alternatives to chrome coatings and reconstructing pictures with structural colors based on multilayer optical thin films. Pictures with more than 200,000 pixels can be reconstructed within 2 to 3 hours with an almost unnoticeable difference from the original picture. The invention can be adopted for wide range of other optical design tasks that require optimizing the material selections and structural parameters.