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Scientific abstract – Advanced Mathematics and Industrial Design: A Symbiotic Relationship

The connections between mathematics and fields such as physics, biology, and computer science of course are natural ones. In this proposal, I would like provoke a new symbiotic relationship between industrial design and abstract mathematics with the following three ulterior goals. The first goal is to show how abstract mathematics concepts can be powerful tools for a designer and can be 'activated' to meet the designer's demands, as detailed in Aim 3 below. In addition, to formulate new theoretical ideas, mathematicians are always seeking inspiration. In my opinion, design has much to offer, and aesthetics is a good example that may, in a certain sense, define mathematics (Aim 2). Lastly, undergraduate mathematics students need to be educated to become problem solvers who can tackle the problems that arise in various fields. I encourage my mathematics students to participate in design–math collaborations to demonstrate the power of their primary field of study. My intent is to turn abstract mathematical concepts into vivid visualizations using the right construction and materials (Aim 1). I will demonstrate, with the help of my team, the utility of our visualization approach in three academic fields that seemingly have little in common with math (art, design, and music) but indeed have powerful symbiotic relationships. In detail, the three aims of this proposal are as follows:

(1) **Aim 1: Definition and classification of songs as three-dimensional objects**. Can a given song in Western music be modeled as a collection of curves or surfaces, or even be defined as a tangible object? If they can indeed be modeled in a pure mathematical fashion, can we sort songs according to an equivalence relation? This research will involve music, industrial design, differential geometry, algebra, and topology.

(2) **Aim 2: Gradient topology**. A gradient is an important concept in mathematics, and surprisingly, this concept is also well defined from a designer's point of view as a gradual change in color (which contains the mathematical definition) in a given image. To mathematicians, this simple design gradient, although it has a geometrical property, is similar to the construction of a cylinder from the respective fundamental polygon, which is obtained by attaching the identical edges. This observation has led us to think is it possible to define design gradients for different topological surfaces. This research will involve design, topology, combinatorics, and complexity; all are influenced by design concepts.

(3) **Aim 3: Defining dynamical tilings in industrial design**. It has been shown that algebraic structures can help designers in the planning stages determine if a dynamical transformation of the components in a design can be obtained simply by using a respective mechanism that defines movement between different patterns/arrangements, each of which accomplishes a different goal. I intend to generalize this result to spherical patterns and especially geodesic domes. This research will involve design, mechanics, differential geometry, and groups.