The Use of Topology Optimization for Artistic Image Generation

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1. Abstract

In this work, we present a non-traditional use of topology optimization – generation of artistic images by the topology optimization method. While the topology optimization method has been widely used in various engineering and scientific problems, it has not been used in art. Here, we will show some of our recent progress made in using the topology optimization method for creating unique, perhaps artistically-meaningful images.

Early attempts[1], [2] go back to 1960's to create artistic images by computational methods. Since then, there has been a growing interest in utilizing them for non-engineering or non-scientific fields including art. For instance, Mandelbrot[3] produced fractal images by mathematical equations. Images generated by computer algorithms or those representing some physical phenomena have influenced artists and designers in various ways. As recent efforts, McCormack[4], Sims[5], and Heijer and Eiben[6] attempted to use evolutionary algorithms for image generation. The parametric method was also considered by Bastanfard and Mansourifar[7] for decorative Islamic pattern generation and Alexander[8] suggested an algorithm to simulate fungal hyphae growth. Other researchers have attempted to generate or create images by mimicking various physical phenomena observed in nature. Examining these earlier efforts, one can conclude that images by computational means are mostly generated through simulations of biological or physical phenomena, not by solving optimization problems. Unlike the aforementioned approaches to simulate physical phenomena, we are developing a new method based on a topology optimization method.

Our unique approach to generate artistic images is to set up the optimization problem on a "virtual physical system," which is used to simulate an artist's act of painting. First, we select the two-dimensional heat-conducting plate as a virtual system of which the physical phenomenon is governed by the two-dimensional Laplace equation. Then, we use the topology optimization method to find heat paths that minimize thermal compliance in the virtual system and use optimized density distributions to create images. The ideas enabling this approach are that 1) "optimal" can be "beautiful" and 2) that acts of brushing strokes can be viewed as optimal paths connecting multiple heat sinks and multiple heat sources in the virtual system. Note that the mass constraints and other parameters in the topology optimization setting result in different tones in the obtained images. Ironically, the convergence issue, not welcome in engineering problems, can be positively utilized to produce interesting, even desirable effects on the generated images. After presenting the underlying ideas of the proposed topology optimization based image generation method, which is called the "variational art algorithm," recent artworks will be presented. In particular, re-created artistic images from famous paintings (such as Kiss by Gustav Klimt) by the developed variational art algorithm will be presented.

2. Keywords: Artistic Image, Variational Art, Topology Optimization, Heat Transfer

3. Acknowledgements

4. References

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