Improving Topology Optimization using Games

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Abstract

Topology optimization has had, and still has, a great impact on the design of structures and mechanical elements. Even though computers and topology optimization algorithms are able to find good solutions to most problems, it is also important for users of such programs to have a good intuition for whether a structure is optimal. We hypothesize that human intuition regarding topology optimization is often led astray. Our goal is to collect data in order to test this hypothesis and at the same time to actively train users (in particular students of mechanical engineering) in designing optimal structures. Consequently, we have created a game, the TopOptGame, which improves the player's topology optimization intuition in a fun and engaging way while collecting data about the users performance.

Technically, the TopOptGame builds on the TopOptApp [1] - an interactive topology optimization application designed for hand-held devices. The TopOptApp solves the 2D minimum compliance problem with interactive control of loads, supports and volume fraction, and thus the TopOptApp allows the user to change the problem on the fly and watch the design evolve to a new optimum in real time. TopOptApp is available free of charge on iOS and Android devices[1].

The TopOptGame is inspired by puzzle-games (a genre of computer games), which constantly challenges the players and gives rewards when progress is

[1] TopOptApp can be downloaded using Apple's App Store (iOS) and Google Play (Android)

made. This engagement loop will take the player on a journey starting with simple problems with few supports and a single load and gradually increase the difficulty by adding more loads, restrictions on the design domain, distributed loads and multiple load cases. The goal is to distribute material in a discretized design domain, under some volume and time constrains, while searching for a good solution (minimum compliance). A visualization of the strain energy density will help the player finding a feasible solution.

Besides training the player in topology optimization, the game also tracks the progress of each player and sends this progress in anonymized form to a database. When enough data has been collected, this will allow us to analyze the data to measure human performance of topology optimization and more importantly, in which cases people's intuition succeed or fail.

The game is currently a working prototype and is scheduled for final release on both iOS and Android before WCSMO-10.

References

[1] Aage, Niels and Nobel-Jørgensen, Morten and Andreasen, Schousboe, Casper and Sigmund, Ole *Interactive topology optimization on hand-held devices*. Structural and Multidisciplinary Optimization, Vol. 47, Issue 1, 2013, Springer-Verlag