Growing Form-Filling Tensegrity Structures using Map L-Systems

John Rieffel
Cornell University
Ithaca, NY
rieffel@cornell.edu

Hod Lipson
Cornell University
Ithaca, NY
hod.lipson@cornell.edu

Francisco J. Valero-Cuevas
Cornell University
Ithaca, NY

Categories and Subject Descriptors: I.2.8 [Artificial Intelligence]:Problem Solving, Control Methods, and Search

General Terms: Design, Algorithms

Keywords: Map L-Systems, Evolutionary Design, Tensegrity]

ABSTRACT

Tensegrities are unique, space-filling structures consisting of disjoint rigid elements (rods) connected by tensile elements (strings), which hold their shape due to a synergistic balance of opposing forces. Due to their complexity there are few effective analytical methods for discovering new, and particularly, large irregularly shaped tensegrity structures. Recent efforts using evolutionary search have been moderately successful, but have relied upon a *direct* encoding of the structure, and therefore face scalability issues [3]. By contrast we employ to a developmental representation grammatically "grow" tensegrity structures, and as such, issues of scalability, both in terms of representation and of performance, are addressed. Specifically we evolve *map L-systems* [4] which produce planar graphs [1, 2] corresponding to the structural elements of a tensegrity. Each tensegrity is then reproduced within the Open Dynamics Engine (ODE), and the volume of the convex hull described by the final location of the rigid element endpoints used as fitness. As shown in Figure 1, the map L-system significantly outperforms the direct encoding across all runs. Figure 2 shows a representative evolved tensegrity.

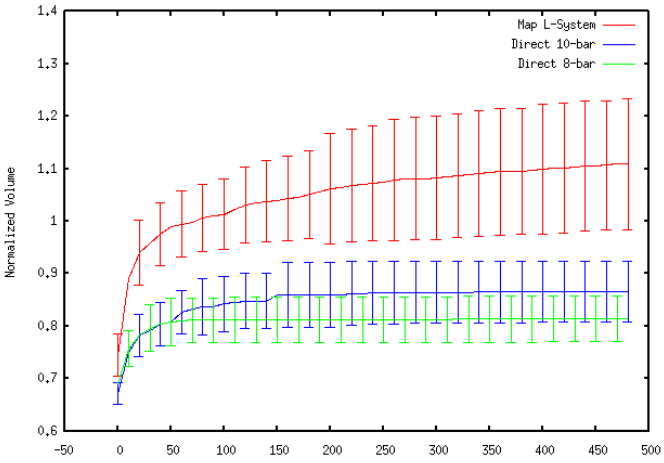


Figure 1: Direct vs. Developmental Methods

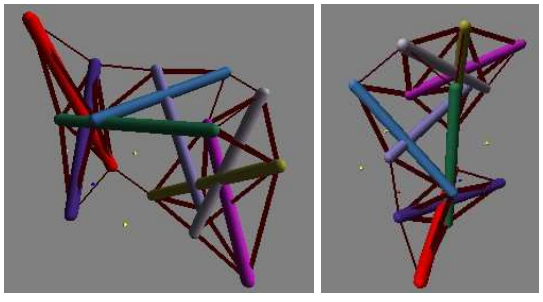


Figure 2: Two views of an evolved tensegrity.

1. REFERENCES

[1] D. Barnette. On generating planar graphs. *Discrete Mathematics*, (7), 1974.

[2] R. Motro. *Tensegrity: Structural Systems for the Future*. Kogan, 2003.

[3] C. Paul, F. J. Valero-Cuevas, and H. Lipson. Design and control of tensegrity robots for locomotion. *IEEE Transactions on Robotics*, 22(5), 2006.

[4] P. Prusinkiewicz and A. Lindenmayer. *The Algorithmic Beauty of Plants*. Springer–Verlag, New York, USA, 1990.

Copyright is held by the author/owner(s).
GECCO'07, July 7–11, 2007, London, England, United Kingdom.
ACM 978-1-59593-697-4/07/0007.