

Exploring Viability of Harvesting Vibrational Energy from Trees

Introduction:

There are multiple ways in which ambient mechanical vibrations in many environments can be harvested to obtain useful energy to power a range of devices in otherwise restrictive scenarios. For a system to be qualified for the harvesting of its vibrational energy it is desirable that it maintains a consistent dominant frequency content as well as have enough power to be feasible for transduction. Trees become a desirable candidate for this sort of energy harvesting due to their natural structure, abundance, and their tendency to capture energy from gust-induced motion. There have been several attempts to harness their energy using photovoltaic [1], piezoelectric [2], as well as sway-based electromagnetic [3, 4] harvesters. However a robust, efficient mechanism that is also commercially viable is yet to be designed. It is therefore proposed to explore a new approach by characterizing the fractal dynamics of tree structures for the purpose of energy harvesting.

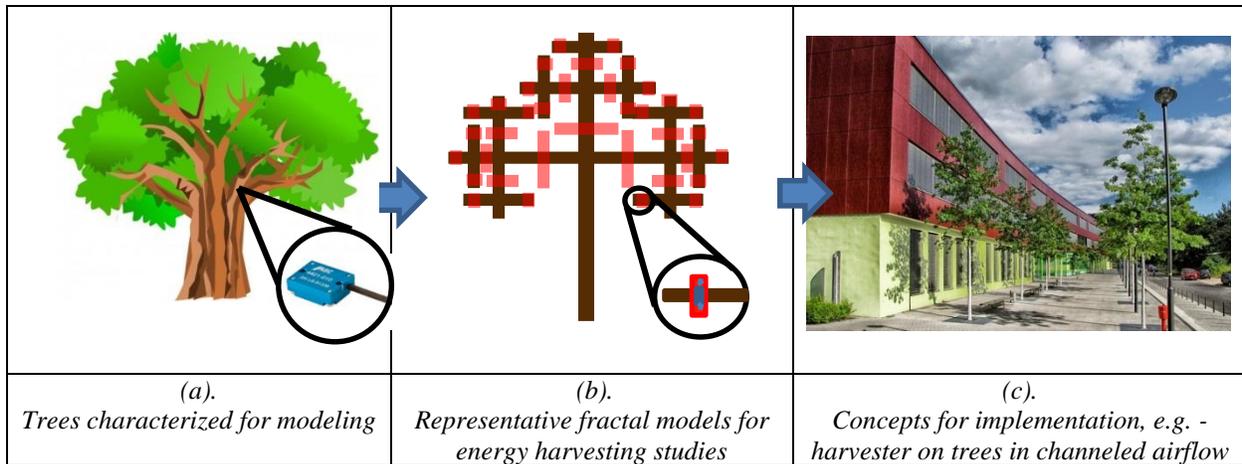


Figure 1: Conceptual depiction of a multifunctional scheme to harvest vibrational energy from trees

Research Plan:

Trees have been shown to have a naturally self-similar structure with a great degree of fractal hierarchy which could be advantageous for energy harvesting [5]. The following steps are proposed in this semester-long study to explore this possibility. **Step 1:** A field study of various locally abundant trees and their structural dynamic characteristics will be done to determine possible candidates for modeling (*Figure 1a*). Using photographs, desirable energy harvesting characteristics such as dimensions and fractal structure will be analyzed. Field measurements using accelerometers will be made to obtain information about the influence of location, time of day and fractal hierarchical level on the dynamic behavior. **Step 2:** Using CAD and FEM analysis, a scaled representative fractal model (*Figure 1b*) will be manufactured using a 3D printer in the lab. Experiments under various types of loading will be performed to correlate the response of the fractal structure with the field measurements from the trees and to further motivate the potential of using fractal responses to harvest DC power directly from the source without the use of a rectifier, contrary to classical energy harvesting devices. **Step 3:** A proof-of-concept lab demo would be conducted in which a fractal tree model would be coupled to a simple energy harvester to conceivably generate enough power to run a small electronic device under idealized replication of the loading conditions. This study is expected to result in new concepts for future research and development (*Figure 1c*).

Expected Outcomes:

Harvesting energy using tuned energy harvesters based on fractal dynamics of trees could provide a robust multifunctional means to power a broad range of low-powered distributed devices in the field. This approach could eliminate the need for a rectifier and other electronic components; power remote sensors and devices for long periods of time without the need for a battery; and provide a multifunctional use as a structural health monitor for the tree which could help extend the life of the tree and protect property and human life from large falling branches or complete structural failure.

References:

- [1] <http://www.gizmag.com/vtt-energy-tree/36115/>
- [2] <http://creativemachines.cornell.edu/node/116>
- [3] http://www.science20.com/cosmic_embryo/cosmic_embryo_6_swaying_trees_produce_wind_energy-107333
- [4] McGarry et al, *Sensors*, v12.9, p12110–12125, 2012
- [5] K. R. James et al, *Arboriculture & Urban Forestry*, v40(1), p1–15, 2014