Electric Flora:
An Interactive Energy Harvesting Installation

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Abstract
We demonstrate an interactive, human-powered energy harvesting system that converts a person's movement into light. The installation explores the interaction of bodies in space, movement, materials, and electrostatic energy.

Author Keywords
Interactive installation. Electrostatic energy harvesting.

Introduction
We demonstrate an energy harvesting installation that converts a user’s movements into useful electrical energy, which is then transformed into visible light. The installation explores the interaction of bodies in space, materials and static electricity, and the concepts of electric current, potential energy and human circuits.

Our goal is to stimulate thoughts on the potential of static electricity beyond the occasional uncomfortable shock. We aim to provide the users with a playground where they can explore the role their bodies can play in generating electrical power. As they experiment with the installation, they can see LEDs flash, glow, and strobe in synchrony with their movements.

System Overview

The installation has three major structural components: the floor, the ceiling, and the rods (Figure 1). In addition, it involves a user's clothing and footwear.

The floor defines the interaction surface; it is an 8 foot by 8 foot square with a raised surface. It is constructed using a wooden frame strong enough to support multiple people. The floor is covered with aluminum foil and then wrapped in polyester cloth.

The ceiling helps define the volume of the installation in space and provides a support structure for the hanging rods. The ceiling is square and matches the dimensions of the floor. The frame of the ceiling is a lightweight aluminum, and the underside of the frame is covered in a layer of plywood to create the finished look of the ceiling. The ceiling is suspended 7 feet above the floor by steel cables attached to the frame.

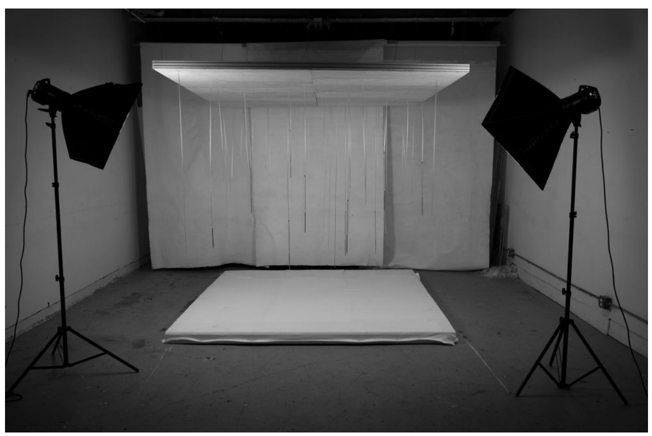

Figure 1. The installation: The floor, the ceiling and the rods.

The rods or "*vines*" are the central part of the experience and hang down from the ceiling. They are made from acrylic rods and are cut to a variety of lengths. The shortest are only a few feet, whereas others are nearly long enough to touch the floor. Approximately fifty rods, which also vary in diameter, are randomly distributed underneath the ceiling. It is worth noting that acrylic rods like these are very flexible and easily pushed aside, allowing a user to walk through. Ten of these rods have conductive tips and 50 light-emitting diodes (LEDs) each, allowing current to flow through the rod and out to an electrical ground, illuminating the LEDs in the process

Figure 2. Acrylic rods: a bare rod and a rod with LEDs, conductive tip (copper) and wiring.

Energy Harvesting Through Electrostatics

The energy harvesting system relies on a person's interactions with the floor, the LED rods and garments. The electromechanical conversion−from a user's movements to electricity−is based on the *triboelectric effect* [2,3,4], where rubbing and contact of different insulators causes them to exchange electric charge.

The system utilizes thin PTFE (Polytetrafluoroethylene) sheets, also known by the brand name Teflon®. PTFE has the lowest electron affinity of all known materials [1], and thus accumulates negative electric charge when rubbed against other materials. Conversely, the polyester cloth that covers the floor accumulates positive charges when rubbed with PTFE sheets.

The user interacting with the rods wears custom-made cardboard sandals that are covered with PTFE on the outside, and aluminum foil on the inside. As the user slides his or her feet on the floor or takes repeated steps, charges accumulate on the PTFE and the floor. With this accumulated charge, repeated motion of the feet creates an electric potential difference between the user's body and the floor. When the user touches the conductive end of the rods with LEDs, this potential difference causes charge to flow through his or her body and to the LEDs, emitting light (Figure 3).

There is a full-bridge rectifier on each LED rod that allows both positive and negative potential differences to be utilized, intensifying the effect. As a result, both contact and separation between the feet and the floor create light.

Energy harvesting is also possible when the user is lying on the floor. In this case, both the PTFE covered sandals and the user's clothes can act as charge sources and contribute to the generated light.

The analog nature of electromechanical conversion gives the user direct feedback on the effects of his or her actions. The quicker and more forceful the user's movements, the brighter the emitted light. This feedback allows the user to explore the movements, topologies and actions that generate more energy (Figure 4). Furthermore, experimenting with multi-user and multi-rod interactions allows the user to understand simple electrical circuit concepts. Multiple users interacting with the same rod create brighter light when their motions are synchronized. Also, a single user who is in contact with multiple rods at the same time observes reduced light intensity.

Figure 3. The user, wearing custom-made sandals covered with PTFE sheets, moves around and interacts with the rods.

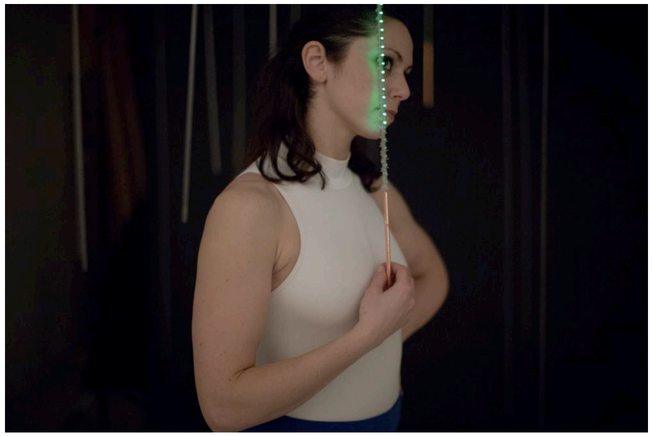

Figure 4. The user touches a rod while sliding her feet, creating enough current to light up LEDs.

Interaction and Design

Most people are familiar with the triboelectric effect through everyday experiences: in dry winter air our body easily charges up; resulting in minor electric shocks when a metal surface is touched. The human body, a big cloud of atoms and electrons, is also an electrical object and carrier of electrical energy. With this installation, we intend to utilize this electrostatic energy and make it visible by lighting up "LED plants". The design of the installation is simple and reduced: as simple as the technology itself. Through clear shapes and the minimalistic design, the focus is mainly on the interaction and the experience of the user in space.

Electric Flora is like a playground for the user; he or she can slide around and touch the "electric vines", can interact with these structures while standing or while lying on the floor. We want to engage the user and allow him or her to explore the technology like a child: play, touch, feel and experiment.

Electrostatic energy is a regenerating source, which can be harvested readily. With this work, we intend to explore and discuss electrostatic energy as a new potential energy source. Because the underlying technology is simple, users without a technical background can enjoy and utilize this demo, and build their own energy harvesters. In the present day, where technology is like a black box for most users, we intend this playful experience to generate discussions and visions for the future.

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