Demo Abstract: Claytronics – Highly Scalable Communications, Sensing, and Actuation Networks

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ABSTRACT

We propose a demonstration of extremely scalable modular robotics algorithms developed as part of the Claytronics Project (http://www-2.cs.cmu.edu/~claytronics/), as well as a demonstration of proof-of-concept prototypes. Our effort envisions multi-million-module robot ensembles able to morph into three-dimensional scenes, eventually with sufficient fidelity so as to convince a human observer the scenes are real. Although this work is potentially revolutionary in the sense that it holds out the possibility of radically altering the relationship between computation, humans, and the physical world, many of the research questions involved are similar in flavor to more mainstream systems research, albeit larger in scale. For instance, as in sensor networks, each robot will incorporate sensing, computation, and communications components. However, unlike most sensor networks each robot will also include mechanisms for actuation and motion. Many of the key challenges in this project involve coordination and communication of sensing and actuation across such large ensembles of independent units.

1. MOTIVATION

The past six decades have brought tremendous reductions in the physical scale of computing hardware. We envision a similar reduction in the scale of modular robotics, made possible by the extension of present high-volume manufacturing techniques (e.g., as in semiconductor fabrication). Millions of sub-millimeter robot modules each able to emit variable color and intensity light will enable dynamic physical rendering systems, in which a robot ensemble can simulate arbitrary 3D models. Such systems could have many applications beyond robotics, such as telepresence, human-computer interface, and entertainment.

2. DEMO OVERVIEW

We will show some of the software and hardware systems we are developing for Claytronics, including 1) algorithms for self-organizing hierarchical computation and communication aimed at networks with dense, 3D structures and diameters of hundreds to thousands of nodes, and 2) a suite of parallelized algorithms for coordination and planning of movement and sensing operations across both local (tens to hundreds of units) and global scales (thousands to millions of units). In both cases we will show videos of results in simulation. We will also exhibit artifacts from our efforts to build hardware prototypes at a 5cm size, and to substantiate the potential for shrinking these prototype designs to sub-millimeter scale.

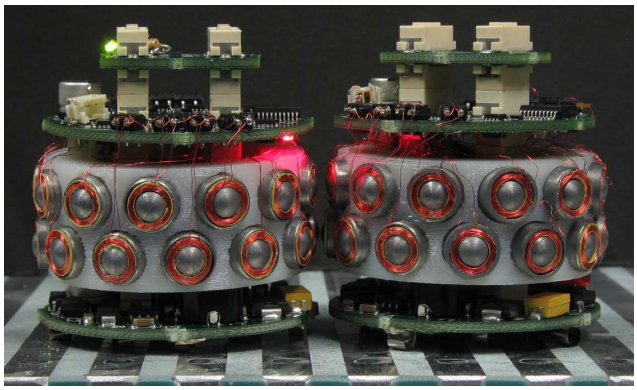

Figure 1. Centimeter-scale prototypes.

3. ACKNOWLEDGMENTS

This work was supported in part by NSF grant CNS-0428738, DARPA Contract N66001-04-1-8931, Intel Research, and Carnegie Mellon University.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: Robotics – *modular reconfigurable robots.*

C.2.4 [**Computer Communications Networks**]: Distributed Systems – *distributed applications.*

General Terms

Algorithms, Design, Performance, Experimentation, Theory.

Keywords

Modular reconfigurable robotics, programmable matter, distributed sensor fusion, distributed planning and coordination, collective actuation, dynamic physical rendering, telepresence.

SenSys'05, November 2–4, 2005, San Diego, California, USA.
ACM 1-59593-054-X/05/0011