MorPhys: Morphing Physical Environment Using Extension Actuators

Shohei Takei[*] The University of Tokyo
Makoto Iida[†] The University of Tokyo
Takeshi Naemura[‡] The University of Tokyo

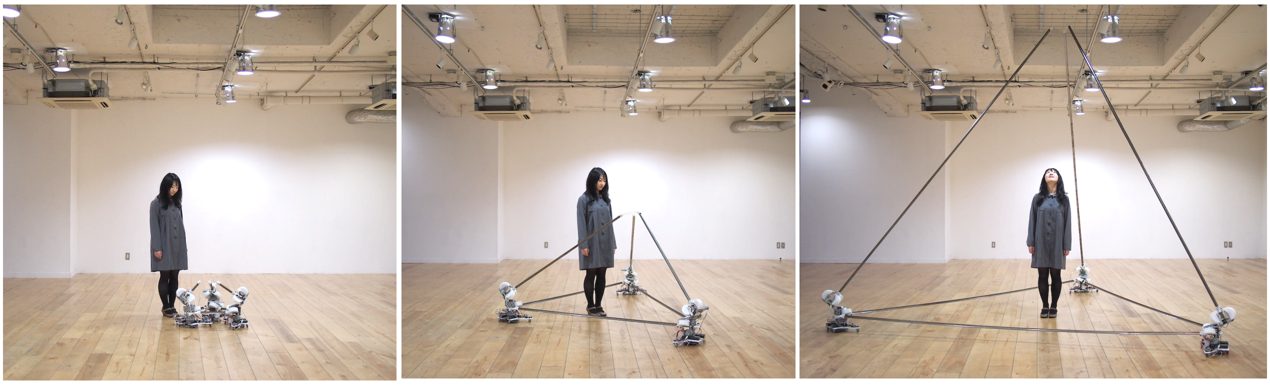

Figure 1: *MorPhys*

1 Introduction

A virtual 3D model in a computer program can easily be manipulated to whatever the creator desires. However the same cannot often be said for objects in the physical world. This study introduces a system called MorPhys, a transformable 3D structure that, like a virtual model, can be manipulated into various shapes by the user.
Over the years, several devices that can mechanically change their shapes have been proposed for information presentation and dynamic architecture. One example is the "Hyposurface" [Goulthorpe], a wall-sized structure constructed of interconnected metallic plates actuated by an array of pneumatic cylinders. It can generate relief patterns such as waves and text by changing its shape and volume. However, these conventional devices are limited to presenting so-called "2.5D" objects since they are comprised of linear actuators.
In this study MorPhys is capable of interactively forming polygonal mesh structures using extension actuators and adjusting its position with an electromagnetically driven anchor mechanism. This system design concept allows real 3D objects to be manipulated as dynamically as their virtual counterparts.

2 Design & Implementation

The extension actuators used in MorPhys were devised in our study of KineReels which mainly focused on acquiring a high extension ratio [Takei et al., 2011]. A single actuator consists of three reels and one motor. The current version has the ability to extend its rod from 150 mm in storage up to 4,000 mm fully extended. It moves with an average speed of 235 mm/second while expanding, or 350 mm/second while contracting. It is equipped with an AVR microcontroller (Atmel ATMega88p) and ZigBee module (Digi XBee Series2) allowing wireless control of the actuators through a PC. It is also possible to control movement through remote web browsing devices by sending OSC (Open Sound Control) protocol to the PC via the Internet. The rods' movements are detected by reading a striped black and white pattern with a photoreflector (ROHM PRP-220). The actuators are battery powered so they can operate independent of electrical outlets.

[*]e-mail: takei@nae-lab.org
[†]e-mail: iida@imi-lab.org
[‡]e-mail: naemura@nae-lab.org

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In this study MorPhys was equipped with six extension actuators, creating a tetrahedron by connecting the actuators' rod ends with joints that have one or two rotation axis and a flexible joint made of piano wires. The actuators on the ground are equipped with casters to move themselves smoothly in conjunction with the other actuators' movement. It is also equipped with an electromagnetically driven anchor mechanism that can arbitrarily adjust the position or base of the entire system in any direction.
Figure 1 (left) shows the smallest state of the tetrahedral MorPhys system (300 mm each side) and Figure 1 (middle) shows the largest state (4,000 mm each side). It is possible to form various tetrahedral shapes by changing the length of the rods as shown in Figure 1 (right). Furthermore, MorPhys is capable of physical interaction since its photoreflectors can detect displacement of the rods by external forces.

3 Conclusion & Future Works

MorPhys effectively demonstrates that an object's shape and volume can be changed dynamically with extension actuators, while characteristics such as transformability, mobility and interactivity are also illustrated. In this particular study the authors used a simple tetrahedron design for their model. The increased number of rods will add structural support to the polygonal skeleton, allowing more complex 3D shapes and design. A more advanced system can be developed to link more actuators through improved rigidity of the rods and trimmed weight of the actuators themselves.
MorPhys would be well considered for use in architectural design, mobile shelters, digital signage, robotics, art displays and so on. For example, a morphing structure that can adjust its volume to the amount of occupants or contents inside could be used to maximize energy efficiency and environmental control. Or contribution can be made to the fields of signage and robotics with its unique mechanism and attractive motion.

References

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