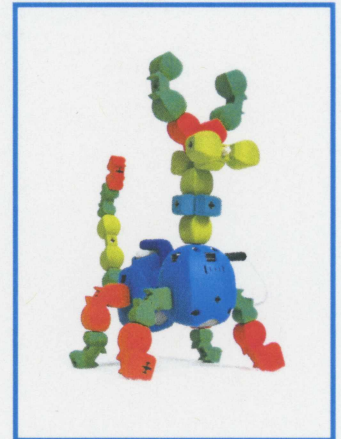


Topobo

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Artistic concept / Objective

What is it like to sculpt with motion? Topobo is a 3D constructive assembly system embedded with kinetic memory, the ability to record and playback physical motion. By snapping together a combination of Passive (static) and Active (motorized) components, people can quickly assemble dynamic biomorphic forms like plants, animals and skeletons with Topobo, animate those forms by pushing, pulling, and twisting them, and observe the system repeatedly play back those motions. For example, a moose can be constructed and then taught to gesture and walk by twisting its body and legs. The moose will then repeat those movements and walk repeatedly. Topobo works like an extension of the body giving one's gestural fluency computation and memory. Picture of moose, or hand+creation



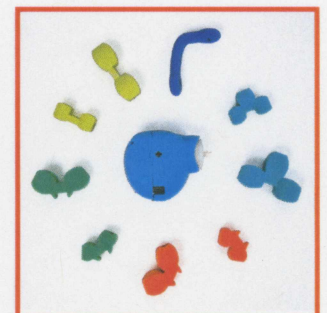
Topobo is inspired by current trends in computational media design and by the work of artists and scientists Ernst Haeckel, D'Arcy Thompson, Muybridge, Marek and Michael Grey. These artists and empiricists used visual explorations and models of natural phenomena to more deeply appreciate patterns found in the natural world. In this spirit, Topobo is designed to allow people to use experimentation, play, and self-expression to discover and explore common natural relationships between natural forms and dynamic motion.

Statement of the problem being addressed

Building toys and educational manipulatives have been used for years by children to learn about the world through model making. Many adults continue to use these media to sculpt and explore their ideas. While some modern construction kits like LEGO Mindstorms couple construction activities with computational activities, none offers an integrated or intuitive approach to the two activities. Topobo embeds computation within a dynamic building system so that gestural manipulation of the material becomes a programming language. Topobo is an artistic exploration unto itself, and is designed to act as a broader platform for gestural expression that allows people to quickly and easily bring kinetic conceptual ideas to life. With Topobo, dynamic expression begins with the press of a button and the flick of a wrist.

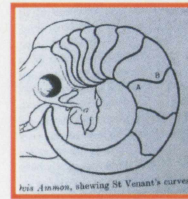
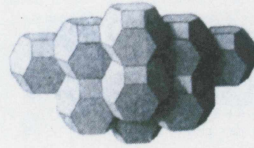
Solution and features

Topobo - for "topology" and "robotics" - is designed to retain the best qualities of existing manipulative materials while giving the material a new identity - an identity that can both reveal new patterns and processes to people, and that allows people to creatively express patterns and processes that can not be expressed with existing materials. The system is comprised of 10 different primitives that can be snapped together in a variety of ways. Nine of these primitives are called "Passive" because they form static connections. One "Active" primitive is built with state-of-the-art modular robotics technology and is programmed by demonstration. These motorized components are the only ones that move, so the system is able to faithfully record and replay every dynamic manipulation to a structure.



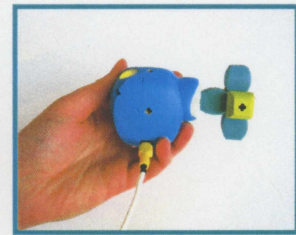
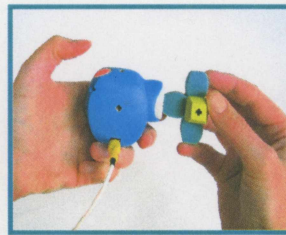
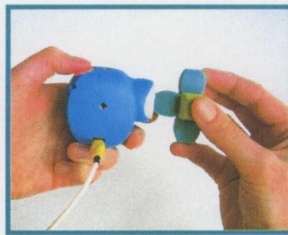
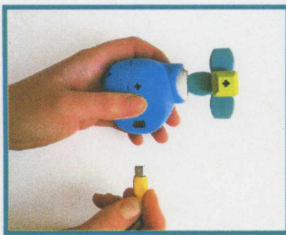
Geometry

Since Topobo is intended to model various natural forms like plants, skeletons and interlacing meshes, the system allows branching and spatial looping. Its geometry is based on cubic and tetrahedral crystals.



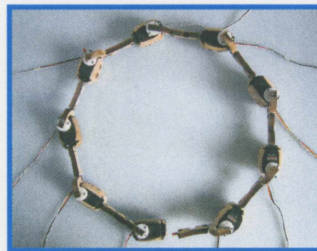
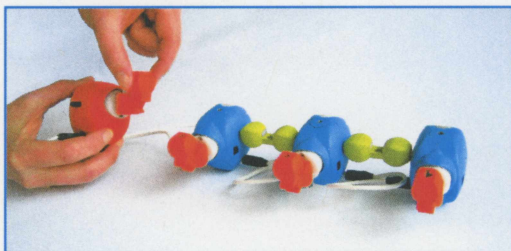
Distributed computation and control

The Active is a motorized, networkable, egg-shaped plastic object with a button and an LED for indicating whether the system is in record (red) or playback (green) mode. To record a movement, the user presses a button on an Active, twists and moves the Active to program a sequence of behaviors, and then presses the button again. The Active immediately goes into playback mode, which repeatedly replays the user's input until the button is pressed a third time, which makes the Active stop moving. In a creation with many Actives, all of the Actives will record and playback at the same time. For example, if a person makes a circular ring of Actives, pressing a button on one of the Actives then sets all of the Actives in the structure to be in recording mode. The person may then move the circular structure of actives in the manner of a tank tread rolling across the floor, and then press any one of the Actives' buttons to set the structure into playback mode.



Centralized Control

Topobo "Queens" are special actives that allow people to experiment with how a simple rule can affect the movement of a larger structure. In both recording and playback modes, all motions of the Queen are imparted directly to all Actives connected to the Queen. For example, suppose that one constructs a linear structure of actives with a Queen at one end. When the Queen is recording, all of the other Actives will mimic its angular position. Thus, increasing rotations to the Queen cause the entire structure to begin to curl into a circular form. Eventually, the ends will touch.

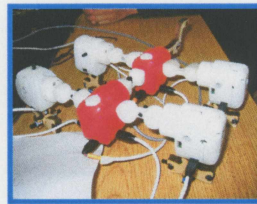
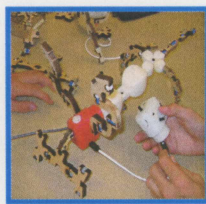
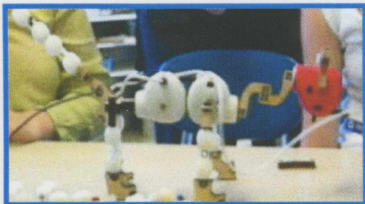


Sculpting Motion with Topological Algorithms

We have utilized three different types of "augmented" Queens that allow people to sculpt motions based on Topobo network topology and motion algorithms. Augmented Queens enable dramatically different motions of Actives. An Active connected to the Decay Queen will scale the Queen's motion based on it's distance from the Queen. Using a Decay Queen, a linear string of Actives can gradually curl into a spiral. Actives connected to the Time Delay Queen mimic the action of the Queen following time delays that are proportional to the Actives' distances from the Queen. Using a Time Delay Queen, linear strings of Actives can move with wave-like motions. Finally, the Faster/Slower Queen speeds up or slows down Actives as a function of distance from the Queen. Due to Topobo's looping playback, a linear string of parts can exhibit harmonic resonance patterns.

Fields of application

We created Topobo at the intersection of contemporary arts and investigations in computational media design. While the core concept is relevant to creators of any age, we have designed the system to look and feel like familiar children's toys to encourage educators to reconsider how computers are used in education. One of our goals has been to reintroduce physical activity to classroom play with computational and mathematical ideas, encouraging exploration, experimentation and collaboration. Through a series of classroom studies, we we found that Topobo can help students ages 7-13 to learn about several educational concepts including balance, center of mass/center of gravity, coordination, relative motion, movement with multiple degrees of freedom and relationships between local and global system behavior.



While educational applications are central to our investigations, Topobo was created by artists and our current work investigates how professional artists can use the system as a new kinetic sculptural medium.

Technological Basis

The Topobo system is built on custom designed and built modular robotics technology. Plastic parts are injection molded in ABS resin. The Active (robotic) component is made of a hobby servo motor and electronics in a plastic housing. The housing has 6 points of mechanical connection, three sockets to connect power/communication cables and a button that is backlit by a red-green LED. One of the mechanical connectors is connected to the output shaft of the servo motor and rotates 170°. On board custom electronics handle power distribution, memory and processing. A 40 Mhz embedded microcontroller has been programmed in C to handle local processing and a custom built peer-to-peer, multichannel serial communications protocol. Each Active is identical and autonomous, and only needs power to function.

Installation Requirements

We envision Topobo being exhibited as an open-ended table top interactive where visitors of all ages can collaborate on building playful animated creations and explore kinetic concepts. No specific installation size requirements.

