RETHINKING DESIGN

ETH Zurich Meets Davos during the World Economic Forum's Annual Meeting (22 – 25 January 2019)

Information, photographs, and video footage

Self-propelling swimming robots and 4D design

Zurich, 15 December 2018

In 2018, researchers at ETH Zurich under the direction of Professor Kristina Shea developed a new propulsion concept for swimming robots. The 3D printed polymer robot exploits temperature fluctuations in water for propulsion without the need for an engine, propellant or power supply. Now Shea and her group explore how 4D Design from spare parts to space exploration.

While industry is still grasping with how best to exploit 3D printing in their businesses, ETH Zurich researchers in Professor Kristina Shea's Engineering Design and Computing Lab (EDAC) are already on to the next step: 4D Design. 3D printing today is revolutionizing manufacturing by increasing the complexity of shapes that can be made, reducing the cost of small volume parts, for example: spare parts, integrating parts to reduce assembly, and offering unprecedented customization and personalization capabilities. There is an even more important evolution occurring now. The functionality of 3D printed parts can increase through 4D design by using special material characteristics to create machines. Electronics, controls, heavy batteries, or conventional motors are no longer needed.

4D design exploits 3D printing and considers not only the three spatial dimensions, but in a fourth dimension - time. 3D printed "shape memory polymers" are designed and positioned in parts so that printed objects can change their shape over time and even propel themselves in response to an environmental stimulus such as a change in temperature. This is an emerging method of design.

Researchers aim to design sustainable parts that can be fully 3D printed and self-assembling - from a flat surface to a pyramid or a more complex structure. This design concept has distinct advantages:

- Less material is required due to the flat printing
- Less transport volume is needed
- No assembly is required when putting a part into operation
- No moving assemblies or parts that can jam

Rather than using conventional actuators and controls, the polymer material itself provides a similar functionality through 4D design.

4D design paves the way for applications on land, in water and in space. Structures designed so that they can be 3D printed flat and then deployed into multiple different shapes could prove useful for deploying technologies in challenging terrain on earth or on other planets. In water, a fully 3D printed swimming robot is demonstrated that requires no battery or conventional motor so that it can be used to passively monitor the environment. Finally, in space, a 3D printed, deployable solar panel is designed to be packed small during launch and then deployed into the final shape in space.

Publications/references

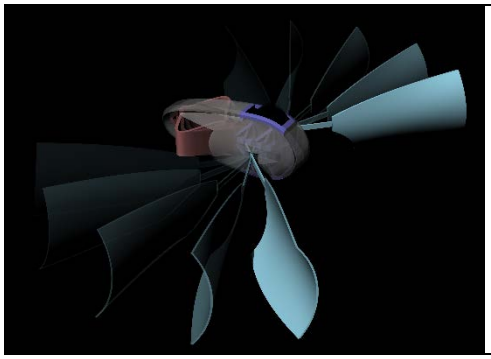
On Land: 4D Design of Deployable and Reconfigurable 3D Printed Structures
http://www.edac.ethz.ch/Research/Design-of-4D-Printed-Deployable-Active-Systems.html
[1] Chen T, Shea K, “An Autonomous Programmable Actuator and Shape Reconfigurable Structures Using Bistability and Shape Memory Polymers”, *3D Printing and Additive Manufacturing*, 5(2), 24 May 2018, doi: 10.1089/3dp.2017.0118

In Water: 4D Design of an Untethered Swimming Robot
http://www.edac.ethz.ch/Research/Designing-untethered-soft-robot.html
[3] Chen T, Bilal OR, Shea K, Daraio C, “Harnessing bistability for directional propulsion of soft, untethered robots”, PNAS, 15 May 2018, doi: 10.1073/pnas.1800386115

In Space: 4D Design of a Deployable Solar Panel
Demonstrated for the first time publicly at the ETH Zurich Pavilion in Davos during the World Economic Forum Annual Meeting 2019

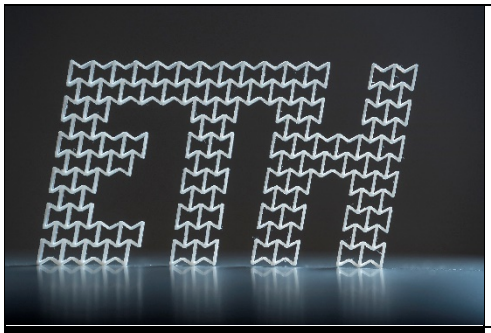
Images and video material

The following photographs and the video footage can be downloaded free of charge for non-commercial use or in news publications provided images are appropriately credited noting the copyright and photographer.



4D Design:
Visualization of a simple self-propelling mini-submarine with two paddles.

Background Information



Shape-shifting polymers
New 3D printed polymer materials morph into the 4th dimension when exposed to changes in temperature.

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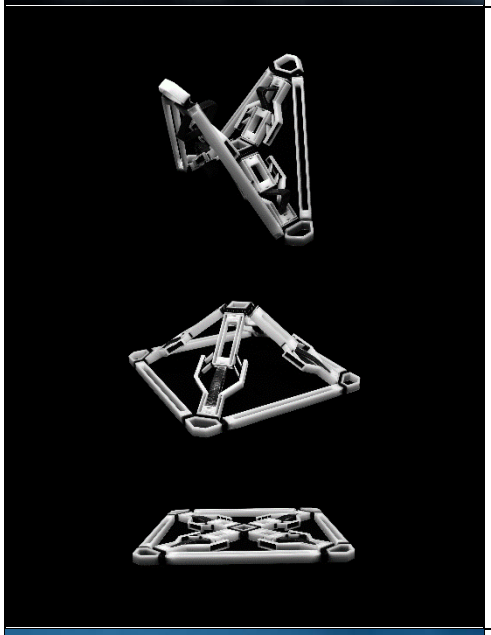

4D Design
Visualization of 4D Design structures can be 3D printed, flat, and deployed into a 3-dimensional shape.

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Video:
Motorless submarine

https://www.youtube.com/watch?time_continue=5&v=ulF1xEfCHBs

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