Shape-Shifting Origami Robotics

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This project addresses the design of shape-shifting robots, which can transform into any desired shape. A deformable robot was assembled, consisting of triangular 3D-printed flaps. The flaps are connected by servo joints, so as to create a triangular 2D mesh. This mesh follows the tetraki tiling pattern (deemed “universal creasing pattern”), which can fold into any 3D shape if the flaps are small and plentiful enough. For this, each joint is equipped with a pair of micro servos, creating a hinge that can rotate 360°. The servos move in a coordinated manner, under the control of an Arduino Uno. This is connected to a PWM Servo Driver, which distributes current and voltage so as to control 16 servos simultaneously. The coordinated movement of the hinges enables the robot to transform into target 3D shapes. For this, a computer graphics triangulation algorithm is first used to create a 3D triangle-mesh representation of the shape. An origami simulation algorithm then calculates the collision-free folding trajectories that map the 2D triangle mesh of the robot into the 3D shape mesh. These folding trajectories are converted into movement commands for the robot joints, and delivered by the Arduino. Two new Arduino libraries have been developed to easily control each of the hinges and individual servos. Several demonstrations have been developed to illustrate the countless applications and potential of this technology. While currently an eight-flap robot is implemented, the mathematics and principles can be extended to any number of triangles, enabling robots that can be specialized for countless tasks.

Awards Won:

Second Award of $2,000

Fondazione Bruno Kessler: Monsanto Award for Innovation in Plant Sciences, First Award of $2,000