Design of a Mechanical Clutch System for a Programmable Surface

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ABSTRACT

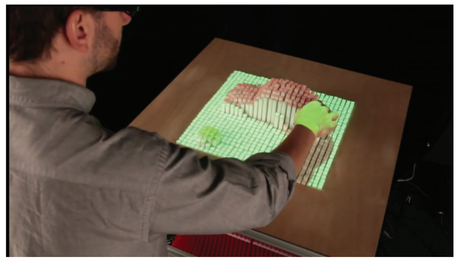
Flatfoot and cavus foot are postural issues that affect approximately 40% of people and can be corrected by means of orthotic inserts for shoes. A programmable surface is being developed as a tool for orthotists to visualize and fabricate orthotic inserts. The surface will be formed by an array of solenoid actuators controlled by the orthotist. The patient will stand on the programmable surface while the orthotist evaluates the patient's needs by manipulating the surface. Once the orthotist is satisfied with the array, the surface position will be held by a clutch system, so the patient can step off the surface and the surface positions can be recorded. This work describes my development of a prototype mechanical clutch for the programmable surface. The result of this project is a proof-of-concept design of an array of twenty-five physical clutch points which may be individually addressed by means of servo motors controlled by an Arduino microcontroller. With the development of this prototype, it is believed that such a control interface could be implemented on a system large enough for an adult human to stand on. This proof-of-concept is a small step in a larger project of developing a full-scale programmable surface by which an orthotist could create posture correcting devices.

MOTIVATION

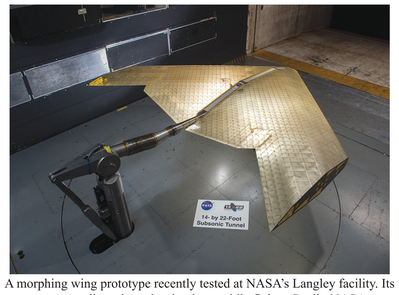
The motivation for this project is to use programmable surface technology for creating orthotic insoles for posture correction. Such a system has been developed for educational purposes and others for studying the application in manufacturing and aerospace fields. Using a programmable surface for orthotic posture correction would allow for an orthotist to educate an apprentice in the art and science of making orthotic insoles. This surface would also allow for an alternative way to manufacture orthotic insoles that is faster than conventional methods.

APPROACH

This attempt is a clean-sheet design to implement a programmable surface. A programmable surface design has been attempted before but produced a prototype system that had elements that were too bulky to be useful. Initial research into systems that would move the pins included hydraulics, pneumatics, ratcheting, and linear electrical motors. It became clear that most actuation systems would need a clutch to hold the pin elements in place when they are not being moved up and down. This portion of the project arose from that need. An initial prototype had a system of sliding bars but that did not allow the pins to move as freely as they should. An alternative design of bars that open and close like a clamshell was proposed and used in this final prototype. Servos are the mechanism of choice to demonstrate the movement of the bars as they would function in a final design.

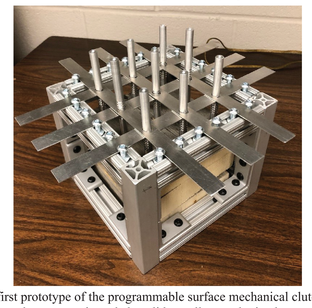


A programmable surface made in MIT's Tangible Media Lab. It is used for research and educational demonstrations. Credit: MIT

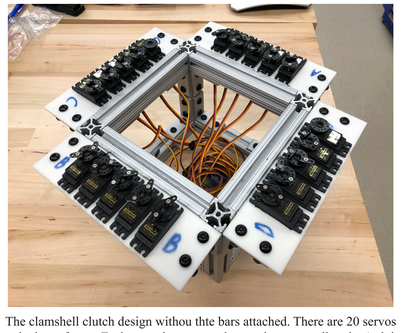


A morphing wing prototype recently tested at NASA's Langley facility. Its structure allows it to alter its shape while flying. Credit: NASA

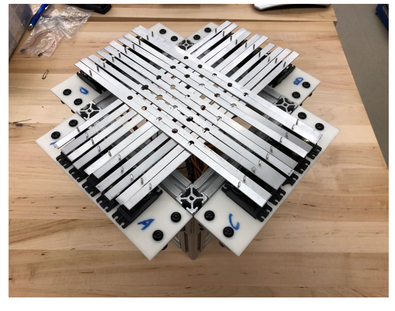
The foam mold that custom orthtoics are typically used when custom orthotics are manufactured. The programmable surface intends to replace this kind of thing with a surface that can be used over and over.



The first prototype of the programmable surface mechanical clutch system. Each bar element was intended to slide to allow each pin element to move up and down when it is desirable by the operator. This design was replaced by the clamshell clutch to allow for more free movement of the pins.



The clamshell clutch design withou thte bars attached. There are 20 servos attached to a frame. Each servo is connected to a microcrontroller, the Arduino Mega. From the Arduino, the servos' rotation is controlled.



The final prototype of the clamshell mechanicla clutch system. Each set of bars is attached to two servos, which when rotated will open and close the bar set. Each hole in the 5x5 matrix represents a pin that can be unlocked and allowed to move up or down, and then locked back in place by the clutch.

SYSTEM COMPONENTS

Components of clutch system:

- Aluminum clamshell clutch bars
- Servo motors
- T-slot frame and attachments
- Arduino Mega microcontroller
- Arduino servo shields

RESULTS

The result of this design effort is a 5x5 array of points controlled by an Arduino Mega. Each point can be addressed individually to allow for one pin at a time to be moved by the yet undeveloped solenoid actuation system.

FUTURE IMPROVEMENTS

- Upgrade to full-sized clutch system (approx. 6"x15 " per foot)
- Reduce size to allow for more pins per square inch
- Develop system to push and pull pins (in progress)
- Continue exploring alternate methods of moving and holding individual elements

A programmable surface is a surface that can be commanded to take different shapes upon input from a user through a computer. Such surfaces have been developed in experimental applications for aerospace, manufacturing, and educational environments. This project is a step towards creating a programmable surface that will be used to create insoles for people with flat feet or high foot arches to put in their shoes to correct their posture.