ME-410: Mechanical Design
Product & Development

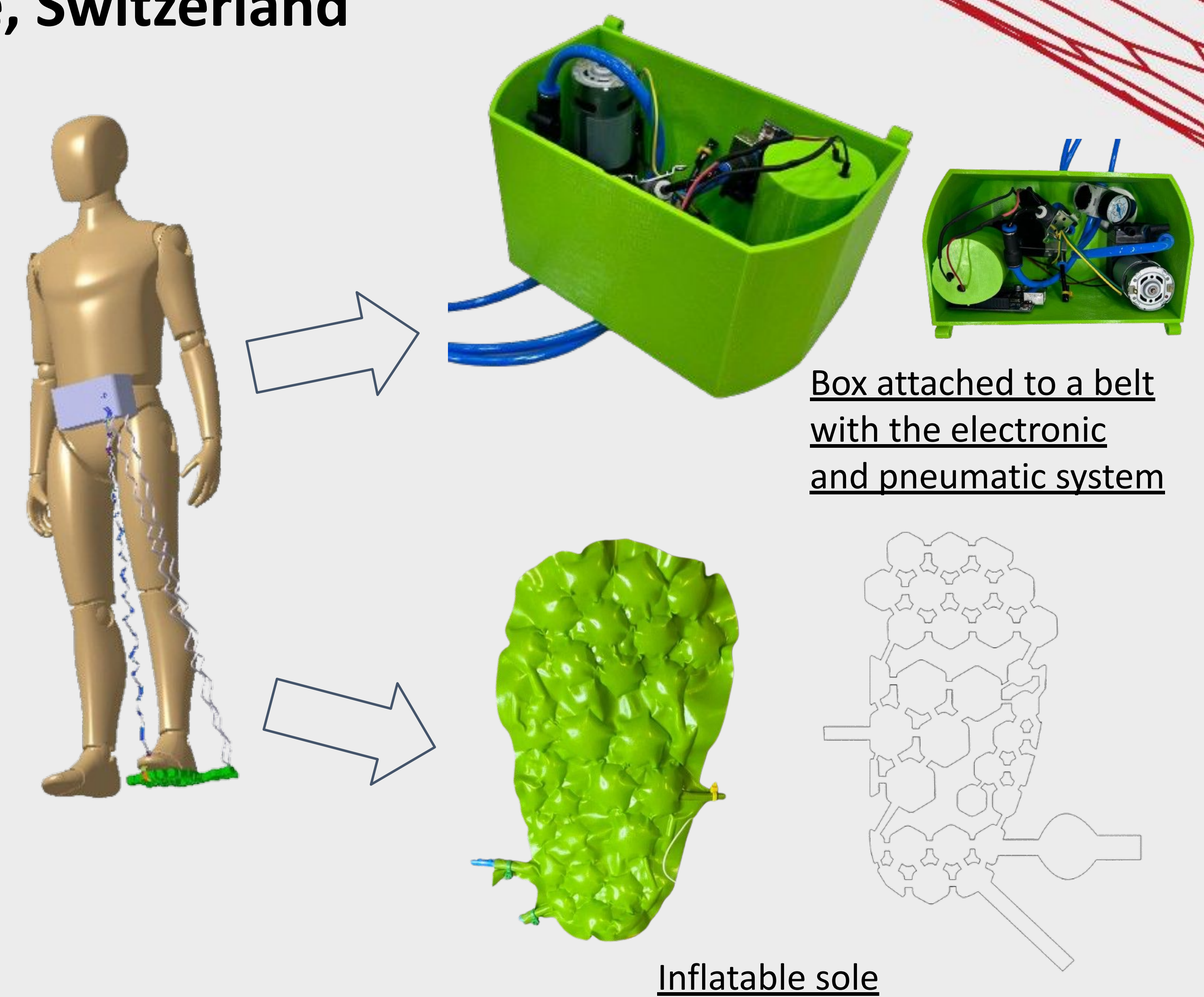
Sally the soft sole

Max Aebi, Nina Bodenstab, Charles Froessel, Marine Moutarlier, Ambre Sassi

Reconfigurable Robotics Lab, EPFL, Lausanne, Switzerland

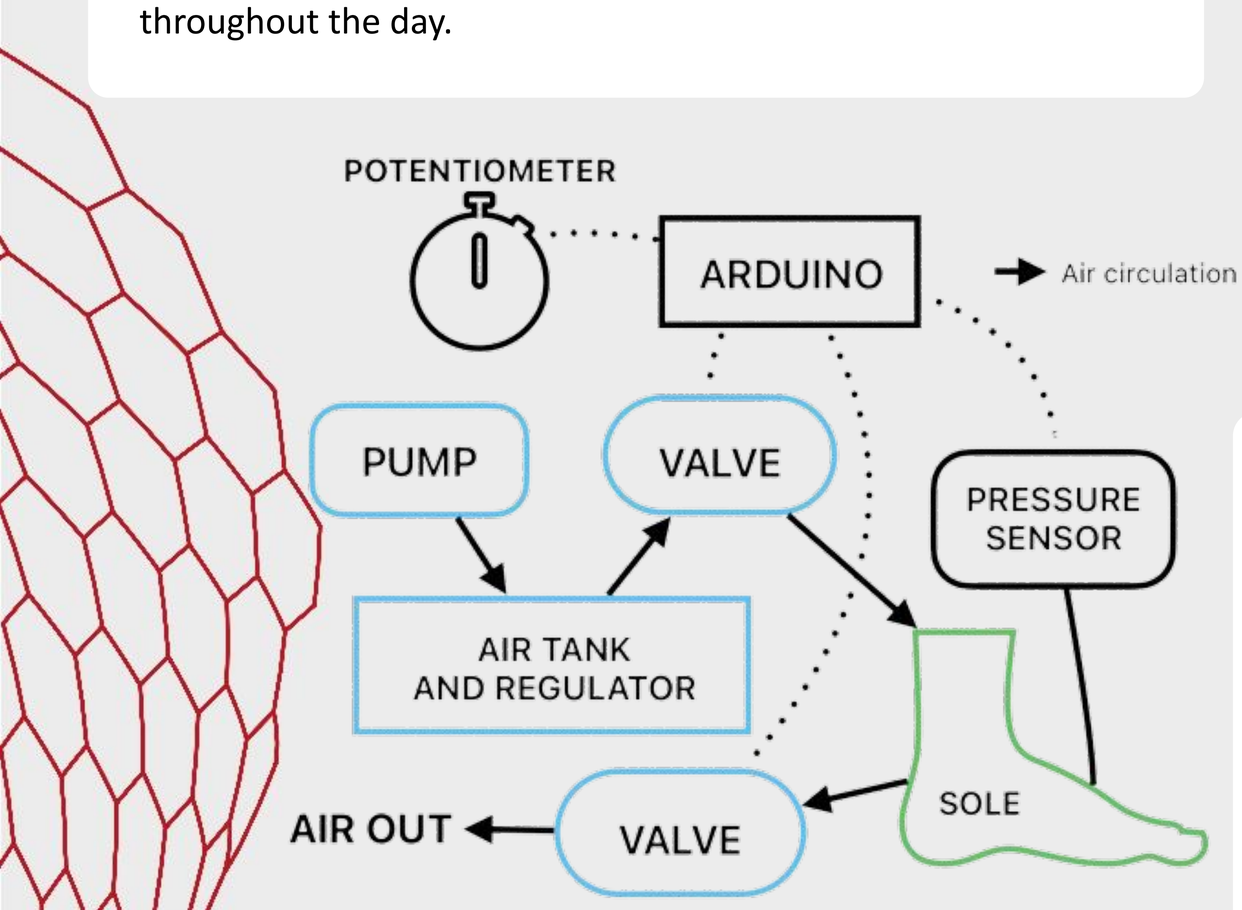
Motivation

The innovative sole design is tailored to address common discomfort and pain during extended walking, daily activities, or prolonged standing, with versatile applications including alleviating conditions like edema. A key feature is the ability for the sole to gracefully **inflate and deflate according to the user's preferences**. By incorporating **customizable inflatable patches**, we offer a tailored foot massage experience, promoting better blood circulation. Designed for everyone, our sole ensures a rejuvenating and soothing experience, enabling comfort throughout the day.



Box attached to a belt with the electronic and pneumatic system

Inflatable sole



Design

Sole: The sole is designed such that the resolution and size of the patches vary depending on the location of the foot. Doing this ensures adapted pressure to the sensitive areas, as well as deformation with respect to the natural shape of the foot.

Pneumatic and Actuation: A pump, an air tank, a mechanical pressure regulator, two solenoid valves, and the sole are what make up our system. The valves are opened - closed, increasing - decreasing the pressure felt by the user. The bulk of the system is attached to any belt, worn by the user.

Control and Sensing systems: A P controller is used to control the opening and closing of the valves, allowing air flow in and out of the sole. The real-time pressure is obtained by a pressure sensor placed inside the sole. The desired pressure can be set using a potentiometer.

State-of-the-art

InflaSole is a similar sole existing on the market. As it's name indicates, it inflates at the bottom of one's foot offering a comfortable sole. It uses a miniature air-pump and valves to allow manual pressure adjustment. *Inflasole*™ mainly aims to absorb shock and reduce skeletal tension, hence its popularity with athletes and people suffering heel spurs.

FlowIO is pneumatic integrated system that fits into a hand and allows to reach a pressure of 2 bar and offers 5 programmable input/output valves. This device offers the same functionality of our pneumatic system, but is significantly smaller and more compact. However, the product is still in development, and not yet commercialized. It is not yet implemented for foot massage applications yet either.

Performance

Category	Max pressure inside sole	Height deformation of patches
Target	1 bar	1.5 cm
Measured mean	0.68 bars	1.4 cm

System reactivity

The minimum cycle period is 75ms.
Below can be seen the measured pressure, desired pressure, in and out solenoids.

Summary and Future Development

Our system works well and has fast response times. The project is tailored for universal adaptability. Utilizing a user-friendly potentiometer, users can achieve precise pressure adjustments, ensuring optimal performance. The further customization of the sole extends to accommodate diverse foot sizes and shapes, providing tailored solutions. Future developments also envision plug-and-play interchangeability of sole sizes and enhancements in specific inflation regions for a refined sensory impact.

References:

Ref #1 “ADJUSTABLE COMFORT INSOLES - Just Pump-It-Up!”, 2011, *InflaSole,* https://www™.inflasole.com/index.html

Ref #2 “FlowIO”, *FlowIO Platform,* 2021, FlowIO Development Platform, https://www.softrobotics.io