ME-410

Jamie Paik

Reconfigurable Robotics Laboratory

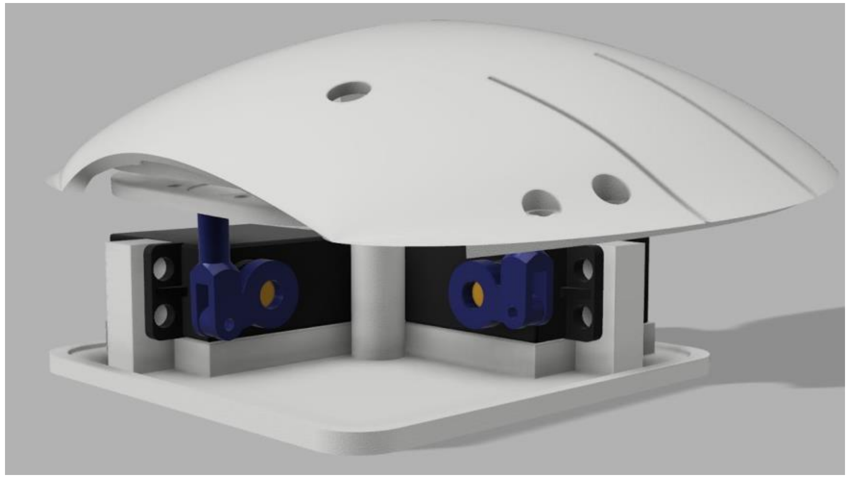
EPFL, Switzerland


SUSHIZEN
0:00:10
GENÈVE
EPFL

Projects from Last Year

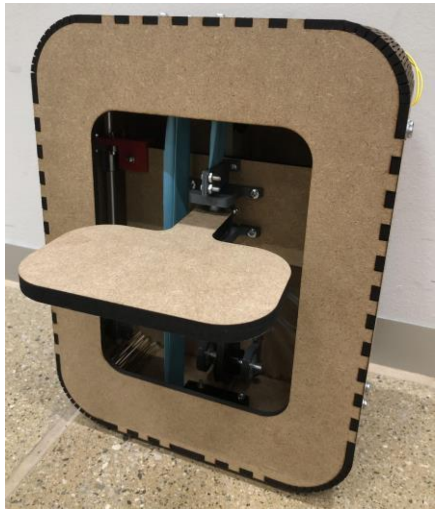
Group 1: The Mouse, Revolutionised

A tilting mouse, whose movements get amplified and controlled by a set of motors, so as to make it less tiring for the user and permit feedback. A mouse has never been so comfortable. The future. In your hand.



Group 2: Auto-Stabilized Baby Carrier

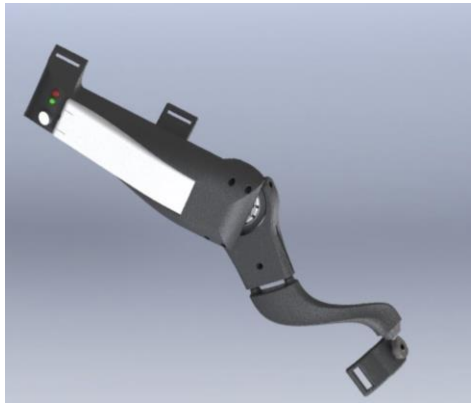
A baby carrier backpack stabilized with accelerometers and a motor to lower strains on the parent's back and comfort for the baby.



Projects from Last Year

Group 3: Synchrowing

Active knee orthosis to synchronize rowing crew members using haptic feedback. Optimize your team's rowing performance with muscle memory.



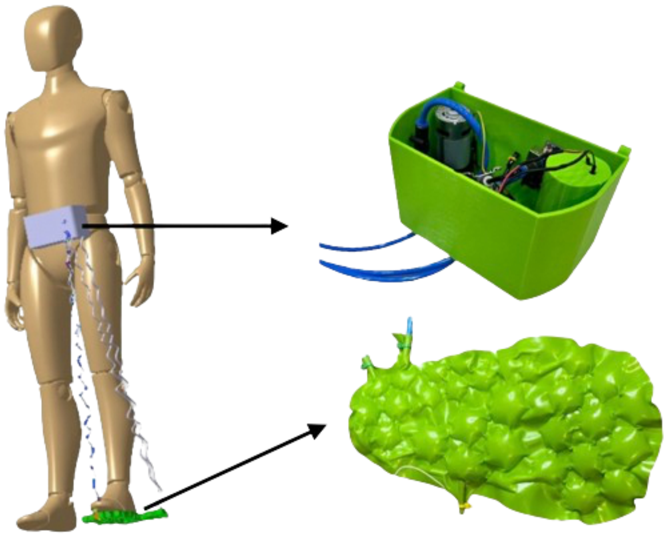
Group 4: Titi the Hugging Monkey

Want a friend that is always there for you? Titi the hugging monkey's pressure activated soft hugs are what you need.

Projects from Last Year

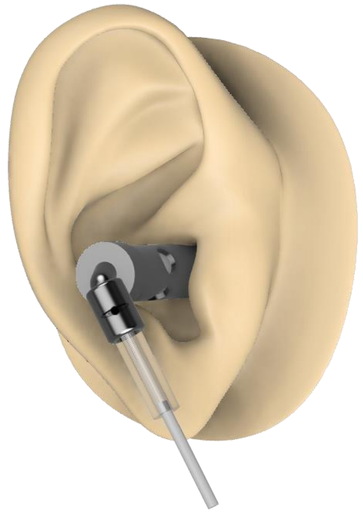
Group 5: Sally the Soft Sole

Sally presents an innovative self-inflating soft robotic sole. It offers a personalized foot massage experience with adjustable pressure settings for optimal comfort.



Group 6: Smart Mechanical Noise-Limiting Device

This invention represents an encouraging step towards a quieter world and greater inclusion of this disability in society.



Clear statements

- Problem
  - is it a real problem?
  - does it need to be automated? does it need to be sensed/ actuated? (folding chair)
  - Is it realistic problem
- State of the art
  - What exists? What's missing?
  - Does a solution exist? Is it too simple? Why does it not exist ?
- Solutions
  - Could the developed technology transfer for other applications? (weight lifting belt vs posture correction, adjusting hiking boots vs workout pads?)

metrics

- How easy is it to create a benchmark for measuring problem conditions (visor hat, snood, shoelace)
- Create solution that can be measured.
- If there were to be a 2,3 rd version of the design, what would be optimized (why not materials, costs, weight?... What is a robust design?)

Group 1 “CROCS” Comfortable Rapidly Automated Closing Shoes

Kilian Scheiwiller, Vincent Philippoz, Baptiste Ranglaret, Alexis Faucheur, Arthur Salamin

Motivation

Back pain prevents people from bending down and tying their shoes. Older people may lack dexterity and experience difficulty tying laces properly, which can cause foot pain and blisters. Therefore, students designed an automated and comfortable shoe that could easily be put on and off without using hands.

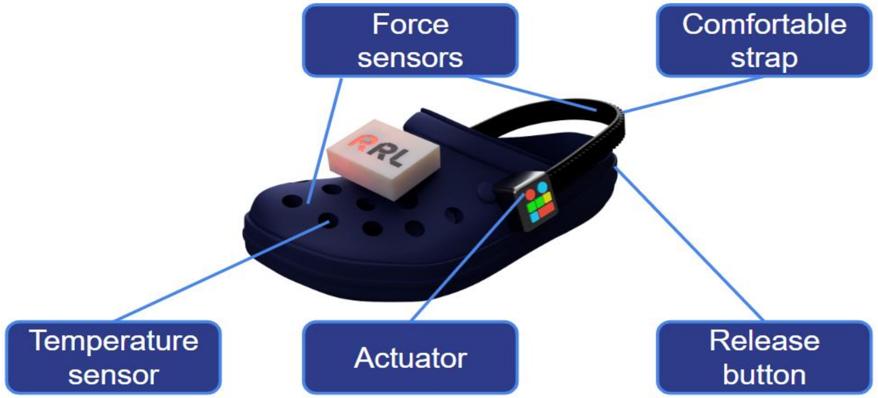


Fig. 1 System physical overall

Engineering Specification	Solution
Range of motion [°]	2*180 = 360
Actuator torque [mNm]	2*170 = 340
Speed [rpm]	80
Control method	Internal
Holding torque	Yes
Weight [g]	2*12,5 = 25
Center of mass	On axis

Fig. 2 Design specifications

Design

The mechanism of the prototype is composed of a 3D printed flexible strap that closes and adapts to the user’s foot using a pinion gear mechanism. The actuation is handled by 2 servomotors, one on each side of the shoe. 2 pressure sensors are used to automatically trigger the closing and detect when the shoe is nicely tightened. Another metric is the foot temperature, if low the shoe is too tight, if high the shoe is not tight enough.

Group 1 “CROCS” Comfortable Rapidly Automated Closing Shoes

Performance

The overall closing time of about 1 second, with a total displacement of the strap of 4 cm. The closing force measured is 65N, which is more than enough for a comfortable shoe. The product weighs 380g, making the shoe as heavy as a classical one. In Fig 3, The relationship between strap position and pressure variation over time is shown.

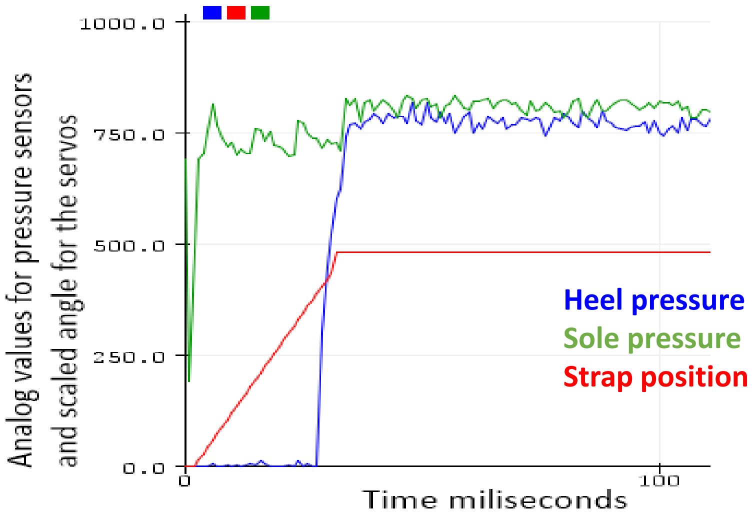


Fig. 3 The perssure when tightening of the show when closing

Gif. 1 System dynamic GIF display

Summary

The Comfortable Rapidly automated Closing Shoe is a prototype that provides a perfect fit for the user’s feet. It proves that automatic and comfortable shoes are possible. They are easily put on and off without using the hand and continuously adapt the tightening force based on the pressure and temperature readings. Moreover, the CROCS provides additional features, such as a step counter and a pace measure, that allow for some characterization of the wearer’s gait.

Group 2 “MSRA” Mixologist Supernumerary Robotic Arm

Barini Ramos Joao, Bejjani Joseph, Blanc Viviane, Garrabos Pierre, Lechartier Alexandre

Motivation

The project aims at helping people requiring additional capacity in upper limb motion who could experience major obstacles in modern society. In order to assess this problem, it is important to consider which activities are to be mimicked/assisted by the wearable device.

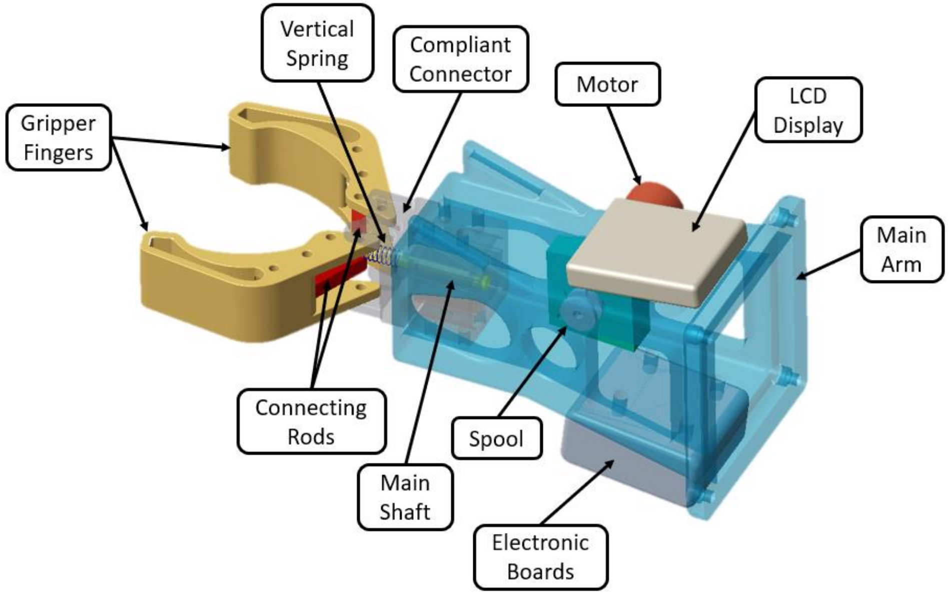


Fig. 1 System overall

Fig. 2 Robotic Arm Wearing Demo

Design

Mechanical and Actuation Systems

The gripper is kept open by use of a spring while the motor is responsible for its closing. In order to convert the motor torque into gripping force between the claws, a cable driven mechanism is used The gripper is mounted on a rigid arm, itself attached to the user’s body using a custom made chest mount Compliance of the gripper is achieved by adding serpentine structures and foam in the wrist.

Group 2 “MSRA” Mixologist Supernumerary Robotic Arm

Design

Control and Sensing Systems

A PD controller based on EMG sensors (convert muscle contraction into a signal) is used to precisely regulate the movement of the clamp Not for that one to crunch the object, it has current sensors that return a force limit.

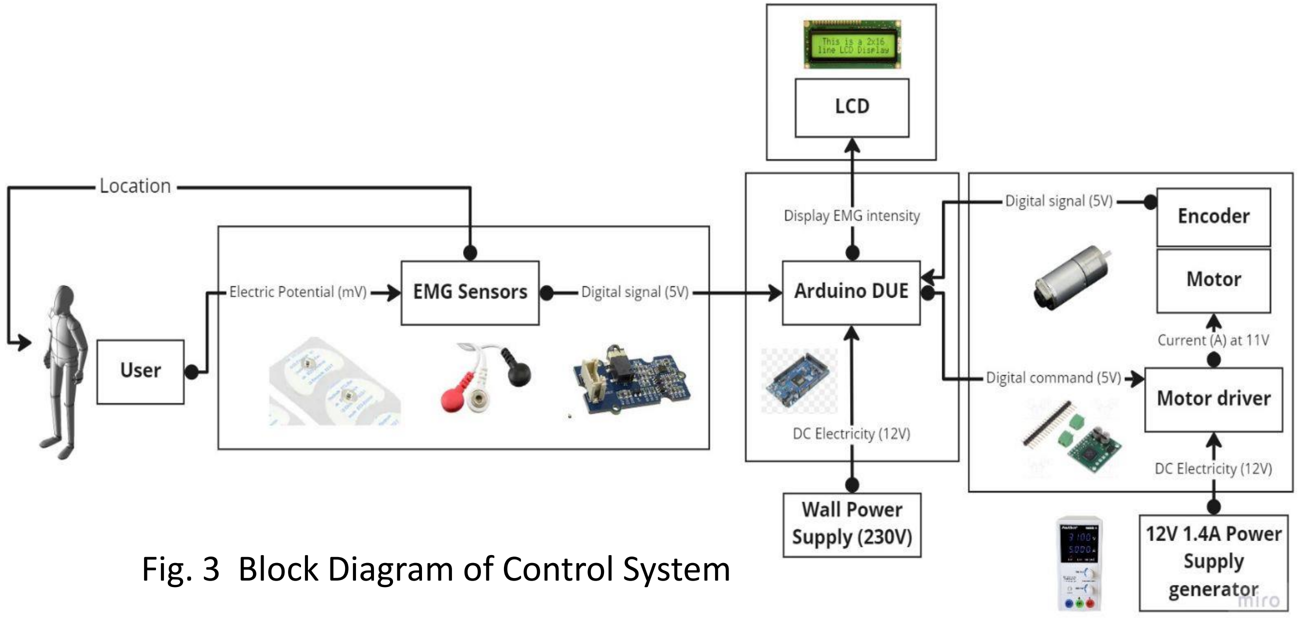


Fig. 3 Block Diagram of Control System

Efficient Grabbing	
- Max/Min cylindrical object grasping	75 mm 30 mm
- Maximum closing force	55 N
- Gripper CoF on grasped material	0.9
- Max Payload	1500 g
Control	
- Number of EMGs needed	2
- Cycle time	14s

Fig. 4 Performance Analysis

Summary

The design is computationally justifiable, affordable, and fits within our engineering specifications. They were able to reach a fully EMG-controlled robotic arm that is operated by the user’s muscles. We proved that our model could be applied to accomplish everyday tasks, and we take bartending as an aspecific example to showcase our proof of concept.

Group 3 Keep Focus: Aoto-focusing Magifying Ocular

Nathan Decurnex, Michael Richter, Erik Mortenson, Nicolas Nouel, Renata Osypova

Motivation

In order to improve efficiency and comfort of precise manual work, such as watchmaking and surgery, we provide a wearable zoom ocular that automatically and rapidly adjusts its focus on the task of interest. In order to achieve this with a wearable device, we established an absolute mapping between the distance to the target and the focal positioning.

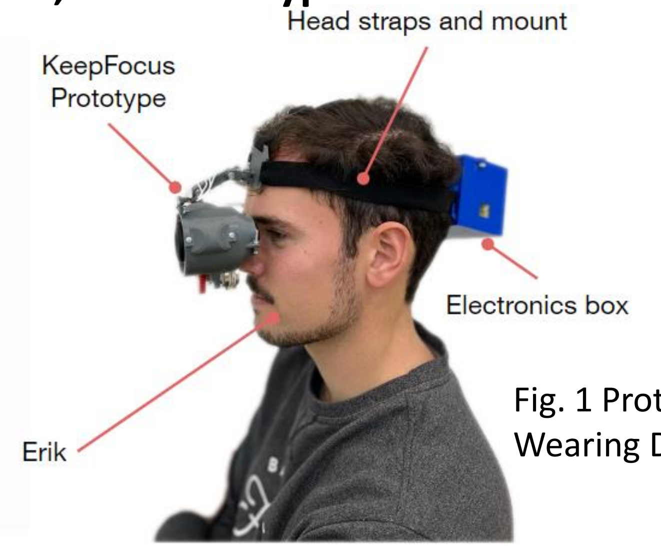


Fig. 1 Prototype Wearing Demo

Design

Actuation: To achieve a precise open-loop position tracking a well as a high torque output, we chose a stepper motor directly connected to a gearbox. A pseudo open-loop controller links directly the measured distance to a rotational tracking reference.

Sensing: To obtain a precise absolute distance measurement on a small field-of-view we decided to use a laser time-of-flight sensor.

Mechanical integration: To accommodate for the two linked degrees of freedom of the monocular, a sliding gear system was adopted. A large gear surrounds the monocular while a smaller one is attached to the motor shaft. When the optical element rotates, it also translates. The gears slide against each other to allow this movement.

Gif. 1 System assembly demonstration gif

Group 3 Keep Focus: Aoto-focusing Magifying Ocular

Working Principle

The link between the distance measured was establish by the time-of flight sensor and the position of the motor. First, we send the values from the time-of-flight sensor to the Arduino, which would then integrate them into its control algorithm. Based on these values, the Arduino would decide the position of the motor and send the corresponding commands to the motor driver. The motor driver would decode these commands and instruct the motor to move accordingly.

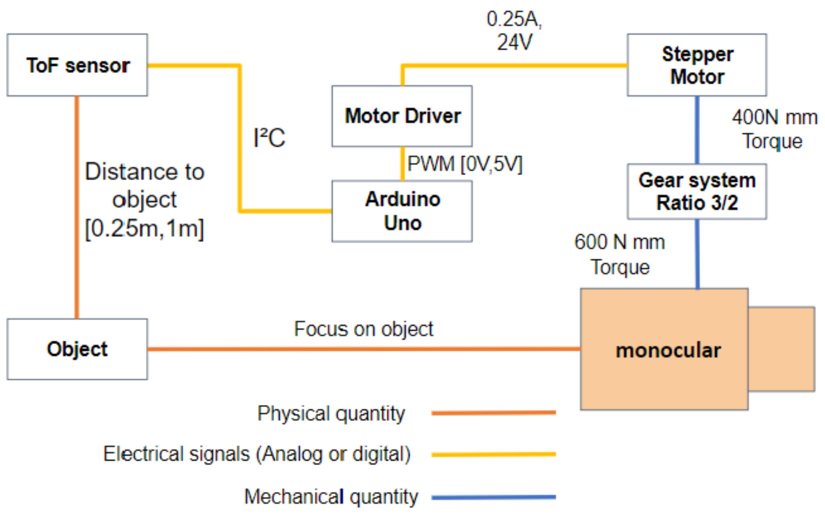


Fig. 3 Working Principle: Condensed Version

Performance

The achieved range of sensing is 25cm to 1m which translate into a 720° turning angle of the ocular out of 1080°. This means that we can currently only focus on objects at this range of distance and we do not exploit the full potential of our ocular especially for long range. The precision of the device is less than 3.5° and is essentially limited by the time of flight sensor, not by the stepper motor or the gear box. The bandwidth of our device is around 50 cm/s. It is this time mainly limited by the stepper motor speed but is acceptable.

Engineering specifications	Values
Range of focus	10cm - 2m
Resolution	<5cm
FOV	$<15°$
Motor torque	367 mNm
Ocular range of motion	1080°
Motor resolution	step angle $<5°$
Focusing speed	>20 cm/s
Price	<300CHF

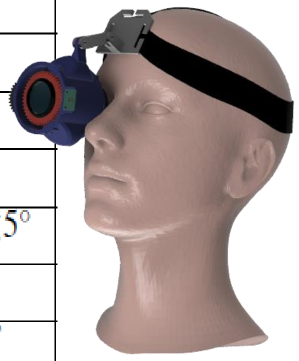


Fig. 2 Table of the Engineering Specifications

Summary

Our functional prototype proved that implementing active autofocus strategies on wearable devices is possible. Through our demo scenario, we achieved performances that meet precision work requirements. Especially, the achieved focusing speed and resolution of focus meet user requirements.

Group 4 FootLoose ? FootFound

Daniel Bakker, Benjamin Colety, Hugo Penichou, James Ziadeh

Fig. 2 FootFound worn by a teammember

Motivation

Drop foot is a symptom which can be caused by an assortment of different nervous system complications. A sufferer of drop foot loses feeling in their foot and often in parts of their lower leg, making it difficult to raise the front of the foot. Without surgery to repair the nerve or a splint to hold the front of the foot up as they walk, the afflicted drag their foot as they walk, causing frequent tripping. In order to walk more naturally, users should not only be provided with support for their foot, but also feedback about how they are putting pressure on the affected foot.

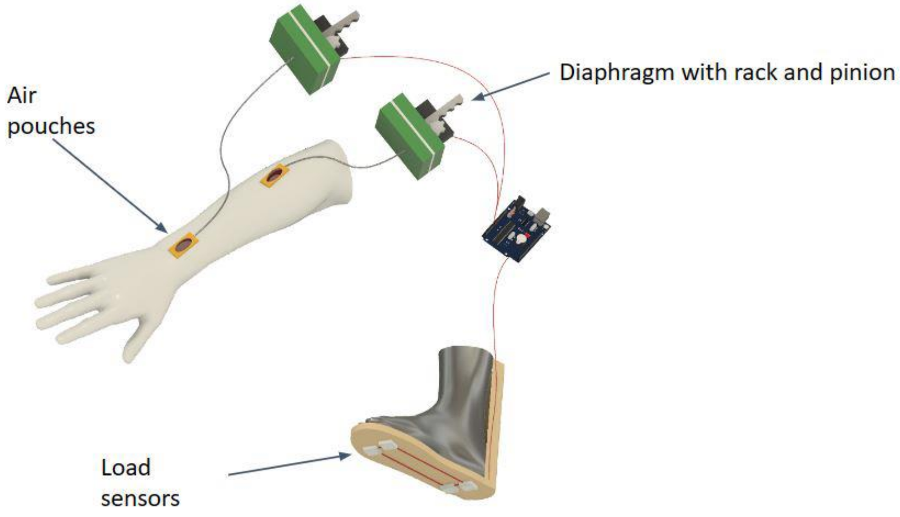


Fig. 1 System overall

Design

The system is separated in 3 different subsystems:

● The **splint**, located under the user's foot, contains load cells, which sense the pressure applied by the user on the ground.

● The **diaphragm** consists of a silicone membrane moved to displace air. The membrane is deformed by a rack and pinion, and it receives information from the **load cells** to determine the displacement required.

● **Feedback bracelets** are placed on the user's forearm. When the integrated balloons inflate, they apply pressure on the arm proportional to the pressure being applied on the foot. The balloons are driven by the diaphragm.

Group 4 FootLoose ? FootFound

Performance

Sensor response: In order to senss the position of the foot, four load cells are placed on the splint. Two load cells are placed in pair on the front of the splint, and two load cells in pair on the rear of the splint. Firstly, the response of these load cells was measured, by walking with the splint at a normal walking pace.

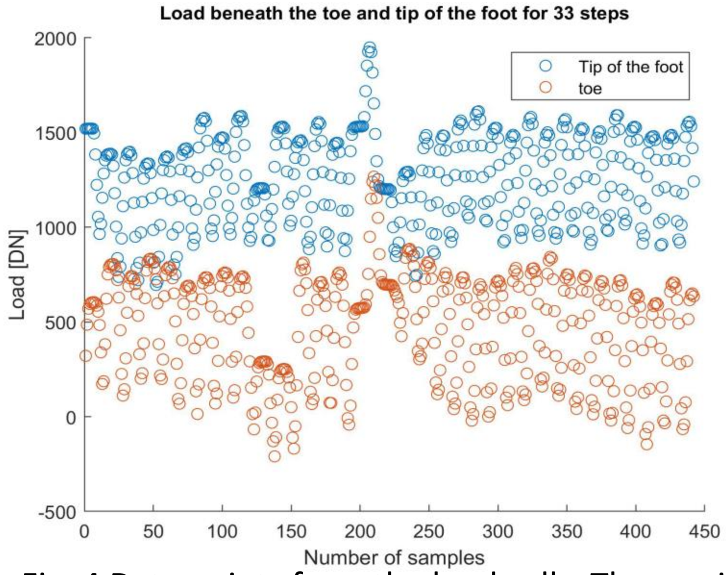


Fig. 4 Data points from the load cells. The x-axis is the number of samples, the y-axis is the load from the sensors

	Target	Measured
Response time	200 [ms]	152 [ms] inflation, 90 [ms] deflation
Peak output pressure	6 [kPa]	3 - 5 [kPa]
Input sensitivity	10 [mV/N]	12 [mV/N]
Feedback sensitivity	10 [mN/N]	12 [mN/N]

Fig. 3 Table of the Engineering Specifications

System response: In order to mesure the actual time needed for the system to react to an actual step applied by the user we placed FSR sensors on the air pouches. Compared to the sampling rate of the load cells, the measurement of the FSR sensors is very fast, around a dozen of microseconds, so we estimated that that our devices took 152ms to inflate the pouches once a step was detected and around 90ms to deflate. The engineering specification required a maximun delay of 200ms which was beat by our prototype. When walking we couldn't feel any delay.

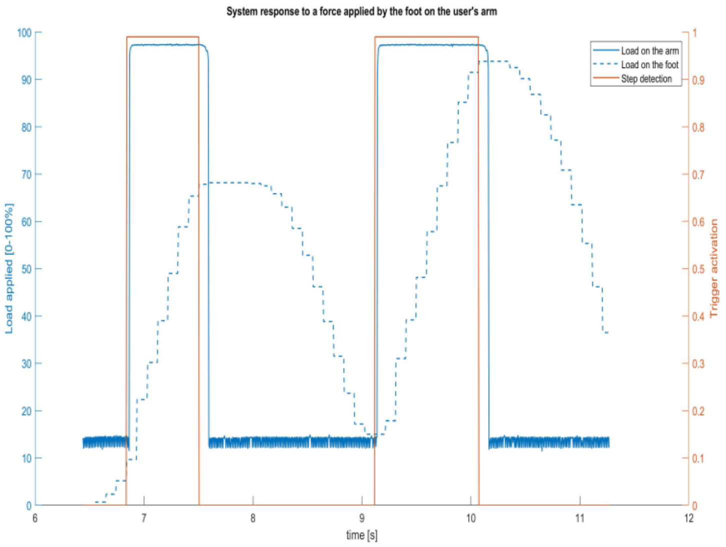


Fig. 5 Response of the complete system

Summary

Footfeel allows a user to regain the feeling of walking through another part of their body that still has feeling. We see that this novel form of sensory feedback could be applied to remap feeling from other parts of the body suffering nerve damage, teleoperation robotics as force feedback, or advanced sensory experiences in entertainment contexts (4DX movies).

Group 5 Manumatic Bike

Karim Zahra, Adrien Chevallier, Pierre-Jean Renaud, Jules Sachot-Durette, Hugo Witz

Motivation

Improper gear placement affects cyclists' bioenergetic efficiency and optimal speed. It triggers fatigue, hinders cruising enjoyment and leads to accidents. Choosing the right gearing is crucial. However, the availability of a wide range of options makes it difficult and frustrating. Our main motivation is to provide cyclists with assistance and automation possibilities to help them optimize their cycling cadence efficiency by choosing the right gear for each moment.

Fig. 1 System overall

Design

The system is divided into different subsystems :

- **Sensory system:** Measures cadence speed with a Hall effect sensor as a binary switch installed at the bicycle's crank arm. The linear potentiometer detects the gear position at each moment.
- **Actuation system:** Converts the rotary motion of the servomotor to linear motion by pulling a string connected the levers. This string pulls the levers sideways moving chains up and down.
- **Control system:** Takes sensory system's signals as inputs and outputs appropriate actuations commands with a control board.
- **Graphical interface:** Allows real time visualization of cadence speed and shifting mode with an LCD.

Fig. 2 Live view of system

Group 5 Manumatic Bike

Performance

This proof of concept meets the engineering specifications except for our cadence accuracy. The former can be improved by filtering noise and installing multiple magnets at the bicycle crank, thereby increasing our cadence update frequency.

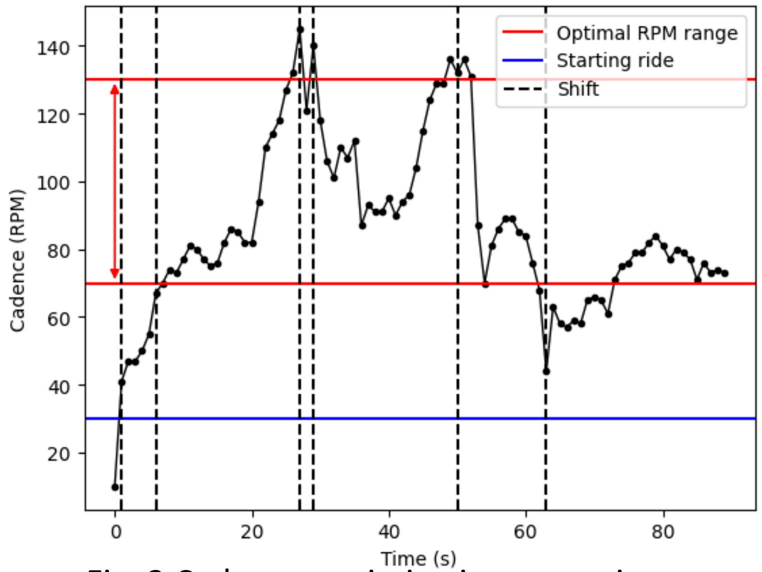


Fig. 3 Cadence optimisation test using Manumatic bike automatic shifting

Specifications	Values	Results
Cadence accuracy	±1 RPM or 0.05%	±10 RPM or 0.5%
Range of motion	> 1.4 Nm	> 1.5 Nm
Response time	< 1s	< 1s

Fig. 4 Table of Engineering specifications

Summary

These promising results demonstrate the technical feasibility of project. This serves as a proof of concept for a fully integrable technology into any road bike with handlebars. Our unique technology constantly tracks cadence and offer cyclists the possibility to always stay in the right gear. this new technology will enhance cruising enjoyment with a consistent effort decided by the rider. For high level cyclists, It could serve for training purposes, like cadence drills to rehearse movement patterns and develop efficiency.

Group 6 "SAFE" Secured Ascent For Emergency

L'Herminé Sandra, Meebed Omar, Nones Roan, Zribi Elyes, Jacquart Sylvain

Motivation

Underwater diving is a leisure activity which unfortunately comports hazards. In the USA and Canada alone, around 4 for 100'000 divers die each year under water. Diving-related injuries, such as decompression illness, affect also 3 per 10'000 individuals, and increases amongst commercial divers to 10 per 10'000 people. Decompression illness can have irreversible effects on the brain and the nervous system. The goal of this project is to automate the divers' ascent mostly in case of emergency, and execute diving stops which consist in stabilizing at reference water depth.

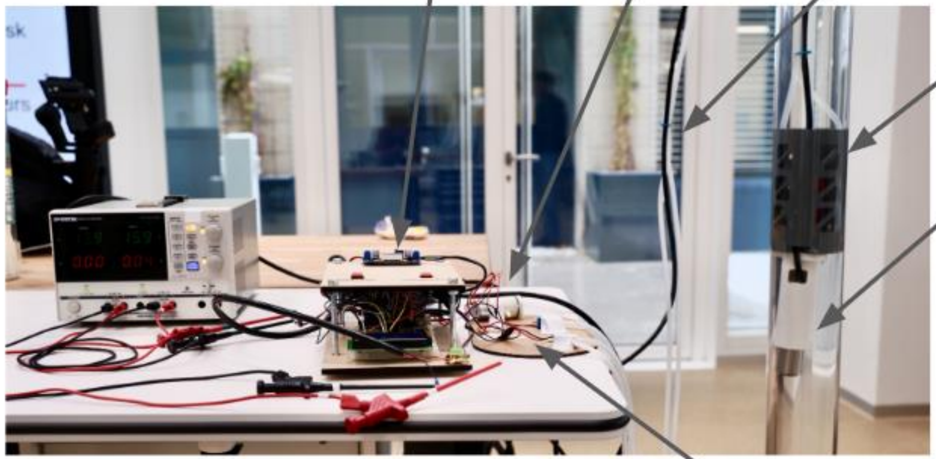


Fig. 1 System overall

Design

The design of SAFE relies on buoyancy control. By increasing or decreasing the volume of an airbag, the buoyancy can vary accordingly. The airbag is filled with air from an air reservoir, and the flow is controlled with two valves (one inlet and one outlet). To stabilize the diver, information on the diver's height is required, which is measured by a pressure sensor recording underwater pressure. From this measurement, it becomes possible to determine the current depth of the diver. The control valves can then follow a preset trajectory, to ensure enough decompression time according to diving regulations.

Metric	Prototype	Demonstrator
Allowed Depth	> 40m	1.5m
Tracking Precision	< 1m	< 2cm
Inflation Time	< 30s	< 30s
Stabilization of Position	± 0.5m	± 1cm

Fig. 2 Design specifications

Group 6 “SAFE” Secured Ascent For Emergency

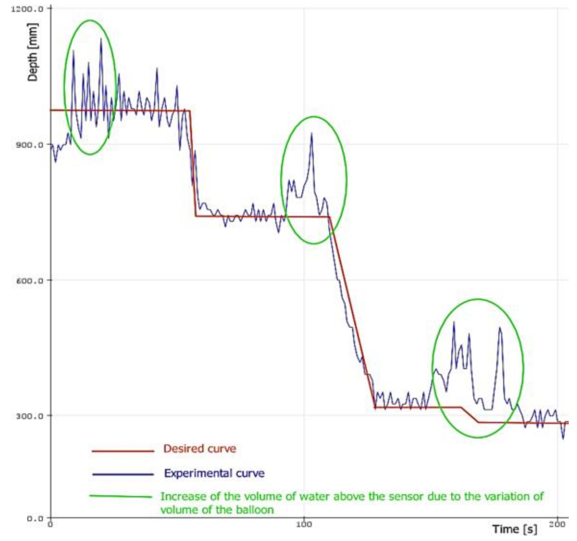


Fig. 3 SAFE prototype: results obtained with the prototype. Depth [mm] is measured every 0.5 seconds (100 corresponds to 50 seconds)

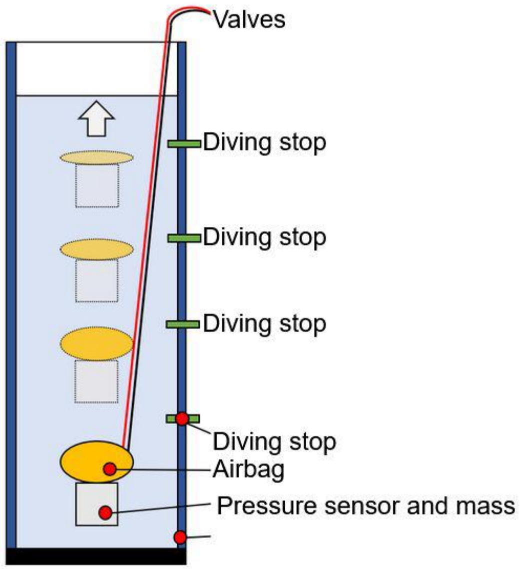


Fig. 4 Experiment schematic

Performance

The performance of this product relies on three essential criterias: an accurate measure of current depth, the speed of inflation and deflation of the airbag, as well as the oscillation amplitude during stabilization at a certain height. Our prototype can measure height with an uncertainty of 2mm, the inflation of the airbag from empty to supplying sufficient buoyancy for vertical ascent is 20s. The deflation time to empty the airbag takes up to 5s, while oscillation at stability is 5mm.

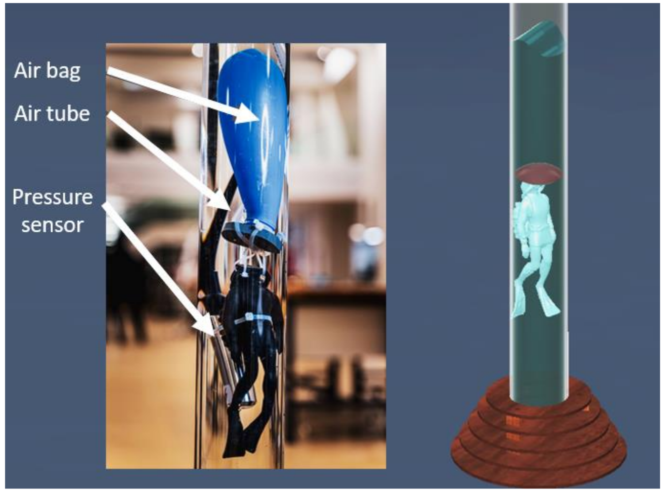


Fig. 5 SAFE system: CAD design and real demo

Summary

The SAFE system is a valuable tool for scuba divers to ensure their safety during deep dives. It is different from traditional diving buoys because it can automatically ascend and respect decompression stops. The prototype of the SAFE system has shown promising results in terms of ascent speed and trajectory tracking.