

Week 9

Prof. Jamie Paik

Dr. Yuhao Jiang

Reconfigurable Robotics Laboratory

EPFL, Switzerland

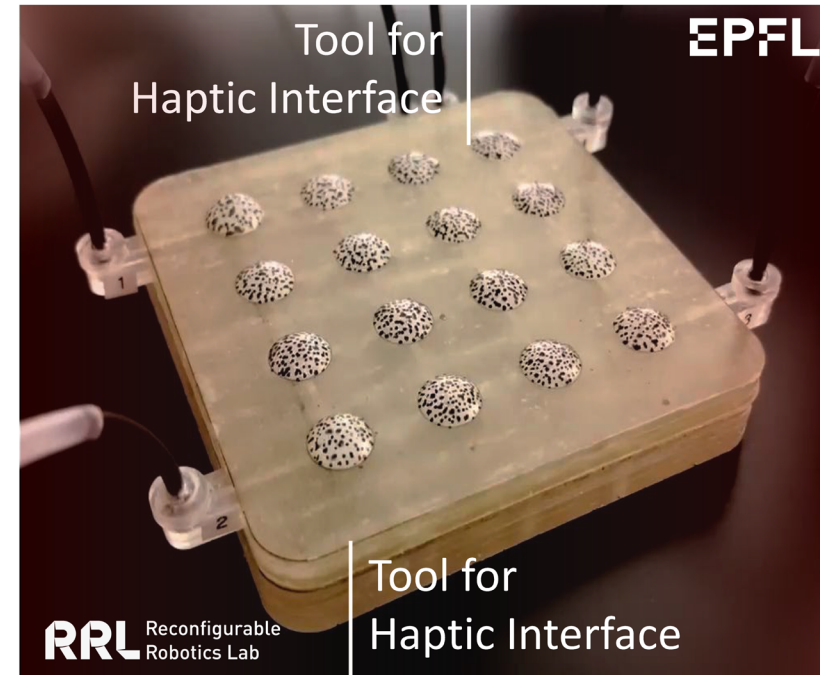
Announcement

Upcoming Important Dates:

- Flyer and poster: submit to Moodle (in ppt), due **Nov. 21**;
- Final poster: due **Nov. 29** (sent for print);
- Invitation is live online: <https://www.paikslab.com/courses>

- Project Title
- Member Names
- Brief Introduction
- QR code: not needed, we will add them and share with you
- We will have this printed

ME-410: Mechanical Product Design and Development



Group #:[Title]

[Member Names]

[Intro]



- Submit to Moodle by **Nov. 21** for review
- Send to Repro by **Nov. 29**
 - We will pay for the print
 - Leave you group name, indicate course name and RRL for invoice;
 - Busy time, plan ahead;
 - Indoor use, standard paper;
 - Size: A0

ME-410: Mechanical Design Product & Development

RRL Reconfigurable
Robotics Lab

RRL

MSRA: Mixologist Supernumerary Robotic Arm

Viviane BLANC, Joseph BEJJANI, Pierre GARRABOS,
Alexandre LECHARTIER, Joao BARINI RAMOS
École polytechnique fédérale de Lausanne (EPFL), Lausanne, Switzerland

Motivation

Due to a lack of independence, disabled people to manual workers are often excluded from numberless activities or further achievements. For them, we developed a supernumerary arm capable of holding different objects of various weight and size which is also easy to use.

For a proof of concept, we consider an application for bartending, allowing people with reduced upper limb mobility to still enjoy the wonderful thrill of being a mixologist. This is used as a specific case study for the general idea of object grasping to increase independence and capacity.

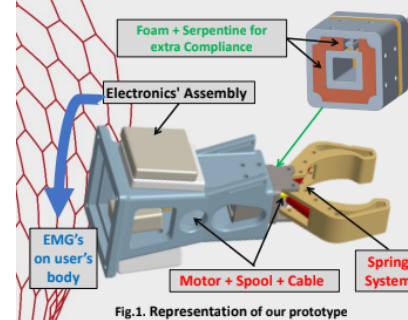


Fig.1. Representation of our prototype

State-of-the-art

Supernumerary Robotic Arms are already well documented and established. Reconfigurable and haptic surfaces are also used in this domain. Existing solutions for operational help usually target a specific goal and are not suitable for everyday use. Also, those already using electromyograph (EMG) for disabilities often aim at permanent injuries.

An EMG controlled Supernumerary Robotic Arm which does not require a full limb to be operated, and which is cheap and easily accessible is a yet **unexplored engineering art state**.

Summary and Future Development

We have shown that our technology works well. We were able to grasp different objects, controlling the gripper by muscle contraction. The device having only one degree of freedom, a restricted set of activities can be performed, which gives a substantial potential for improvement ! The next step is to avoid spilling the content of a glass by stabilization, hence, the need for more degrees of freedom. New actuators and new sensors must be added to reach a better manipulation angles with the wrist and to change the arm length. Further development is promising !

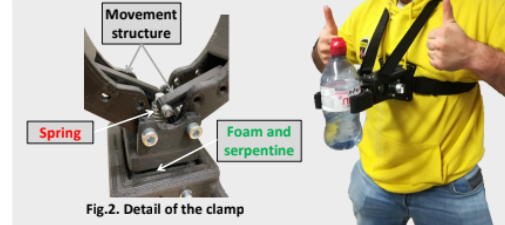


Fig.2. Detail of the clamp

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.

Control and Sensing Systems

A PD controller based on **EMG sensors** (Electromyography, 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.

Performances

The main metrics are the carried mass and the cycle time (grasp and discharge). To assess performances the metrics were divided into three categories: **Grabbing mechanism**, **Control mechanism** and **Wearability**.

	Object			Control		Ease of use
	Weight [g]	Max Size [mm]	Min Size [mm]	Cycle Time [s]	Nb of used muscles	Dressed with one arm ?
Goal	2000	110	50	4	1	Yes
Theory	2740	90	50	5-7	2	Pending
Trial 1	1644	80	60	7-9	2	Yes
Trial 2	1744	85	55	7-9	2	Yes

Tab. 1. MSRA metrics comparison and proof of concept

EPFL

Ref: [1] A. S. Ciullo, M. G. Catalano, A. Bicchi, and A. Ajoudani, "A Supernumerary Soft Robotic Limb for Reducing Hand-Arm Vibration Syndromes Risks," (in English), Frontiers in Robotics and AI, Original Research vol. 8, 2021-August-17 2021, doi: 10.3389/frobt.2021.650613.
[2] D. Leonardis et al., "An EMG-Controlled Robotic Hand Exoskeleton for Bilateral Rehabilitation," in IEEE Transactions on Haptics, vol. 8, no. 2, pp. 140-151, 1 April-June 2015, doi: 10.1109/TOH.2015.2417570
[3] Mustafa Mete, Super Bartender, Reconfigurable Robotic Laboratory, Ecole Polytechnique Fédérale de Lausanne, September 2022

- **Motivation**
 - Problem definition;
- **State of the art**
 - What is new;
 - Your approach is better in what aspect;
- **Design**
 - Mechanical design;
 - Control design;
 - ...
- **Performance/Results**
 - Quantified Table/Plot;
 - Scientific language;
- **Summary/Contribution**
 - Impact/Novelty;
 - ...
- **Refs**

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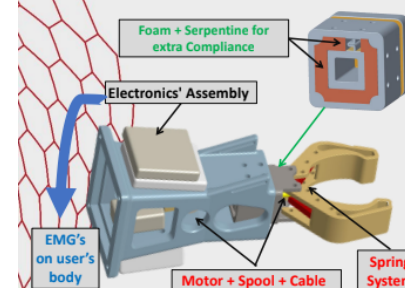


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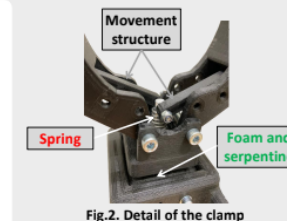


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Final Report

- Follow the Latex template in Moodle;
- Support your statement with data/plot/table;
- Write it as if you are showing off to a potential CTO to join your company;
- Make sure you have **quantified** and justified the mechanical performances of the product and how it relates to the major **functionality**.

Next Week

- Mock demo presentation;
- Flyer and Poster for review;
- SPOT bench desks are reserved for your use whole day Friday;
- After today's class, group leaders meet in SPOT to register for the tool cabinet;