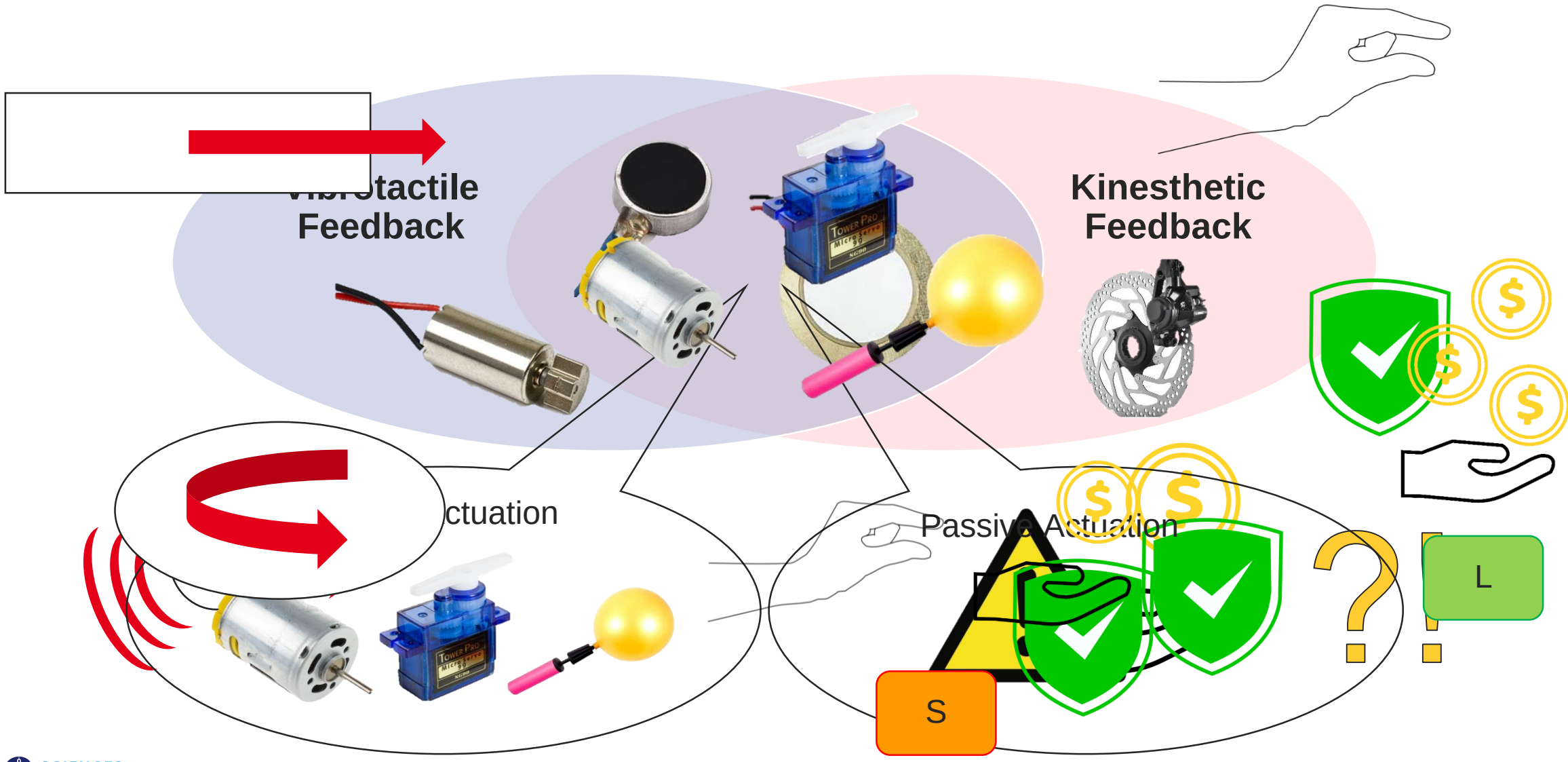
# Brake based on Active Lubrication for the design of Haptic Devices

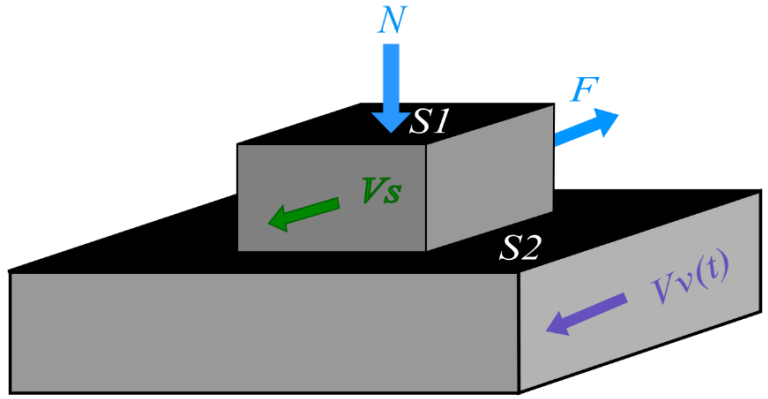
Marion Pontreau, Sabrina Panëels, Sylvain Bouchigny and Sinan Haliyo

# State of the art



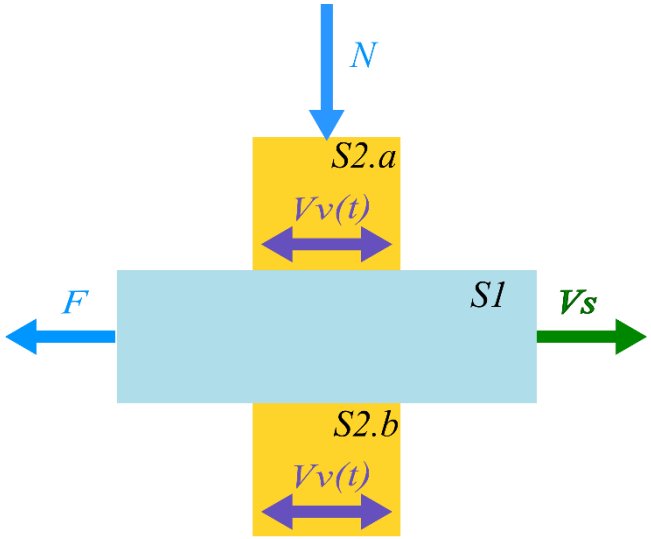
# Brake based on Active Lubrication

The brake uses active lubrication: a phenomenon that reduces friction force by introducing vibrations (>20 kHz).

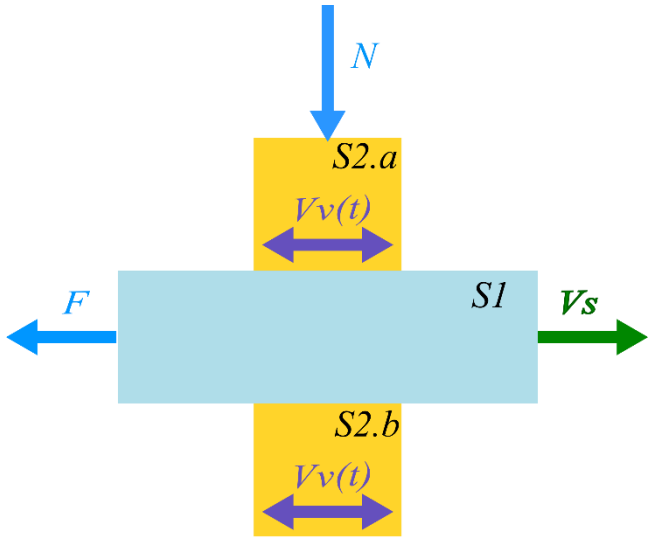


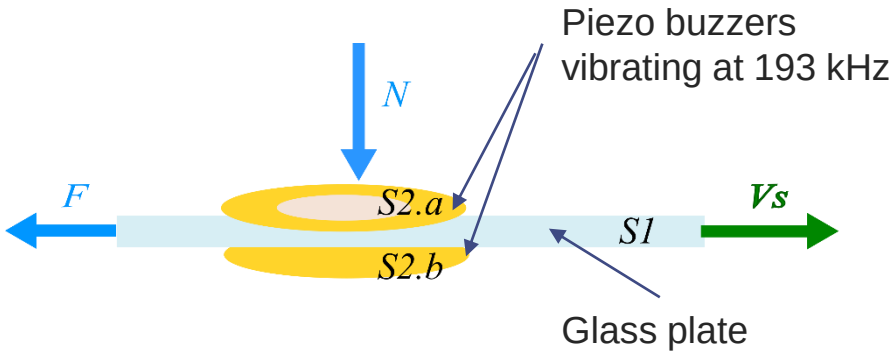

We used longitudinal vibrations because:

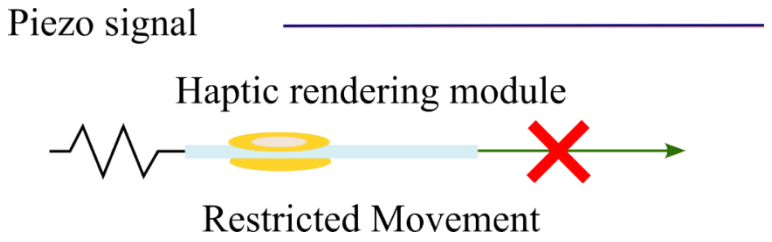
- less energy consuming than normal vibrations [1]
- better friction reduction than the transversal ones [2]

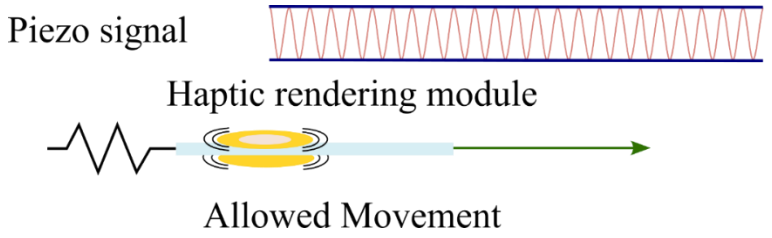


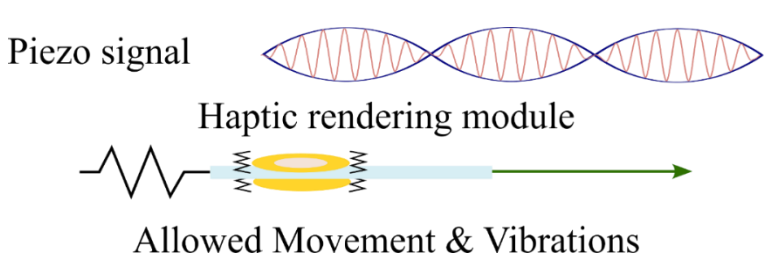
# Brake based on Active Lubrication

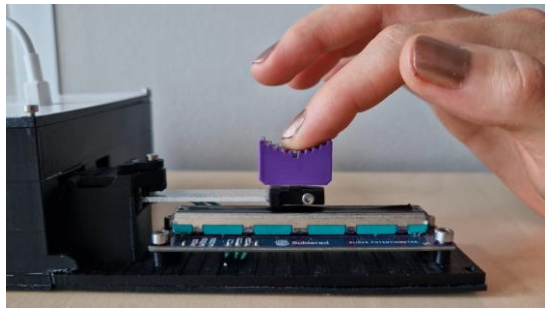


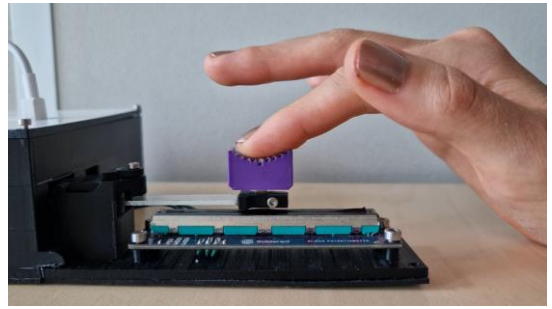



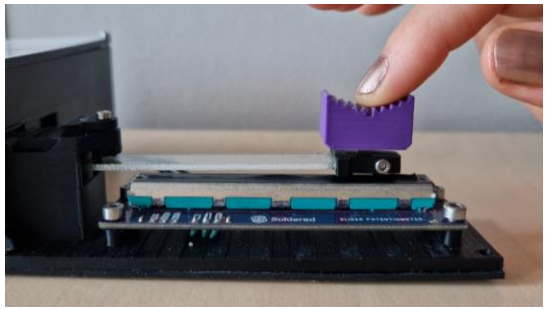



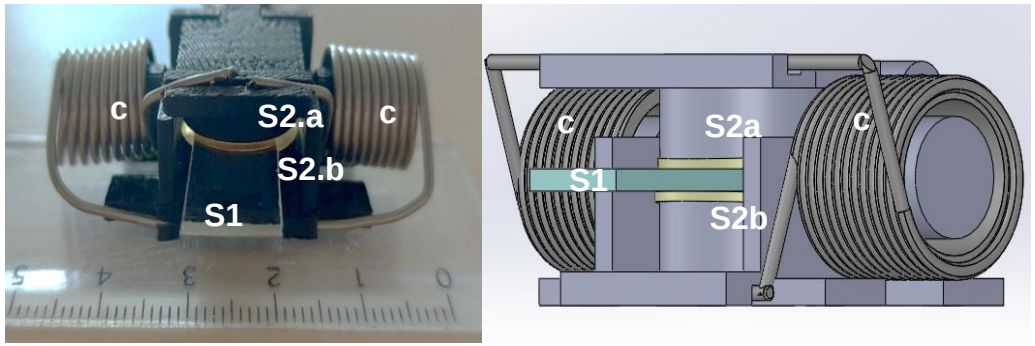




# Medical Use Case
# Brake based on Active Lubrication

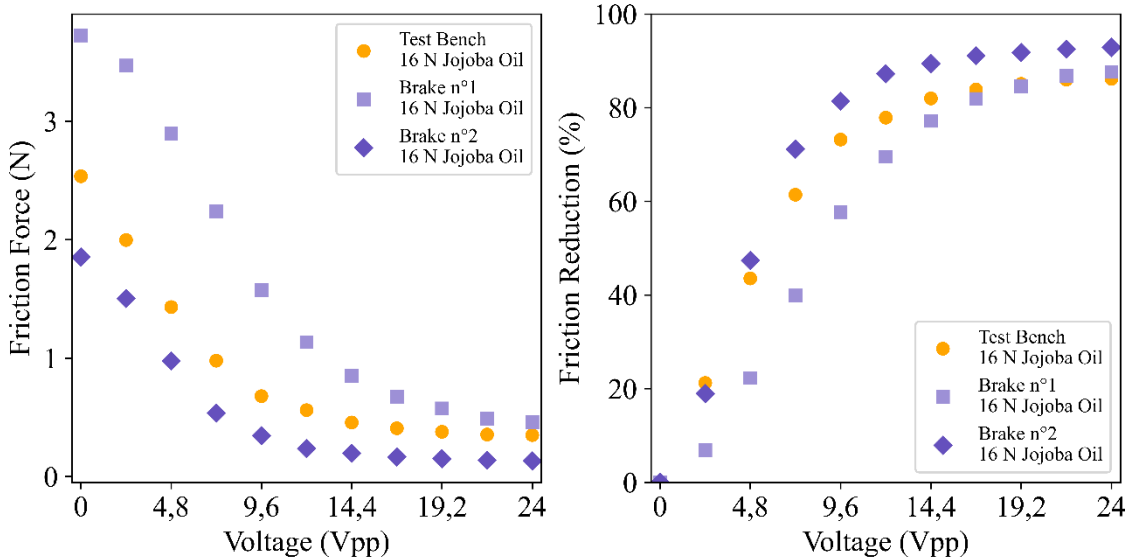
We created two brakes with the same design:

- Piezo buzzers glued to plastic support
- Glass plate is placed beside them for the user/setup to move
- Torsion springs are used to create the compression force



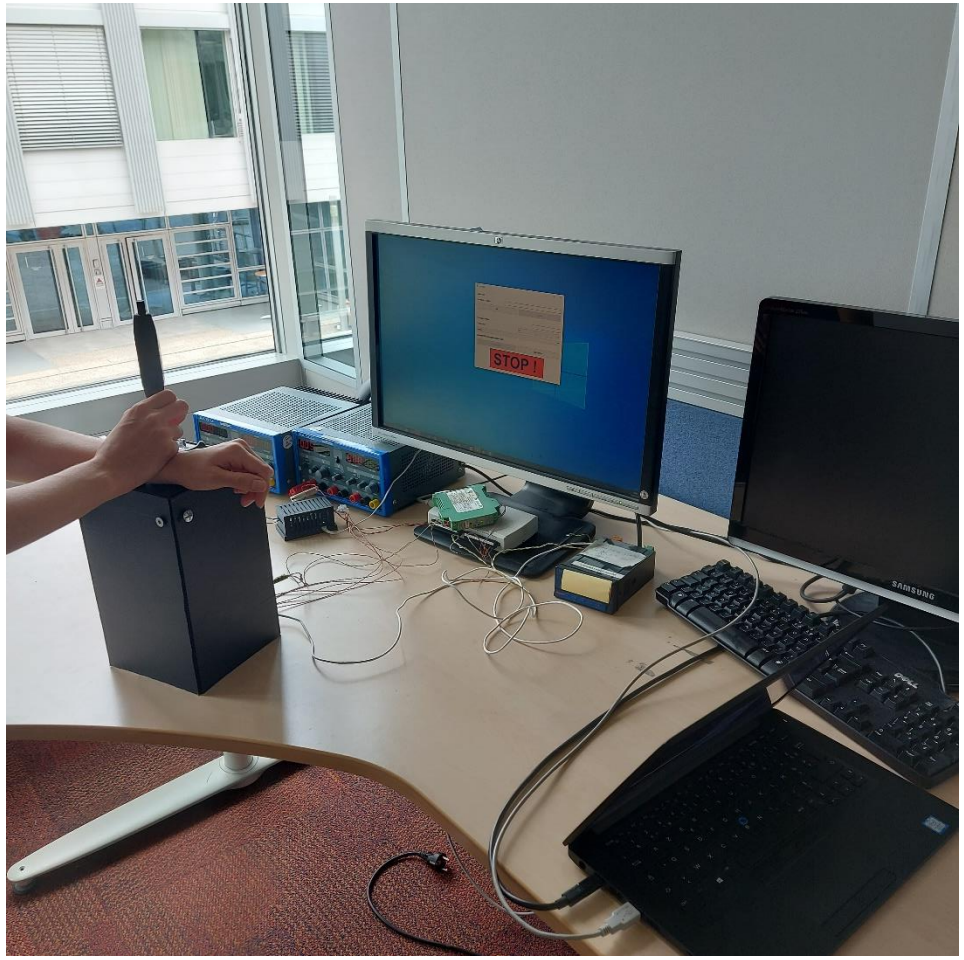

Performance:

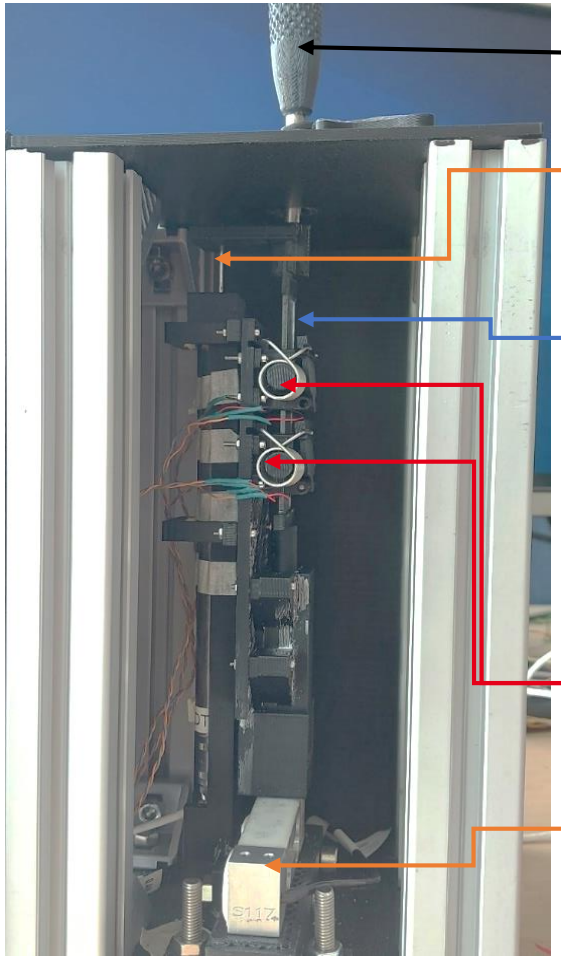
- Slight difference of friction force between the two brakes
- Similar behaviour depending on the voltage applied




*M. Pontreau, S. Panëels, S. Bouchigny and S. Haliyo, "Design and evaluation of an active lubrication brake for a surgical drilling simulator", in World Haptic Conference , Suwon, South Korea, Jul. 2025*
*Demonstrator : M. Pontreau S. Panëels, S. Bouchigny, and S. Haliyo, "A Haptic Training Simulator for Maxillofacial Surgery," presented at the IHM'24 - 35e Conférence Internationale Francophone sur l'Interaction Humain-Machine, Mar. 2024. [Online]. Available: https://hal.science/hal-04500128*

# Medical Use Case
# Medical tangible training device




Our device reached force between 0 N and 4.5 N

*M. Pontreau, S. Panëels, S. Bouchigny and S. Haliyo, "Design and evaluation of an active lubrication brake for a surgical drilling simulator", in World Haptic Conference , Suwon, South Korea, Jul. 2025*
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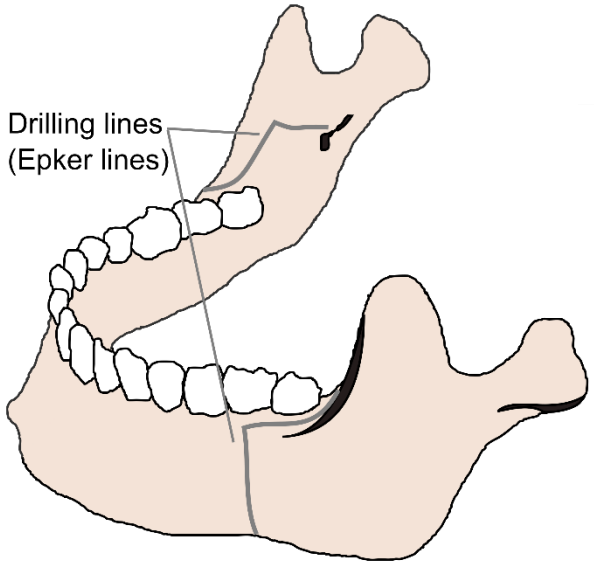
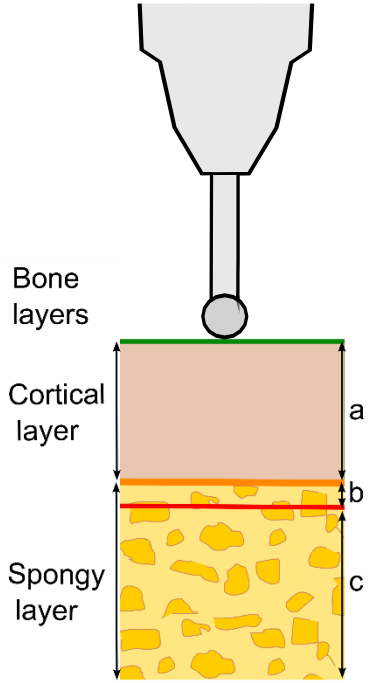
# Medical Use Case
# User Studies

Task :

Drill integrally the cortical layer as fast as possible while minimizing the penetration in the spongy layer

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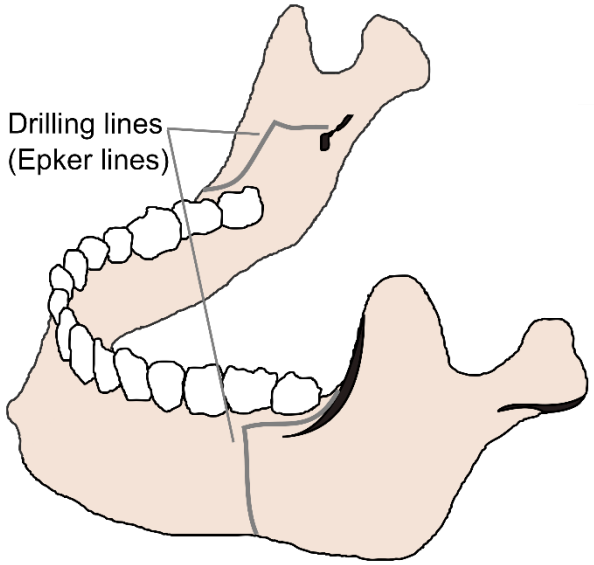
# Medical Use Case User Studies

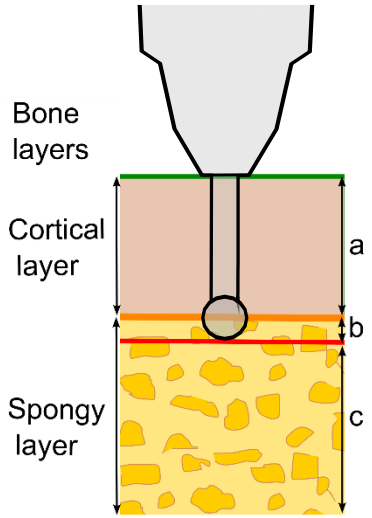
Task :

Drill integrally the cortical layer as fast as possible while minimizing the penetration in the spongy layer

RQs:

- Are our brakes applicable for such use case ?
- Is the combined feedback an improvement on this use case ?




1st Study:

Three conditions (KV, K, V) 7f, 7m

2nd Study:

The best conditions (KV, K) 3f, 3m

K: Kinesthetic feedback, V: Vibrotactile feedback

*M. Pontreau, S. Panëels, S. Bouchigny and S. Haliyo, "Design and evaluation of an active lubrication brake for a surgical drilling simulator", in World Haptic Conference , Suwon, South Korea, Jul. 2025*
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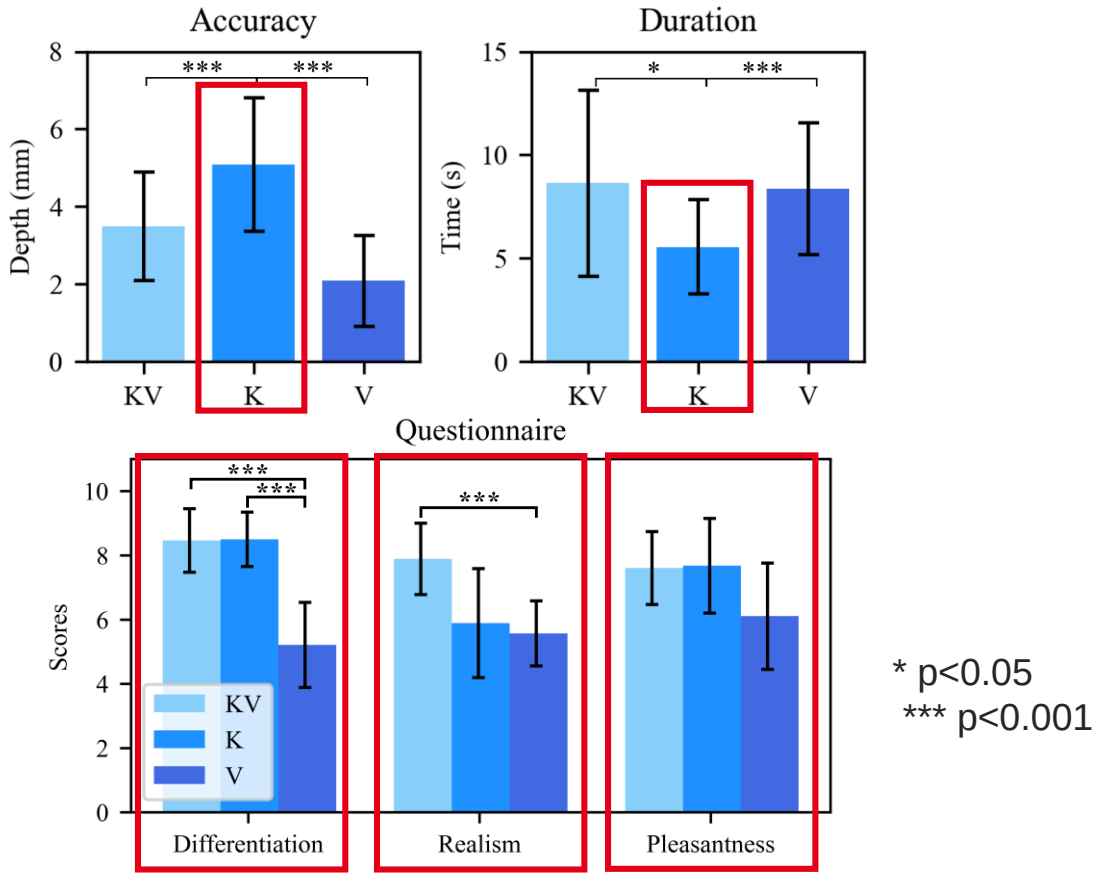
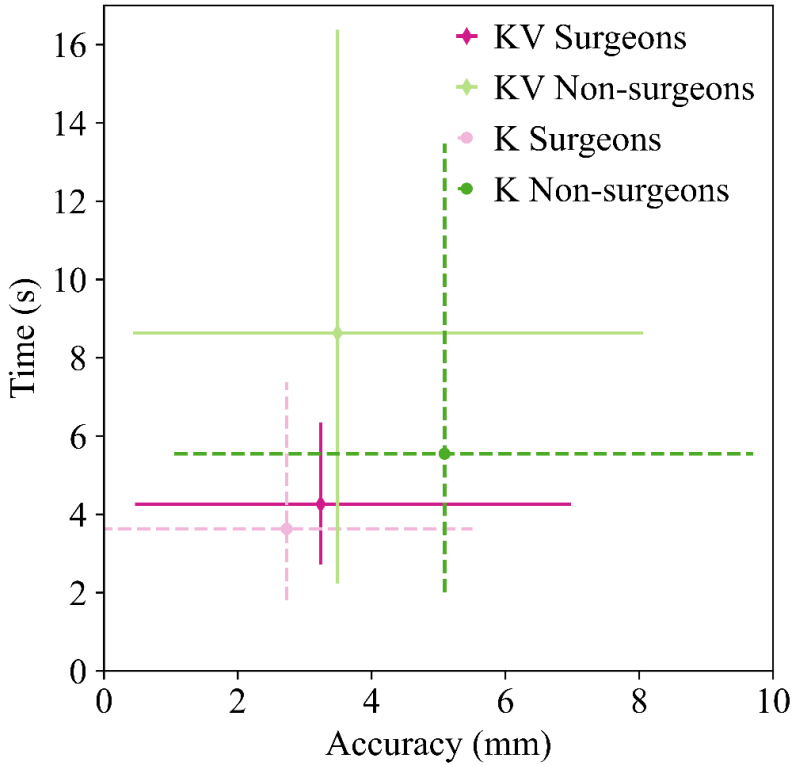
# Medical Use Case Results

## With Non surgeons




* p<0.05
*** p<0.001

## With Surgeons

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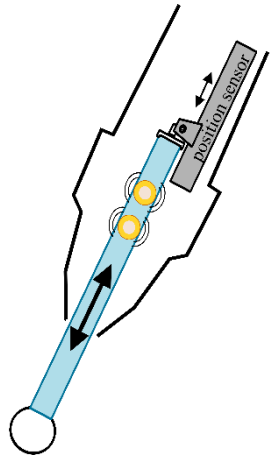
# Medical Use Case
# Conclusion & Future work

Results:

- Design of a novel brake for force and vibrotactile feedback
- Successful implementation in a training module able to render force between 0 N and 4.5 N as well as vibrations.
- The user studies showed a potential applicability of our brake for the drilling training surgery
- Providing both vibrotactile and force feedback was better than providing one modality

Future work:

- Design an upgraded version of the training module (hand-held drill mock-up with adaptative speed adjustable by a foot pedal)




- Fine-tune the drilling sequence and haptic sensations with expert maxillofacial surgeons

*M. Pontreau, S. Panëels, S. Bouchigny and S. Haliyo, "Design and evaluation of an active lubrication brake for a surgical drilling simulator", in World Haptic Conference , Suwon, South Korea, Jul. 2025*
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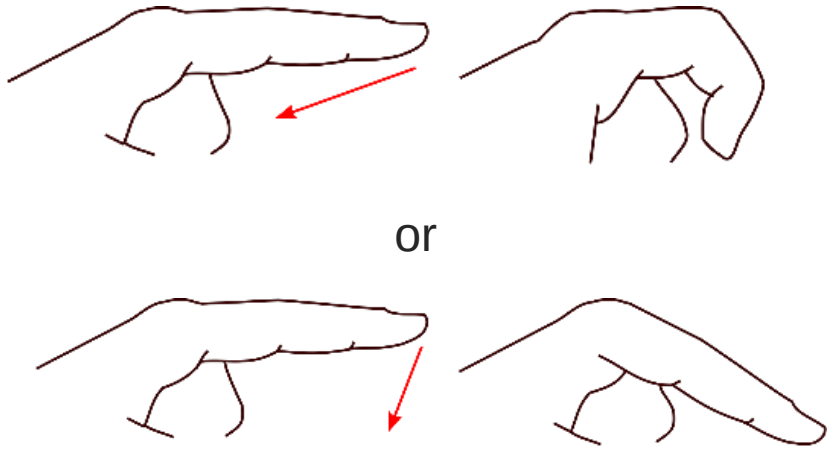
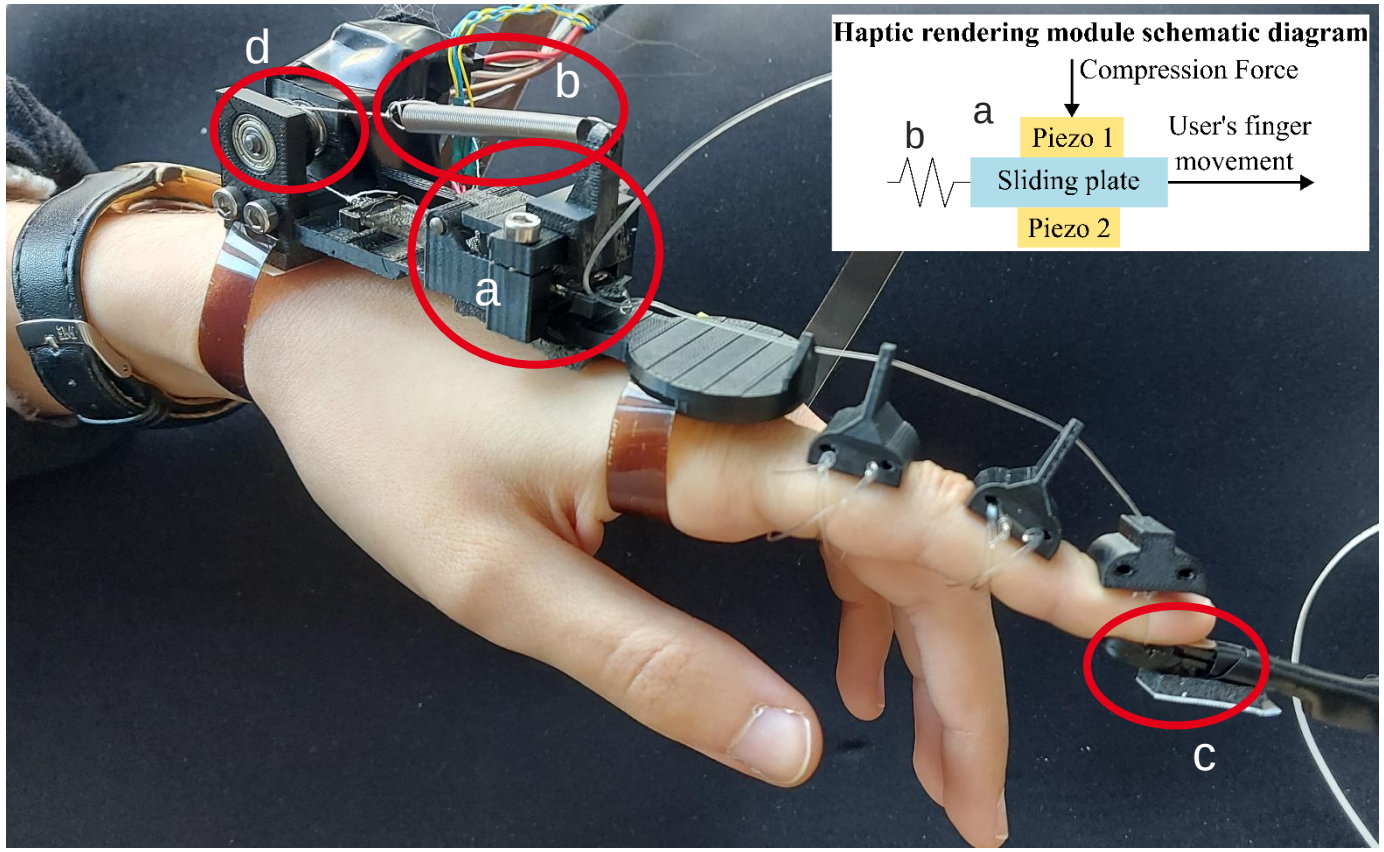
# Wearable Use Case 1st Design

WAL enables vibration or force resistance on the closure movement on the index finger tip



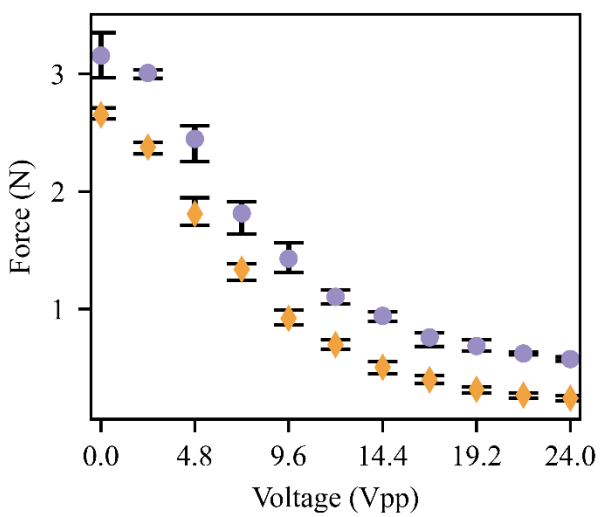



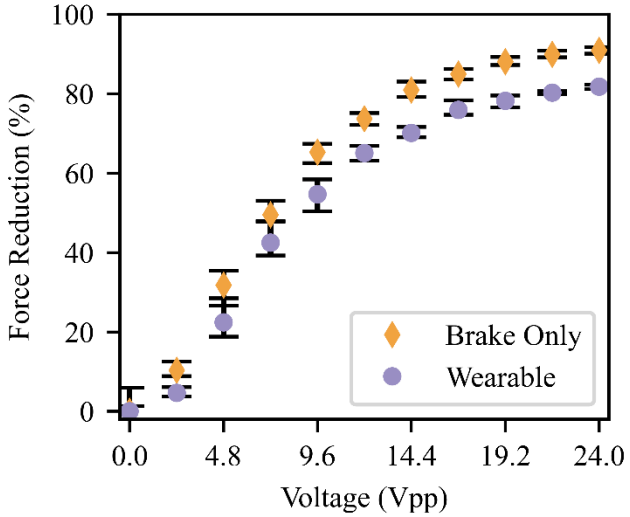

Wearable with a: brake (i.e. piezos and sliding plate), b: spring, c: pressure sensor, d: rotary sensor

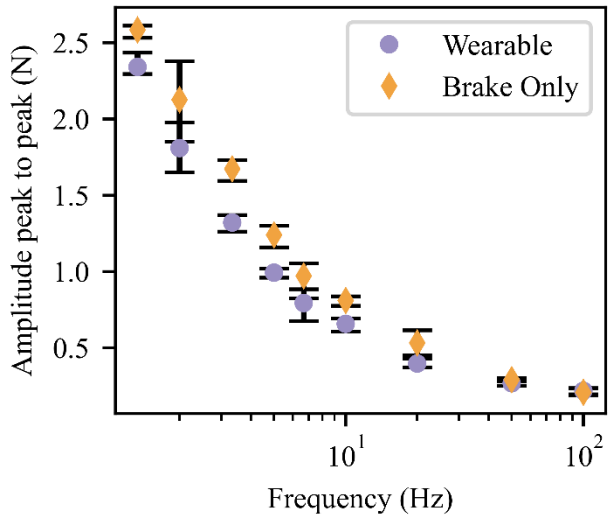
*Conference Paper & Demonstrator: M. Pontreau, S. Bouchigny, S. Panëels and S. Haliyo, "WAL: Wearable based on Active Lubrication for Virtual Reality". EuroHaptics, Lille, France, Jul. 2024.*

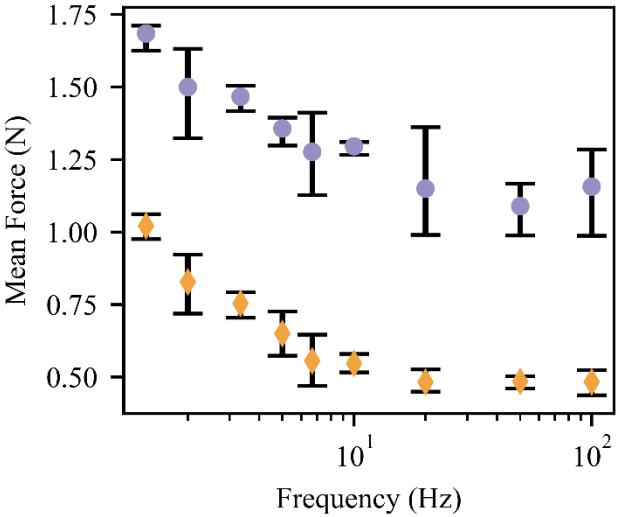
# Wearable Use Case Characterisation

The brake was reached force between 0.5 and 3.15 N and vibrations of at least 0.2 N of amplitude.



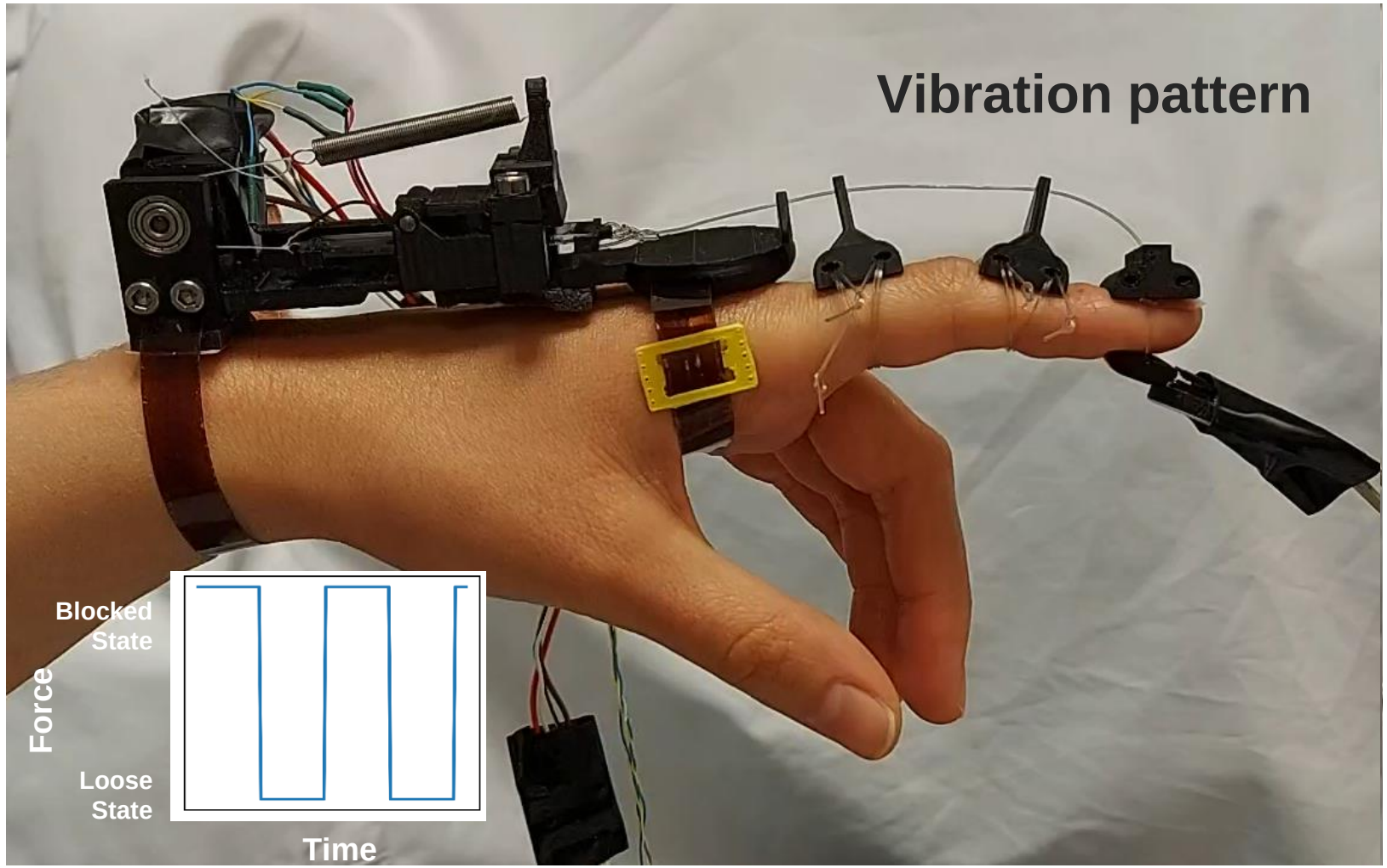




Due to the force range and vibrations amplitude we hypothesises that:

- Up to 3 absolute levels of force could be identifiable
- Vibrotactile pattern at different frequency should be perceptible

# Wearable Use Case
# Haptic feedback example



# Wearable Use Case User Studies

RQs:

- Are our brake able to produce up to 3 differentiable level of force ?
- Are our brake able to produce differentiable vibrotactile pattern differentiable ?

Task :

Close the finger and indicate which force level or pattern was perceived.

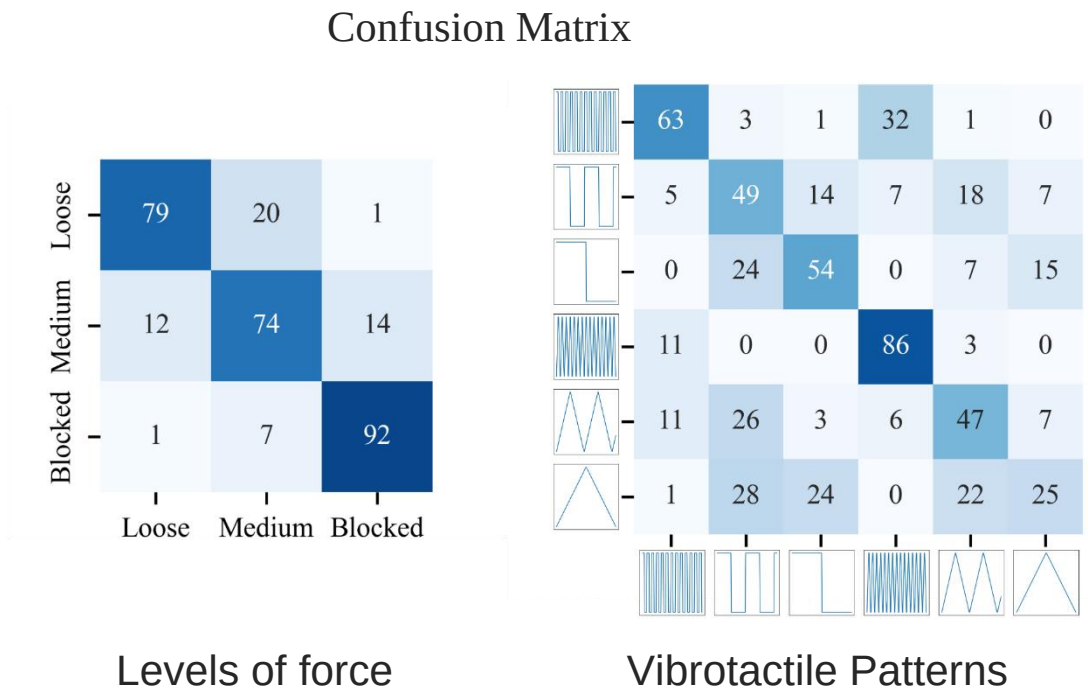
30 trials for force level (3*10)

36 trials for patterns (6*6)

Study

12 (4f-8m)

Results




Levels of force

Vibrotactile Patterns

*Conference Paper & Demonstrator: M. Pontreau, S. Bouchigny, S. Panëels and S. Haliyo, "WAL: Wearable based on Active Lubrication for Virtual Reality". EuroHaptics, Lille, France, Jul. 2024.*

# Wearable Use Case
# 2nd Design

Three brakes were implemented on a wearable with other actuators (voice coil & motor) and the wearable was linked to a VR scene on Unity displayed by a VR headset.


palmar side


dorsal side

*Demonstrator: M. Pontreau, C. Louison, P. Orefice, S. Bouchigny, T. S. Le, D. Gueorguiev, S. Panëels, " Demonstrating WAVY: a hand wearable with force and vibrotactile feedback for multimodal interaction in Virtual Reality", presented at the 32nd IEEE Conference on Virtual Reality and 3D User Interfaces (IEEE VR 2025) , St Malo, France, Mar. 2025.* ***Award Best Research demo***

# Summary of contributions

- **Design of a brake** based on active lubrication enabling **kinesthetic and vibrotactile feedback**
- **Characterisation** of the brake
- **Comparison** of the brake **behaviour to existing models**
- **Design of a first set of actuators** implemented in button, knob and slider

- Medical Training device:
  - **Design** & **characterisation** of an grounded training device for medical drilling
  - **Two user studies conducted** to assess the **applicability of the brake** and **best compromise for performance** and preference when **both type of feedback** are provide
- Wearable for Virtual reality:
  - **Design** & **characterisation** of a wearable
  - A user study conducted to assess the **applicability of the brake** and **recognition performance** of haptic feedback (force and vibrations patterns)
  - **Design** of a second wearable and **survey** carried out (with the consortium WAVY)

# Thank you

Looking for a postdoc !

Feel free to contact me here !

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Bibliography:

*[1] Torres Guzman, D. A et al. (2020). Energy Analysis of Lateral vs. Normal Vibration Modes for Ultrasonic Surface Haptic Devices. EuroHaptics 2020.*

*[2] Kumar, V. C., & Hutchings, I. M. (2004). Reduction of the sliding friction of metals by the application of longitudinal or transverse ultrasonic vibration. Tribology International, 37(10), Article 10.*