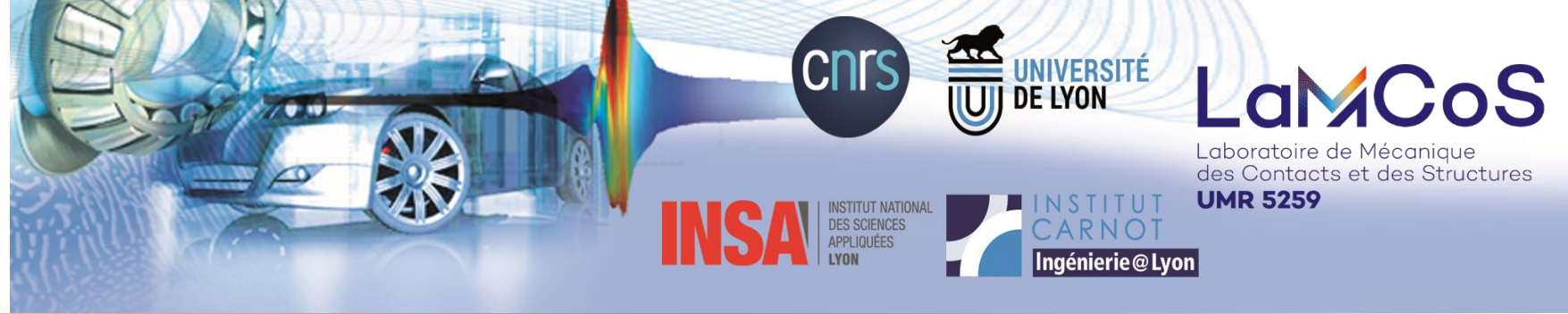




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# *Tactile discrimination of isotropic surface textures rendered by Friction-Induced Vibrations*



Lille, France

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Toucher  
Analyse  
Connaissance  
simulation



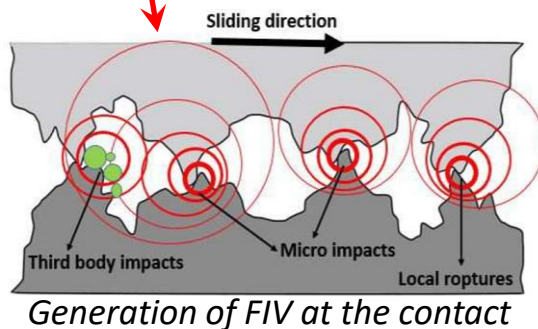
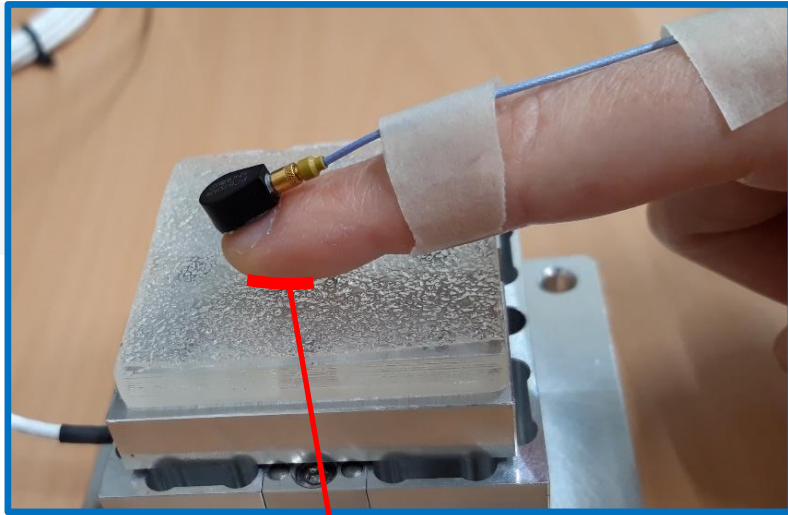
*Lille, 7-8 juin 2023*

# Content

- **Objective: analysis and mimicking of tactile mechanical stimuli**
- **FIV analysis of isotropic samples**
- **Mimicking FIV stimuli by an Electro-Active Polymer piezo device**
- **Discrimination campaign**
- **Conclusions**

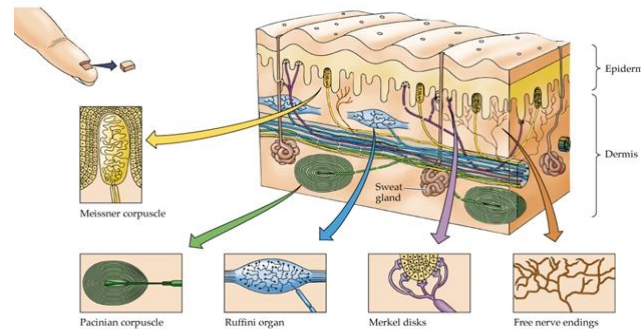
# Objective: analysis and mimicking of tactile mechanical stimuli

## Tactile perception and Friction-Induced Vibrations (FIV)



When we explore a surface, we generate and propagate Friction-Induced Vibrations at the contact interface

stimulation of mechanoreceptors



Mechanical signals at the origin of tactile perception:

- Contact pressure
- Friction
- Temperature
- Friction-Induced Vibrations (FIV)

Which is the link between texture topography, mechanical stimuli, and texture perception and discrimination?

# Objective: analysis and mimicking of tactile mechanical stimuli

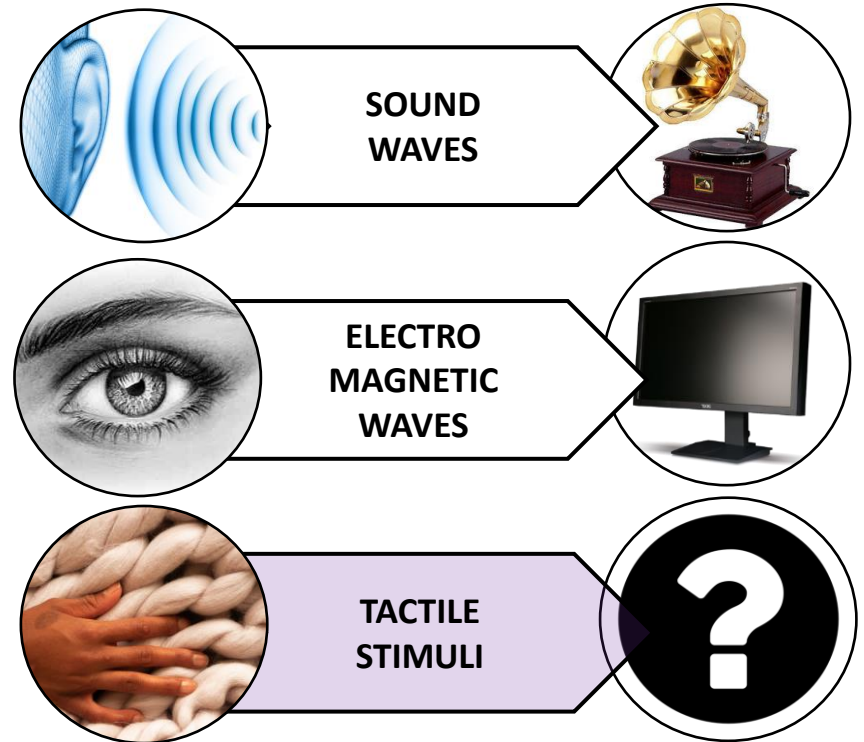
## Mimicking tactile mechanical stimuli

### Can we mimic the tactile mechanical (FIV) stimuli?

*We master acoustic and sight stimuli and*

*we are able to render them...*

*...but what about tactile perception?*

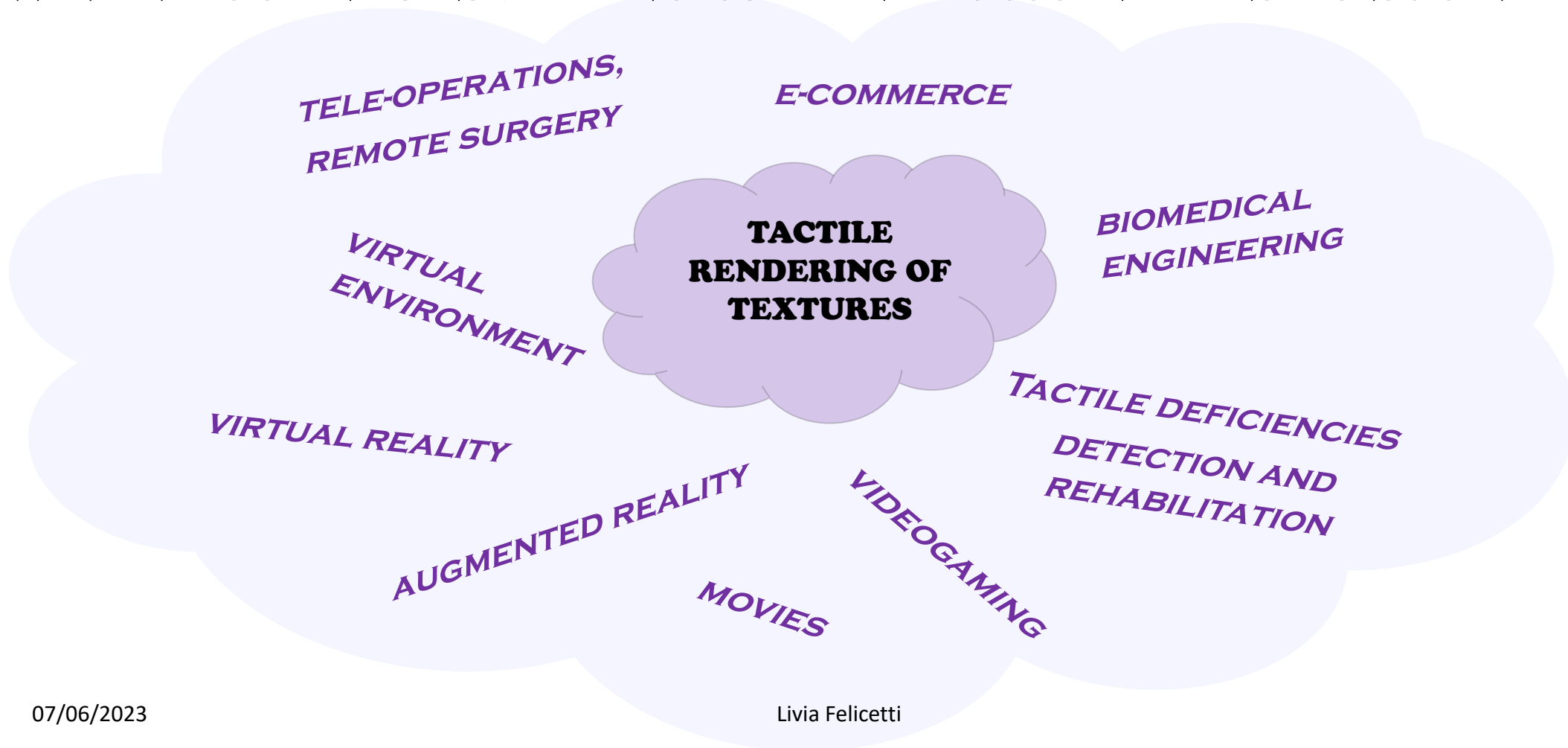


# Objective: analysis and mimicking of tactile mechanical stimuli

## Applications

What if we artificially recreate tactile feeling of textures?

*TACTILE RENDERING OF TEXTURES MAY HAVE GROUND-BREAKING SOCIAL AND TECHNOLOGICAL APPLICATIONS*



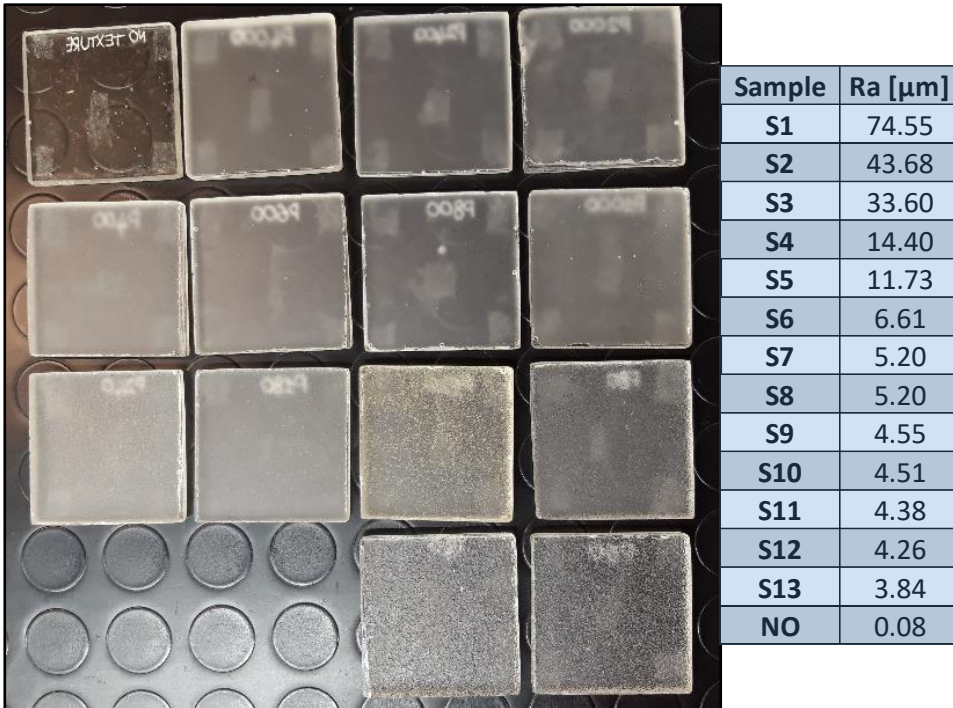
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# FIV analysis of isotropic samples

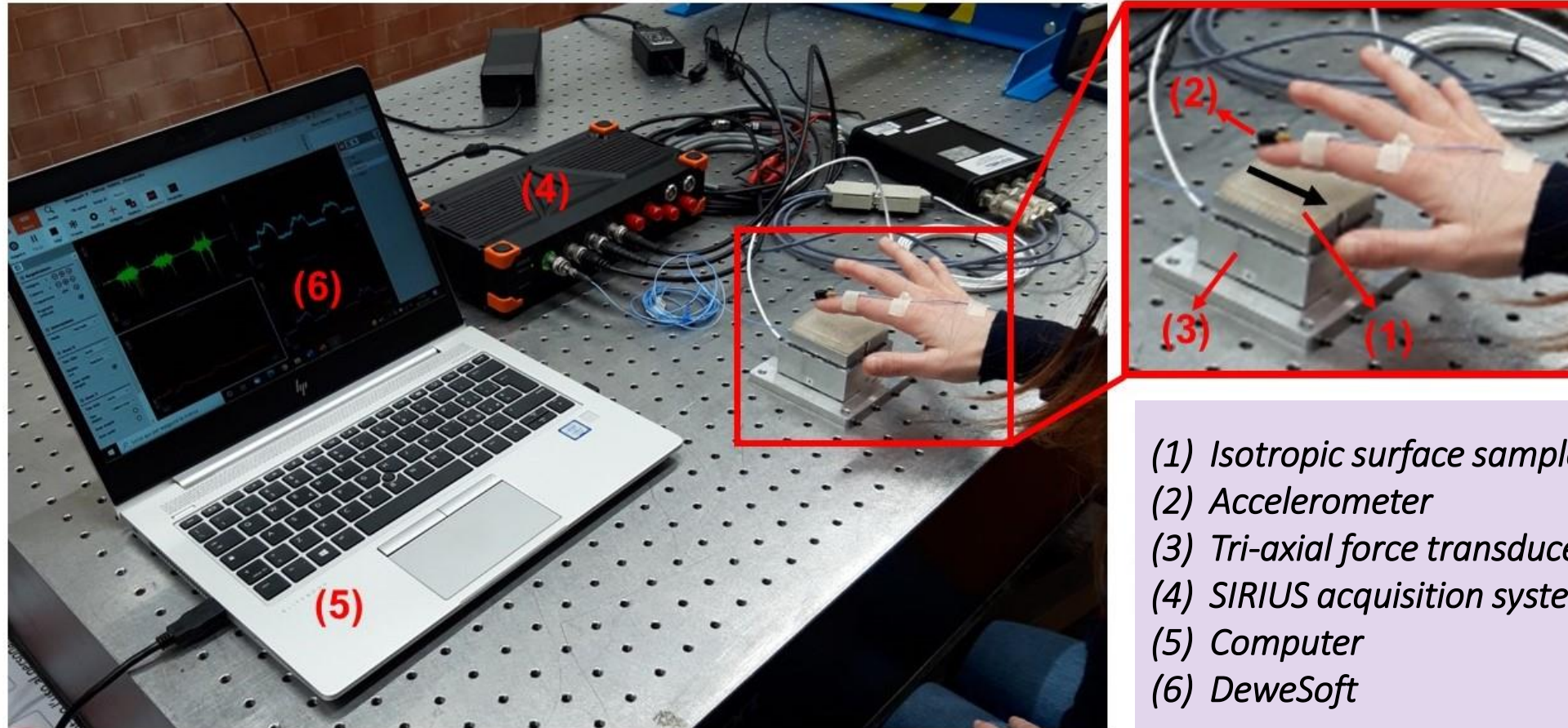
## Isotropic surface samples manufacturing from glasspapers



Epoxy resin isotropic samples manufactured from sandpaper of different grain sizes

# FIV analysis of isotropic samples

## FIV measurement by active touch



- (1) *Isotropic surface sample*
- (2) *Accelerometer*
- (3) *Tri-axial force transducer*
- (4) *SIRIUS acquisition system*
- (5) *Computer*
- (6) *DeweSoft*

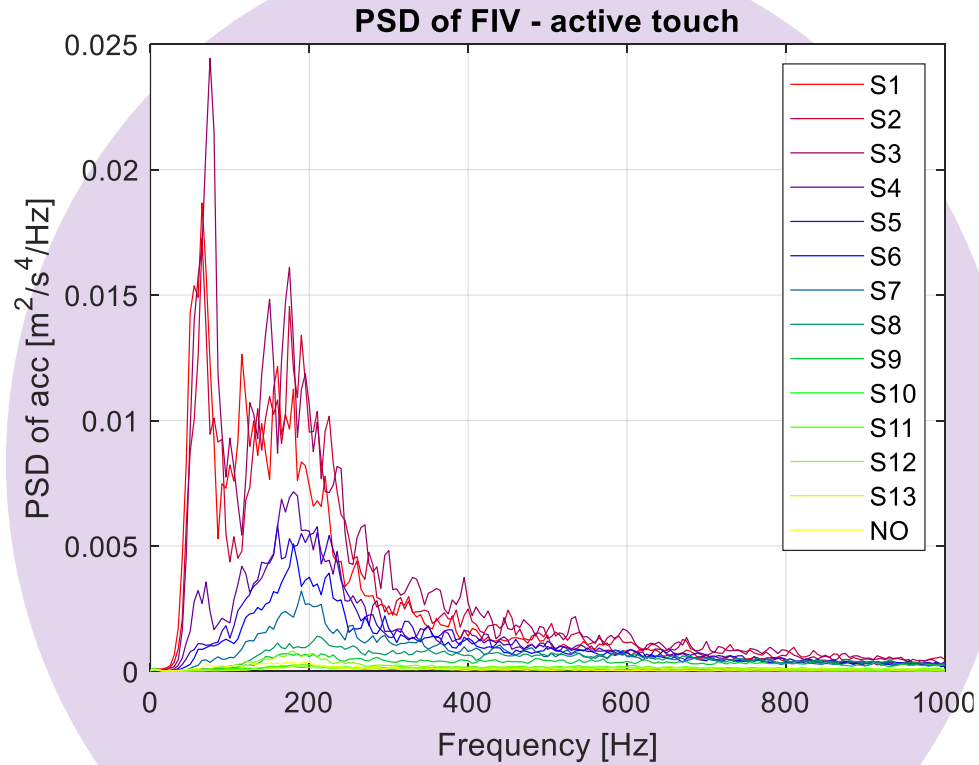
Active touch setup to measure tactile mechanical stimuli



# FIV analysis of isotropic samples

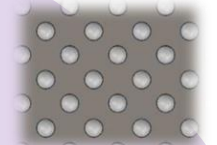
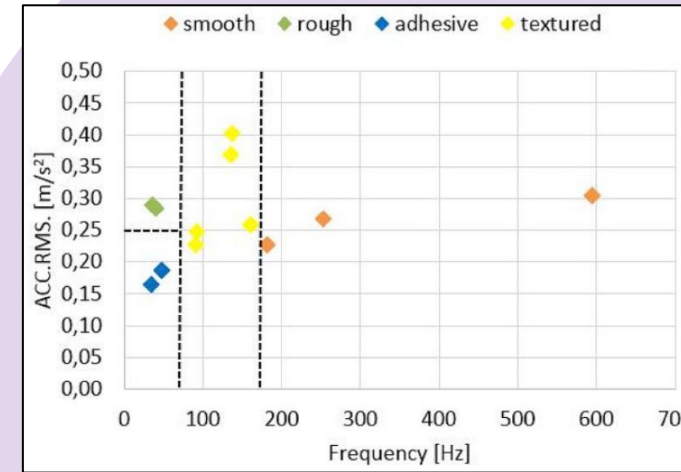
## Isotropic VS periodic samples

### ISOTROPIC TEXTURES

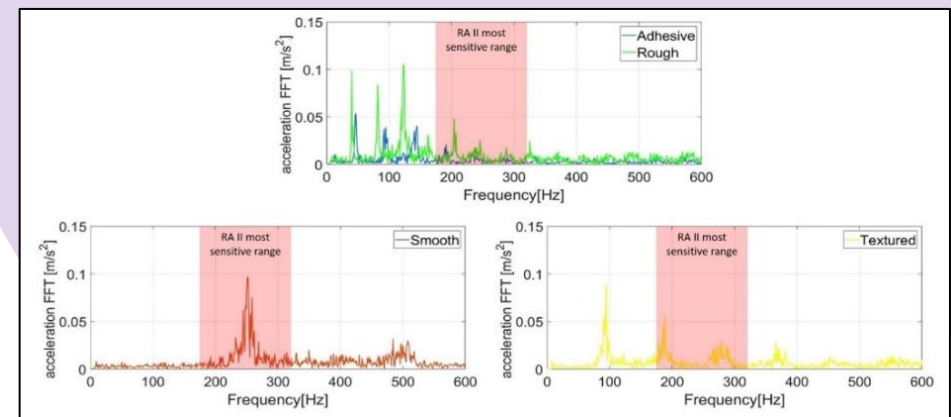


The isotropic samples seems to be differentiated by the FIV amplitude, while the frequency distribution is similar between samples.

### PERIODIC TEXTURES



The FIV frequency distribution changes for different textures and correlates with descriptive and hedonistic perception. Ref [3]



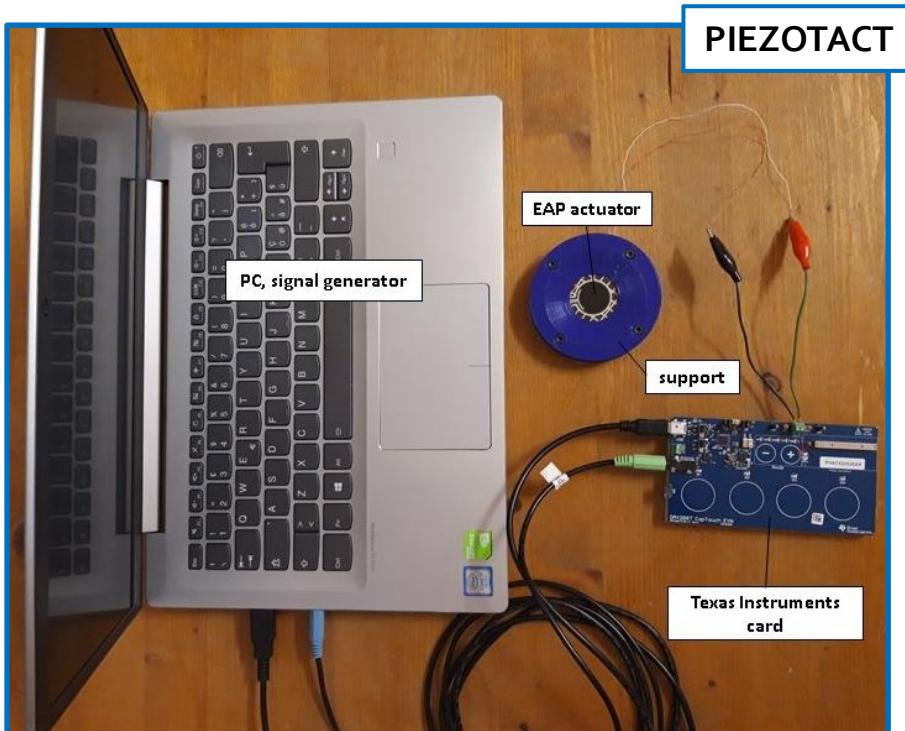
[3] V. Massimiani et Al., The role of mechanical stimuli on hedonistic and topographical discrimination of textures, Tribology International, 2020, 143.

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# Mimicking tactile FIV stimuli by an Electro-Active Polymer piezo device

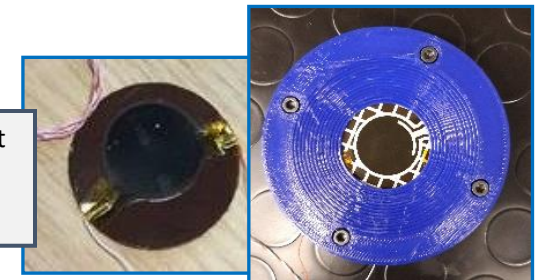
## Piezotact tactile device



Felicetti, L., Chatelet, E., Latour, A., Cornuault, P.-H., & Massi, F. (2022). Tactile rendering of textures by an Electro-Active Polymer piezoelectric device: mimicking Friction-Induced Vibrations. *Biotribology*, 31, 100211.

Tactile device able to reproduce  
the FIV measured on real surfaces

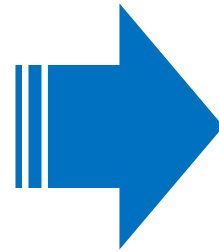
- lightweight
- flexible
- thin



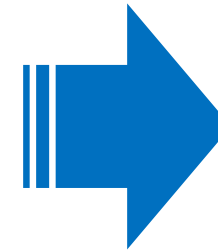
# Mimicking tactile FIV stimuli by an Electro-Active Polymer piezo device

## Objective and overall procedure

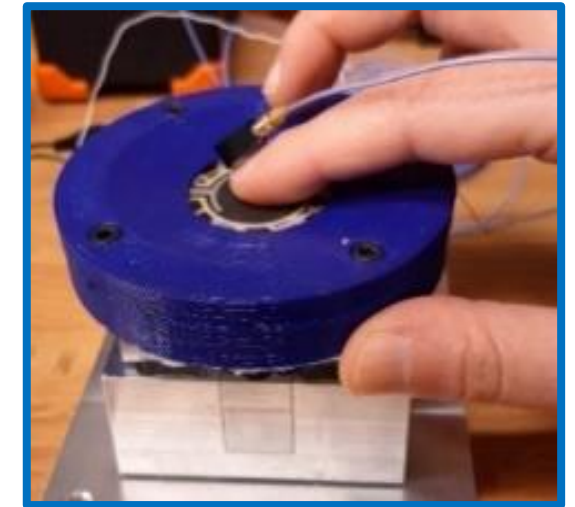
To measure FIV



FIV processing



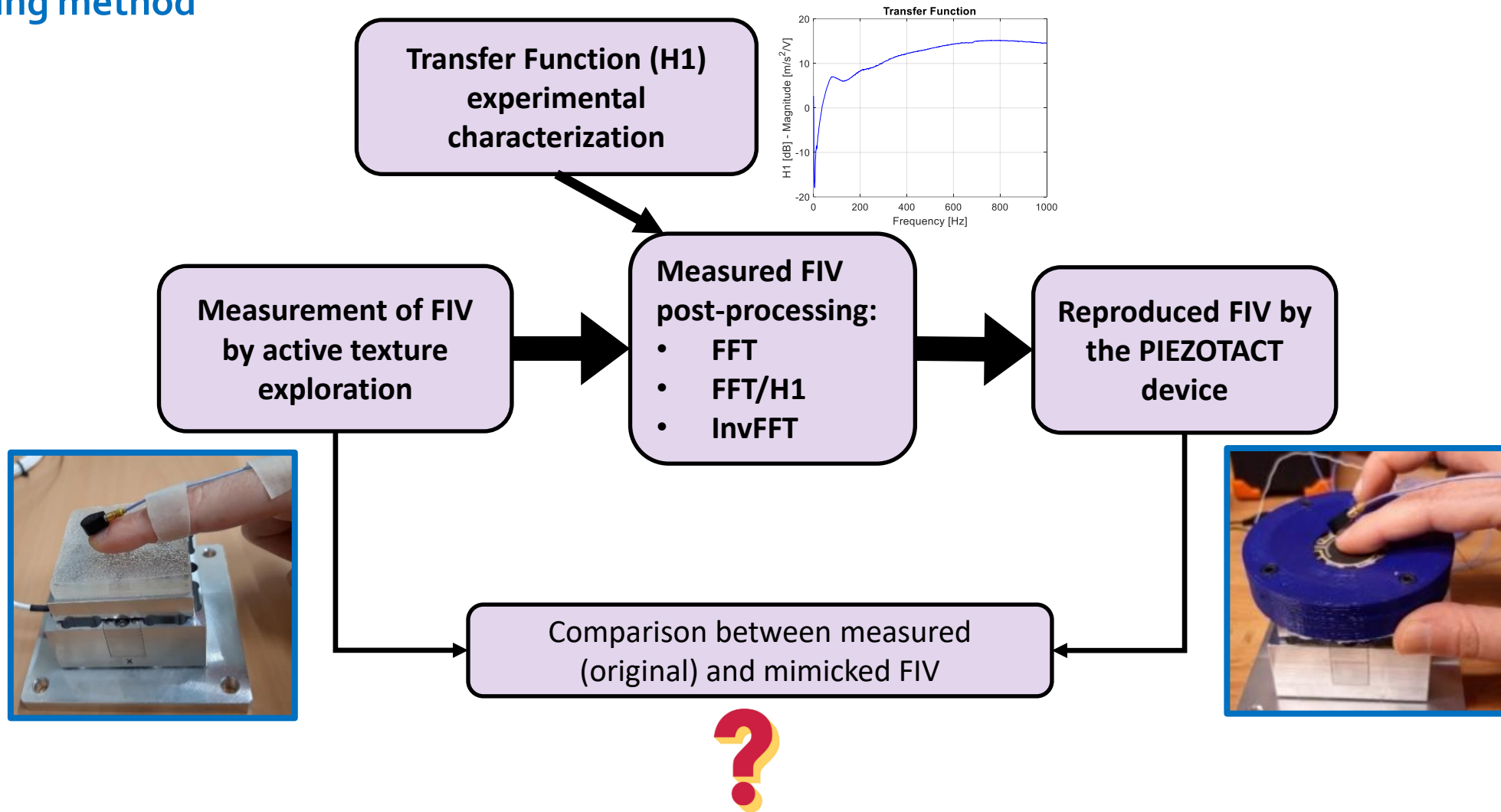
To mimic FIV





# Mimicking tactile FIV stimuli by an Electro-Active Polymer piezo device

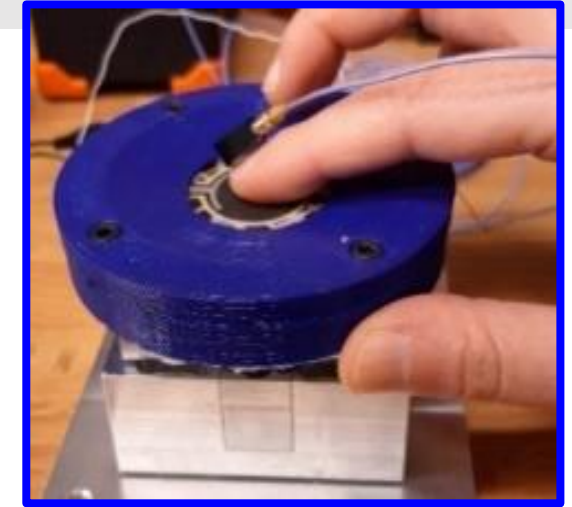
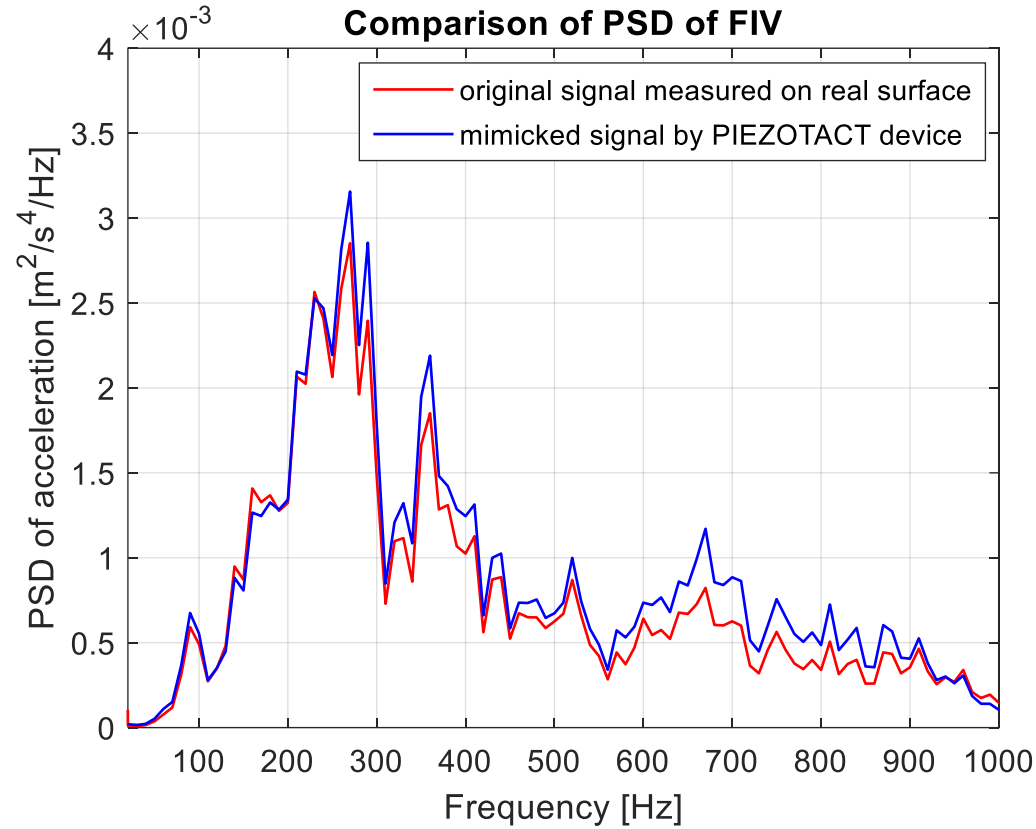
## Rendering method



# Mimicking tactile FIV stimuli by an Electro-Active Polymer piezo device

## Verification of mimicked FIV spectra

### REAL VS SIMULATED FIV

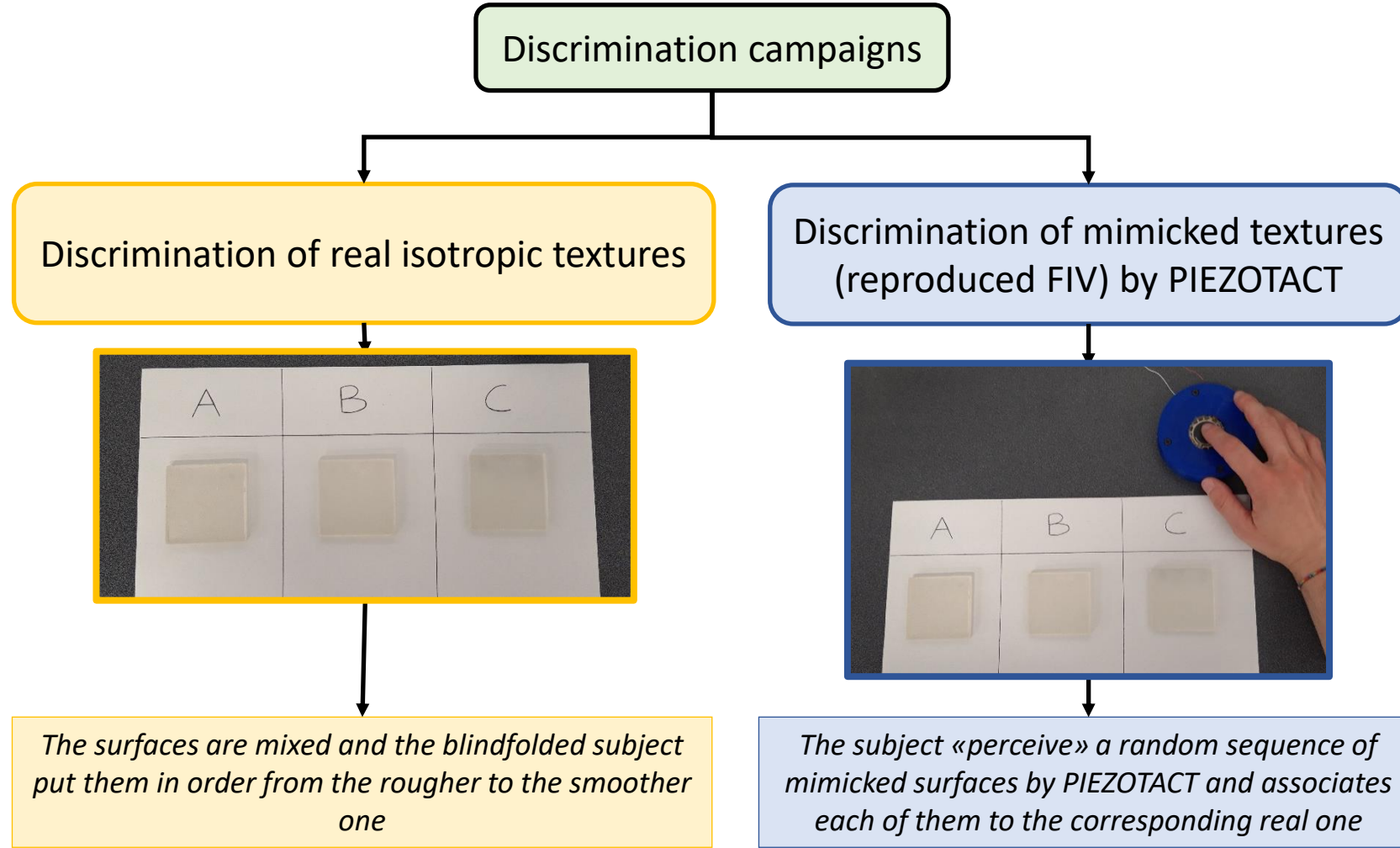


Correct mimicking of tactile FIV stimuli by the PIEZOTACT device

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# Discrimination campaign Protocol



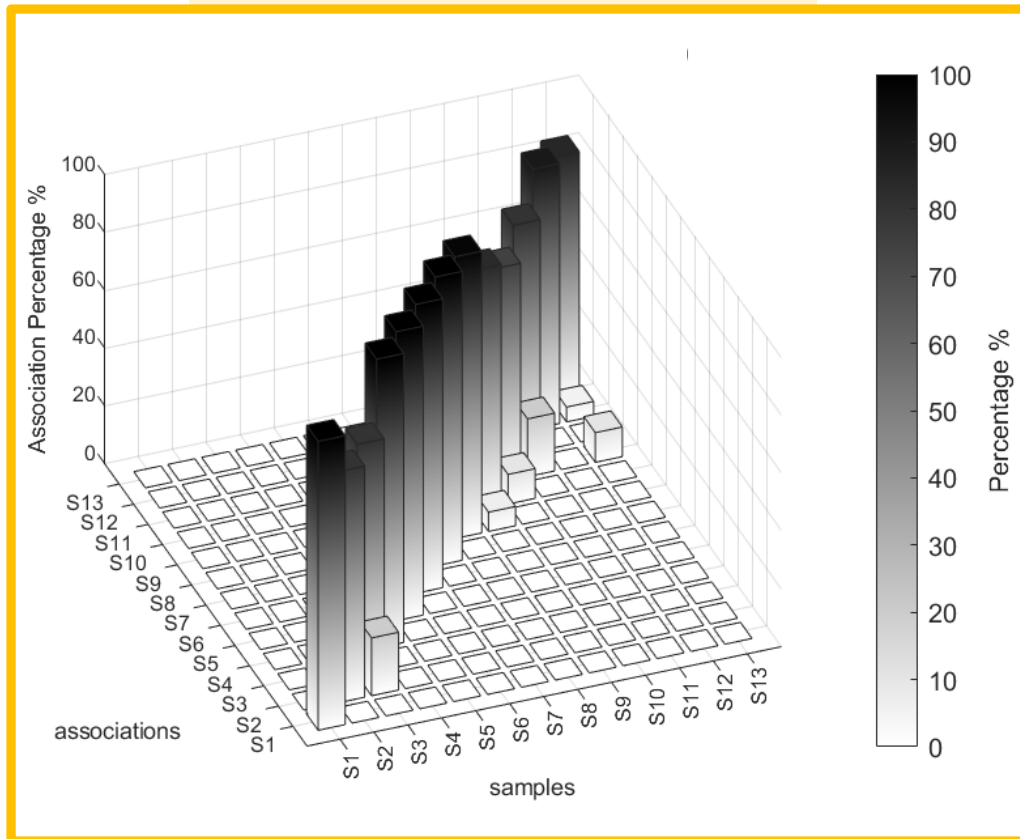
| SET | SAMPLES |     |     |
|-----|---------|-----|-----|
| A   | S2      | S4  | S8  |
| B   | S5      | S7  | S9  |
| C   | S6      | S11 | S10 |
| D   | S1      | S3  | S13 |
| E   | S5      | S8  | S12 |
| F   | S5      | S9  | S10 |
| G   | S2      | S3  | S4  |
| H   | S1      | S8  | S13 |
| I   | S1      | S7  | S12 |
| L   | S4      | S13 | S10 |
| M   | S4      | S8  | S9  |
| N   | S13     | S12 | S10 |

*10 participants*

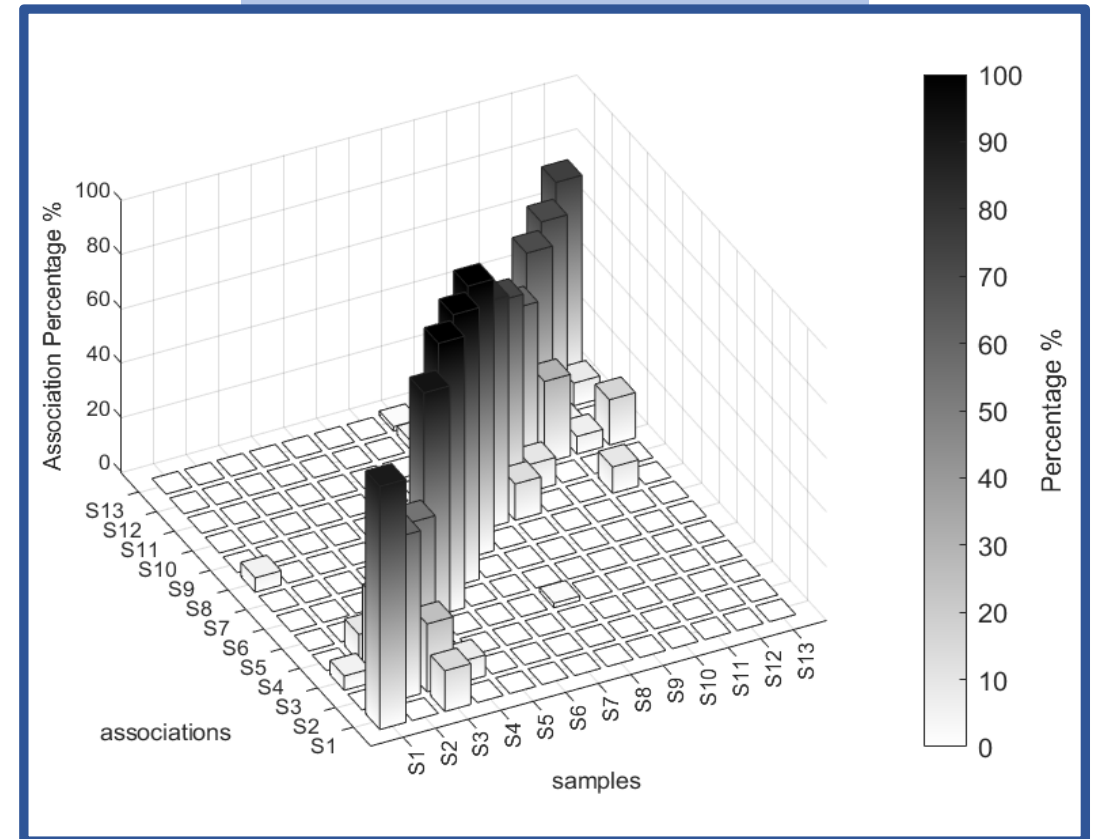


# Discrimination campaign Results

## Real surfaces



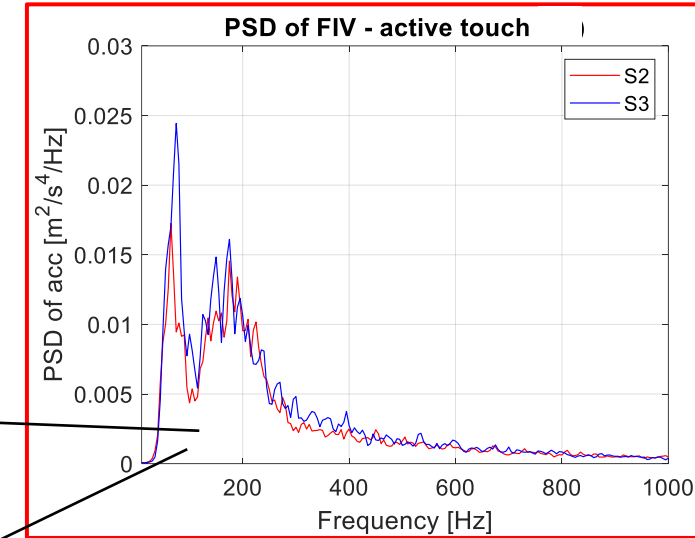
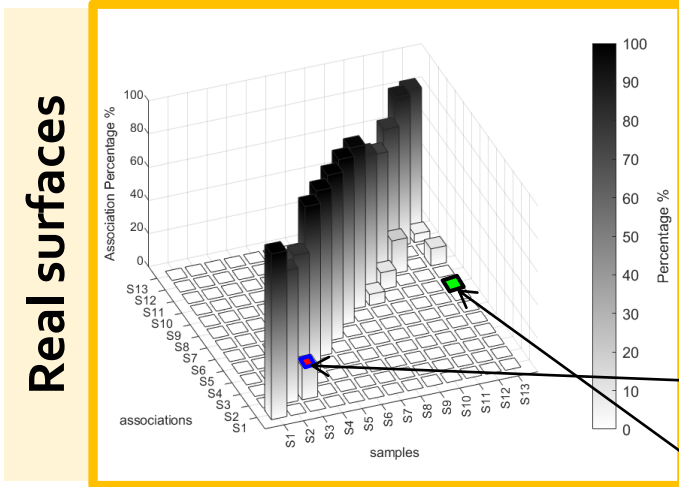
## Mimicked FIV



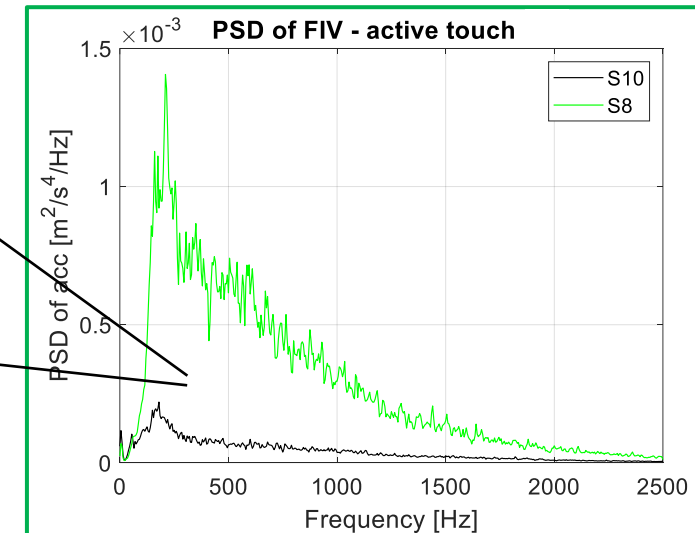
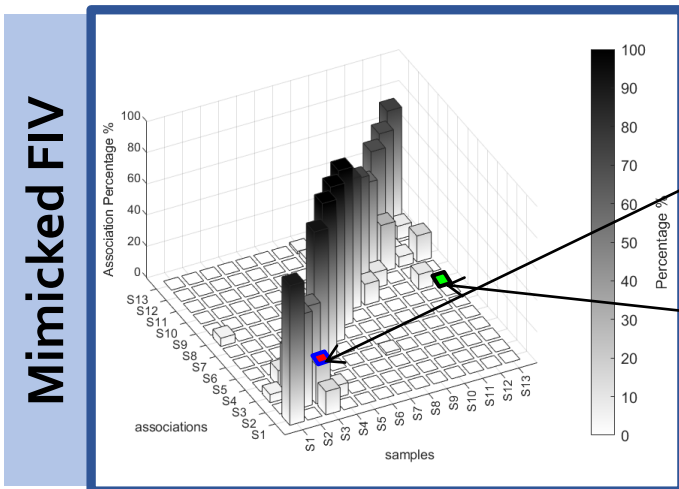
*Good discrimination performance in both discrimination campaigns  
Agreement between results of the two campaigns*

# Discrimination campaign Results

## Interpretation of the results by means of the FIV



*Example:  
FIV spectra of  
samples, frequently  
confused in real and  
simulated  
discrimination test,  
are similar*

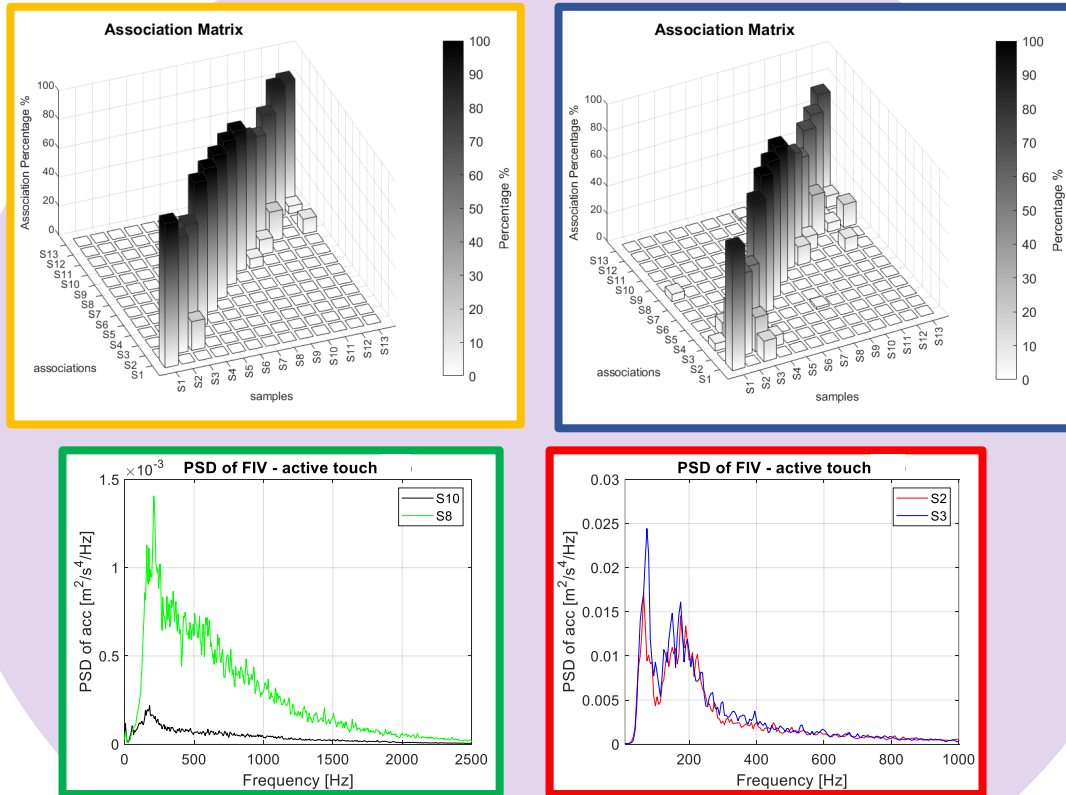


*Example:  
FIV spectra of  
samples, not  
confused in real and  
simulated  
discrimination test,  
are different*

# Discrimination and FIV spectra: isotropic VS periodic textures

## Results from isotropic textures VS the ones from periodic textures

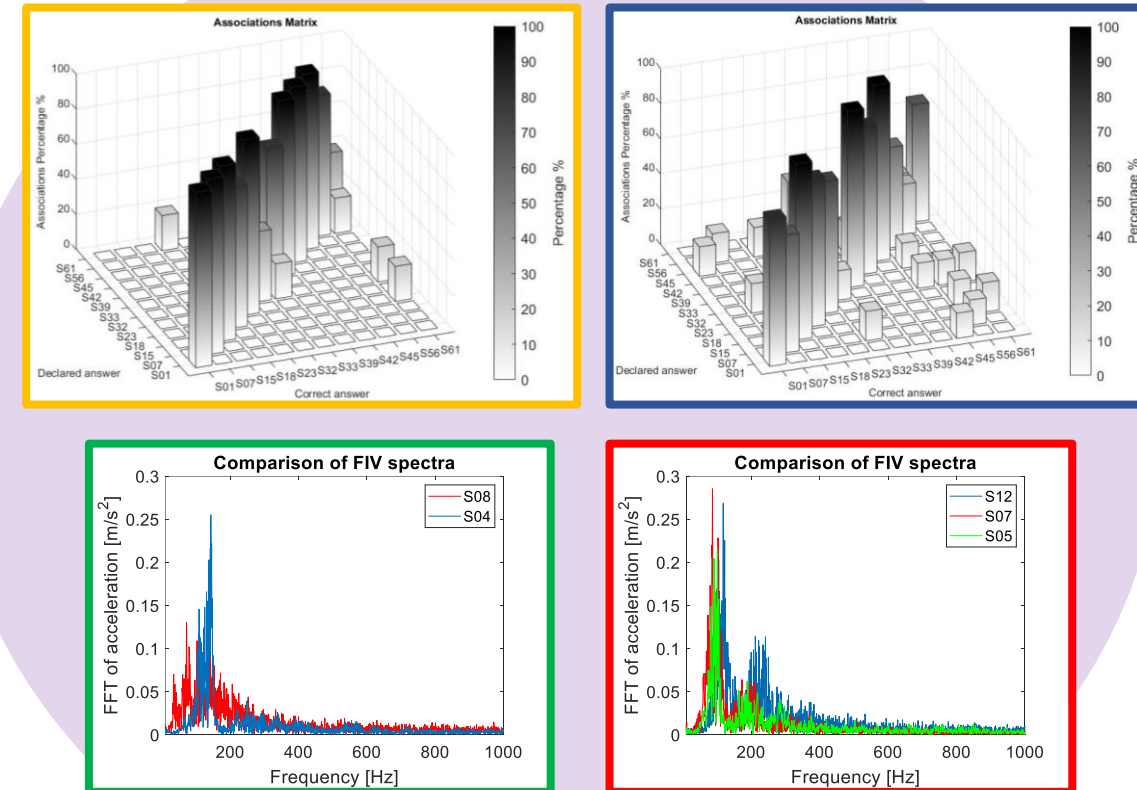
### ISOTROPIC TEXTURES



L. Felicetti, C. Sutter, E. Chatelet, A. Latour, L. Mouchnino e F. Massi, «Tactile discrimination of real and simulated isotropic textures by Friction-Induced Vibrations,» Tribology International, vol. 184, p. 108443, 2023.

07/06/2023

### PERIODIC TEXTURES



Felicetti, L., Chatelet, E., Latour, A., Cornuault, P.-H., & Massi, F. (2022). Tactile rendering of textures by an Electro-Active Polymer piezoelectric device: mimicking Friction-Induced Vibrations. Biotribology, 31, 100211.

Livia Felicetti

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# Conclusions

- Analysis of mechanical stimuli induced by touch of isotropic texture
  - Importance of amplitude of FIV for isotropic textures
- Mimicking of FIV by the PIEZOTACT tactile device
- Discrimination campaigns on real and simulated isotropic textures:
  - Excellent results
  - Agreement between results for real and simulated textures
  - Interpretation of results by FIV
- The results found for isotropic and periodic textures were in agreement, *highlighting the role of the FIV in the discrimination of textures.*

## References

- *L. Felicetti, C. Sutter, E. Chatelet, A. Latour, L. Mouchnino e F. Massi, «Tactile discrimination of real and simulated isotropic textures by Friction-Induced Vibrations,» Tribology International, vol. 184, p. 108443, 2023.*
- *Felicetti, L., Chatelet, E., Latour, A., Cornuault, P.-H., & Massi, F. (2022). Tactile rendering of textures by an Electro-Active Polymer piezoelectric device: mimicking Friction-Induced Vibrations. Biotribology, 31, 100211.*
- *V. Massimiani et Al., The role of mechanical stimuli on hedonistic and topographical discrimination of textures, Tribology International, 2020, 143.*



Lille, France

*Thank you for your  
attention!*



Toucher  
Analyse  
Connaissance  
simulation



*Lille, 7-8 juin 2023*