

Smart objects for upper limb monitoring of stroke patients during rehabilitation sessions.



Maxence Bobin¹, Mehdi Boukallel², Margarita Anastassova² & Mehdi Ammi¹

LIMSI, CNRS¹, Université Paris-Saclay, F-91405 Orsay
CEA-LIST², Université Paris-Saclay, F-91191 Gif-sur-Yvette
maxence.bobin@limsi.fr



Context

- 15 million people are affected by stroke every year. [1]
- Stroke patients encounter varied cognitive and motor impairments.
- Monitoring performed via visual estimations during rehabilitation session without objective data.
- Objective data only collected during monthly checkup.

Objectives

- Monitoring during rehabilitation session.
- Collect objective data of the upper limbs.
- Based on ARAT checkup protocol. [2]
- Provide visualization tools for the therapist.



Ecosystem of smart objects for upper limbs monitoring

Design Process

Identification

Observational study

► Using custom objects for prehension exercises (cones, cylinders, cubes, sticks and rings).

► Collect objective data only during checkup with prehension measurement tools (Jamar, dynamometer, etc.)

► After the session, pendulum exercise to relax shoulder. Pendulum movement has to be natural
→ evaluation of voluntary movements to move the arm.

Based on ARAT

Action Arm Research Test

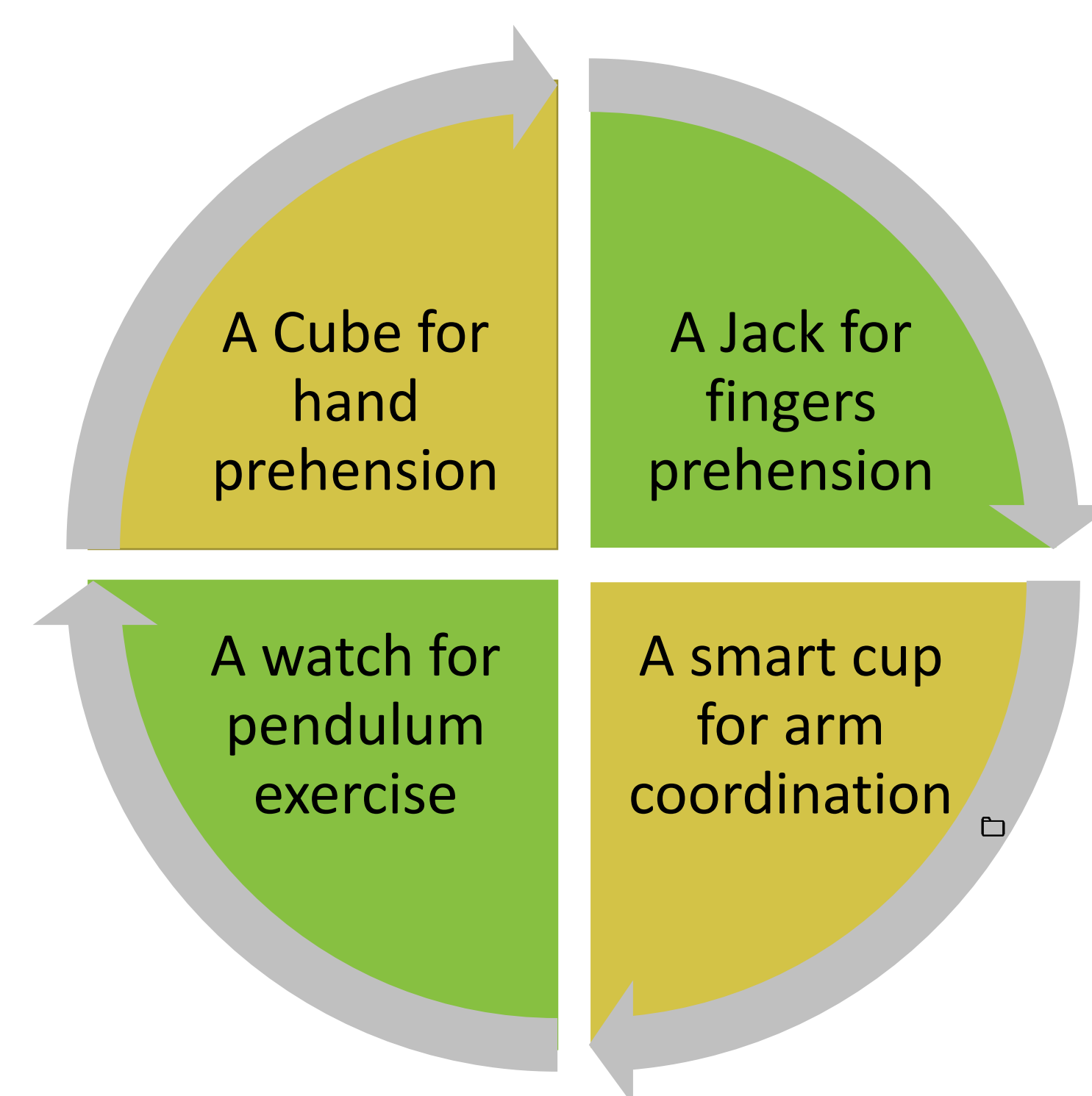
→ **evaluative measure to assess specific changes in limb function.**

► Based on different motor sub-tasks (pinch, grasp, grip and arm movements) with the upper limb.

► Sub-tasks required for daily independence (grasp object, fill a cup, move objects etc.).

► Using cube, cylinder, sphere of different sizes and cups.

Instrumented objects ecosystem



Monitored information and sensors

Cube for hand prehension

Monitored Information:

- Force applied on the cube
- Orientation and tremor during manipulation

Sensors:

- 6 FSR (Force Sensing Resistor) for force
- IMU (Inertial Measurement Unit) for orientation and tremor

Jack for fingers prehension

Monitored information:

- Force applied on the edge of the jack
- Position of the fingers on the edge
- Orientation and tremor during manipulation

Sensors:

- 4 FSLP (Force Sensing Linear Potentiometer) for force and position
- IMU for orientation and tremor

Watch for pendulum exercise

Monitored Information:

- Movements of the arm

Sensors:

- IMU for movements

Smart cup for arm coordination [3]

Monitored information:

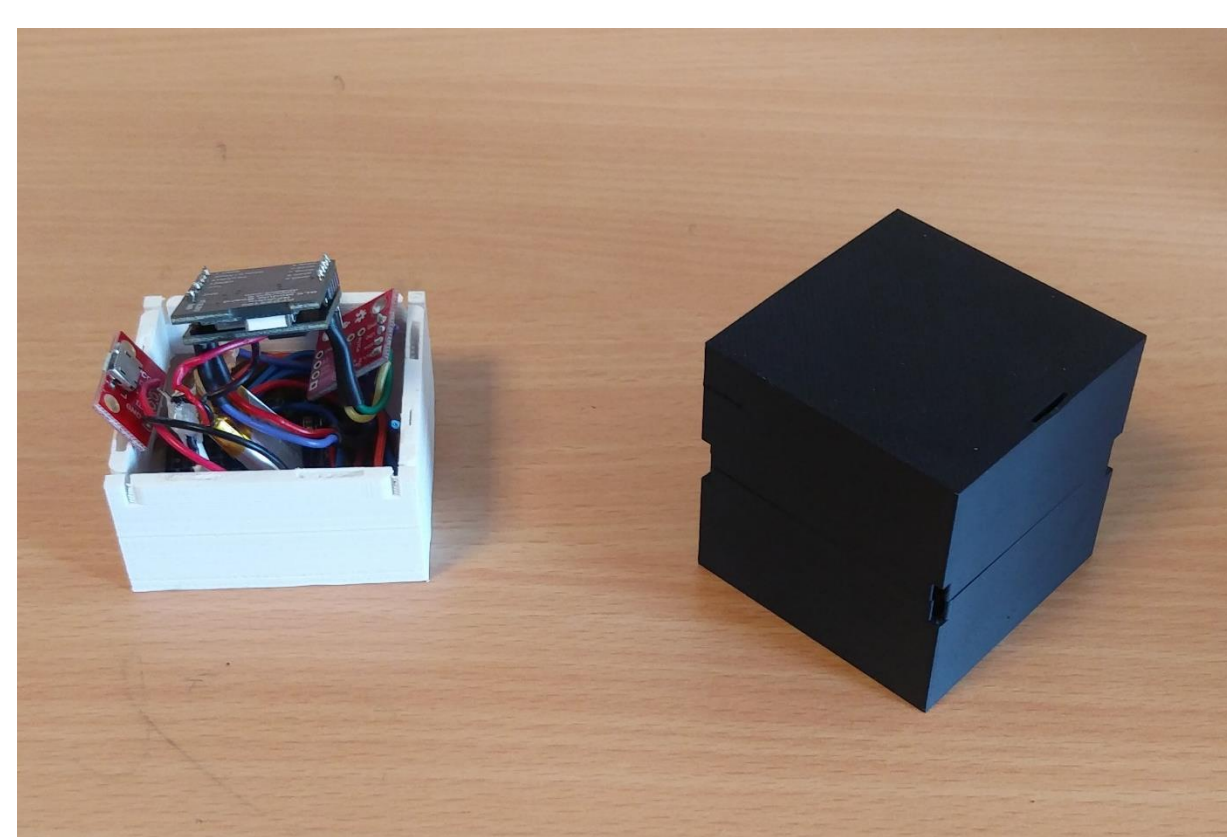
- Force applied on the cup
- Liquid level
- Orientation and tremor during manipulation

Sensors:

- 4 FSR for force
- Liquid level sensor
- IMU for orientation and tremor

Implementation

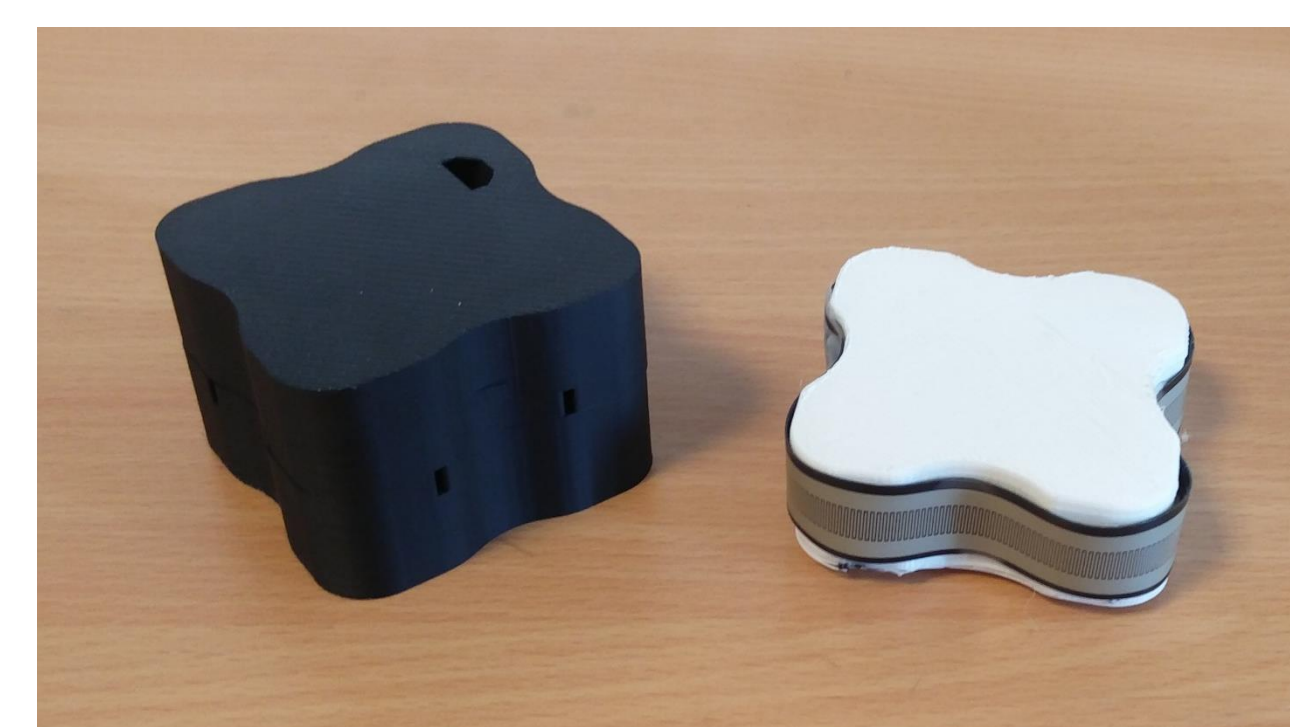
Cube



Watch



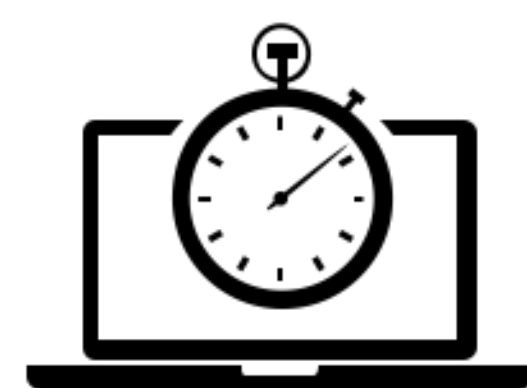
Jack



Smart Cup



Visualization tool



Real-time monitoring



Local data recording



Easily analyze patient's data

Conclusion & Future Work

Conclusion

- ✓ Design of instrumented objects for data collection during rehabilitation session.
- ✓ Implementation of the devices and visualization tools in progress.
- ✓ Recording of objective data about the patient upper limbs state.

Forthcoming Research

- A study is planned with patients and therapists to validate the tools
- Update therapists interface according to feedback
- Perform machine learning on the collected data to predict relapse

Acknowledgments

We would like to thank ISN for their financial support.

References

- [1] J. S. Kim. Delayed onset hand tremor caused by cerebral infarction. *Stroke*, 23(2):292-294, 1992.
[2] <https://www.strokeengine.ca/assets/arar/>
[3] M. Bobin. SyMPATHy: smart glass for monitoring and guiding stroke patients in a home-based context. In Proceedings of the 8th ACM SIGCHI Symposium on Engineering Interactive Computing Systems (pp. 281-286). ACM, 2016.