Normandie Université

2018

TactiBelt: Integrating spatial cognition models into the design of assistive devices for VIP

1

RIVIERE Marc-Aurèle

2nd year PhD Student
LITIS Lab
University of Rouen

GAY Simon

Post-Doc
LITIS Lab
University of Rouen

PISSALOUX Edwige

Tenured Professor
LITIS Lab
University of Rouen

Introduction: our project

TactiBelt

- **Assistive device** for VIP
- **Navigate autonomously**
- Perceiving the **topography** of their environment
- **Indoor** and **outdoor**

Sensory Substitution | **ICT** | **Neurocognitive models**

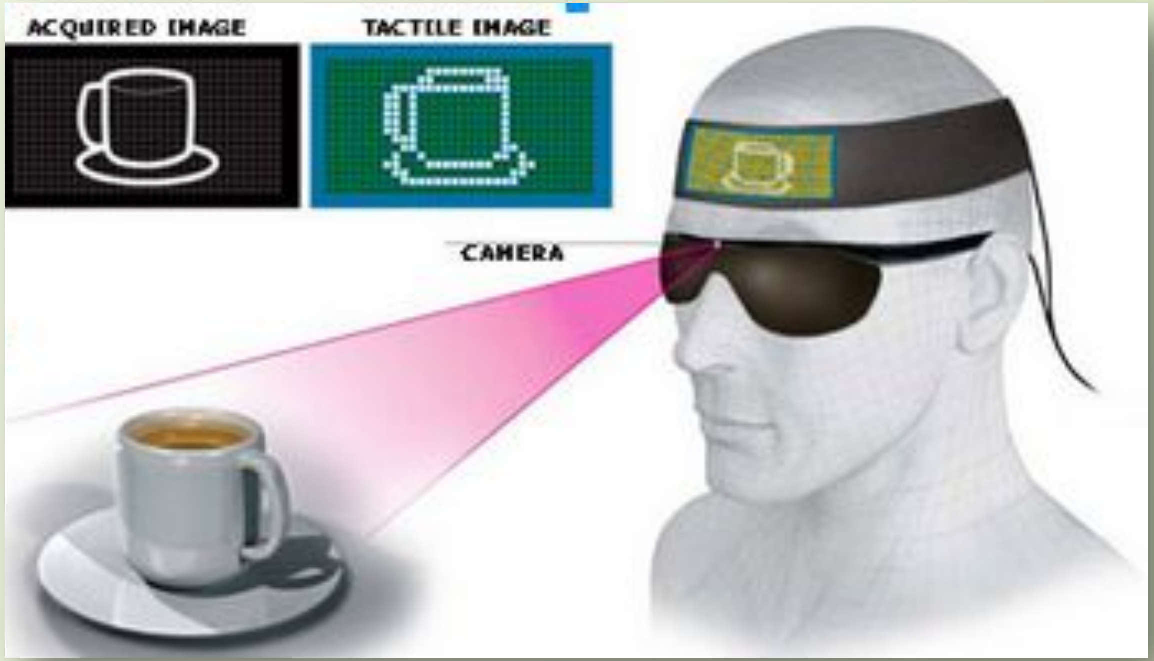
Introduction: sensory substitution

- **Sensory Substitution:**
  - Convey **no longer accessible** information through an "**unusual**" **sensory channel.**
- **Sensory Substitution Device (SSD):**

Sensors

Actuators

Algorithms



Introduction: motivation

- Many **mobility assistive devices** focus on <u>**locomotion**</u>

Autonomous Navigation = **Locomotion** + **Orientation**

- Provide **large-scale "map" of their surroundings**

Where they are | **Where they want to go** | **Where they can go**

- Construct a **mental representation** of their surroundings

Autonomy | **Safety**

Introduction: challenges

1. **Tactile & audio sensory channels** → smaller than vision
   - **Synthesize**

2. **Geographic map format** → complex, made for the sighted
   - **Adapt** (task, substitution channel, impairment)

↓

- **Simplified substitute representation** of a map
  - Provide a minimal yet sufficient set of features
  - Intuitively represent the topography of the VIP's surroundings

I. Spatial substitution

I. Spatial substitution: idea

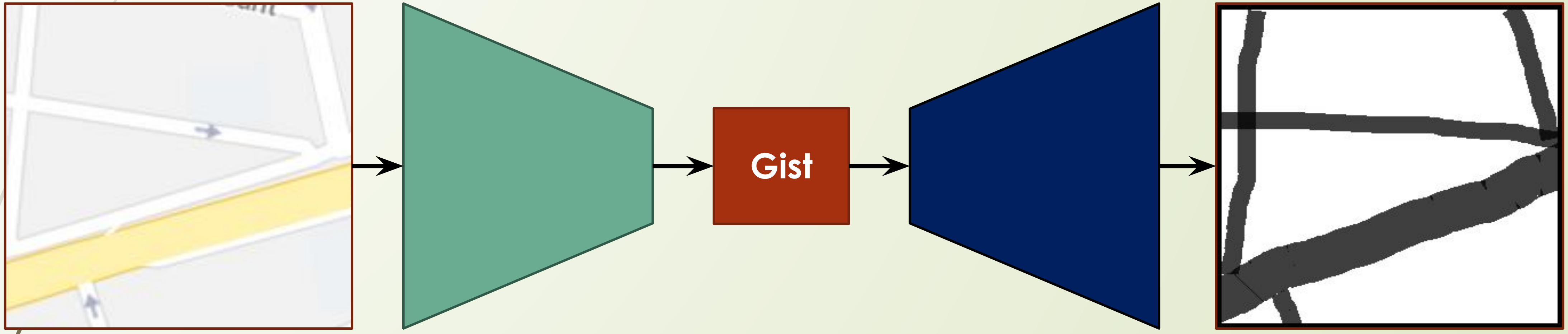
- **Neurocognitive processes** & **specialized brain areas** dedicated to **process spatial information**:
  - Specific environmental cues
  - Extrapolate spatial topography (mental map from minimal data)
  - Those process are amodal

- **Provide the right cues → leverage those processes**
  - Information they have evolved to process
  - fMRI studies → tactile and audio cues activate occipital cortex

- **Facilitating plasticity** and learning

I. Information selection: spatial gist

Spatial gist



Information to convey

Gathered by the SSD’s sensors

Adaptation & Synthesis

Match the information “expected”

Extrapolation

Existing spatial cognition processes

Mental representation

Close enough to the initial information

I. Information selection: spatial cognition

Spatial Cognition

Integrate multisensory information → Extract relevant features → Build mental representation

Which **information humans use to orient themselves ?**

Which rely on vision → substitute them → Spatial gist

Hierarchical models of navigation (E. Spelke)

I. Information selection: spatial substitution

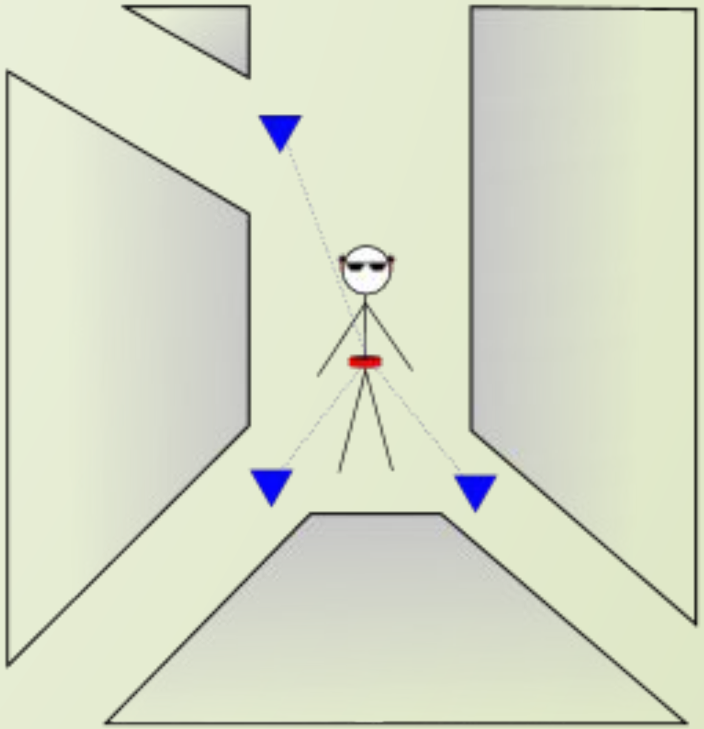
Hierarchical models of navigation

Spatial cognition model	Information needed	Substitute (spatial gist)
Path integration	Proprioceptive	🚫
(Oriented) **Visual place recognition**	(Vision) **Memorized scene features**	**Points of Interest** (landmarks)
Topographical reorientation	(Vision) **Layout** (room, street)	**Path possibilities** (“nodes”) **Destination**

I. Information selection: spatial gist

Spatial gist

- **Obstacles** (small-scale)
- **Nodes** (medium-scale)
- **Points of Interest** (large-scale)
- **Destination** (large scale)



Nodes

I. Information selection: spatial gist

Hypothesis:

Spatial gist

↓ Emergence

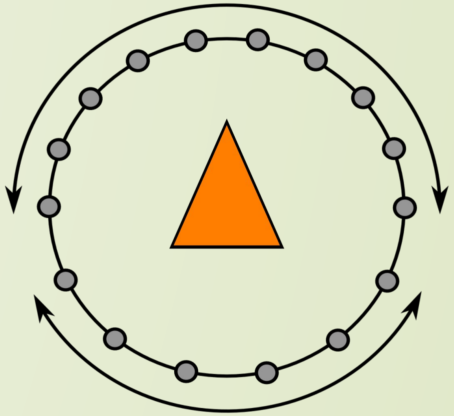
Mental representation

Intuitive ↓ Relevant

Autonomous navigation

II. TactiBelt design

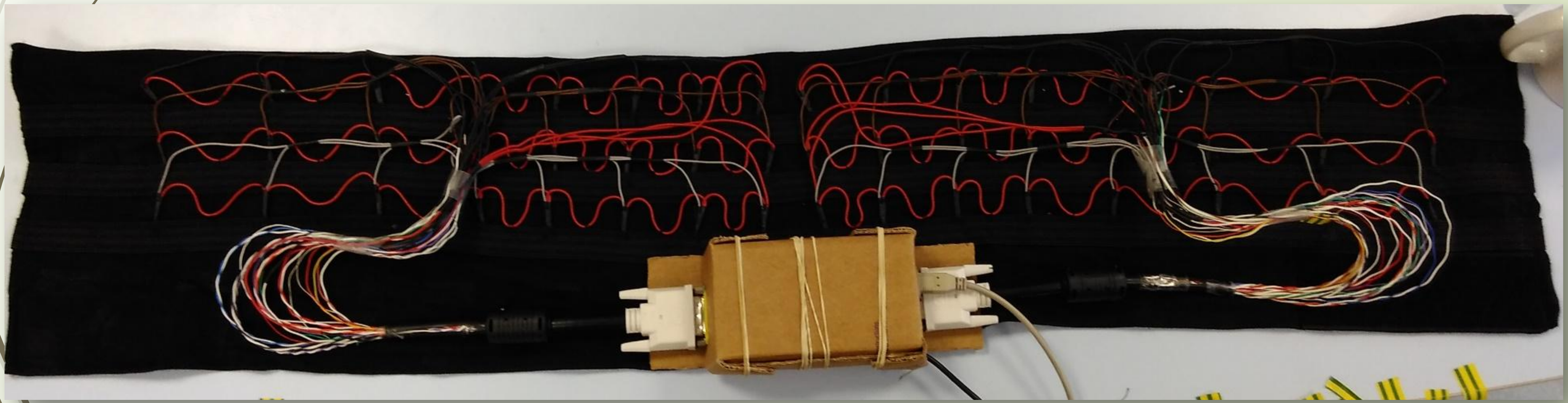
II. Interface design: TactiBelt



TactiBelt

Waistband fitted vibrators

- Java interface → Arduino mega → Vibrators (LRA)



II. Interface design: vibration code

- **Features' position → ego-centered referential** :
  - Orientation → orientation of active vibrator
  - Distance → pulse intensity
- **Distinguish features → type of vibration** (signature)
  - One type of vibration at a time, rotating between all 4 types
  - Max of 5 vibrations simultaneously (cognitive load)
- **Audio feedback** (on demand) for landmarks (PoI) identity

III. Conclusion & future work

III. Conclusion

To summarize :

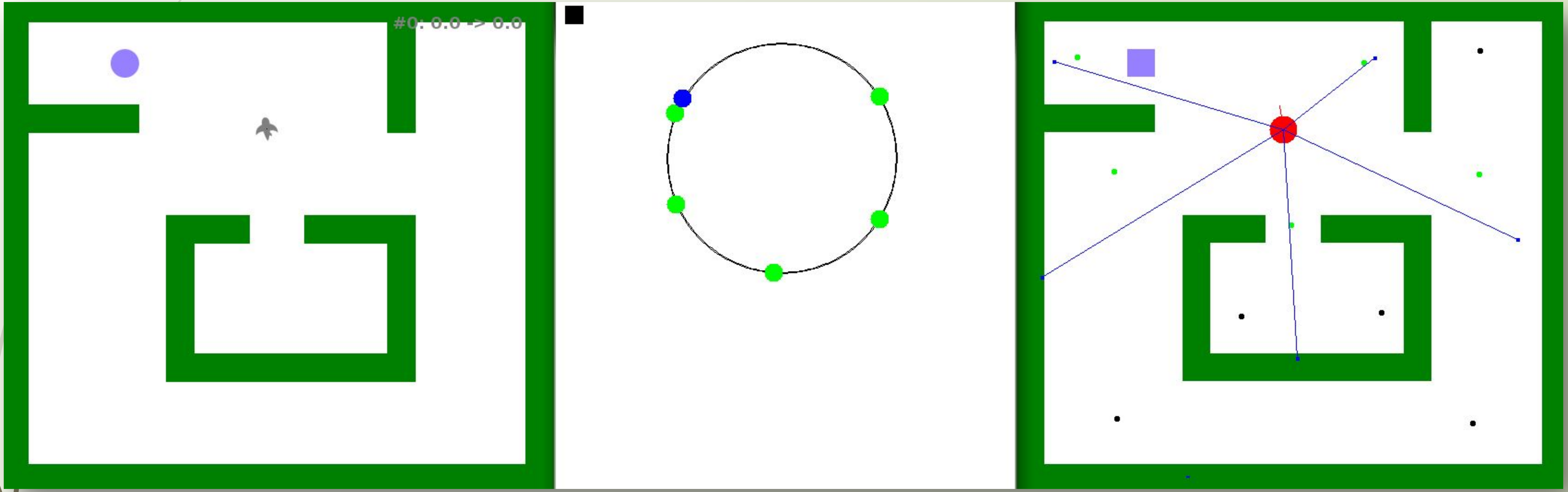
- Integrate human spatial cognition models → design of our SSD : TactiBelt
- Spatial information → spatial gist → leverage existing processes
- Ego-centered code → TactiBelt
- Mentally represent their surrounding's topography
- By knowing where they are, were they want to go & how to get there

Will allow :

- Intuitive learning & use (low cognitive load)
- Efficient assistance in navigation tasks
- Acceptability

III. Future work: evaluation

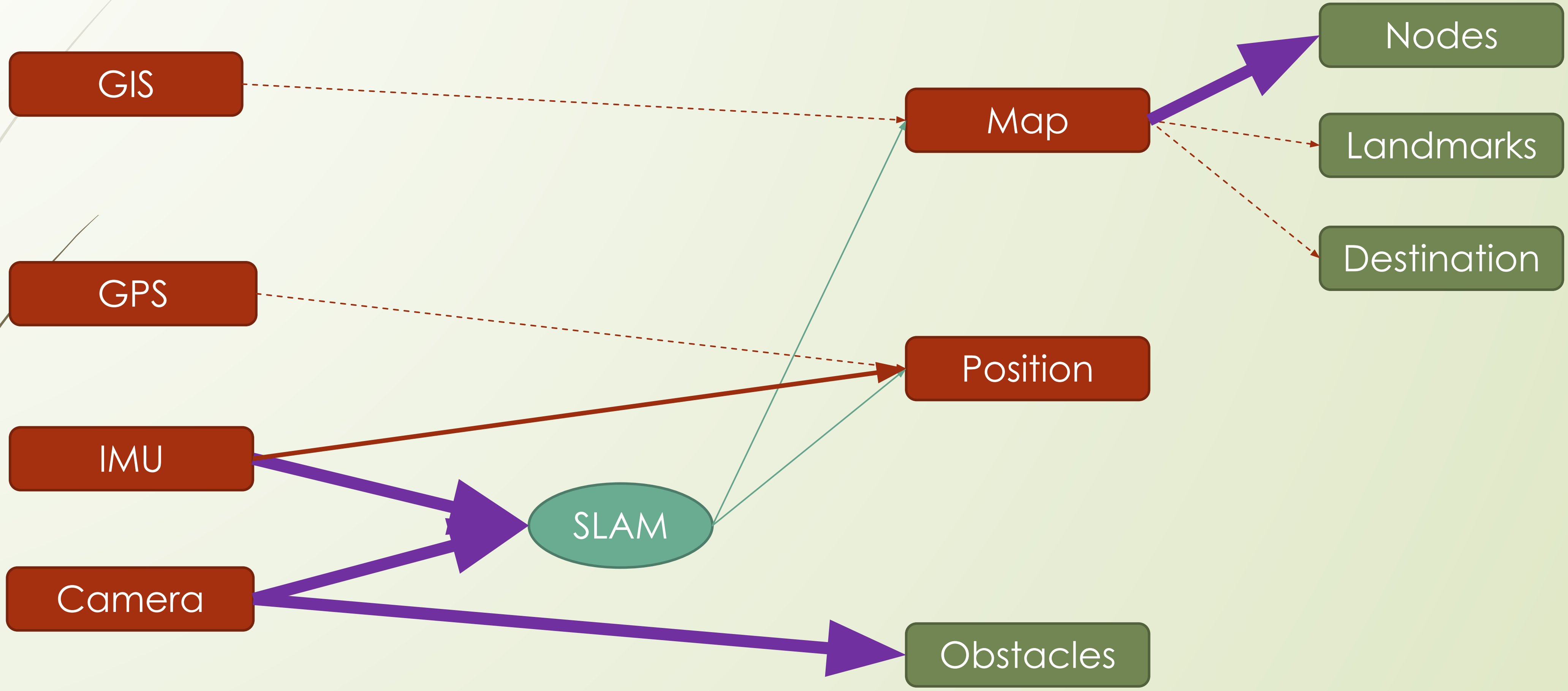
First evaluations: virtual environment



1. Relevance of the provided spatial features
2. Intuitiveness of the interface and tactile code use

19

III. Future work: environment sensing



Espace Handicap

Thank you

To all our partners