



Assistive technologies to support independent mobility of visually impaired



PARIS

Edwige Pissaloux

Institut des Syst mes Intelligents et de Robotique
(ISIR) UPMC/CNRS UMR 7222

France

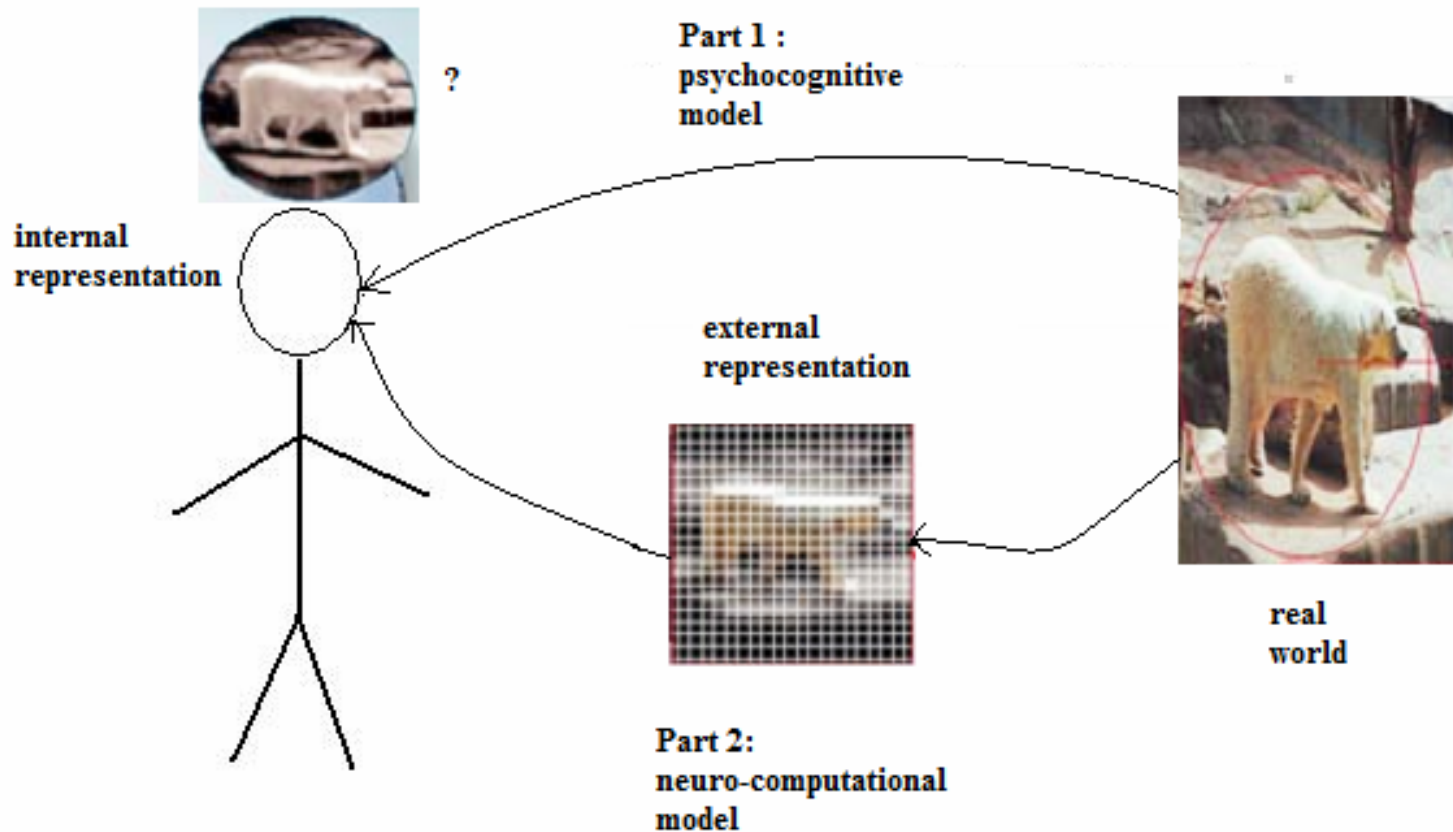


VERSAILLES

Outline

1. Psycho-cognitive vs neuro-cognitive computational model for independent mobility
2. Some basic concepts and definitions for independent mobility.
3. Known neuro-cognitive functions useful for mobility.
4. Technologies for supporting mobility functions
5. Example of mobility assistance :
commercially available device, european and laboratory projects.
6. Conclusion.

1. Psycho-cognitive vs neuro-cognitive computational model



Psycho-neuro-cognitive model

- what memorise
- how memorise
- how to extract
- when to extract
- what presentation in brain
- where in the brain calculation is performed

Neuro-computational model

- which functions
- what are their parameters & values
- what are results
- how their are calculated

Holistic model of brain calculations (redundancy)

2. Some basic concepts and definition for independent mobility

Walking, Navigation, Orientation, Space perception, Mobility

Near space = space immediatly perceptible

Far space = space not immediatly perceptible

Walking

displacement without specific goal to reach with obstacle avoidance
near space

Orientation

self localisation in space (« where am I?», « where is my goal to reach »,
« From what direction did I come ? «In what direction should I continue? », etc.)
near & far

Navigation

displacement with a specific goal to reach with obstacle avoidance
near and far space

Space perception

space awareness

near and far space

Mobility

walking + navigation + orientation + space perception

posture/balance keeping

movement execution

Remarks.

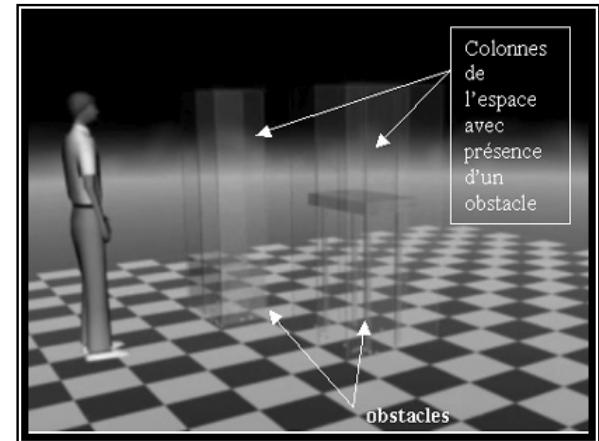
G. Jansson « definitions are never right or wrong, only more or less suitable ».

E. Pissaloux : for computation purpose/assistive device design, we should have definition of appropriate abstract level suitable for technology implementation.

3. Known neurocognitive functions useful for mobility

Walking

- obstacle consciousness = detection and localization (straight ahead from me)
- distance to obstacles estimation
 - ego-distance = “me and obstacle”
 - allo-distance = between two obstacles
- heights estimations
- directions and orientation estimations



Space virtual
Partition mobility

Enactive interfaces, IST-2004-002114, <http://www.ist-world.org/>

Hersh, M., A., Johnson, M. A., (Ed.), Assistive Technology for Visually Impaired and Blidn People, Spinger, 2008

Pissaloux, E. E., Interfaces visuo-tactile d'aides à la mobilité de déficients visuels : un état de l'art, STH J., Hermès, 2009

Uzan, G., Deleammes, M., seck, M., Rennesson, C., Besoins en sécurité, localisation et orientation des déficienst visuels en milieu urbain : analyse de la situation et pistes d'évolution, CR Handicap 2008, Paris, 10-12 juin 2008, pp. 37-42

Orientation

- self-localisation relatively to a goal to reach
- self-localisation in a space
- self position continuous estimation to the goal to be reached,

Navigation

- « walking functions »
- « orientation functions »
- moving toward (sub)goal(s) (way finding)
- landmarks detection, recalls, sequentiality confirmation (following)

Space perception

- understand of the geometry of the space
(« all near-by obstacle » detection and localisation),
- understand social and urban organisation of the space
(urban and social data memorisation and explanation)
- (continuous) self-localisation

Mobility

Walking + navigation + orientation + space perception functions

+ posture/balance keeping + movement physical execution

Assistive devices for visually impaired assume that are well mastered

- posture/balance keeping
- movement physical execution

An assistive device should

- support efficiently all mobility functions
- provide all near distances in euclidean metric used in physical displacement
- provide Riemanian metric for far distances estimation
- assist/correct “usual” errors in distance estimation
- assist/correct “usual” errors in direction estimation
- assist the scale judgement between perceived and physical distances
- correct the perspective errors (if pertinent)
- personalisation and memorisation of journey paths
- allow learning/preparing new journeys.
- share the mobility experience.

4. Technologies for supporting mobility functions

Criteria : (1) distance (2) invasivity of sensors

- obstacle detection and localization in near space :
 - passive sensors : tactile, vision
 - active sensors : sound, laser, infrared
- obstacle detection and localization in far space : vision
- distance (ego- and allo- centered) estimations
 - near space : vision, active sensors
 - far space : GPS (if works)
- heights estimations (relative hight)
 - near space : vision

- directions and orientation (ego- and allo- centered) estimations
(tactile & GIS) map, (journey) memory
verbal assistance (voice synthesis)
- landmarks detection, recalls, sequentiality confirmation
vision, specific map, verbal assistance (voice synthesis)
- self-localisation
GPS (if works), (journey) memory
- self position continuous estimation to the goal to be reached,
- way finding
tactile map, memory (path integration strategy)

- spatial and urban awareness,
 - + “global” space geometry perception and understanding
 - + urban and social data memorisation and explanation

GIS map

verbal assistance (voice synthesis)

5. Example of mobility assistance : commercially available devices, european and laboratory prototypes.

Classification criteria

- (a) the nature of the assistance provided (mobility or orientation or both),
- (b) the space which will be investigated (near or large),
- (c) the complexity of the technology.

The main classes:

- 5.1. Traditional low-tech aids
- 5.2. ETA (electronic travel aids of medium-tech)
- 5.3. EOA (high-tech electronic orientation aids)
- 5.4. Assistances for navigation
- 5.5. Assistance for mobility

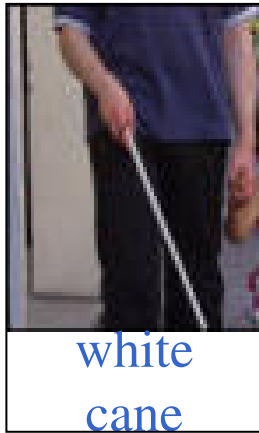
5.1. Traditional low-tech aids : canes

° for walking

(Long) cane : 0,7m (1m)

° near space exploration

° for immediate and surface-located object detection and localisation



GuideCane

(University of Michigan, Borenstein, 1997).

Dog

- can assist walking and navigation
- more or less effective for obstacles avoidance
- more or less effective for orientation.
- training has considerably improved
- inefficient for space perception

- 10 years on average,
- a significant cost (about 10K€).



Tactile map

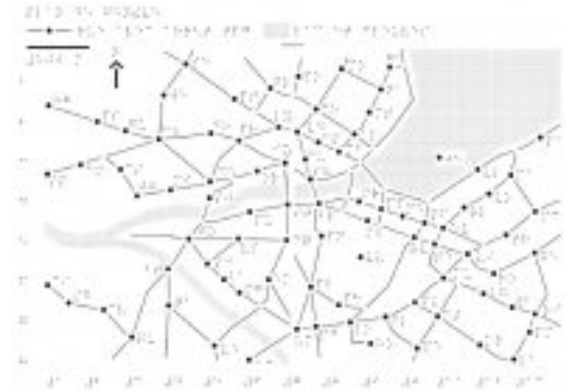
° for far space understanding



Paris



Hamburg



Genova

5.2. *ETA (electronic travel aids of medium-tech)*

- for near space exploration (beyond the reach with the long cane)
- provide information about obstacles (without object recognition) & landmarks

Two types of devices

- (a) cane with active sensors (laser, infrared or ultrasonic sound : echolocation)
in order to increase the user protection against overhanging obstacles
- (b) camera(s) with tactile surface.

Canes

- The obstacle detection is based on a triangulation principle;
- Feedback to user : hand tactile or audio feedbacks.

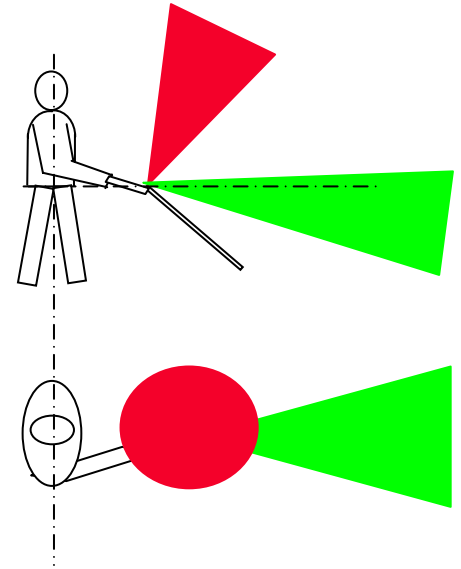
First « intelligent cane » : Laser Cane (Benjamin, 1973),



Ultra Cane,
University of Leeds, UK
2006



Paris 11, 2008

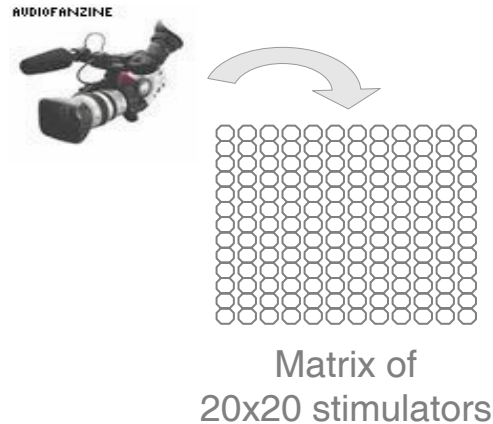
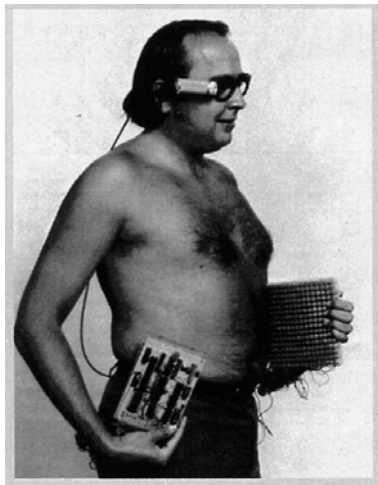


Intelligent canes principles
With vibro tactile/audio feedbacks

One camera with tactile surface

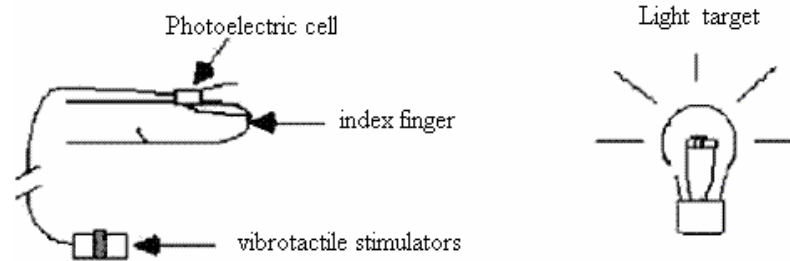
(Starkiewicz, 1963 (Electrophthalm); Bach-y-Rita, 1972 (TVSS, TDU), Deering, 1985 with use of synthetic speech)).

- the tactile stimulation in these systems is directly applied to the human skin.
- one camera does not allow to estimate the depth distances to obstacles;
- all visual illusions related to 3D scene perception persist in their tactile coding.



TVSS

One camera with one tactile element (Lenay, FR, 1995) ⁽¹⁾ (laboratory prototype)

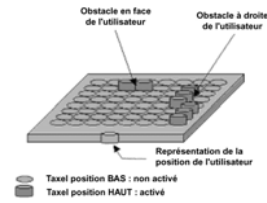
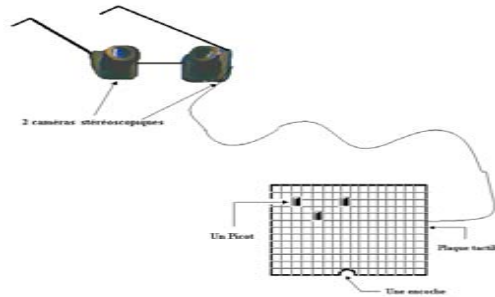


- A photocell is fixed at one's index finger.
If the index points to a light target, the photocell is activated and the vibrotactile stimulator is activated ; the subject perceives the vibrations.
- The naive blindfolded subjects have been able to perceive the light source as existing point and attribute it the global spatial characteristics such as
 - ego centered relative distance and
 - direction.

Stereo rig with tactile surface

UPMC-Paris 6/Intelligent Glasses, 2002

- for walking in near space
- all obstacle detection (static and dynamic)



5.3. EOA (high-tech electronic orientation aids)

for exploring larger spaces,

- obstacles detection
- assistance of
orientation,
self-localisation
“global space verbal perception”.

Two types of technologies for self-localisation:

- GPD/DGPS
- hybrid Wi-Fi & GPS.

The **Global Positioning System** (GPS)

- an imprecise localisation (less than 20m) (useless for self-navigation.)
(due to reflected signals (multipath), atmospheric perturbations,
and satellite geometry; signal is difficult to capture in urban areas,
absent indoors and underground).

Example :

a) **GPS + GIS**

- + virtual travel before a trip,
- + guidance by the device during the trip

The Mobic Travel Aid, EU project (Petri, 1995, 1996)

b) talking digital map (Atlas)

c) **GIS + GPS** (Strider, commercialised : www.senderogroup.com)



<http://www.humanware.com/en-europe/home>

◦ **Differential GPS** (DGPS) (Loomis, 2001)

- localisation with a precision of about 1m.
- requires ground base installation (cost and cumbersome environment instrumentation).

◦ **Galileo** will provide

- two levels of precision 5m (open service) and 1m (commercial service).

Hybrid technology

- Wi-Fi & GPS
environment instrumentation (cell tower signals)
- produce the best possible localisation regardless of environment
(Skyhook Technology's Loki, June 2008).
- limited precision of about 20m.
- end-user tracking (for reaffirmation of cognitive landmarks during the journey, for example)
is a complex not yet solved task.

5.4. Assistances for (both-near and far- space) navigation

Global space perception is assisted by

- spatial displays with active sensors for data acquisition
- obstacle detection & localisation
 - + via a speech synthesis (compatible with an arbitrary predefined gaze orientation)
(NOMAD, Parkes, 1988; TACTISON, Burger *at al.* 1993; AUDIOTOUCH, Löttsch, 1995)
 - + or 3D space haptic coding perceived by hand or by the back.
(Robot Assisted Navigation : Haptica's Guido, Cyclop/Clermont University, FR)
- environment instrumentation (beacons, RFID).
- might cause the masking of sound environmental cues useful for orientation.
- not precise user self-localisation and self-orientation.
- not continuous landmarks and check points for journey confirmation.



Other projects:

EO Guidage/FR,

Talking Signs,

CASLIB/EU project;

Haptic Pointer Interface (HPI/Santa Barbara University),

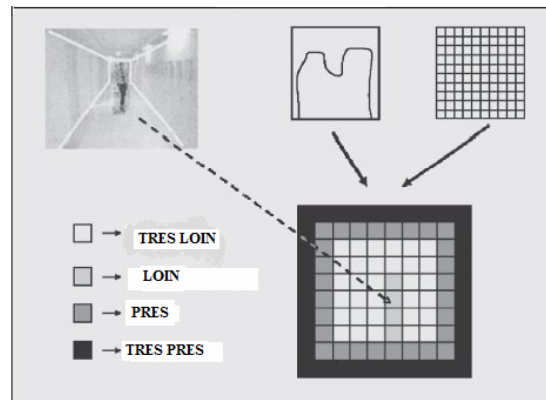
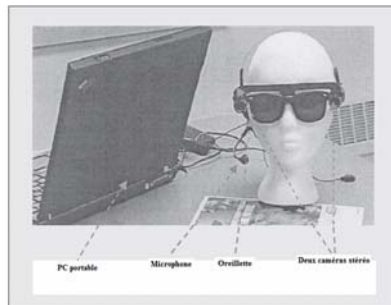
Universal Real-time Navigational Assistance (URNA),

Drishti pedestrian navigation system,

Ertan's wearable navigation system

ASMONC/EU IST project, Tormes/ESA and ONCE

Tyflos, Wright State University (2008).



6. Conclusion

1. Low-tech traditional mobility and orientation aids will continue despite of their limited usefulness (simplicity of use, symbol of fragility, low cost)

Medium-tech aids do not add significantly new functions to traditional aids.

High-tech EOA are too dependent of the GPS technology

None of these technology supports all mobility neuro-cognitive functions.

2. New assistance for mobility should

- + be based on space augmented perception and
- + assist all mobility functions
- + be a portable system independent of GPS
- + be based on passive sensors only
- + without environment instrumentation

3. New assistance should allow

- + journey planning, preparation and execution
- + detect temporary changes in the environment (road works, dynamic obstacles)
- + provide directional information and affirming landmarks
- + provide more detail when arriving to the targeted destination.
- + provide personalised mobility assistance