WIRELESS INDOOR NAVIGATION SYSTEM

TECHNOLOGY AND STRATEGIC PLANNING PRESENTATION

Enrico M. Staderini MD, PhD
Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud – HES-SO
Western Switzerland University of Applied Sciences
Route de Cheseaux, 1
CH-1401 Yverdon les Bains (Vaud) Switzerland
enrico.staderini@heig-vd.ch

Previous history

My seminal and pioneering work in UWB radars started in 1995 after UWB radio was mostly declassified from the military

Why the military were so interested into it:

STEALTH radio
- very low probability of intercepting and jamming
- intrinsic cyphering

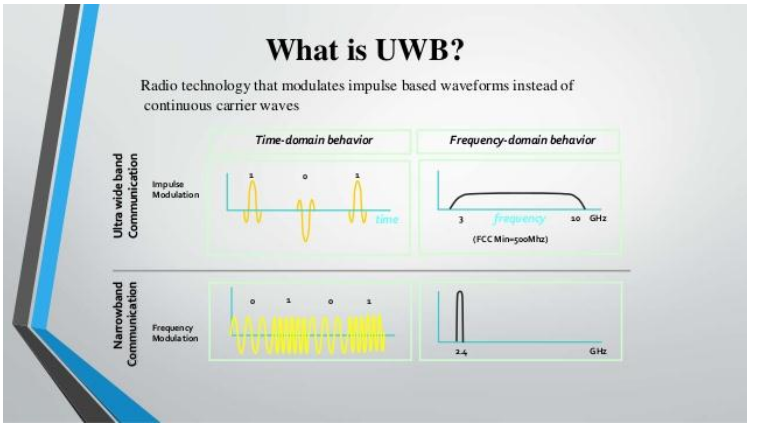
STEALTH radar
- very low probability of detection (signal hidden into the noise floor)

Through wall object detection
- spying and anti-terrorist applications

Non-contact mine detection, ground penetrating radars
- safe de-mining (even for plastic bodied mines invisible to magnetic sensors)

Previous history

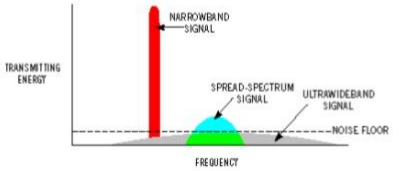
What is UWB all about ? Why this name ?



Previous history

How UWB works

- Generation of extremely short digital pulses in the subnanosecond range.
- Uses and extremely wide band of RF spectrum to transmit data

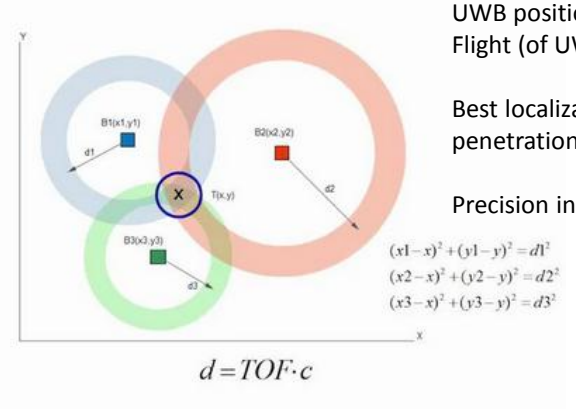


Because of its frequency content, UWB pulses are much more penetrating than conventional radio

Because of its low power, UWB pulses are not interfering with existing radio services

Previous history

The use of UWB radio for localization and positioning



UWB positioning by measuring Time of Flight (of UWB radio pulses)

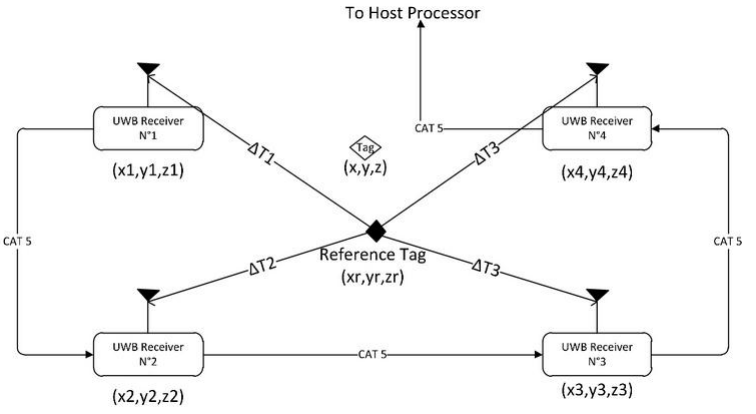
Best localization method indoor (wall penetration, multiple paths mitigation)

Precision in the order of 15 to 50 cm

Previous history

The use of UWB radio for localization and positioning

UWB fixed receivers acts as the satellites in the GPS system



Going forward

The idea of using UWB localization for blind people navigation

Conventional GPS systems not working indoor
Navigation problems of blind people not yet commercially viable
Location based services business model

The application for sport performance evaluation
The large field of localization based services (LBS)

New business models for navigating large buildings
    Destination management systems (DMS)

The future of LBS

Blind people navigation aid

What is all about

Most of systems for aiding the blinds are focused on local obstacle avoiding (local navigation)

Blind people navigation aid

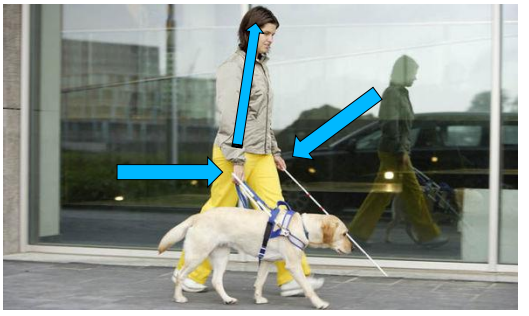
What is all about

Guide dogs may also provide wider range navigation guide (global navigation)

Blind people navigation aid

Please note

Both white cane and guide dogs send information to the blind people by means of a tactile interface (haptic interface)



Vision of the WINA system

Providing blind people a navigation assistant system able to cope both with local obstacles and with complete path planning from a location to a destination with the possibility of being interoperated in many different places

Mission of the WINA system

Providing blind people a socially acceptable navigation assistant system simple and naturally operated, unobtrusive, mobile, user friendly

GPS vs. WINA

There are many misunderstandings between standard and well-known GPS system and WINA

	GPS	WINA
use	outdoor	indoor/outdoor
coverage	global	local
precision	15 meters	15 centimeters
path finding	on existing roads (locus of points on a graph)	on steppable surface (locus of points reachable by walking)

GPS vs. WINA

	GPS	WINA
obstacle	detection left to the user	known by the system
obstacle definition	left to the user's appreciation	any point on the surface which is not reachable because of its elevation compared to current elevation of point where the user stands
obstacle avoiding	left to the user's appreciation	partially managed by the system
map	local to the user (may be obsolete)	maintained by the server, available to any user, continuously dynamically updated

GPS vs. WINA

	GPS	WINA
user's position	only known to the user	known by the system for navigation aid, multiple users interaction, location based services delivering
location based services	limited to points of interest (restaurants, gasoline stations)	extended, dynamically changing and updated, user configurable
obstacle avoiding	left to the user's appreciation	partially managed by the system
navigation	2D (incertitude when passing under/over bridges or close to other roads)	full 3D (steps, staircases, different floors positioning managed)

WINA

	WINA
contestuality	location description: "at the entrance", within 100 m from", "under of", "over of", "on the right of", "on the left of", "in front of", "behind of"
contestuality	possible destinations from the present location: "ticket counter", "bar", "toilette", "first aid", "platform", "bus stop", "door", "window", "object", "lost object"
environment description	system may describe the local environment to the user : "you are in a living room", "there is a sofa on the right", "there is a window in front of you", "the room you are in is 4m by 3m wide", "there is a door on the left opening on the corridor", "the window is open", "the door is closed", "there is an object hanging from the ceiling"
animated/unanimated objects	location based services are provided on request or by default (wheelchair, normal walking user)

Location based services

They are services like messages or actions (automatically delivered or provided on request) which are timely provided in the place where the user is and/or the condition in which the user is

(i.e.: because of the present location and condition of the user)

Location based services

How to trigger LBS

Location, i.e. proximity, direction, speed
Local measures (temperature, light, wind)
Will of the user
Time in a given location
Automatically

Location based services

LBS imply automation

Home automation: domotics
Public place automation: ambient automation

Feedback loop:
position → required service → actuator → position

Location based services

LBS may be integrated by local measures

User enters home → Sensor detects home is cold → Heaters are automatically switched on in the room where the user is

User sits on the sofa → location based service switches on the Hi-Fi system

User approaches stove → location based service warns if hot

User leaves the kitchen → location based service warns if cooker still switched on

Location based services: messaging

LBS messages dispatching

To/from the user:

advertising, navigation aid, help, assistance, security, other services

To/from local automation systems

heaters, entertainment, kitchen, bathroom

To/from local human provided services

the blind user approaches the queue at the counter → a message is sent to the box office employer → the box office employer looks for the blind user and offers him to jump the queue

Internet of things

Positioning and navigation technology

What's about navigation ?

Global navigation:

the ability to determine one's position in absolute or map-referenced terms, and to move to a desired destination point. **Getting between locations**

Local navigation:

the ability to determine one's position relative to objects (stationary or moving) in the environment, and to interact with them correctly. **Carrying out a task while at a location**

Personal navigation:

it involves being aware of the positioning of the various parts that make up oneself, in relation to each other and in handling objects. **Monitoring his own body and anything in contact with it**

Positioning and navigation technology

What's about navigation reference ?

Global navigation:

there is a point on the planet Earth to which any other point (fix) is referenced (measured). **Absolute reference**

Local navigation:

There is a point in the environment of the user to which any other point (fix) is referenced (measured). **Relative reference**

Personal navigation:

There is a point in the user (head, center of gravity) to which any other point (fix) of the body is referenced (measured). **Own reference**

Positioning and navigation technology

Vision based positioning

Map based positioning:

A global fix is reported on a map to assess where the user is

Create a local map and then compare this map with the global map to understand where the user is

Landmark based positioning:

A relative fix is considered on the distances between known landmarks in the scenario

Positioning and navigation technology

Vision based positioning

Landmark-Based Positioning

Model-Based Approaches

- Three-Dimensional Geometric Model-Based Positioning
- Digital Elevation Map-Based Positioning

Feature-Based Visual Map Building

Sensors

Laser range finders

Visual cameras

Depth cameras

Positioning and navigation technology

Other technologies

Dead-reckoning

- Odometric sensors
  - Optical, magnetic encoders
  - Doppler sensors
  - Accelerometers and gyroscopes

Active beacons

- Laser, sonar, radio, microwave
  - RF-ID
  - Ultrasound
  - Microwave

Positioning and navigation technology

Active beacons

Triangulation (AOA angle of arrival positioning)

it uses the bearing between the user's heading and a number of beacons

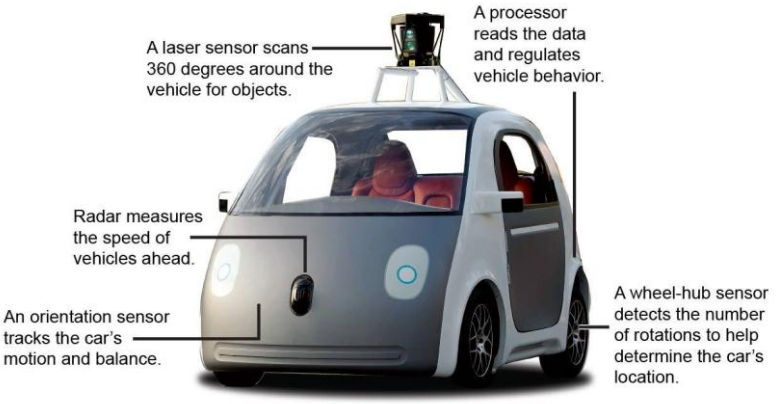
Trilateration (TOF time of flight positioning)

it uses a measurement of distance between a number of beacons and the user

1. Scanning detectors with fixed active transmitting beacons
2. Rotating emitters with fixed receiving beacons
3. Scanning emitter/detectors with passive reflective beacons
4. Scanning emitter/detectors with active receiver/transmitter beacons

Positioning and navigation technology

Environment Ranging Sensors



Source: Google

Raoul Rañoa / @latimesgraphics

Positioning and navigation technology

Environment Ranging Sensors

Most sensors used for the purpose of map building involve some kind of distance measurement. Below are the three distinct approaches to measuring range:

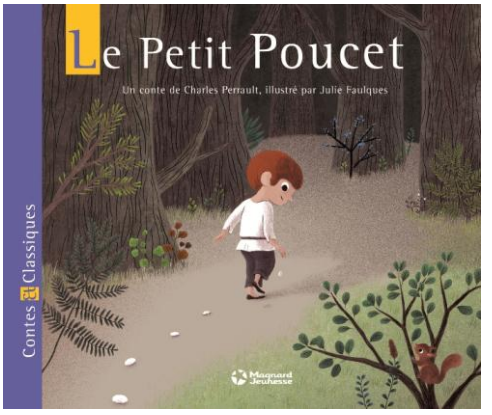
Sensors based on measuring the time of flight (TOF) of a pulse of emitted energy travelling to a reflecting object, then echoing back to a receiver.

The phase-shift measurement (or phase-detection) ranging technique involves continuous wave transmission as opposed to the short pulsed outputs used in TOF systems.

Sensors based on frequency-modulated (FM) radar. This technique is somewhat related to the (amplitude-modulated) phase-shift measurement technique.

Positioning and navigation technology

Landmark based navigation



Positioning and navigation technology

Landmark based navigation

Natural landmarks

A sensor (usually vision) for detecting landmarks and contrasting them against their background.

A method for matching observed features with a map of known landmarks.

A method of computing location and localisation errors from the matches.

Artificial landmarks

Line navigation

Electromagnetic Guidance.

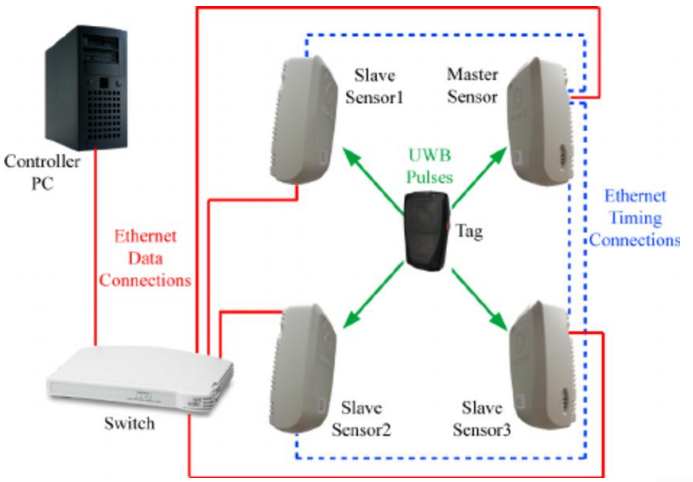
Reflecting Tape Guidance or Optical Tape Guidance.

Ferrite Painted Guidance, which uses ferrite magnet powder.

Thermal Marker Guidance.

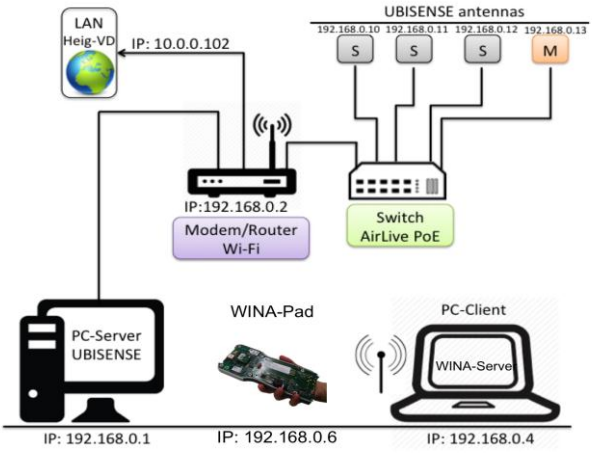
The WINA system technology

The UBISENSE infrastructure



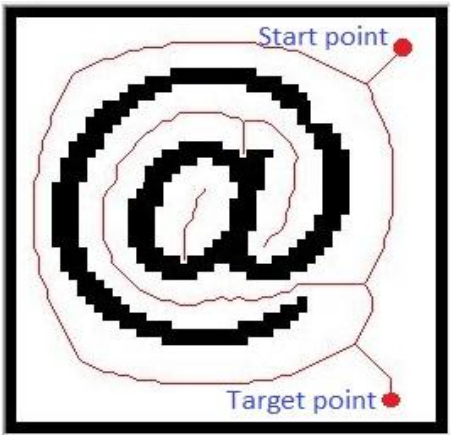
The WINA system technology

The WINA complete system



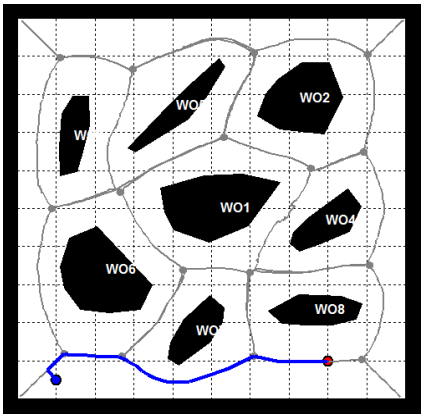
The WINA system technology

Path planning based on binary map of the steppable surface



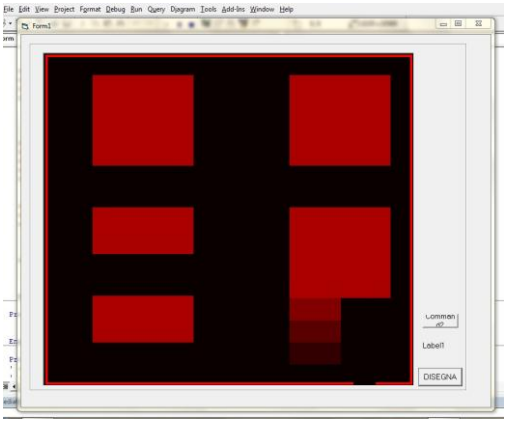
The WINA system technology

Skeletonization



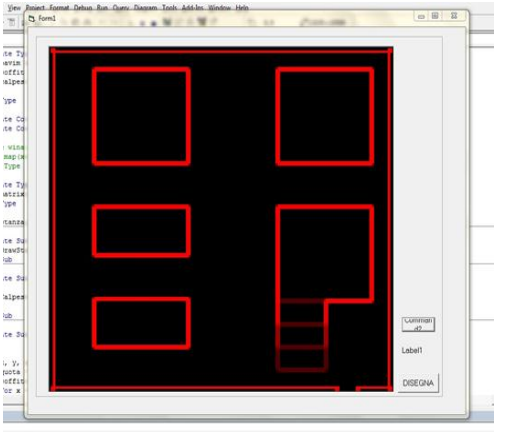
The WINA system technology

Obstacles and staircases



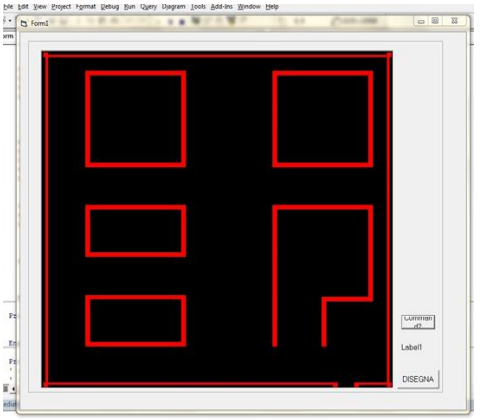
The WINA system technology

Obstacles and staircases



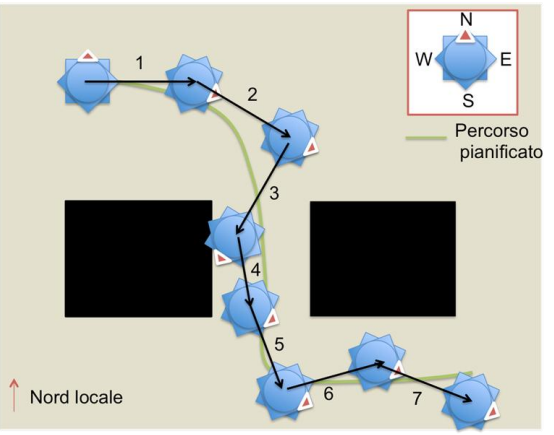
The WINA system technology

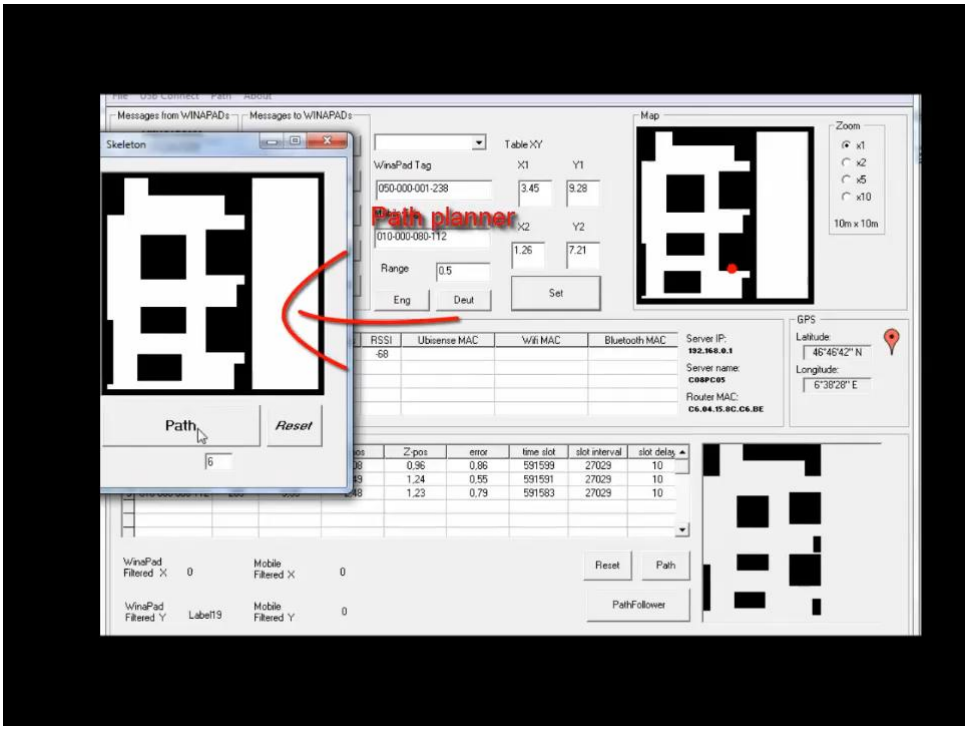
Obstacles and staircases



The WINA system technology

Path planning and guiding





The WINA path to the future

Technology

Location and positioning infrastructure
- From UBISENSE to DECAWAVE

Embedded solutions
- Instrumented white cane
- Smartphone based solutions

User interfacing
- Audio
- Haptic

The WINA path to the future

Business models

Healthcare	Hotels
Institutional	Office
Residential	Expo, Mall & Retail
Sport	Cruise ships
Transport	Domotics & AAL (Active and Assisted Living)

The WINA path to the future

Research and Development work

From the proof of technology to a commercial product

- simple installation
- simple maintenance
- low cost

- miniaturization
- intuitive use
  - haptic interfaces
  - audio interfaces

The WINA path to the future

What's haptics ?

Remember: blind people are more often guided through tactile cues
white cane, dog

Haptic interfaces use tactile sense to bring info to the user.

The WINA path to the future

What are we looking for

User cases
End user collaborations on a Ra&D project
Software companies able to create commercial software
Rapid prototyping companies
Funding bodies to sustain Ra&D of start-ups

The WINA path to the future

What is our time path

- Bring to the end users, for testing and validation, any prototype as soon as it is ready to be tested
- Study user feelings and interaction with haptic navigation solutions
- Get user's feedback in different scenarios
- Proceed developing technology ready to feed commercial solutions

The WINA path to the future

A look at the future

WINA Sarl - Switzerland