GUIDING VISUALLY IMPAIRED PEOPLE - EXPERIMENTATION WITH AN RFID CANE

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Abstract
Accessibility for all of transport systems is a great challenge for railway companies. The RFID cane presented in this paper enables to obtain the fine and accurate localization necessary to describe in a relevant way to blind people close environments like a train coach. This RFID cane has been tested during the one month SNCF experimentation: “Laboratory Train for Accessibility” in May-June 2009 in Paris East Station. Six hundred disabled people tested many types of equipment for accessibility in a real scale mock-up of a passenger coach with access platform, toilets and part of a passenger room. Thirty people participated to the tuning and to the test of the cane.

RFID tags have been positioned in key places of the coach. The RFID reader on the cane detects these tags and sends their id to the user smartphone through a Bluetooth link. Depending on the context and on the map of the coach, the smartphone produces, with a standard voice synthesiser, relevant descriptions of the environment: main directions when boarding, spatial organisation of toilets, priority seats position and seat numbers when walking along the corridor.

Results showed that for a large majority of the participants the prototype was considered as simple, rapid and reliable enough. Description of the entrance, how to open / close toilets and seat numbers were judged as “useful” or “very useful” information. A short experimentation in a station showed that it is also possible to detect such tags walking at normal pace along a blind people guiding line.

Fine and accurate localization by RFID is one of the solutions explored by SNCF to facilitate access to visually impaired people. Even if it has many advantages, it is still in balance with a few other techniques as WIFI localization or use of audio elements in the environment to provide indications.

This project benefits of experience of the previous French Predit research project “Guide Urbain” aiming to describe itineraries in a railway station and from the guiding system proposed for the mooviTER concept train, based, for its first version, on physical clues enunciation, helping blind people to take one’s marks. Aim of such guiding systems is to increase autonomy, to allow, in the end, to walk outside of guiding lines, but also to gain access to useful information that everyone obtains at a glance. Pieces of information transmitted may also be more general as cultural points of interest outside of the train or even anecdotal descriptions as, for example, how optic fibres are weaved to provide diffuse lighting in the ceiling-covering tissue of the train, a kind of social accessibility and inclusion not to be neglected.

What's new:
This experimentation shows, for the first time, the use in a train of an RFID cane to easily provide contextual and fine description of the environment to blind people.

Introduction
Mobility and accessibility of transport systems for everyone is a great challenge for railway companies. By 2015, SNCF will have made capital investment of € 500 millions, engaged a large set of actions (including experimentations as “Laboratory Station for Accessibility” to validate equipments, the “Accès +” service creation ... [1]) and worked on equipments to improve trains and stations accessibility (podotactile guiding lines, Jade a virtual signing character to announce information in the stations, ... [2]).
The RFID cane tested and presented in this paper enables to obtain the fine and accurate location necessary to describe, in a relevant way to blind people, close environments like a train coach. Coupled with speech synthesis on a mobile phone, it has demonstrated a first version of what could be achieved with such location accuracy in this context.

The system has been achieved and tested with disabled people during the “Laboratory train for accessibility” experiment.

This article describes briefly the “Laboratory train for accessibility” experiment, then the principles of the cane, the experiment of the cane itself and a few other experiments carried by SNCF before to conclude.

The Laboratory train for accessibility
The “SNCF Laboratory Train for Accessibility” was a one month experiment conducted by SNCF in 2009 from May 12th to June 12th. It was lead by SNCF’s Delegation for Accessibility and the Rolling Stock engineering centre, two travel divisions: “Voyages” and “Proximités” and the most important French Persons with Reduced Mobility (PRM) associations. It consisted in a 300m² space including a real size carriage model and areas where last innovations for accessibility were demonstrated but, first of all, tested with disabled and valid people.

The real size train model includes a platform, toilets and a part of a passenger coach. In these spaces, SNCF tested among, a total of 25 new solutions (some being SNCF patented), accessible toilets designed for all, user friendly automatic locks with tactile information, very slim tables facilitating transfer to their seat of all passengers included wheelchairs users, new screens for a better readability and visual or acoustic signals for doors or emergency buttons.

Visitors disabled or not were invited to try out and give their opinion on these solutions conceived to make life on board easier to passengers. They were recruited through information sent by associations, flyers, emails, users of SNCF “Accès+” service and on site. A free phone number was also available to make an appointment.

The global survey was conducted by TNS-Sofres pollsters. Nearly 600 disabled people, 175 valid persons and 144 SNCF employees were interrogated. The total visit, tests and questionnaires took 1h for valid people and 1h30 to 2h for disabled people.

In the global test, the platform and many types of equipment were appreciated. Among them: the double contrasted handrails for children or small people, buttons at the same height than handrails facilitating their search, indirect and diffuse lighting (judged as sufficient without being dazzling). Toilets were considered as large enough and satisfied in a same way valid and wheelchair customers. The passenger room was also estimated as large enough, handrails and alert buttons well positioned, new tables are easy to use and more comfortable with a good size and ergonomic. Detailed results with privileged choices and recommendations are presented in [3].

The better and most popular solutions will be integrated into future specification and equipment modernisation programs.

It is during this operation that, with a 30 people sub panel, SNCF Research and Innovation Department tuned and tested an RFID cane aiming to describe the train to blind people while walking inside.

Previous RFID cane experiments
Use of RFID as a geolocalization mean has been tested in Japan [4] and in Italy (Sesamonet project [5]). Results of the Japan experiment let us think that this technology may be also used in stations.

Japan experiment
The Japan experiment has been developed from 2003 to 2006 in the « IT Barrier Free » project that was commissioned by the Japanese Ministry of Economy, Trade and Industry (METI) and by the New
Energy and Industrial Technology Development Organization (NEDO) for implementation. The consortium included a few industrials as NEC, Mitsubishi and NTT DoCoMo.

The platform uses GPS, infrared and FM radios (compatible with PICS a Pedestrian Information and Communication Systems previously installed in Japan and using Remote Infrared Audible Signage (RIAS) defined in ANSI A-117.1). It also uses RFID tags generally disseminated in the tactile walking surface indicator (tactile block).

The Bluetooth RFID reader of the cane communicates with the GPS smartphone. The cane reads tags in the blocks. The smartphones give the way and alerts for potential dangers. Results show that the system has been well evaluated. But even with a very simple network (3 cross and 3 turns) only 80% of the users succeeded at the first try and 90% at the second one.

**Italy experiment**

The Sesamonet project (Joint Research Centre of the European Commission) consisted in inserting 5000 RFID transponders into the sidewalks of Laveno Mombello on a distance of 2km. These are recycled RFID tags from slaughtered European livestock. They are positioned at the angles of a triangle of 60cm. Tags detected by the cane allow people to know if they stay or not on the right way and to receive information about obstacles [5]. Frequency used is 134.2KHz. This frequency allows reading in a range of 20 to 25cm with a 8 hours autonomy for the tested readers.

**SNCF approach**

Passive RFID geolocalization is not completely satisfying for all the cases in our opinion. This is generally a method based on cells (tags) detection. Depending on the kind of tags (passive, active) on the radio frequency chosen, the size of the cells may be very short. It may be very accurate as needed in trains but not very useful to answer easily to geolocalization problems in a large open space like stations where methods using triangulation or fingerprinting of radio fields may be easier to manage. RFID method may be coupled with other indoor geolocalization methods as WiFi geolocalization.

**RFID Cane tested**

The system designed and tested by SNCF is composed of:

- a standard cane for blind people, very current in France and known as a “Canadian cane”, (but a bit heavy - nearly 300g)
- a standard Java Bluetooth smartphone (here a Nokia N70) equipped with a standard voice synthesiser for blind people.
- a Bluetooth RFID reader (nearly 150g)
- some passive RFID tags disseminated in the place

**Principle**

RFID tags are positioned in key places of the coach. The RFID reader on the cane detects them and sends their id to user’s smartphone through a Bluetooth link. Depending on the context and the map of the coach, the smartphone produces relevant descriptions of the environment through a standard voice synthesiser.

**Tags**

A very precise localisation is necessary to avoid ambiguity between two rows of seats in a coach. But we want to use the technology also to detect the...
luggage rack when walking near or receive information in the station where precision of a 1.5 or 2 meters would be usually sufficient. So we choose a frequency authorised in France around 868Mhz enabling a detection of a few meters in good radio environment conditions and the use of cheap passive tags.

Even if this technology is used in the train at a very small distance (less than a meter), advantages of long distance reading range are multiple:
- it allows to put the tags not only on the floor but also on the walls or on pieces of furniture where they may be more protected (avoiding problems due to frequent washing, rain water, many chocks, people walking on or even trolleys circulating in the station ...)
- when such a fine localisation precision is not necessary, users do not need to search them too much
- on a guiding path with a sufficient reading distance they may be found even when walking quickly and with a quite large sweeping movement with the cane.

With such a long reading distance, tags may be used on the external door of the coaches, on guiding path, at the entrance of shops on tickets validation machines...

The proposed application can also read very short range Near Field Communication (NFC) tags (a few centimetres) allowing a second type of interaction for example with future NFC phones.

**Reader position on the cane**
The reader height on the cane has been chosen to be coherent with our previous choices and to facilitate detection of:
- tags with short reading distance (40 cm for example); the user can then validate a very precise position using the extremity of the cane,
- tags on the walls,
- tags on a guiding path and that have to be read very quickly when walking at a good pace,
- tags that would have to be read by a reader carried by a dog.

**Reading range modulation**
The reading range can be modulated choosing the size of the tag, the emplacement chosen to stick or embed them (on metal or not), the fact they include or not an isolation slice for use on metal. This modulation capability is important because it allows to cover wide zones with one tag but also to cover a small zone, as the toilets, with a few tags (3 for example in the toilets) giving very precise information depending on where the cane is in the toilets.

**Experimentation of the cane**

**Organisation**
The test took place from May 12th to June 12th, for nearly five weeks. The first three weeks were used to tune the system taking in account users’ observations and remarks:
- to improve messages content
- to improve better adaptation to context
- to improve tag position to optimise detection and avoid some interference

Questionnaires were applied during the last 4 weeks. Open questions were reformulated during the test to avoid misunderstanding. 30 people were interrogated. The objective was not purely statistical but mainly qualitative.

**Population**
People were taking a rendez-vous by phone to visit the Laboratory train for accessibility. They indicated their deficiencies. The cane test was proposed on site to blind people or visual impaired
people. People may have visited the train and passed the questionnaire for the other equipments before to test the cane.

<table>
<thead>
<tr>
<th>Total number of testers</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Uses a cane</td>
<td>25</td>
</tr>
<tr>
<td>Uses a phone with speech synthesis</td>
<td>23</td>
</tr>
</tbody>
</table>

People visited the train before.  

<table>
<thead>
<tr>
<th>People visited the train before.</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23</td>
<td>7</td>
</tr>
</tbody>
</table>

People not using a cane had a dog. Only a quarter of people were not used to manipulate a phone with speech synthesis. This number has not been correlated with the equivalent proportion in the real target population; figures were not available. 3/4 of people had visited the train before. We do not think it is a problem for the tests. The cane would be used also in known environments. Even after a first visit some people still discovered or understood elements walking in the train with the cane.

**Experimentation**
- The test of the cane was proposed to people.
- The cane with the RFID reader was presented. They were able to touch, explore and manipulate it before to use it.
- The phone was presented to them turned on. They were familiarised with screen, the numeric keyboard of the phone and the speech synthesis. The “Train Labo” application was searched for the users in the menus by the experimenter (as any other application agenda, games …) and started for them.
- Connexion of the telephone with the Bluetooth cane asked by the guiding program was done by a part of people testing the system.
- How to find a tag in the environment with the cane and to hear the associated message were demonstrated at the main desk.
- People were conducted to the train and then walked inside. The way to repeat the last message was presented when needed at the desk or in the train.
- A specific questionnaire was presented at the end, outside of the train.
- The visit took 20 minutes. Some people were not able to visit the toilets due to a lack of time or too much people exploring the train.

**Train description**
Challenge D: A world of services for passengers

People enter onto the coach platform. They find on the left a closed passage, in front on the right a stair with a few steps to a simulated second floor, then a luggage rack in the corridor with a grill, toilets and the passenger room with ten seats and three tables.

When entering, the cane detects the entrance tag. People are welcomed by the equivalent of this message in French. “Welcome on board “Train Labo - coach one”. From left to right, when entering, a closed passage, in front opposite access door; then a stair to seats 11 to 20 (now closed). At the end, completely on the right, corridor to passenger room seats 01 to 10.”

Walking in the corridor another detected tag indicates: the luggage rack; then the toilets with the round recognisable shape of its door and where to find the open lock to enter and last the passenger room.

When entering the toilets the system indicates immediately where the closing button is and how to push it to the right to lock the door. Then other tags allow describing the toilets presented as in the main entrance from left to right. Are also successively indicated: where to find the flush button, toilet paper in the continuation of a handrail, the coat-peg for clothes, the lavabo and the disposition of the soap, the water with its infra-red detector and the blower.

Information is contextual. At toilets exit, information about the lock presents this time the way to open it (and not to close it). In the same way in the corridor, the luggage rack is indicated as being on the left the first time but being on the right if walking back to the entrance door.

Generally, sentences are designed to be as short as possible. But they also include, when needed, elements to sequence the description (“then … then …”) and to help to pass in the description from one element to the other. Are also indicated security elements as where to find the emergency button (in the toilets or in the passenger room).

Entering in the passenger room, the priority seats are indicated and also practical information as where to find electricity plugs. Walking along the central corridor, it is possible to hear the seat numbers bringing the cane near them. At the seat some additional information is available on request.

Leaving the train by the entrance or the exit door, a “bye-bye” message is provided.

**Questionnaire**

**Simplicity, rapidity, reliability**
The system was judged as globally simple, rapid and reliable enough
Did you find the system …

<table>
<thead>
<tr>
<th></th>
<th>Very</th>
<th>Enough</th>
<th>Little</th>
<th>Not enough</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple to use?</td>
<td>12</td>
<td>17</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Rapid?</td>
<td>6</td>
<td>16</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Reliable?</td>
<td>6</td>
<td>18</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

But it’s necessary to temper a bit:
- The system was dedicated to this train (avoiding the complexity of a whole system)
- People did not have to search the application in their phone to start it
Any further development should try to retain these qualities. Simplification of messages should be continued, it still may accelerate the system.

Was the device on the cane disturbing?
The device on the cane was not considered as very disturbing by itself but the whole (cane + reader) was considered as heavy.

<table>
<thead>
<tr>
<th></th>
<th>A lot</th>
<th>Much</th>
<th>Little</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance</td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

We should note that the chosen cane (« cane canadienne » in French) 1,20m long is one of the heaviest canes (300g) and that some people refuse to use this cane even alone because of its weight. The reader with the battery weight around 150g. Some remarks have been also done on the device fragility, on the problem due to the whole load (cane and phone) and potential multiplicity of tools.

Information usefulness
The messages
- informed of the entrance distribution (from left to right – closed passage – opposite door – stair – corridor to the passenger room);
- described the corridor and the luggage rack then the toilets
- described how to close and open the toilets door, the place of all equipments in toilets (waters, washbasin, coat-peg, handrail)
- the passenger room with priority seats and seat numbers
- exit

Message were globally seen useful or very useful.

<table>
<thead>
<tr>
<th>Was the description of …</th>
<th>Very useful</th>
<th>Useful</th>
<th>Not so useful</th>
<th>Useless</th>
<th>Not heard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance</td>
<td>10</td>
<td>17</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Toilets button</td>
<td>10</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Toilets whole</td>
<td>5</td>
<td>7</td>
<td>3</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Washbasin</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Seat number</td>
<td>17</td>
<td>9</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Other information was available: seat description, S.O.S button. These pieces of information need to be asked through the phone menus once seated. People did not well understand this functionality and it has not been presented to all in this first test. Some people did not hear messages in the toilets due to a lack of time or too much people around them.
Use of the system

At the question: “Would you use this kind of application in the trains you take often or rarely?” answers were.

<table>
<thead>
<tr>
<th></th>
<th>A lot</th>
<th>Yes</th>
<th>Why not</th>
<th>Not really</th>
<th>No</th>
<th>Not at all</th>
</tr>
</thead>
<tbody>
<tr>
<td>In rarely taken trains</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total =&gt;</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>In often taken trains</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Total =&gt;</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>9</td>
<td></td>
</tr>
</tbody>
</table>

1 person did not answer to this question

Even if this system seems attractive for a good majority, we have to qualify these answers, because discussions showed that people added comments that may, in the end, modify their opinion if the final product does not match exactly what they expect.

So what are really the advantages and drawbacks of the system?

Plus for the system

These properties have been extracted from open questions and remarks to closed questions for the 30 people (they are given on a scale of 16, near the maximum for one answer). The real stake is not the exact number of answers but more to list the main properties.

![Chart showing plus points for the system]

Minus for the system

We distributed the minus found among four categories:

- Usability
- Speech synthesis
- Human factors
- Other elements

Usability
Weight and the fact that during the experimentation the system needs the two hands (cane and phone) make the system not so practical. Some people do not want to disturb people sweeping with the cane to find seat numbers. The system has sometime been found not reactive enough or giving too much information.

Speech synthesis

Speech synthesis has not been questioned. Users in the test generally use yet speech synthesis (23/30). But even if there was some noise, test conditions were not those of a running train. These answers should then be read in this context. Use of hands-free headsets should be tested even if some people, now, would refuse them arguing that they really need their ears and for attention reasons. This point has to be designed with a lot of care.

Human factors

Spontaneously people expressed the fear to see the human service “Acces+” replaced by such machines. Or they consider that human service is more efficient than such a system and that use of it may isolate people.
Other aspects

Utility of the system has been questioned. Some declare themselves as not motivated or convinced by such a system. Some see it as another tool and mention the problems of compatibility with others. Some mentioned a risk of vigilance drop. Reliability and cost have also been mentioned and a wish to have an interface in Braille.

Impact on use of the trains

Would they take the train more willingly having a description of the train by such a system? A quarter only of people (7/29) would take the train more often. They take it because they need it. The system is seen as a facility. They now ask people around to obtain information. One of them put the stress on the fact that it would be more important in stations.

Adoption factors

What would make them use this system? Mainly autonomy gained (move on board, find the seat), have a cane more convenient and may be a system on a dog and use it in the station

What would make you not use this system? Mainly the cost, understanding of the system (not too much information, voice quality) and then ergonomics (weight …)
And elsewhere
In which other situation does this system may be useful? Mainly in stations, in other transports, in the street when there are road works or to recognise traffic lights, in shops, or to know by which side to get off the train, to know if a seat is booked, in complex places as hospitals or museums.

Other experiments
Talking signs
Use of talking signs to find the coach door was tested. People could use a standard remote control for making traffic lights to talk. A loudspeaker was placed just over the opening button, at the left of the door. The remote control activated, here, a message indicating the entrance door of the coach. A loudspeaker was placed just over the opening button, at the left of the door. If it was not rejected by principle, the whole present design was not efficient enough. Due to acoustic problems (mainly resonance) the speaker did not help so much to find the button. Since, other work has been undertaken to provide a new design of this solution.

Test on a guiding line
As users requested to be able to use such a guiding system outside of the train, a short experiment was done to verify the possibility to use such tags on a blind people guiding line in the station.

If inside a train the walking pace is quite slow, this is not the case for the scenario considered for stations. Blind people with normal activity have to move quickly and in a safe way as everybody in everyday known areas as stations and particularly when they are on blind people guiding lines.

So, tags detection was tested. First attempt showed that the tags were not always detected sweeping over the floor with the cane and walking at a good pace on the line. The solution was to take tags with a sufficient antenna size and to increase the reading rate for this case. To adapt the reading rate to the context in order to save energy when such a high rate is not needed was proposed.

Short range tags
Since the beginning, the application was designed to be able to deal with very short range (a few centimetres) NFC tags. A lot of NFC enabled phone should appear in the coming years. The use of an NFC phone in the way the cane is used does not seem realist. Even if people often walk with a phone in the hand, one can’t assume that blind people will be able to search tags they do not see for a complete guiding in the station. But such tags may be used at standardised positions, at a certain height at each door in context as hotels or office buildings or seat numbers. A small scenario was designed and fully works with such tags but has not been tested yet in the coach.

Conclusions
This article has introduced the RFID cane experimentation carried in 2009 by SNCF. Results showed that for a large majority of the participants the prototype was considered as simple, rapid and reliable enough. Description of the entrance, how to open / close toilets and seat numbers were judged as “useful” or “very useful” information. A short experimentation in a station showed that it is also possible to detect such tags walking at normal pace along a blind people guiding line.

Fine and accurate location by RFID is one of the solutions explored by SNCF to facilitate access to visually impaired people. Even if it has many advantages, it is still in balance with a few other techniques as WIFI location or use of audio elements in the environment to provide indications.

This project benefit of experience of the previous Predit project “Guide Urbain” aiming to describe itineraries in a railway station and from the guiding system proposed for the mooviTER concept train based for its first version on physical clues enunciation helping blind people to take one’s marks. Aim of such guiding systems is to increase autonomy, to allow, in the end, to walk outside of guiding lines, but also to gain access to useful information that everyone obtains at a glance. Pieces of information transmitted may also be more general as cultural points of interest outside of the train or even anecdotal descriptions as in this case, for example, how optic fibres are weaved to provide diffuse lighting in the ceiling-covering tissue of the train, a kind of social accessibility and inclusion not to be neglected.

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