"ADAPEI-TRANSPORT": A GPS Based Mobile App for Learning Paths and Improving Autonomy for Young Adults Having Intellectual Disabilities to Take Public Transport

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Abstract. Children and young adults with intellectual disabilities (from 10–20 years old) are trained by educators for their journeys taking public transport (buses). This training is done teaching them the different steps and actions to do in a sequential way using photos, pictograms, times, texts (e.g. walk to the bus stop Roppe and take the line 21 direction République, do not forget to press on the stop button to alert to take off, take off at the stop station République, etc.). Currently, specialists from ADAPEI association in Belfort (France) use booklets in which all the steps to follow are printed. With the increasing of the use of mobile apps in Assistive Technology, the aim of this partnership between Altran and ADAPEI from Belfort is to develop new supports to teach children (from the least to the most autonomous) the paths using GPS mobile and tablet apps before and while doing the journey. Moreover, for the most autonomous children familiarized with the use of apps, two ways of navigation using GPS have been developed. Either using maps showing the path or without using maps showing strategically the actions to do in an ordered way when the user is close to a point of interest. In this article, we will show the first results of the use of the app as a teaching system based on observations with disabled children in different situations, and the difficulties found to detect change of directions in noisy GPS data in cities.

Keywords: GPS · App · Intellectual Disability · Transport · Mobility

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1 Introduction

The complexity of the public transport network and the management of unexpected situations cause that children having intellectual disabilities experience difficulties to become autonomous to take buses. Some examples to illustrate this can be that the bus does not arrive at the expected time or the bus has to change its normal path because of unexpected problems. Moreover, children can be stressed when they are lost without finding any help. Additionally, the process of learning different steps to take public transport in a sequential way may be long and depends on the capability of each child’s memorization. Currently, specialists are creating paper supports by using different software tools. However, the creation of a path is normally time-consuming. Additionally, specialists practice the path with the child as much as possible until they consider that the child is autonomous to follow the path by himself/herself.

In order to develop new technological supports (apps) for learning the paths and for the adapted navigation to children with disabilities, researchers and engineers from Altran Technologies are working in collaboration with the specialists of the transport workshop from the ADAPEI association (http://adapei90.fr/) where they teach the different actions to do to arrive to a destination using the bus. ADAPEI is an association and educational institution that helps children and adults having intellectual disabilities to become autonomous in different activities (for example cooking workshops, etc.) in daily life.

In this article, we will explain the different parts of the developed mobile app and some tests done with end users in different situations. We will complete our analyze showing the difficulties found using real GPS data in cities and the filters used to reduce errors.

2 State of the Art

The state of the art presents some examples of how technology has been used to improve autonomy of people having disabilities.

Irma Alaribe, from the Montreal University, has worked on the creation of a serious game to support the learning of fixed routes for people with intellectual disabilities [1]. This article explains how the development of a serious game encourages the transition between theory and practice.

Price R et al. [2] have investigated the way on facilitating the use of public transport for young adults with intellectual disabilities. This study shows the interest of Google Maps as a help for improving navigation skills to take public transport. Four young adults were involved in this study, with different ID (Intellectual Disabilities) types. The results show an increase of the navigation skills, but also at different speeds of acquisition. The main factors are background with electronic devices or smartphones, natural skills with navigation, learning capabilities in addition with ID types. One of the young adults helped herself with visual indications in addition with Google Maps. The article highlights that a navigation app like Google Maps may be very useful for the autonomy of people with intellectual disabilities but depending on their social and technological background they may need some training. People also need eye contact with the environment which confirms the interest of Augmented Reality in navigation apps.

Don D. McMahon et al. [3] have studied the comparison on the levels of independence in navigation between two groups of adults with intellectual disabilities, helped with 3 tools: paper map (printed from Google Maps), Google Maps (on a mobile device), Augmented Reality app (Navigator Heads Up Display). 6 adults with ID (Intellectual Disability) were involved on different travels with each tool. The way of evaluating them was to score if the patients needed help or not to go from spot A to spot B. It was clearly seen that people have far better results using the Augmented Reality app.

There is an application called way2B [4] invented by two Trinity College graduate engineers in Ireland. This is a mobile app and watch that gives directions, which means that way2B gives users simple step-by-step instructions that are inputted by a carer who is then able to monitor their progress on the journey.

As it was described before, we have found research papers about intellectual disability people using mobile apps for navigation. However, they are based on people with intellectual disabilities who are already autonomous, and they can be familiarized easily with the use of apps on phones and connected watches.

Our objective using ADAPEI transport is to focus on the way to accompany children (early ages) to become autonomous using the app from a learning phase to an autonomous navigation phase in the transport workshop.

3 ADAPEI Transport App

In order to develop the app, specialists from the transport workshop in the association were involved, using the interfaces developed and giving us feedback. The information given about colors of the buttons, the type of pictograms and the prioritization of the information was important to develop a more intuitive app for them and disabled children.

Our app has been developed in the Android Operative system, with three main parts: (1) an interface for the creation of the path mainly used by the specialist where they can add information about the time, GPS coordinates, a pictogram, a photo about the point of interest and a recorded voice of the action to do. This path can be modified by changing the elements in case of errors. (2) A second part is the visualization of the path in which the children can watch all the steps and if they click on a step, the app shows more information about the step itself (for learning before doing the path). (3) The third part is the navigation part, in which the children can choose between a classical map with the path and markers indicating the steps, and another way to show the information displaying in a bigger spot the current step to do using pictograms and photos (Fig. 1).

The app in the tablet is used during theoretical workshop. It is connected to Internet in order to show the map and the marker with the information of the step. However, disabled children in the workshop do not use last generation smartphones and they do not have internet connection. This is the reason why another user navigation interface has been created without using maps and just showing the current actions to do with pictograms and photos when we are close to a landmark prerecorded in the app (* in Fig. 1).

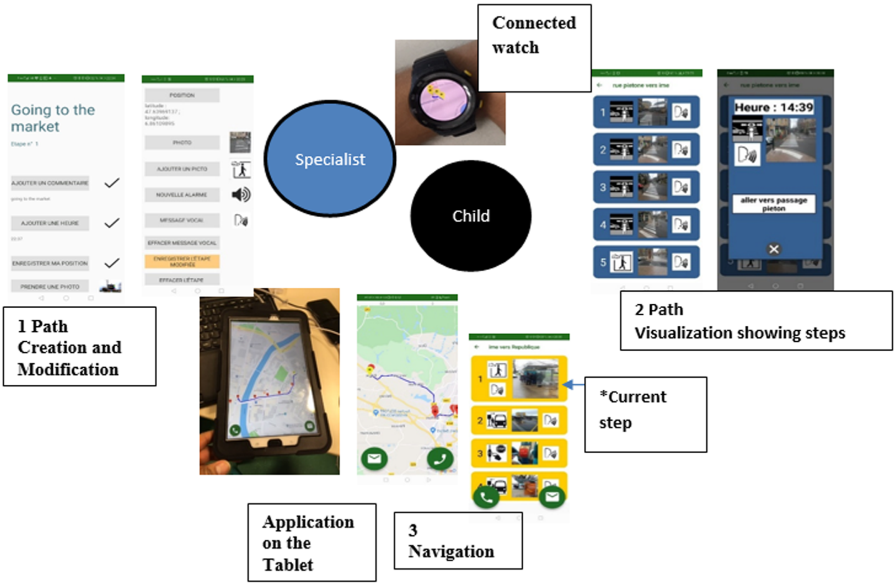

Fig. 1. Different parts of the app (1) path creation and modification, (2) path visualization and (3) navigation part.

4 GPS Data in Cities

We collect the GPS coordinates to save the whole path (every 5 s) done by the specialist while recording the information of every step (landmark) of the path. One of the main problems of the GPS data is that in the city there are plenty of reflections on buildings so that the signal recovered by the GPS antenna from the mobile phone induces errors in the position (Fig. 2) when the person is walking.

Fig. 2. GPS errors close to a bus station.

5 Methodology

The methodology has been divided into 2 parts.

1. From an ergonomics point of view:

There are 2 profile of specialists: one who is familiar with the use of mobile apps and the other person who is not familiar with it.

Tests with the disabled children were done with a specialist and a researcher observing the way children (with medium level of intellectual disabilities) interact with the information coming from the app. Five different children with an intermediate level of mobility between 14 and 20 years old were part of the tests. The tests were done on 4 different days with different trajectories including bus trajectories and walking parts. The tests took about 1 h.

Different situations: recording a path, looking at the information on the map, listening to the sounds and images delivered during navigation were implemented.

2. From a technological point of view:

Despite the noisy GPS data, we have worked on detecting the change of directions in the path. These points have been used to deliver information about the arrow turning right or left 30 m before a change of direction point in the path. In order to accomplish our objective and to segment the GPS trajectory, we have used and compared kalman filter algorithms, Ramer Douglas Peucker (RDP) [5] algorithm and another algorithm based on the speed between 2 GPS points (calculated speed/user's walking speed). Finally, all the results were compared to choose the best mix of algorithms using the quantity of true positive (tp) and false positives (tp/tp + fp).

6 Results

From an ergonomic point of view:

- The alarms for advising to press the stop button in the bus were understood by the children and automatically they pressed on the button.
- The information on the map, like the current position and the arrows for turning right or left, seem to be understood by the children once their meaning has been explained to them. For example, while they were doing the pedestrian path, we have asked them what actions to do when arrows appear and they answered correctly.
- It seems important to do and record the path with the child, in this case the specialist can record the voice saying the action to do or to report a danger. The specialist can ask the child if he understands the message or not to change it.
- Another test was to make a child record a path. In order to avoid stress while saving the path, the child was not asked to record the GPS coordinates for every landmark. They were asked to record the message, the pictogram, the photo and the message voice. Two children have done the test: one who knows how to read and the other who does not know. For the child who knows how to read, she was able to record the path just by indicating her at what moment she had to add the information. After

2 steps of explanation, she was able to record the steps by herself. On the other hand, for the person who did not how to read, it was more difficult for her to follow all the instructions. A more specific user interface including more pictograms will be developed in order to enable children who do not how to read to record the path. We think it can be a good exercise to record the path for memorizing the steps to do.

From a technological point of view

- The segmentation of the GPS data was done in two different walkable paths using a specific pipeline: RDP algorithm along with the filter of speeds followed by angle detection give better results. There are more true positives than false positives in the detection than using the other algorithms (more than 20% of better results in the change direction detection) (Fig. 3).

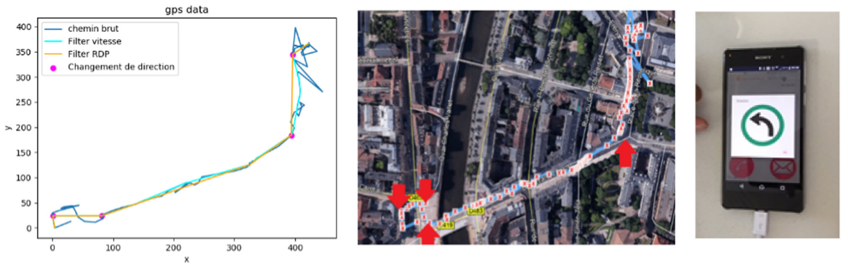

Fig. 3. On the left, the results (pink circles show changes of direction detected) after each part of the pipeline. In the middle, the map with the real path and the real changes of directions. On the right, the image of the arrow on the screen of the app. (Color figure online)

As we can see in the figures above, our algorithms were able to detect all the changes of directions except for one. We have observed that the most difficult detection was the change of directions in small spaces.

7 Conclusions and Future Work

- In this article, we have shown the efficiency of ADAPEI transport having encouraging results with the information given by the children. Tests were made on the creation and modification of the path, visualization and the navigation of the path with no technical errors.
- Children have understood different information like alarms and images which appear on the screen during navigation confirming their accuracies. Additionally, a child who knows how to read was able to understand the sequential way to record a path.
- Using just a type of filtering between kalman, speed filtering or RDP cannot give the ultimate result for a noisy data set, especially in the domain of navigation where GPS data are influenced by multiple factors such as: buildings perturbation and atmosphere. After multiple researches and applications of different methods of

filtering, we found that applying a filter based on speeds followed by an RDP segmentation can give better results. We are going to test this pipeline with more data in different situations in order to validate our approach.

- The most difficult case in change detection is found in small spaces. In this case, an idea is to ask specialists to record different steps in the creation of the paths, when the changes of directions are very close. Another idea is to use augmented reality, but in this case the smartphone should be more powerful than a low cost one.
- In order to avoid children to lose the phone while doing navigation, we have associated the smartphone to a smartwatch using a Bluetooth connection. If the smartphone is separated more than 15 m, the phone will send a SMS with its GPS coordinates to a prerecorded phone number to know its last position.
- In order to test the learning improvement and the autonomy of the children, a way to reduce the number of steps in the path has been developed. Using the modification menu, we can stop the visualization of some steps, if the specialists consider that it is not necessary anymore because it has been integrated and learned by the child. In the visualization part, we observe that the step is in gray color with a green thumb up (Fig. 4). In this way, it can be encouraging for the child to see that he/she is progressing (for instance, in the same path I need 7 steps instead of 10 steps). In the long term, the objective is that the child will not need the use of the app for the path he/she learned.

Fig. 4. Visualization path with 2 learned steps (steps with the thumbs up in green). The child has learned to cross the street and push the button to alert the driver to get off the bus. (Color figure online)

- We have also added the information of the GPS coordinates of the different bus stops, thanks to the collaboration with Optymo (the bus network company). The idea is to give information not only from the bus stop to get into or to get off from at a determined schedule, but also to deliver the name of the intermediate bus stop stations for learning. Moreover, warning information when the bus comes out from its regular itinerary will be delivered.

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