
Software for a wheeltable/wheelchair control via WLAN with optional application of a robot arm

By David Greve

Summary

People become older and older. Because of the problems arising from that, people will have to switch to technical solutions in the long run because there won't be enough people to care for the older people. Vehicles, which can transport people with a minimum of application of people, will become more and more important in the future.

Because of these reasons, I've developed a software based on a wheelchair, that can also be easily altered to a wheeltable with a robot arm, which the wheelchair can automatically controlled with. You can manually navigate the wheeltable/wheelchair right, left, forward and backward by pressing buttons or you can also let the wheeltable/wheelchair go to a defined location indepently at a specific time. The PC can be at standby state until driving, too.

The positioning of the wheeltable/wheelchair happens with the aid of barcodes. My software can create and print special barcodes in a specific arrangement. For the manual control, I've developed a computer program for the Pocket PC platform. The robot arm can be controlled manually via a WLAN. On the wheeltable/wheelchair there are, among other things, two webcams and two distance sensors which are controlled by my software, too.

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Introduction

The excess of age in society gains in importance more and more. Necessary services in the field of maintenance cannot be guaranteed in the long run because of increasing staff shortage and the costs linked with it. My project „Software for a wheeltable/wheelchair control via WLAN with optional application of a robot arm“ could be an impulse for developing solutions for this problem with existing instruments.

Hardware of the wheelchair

Wheelchair Control

Fortunately, I could get an old wheelchair of the type Impuls by the company Ortopedia, which was taken over by the company Meyra, at a jumble sale. Unfortunately, the company Meyra couldn't make all data of the wheelchair control electronics available for me because of the high age of the wheelchair. Because of that, I couldn't control the wheelchair via a PC directly.

Due to these reasons, I attached a square enclosure made from iron at the top of the joystick (see figure 3). Each side can be pulled by a lifting magnet, so the joystick can be moved in all directions (see figure 3).

The lifting magnets of the type TDS-16A by the company EBE are controlled by a relais interface by the company AK-Modul-Bus, which is controlled by the notebook on the wheelchair/wheeltable (see figure 2).

Both the lifting magnets and the relais interface are connected to a 12V lead battery (see figure 2). The notebook is a server, whereas the computers that aren't connected to the wheeltable/wheelchair are clients (the Pocket PC, too). The client computers exchange data with the server via WLAN and the TCP (Transmission Control Protocol) – a protocol standard to the connection-orientated data exchange – to control e.g. the wheeltable/wheelchair.



figure 1: General View

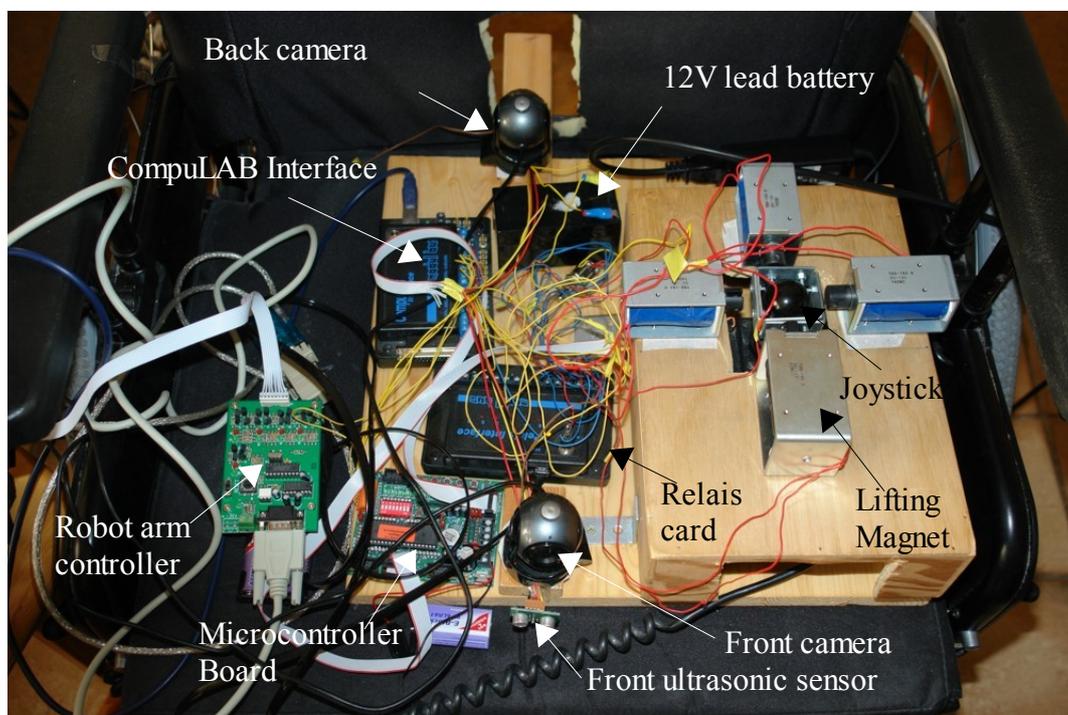


figure 2: The Interior of the Wheelchair

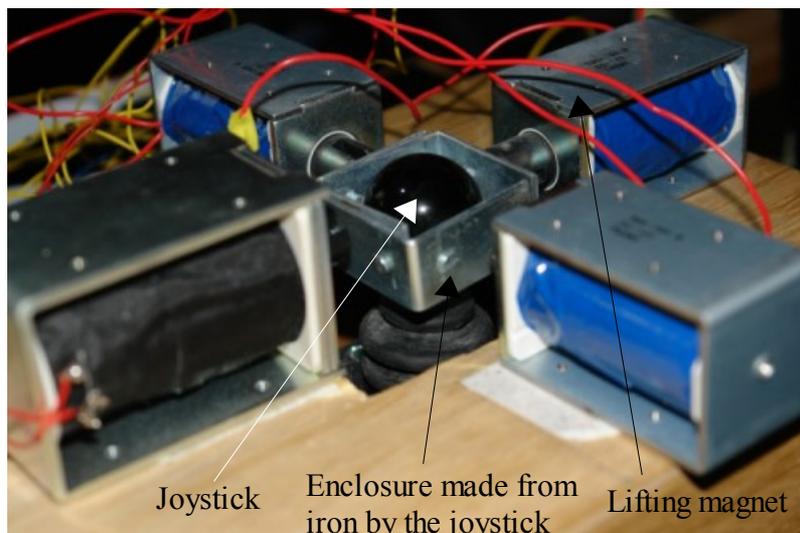


figure 3: Lifting magnets by the joystick

The Cameras

Two webcams and the CompuLAB Interface by the German company AK-Modul-Bus, which is used for controlling the ultrasonic detectors, are connected to the notebook on the wheelchair, which a 32-bit version of Windows Vista runs on (see figure 2). The cameras can provide the user monitoring of the drive of the wheeltable/wheelchair and the robot arm (see section "Robot Arm"), when they aren't in the range of vision of the user.

The Ultrasonic Detectors

The notebook sends signals to the microcontroller board RN-Control 1.4 via the CompuLAB Interface (see figure 2). The microcontroller receives signals from the two ultrasonic detectors (each of the type SRF10) via the I2C-Bus. The ultrasonic detectors (attached at the front and the back of the wheelchair, see figure 2) are meant to serve for stopping the wheelchair automatically if a specific safety clearance isn't kept.

Reading of the Barcodes

A USB laser hand-held scanner is used to read in the barcodes. The scanner reads in the barcodes which are assigned to a specific position on the driveway of the wheelchair (see figure 4).

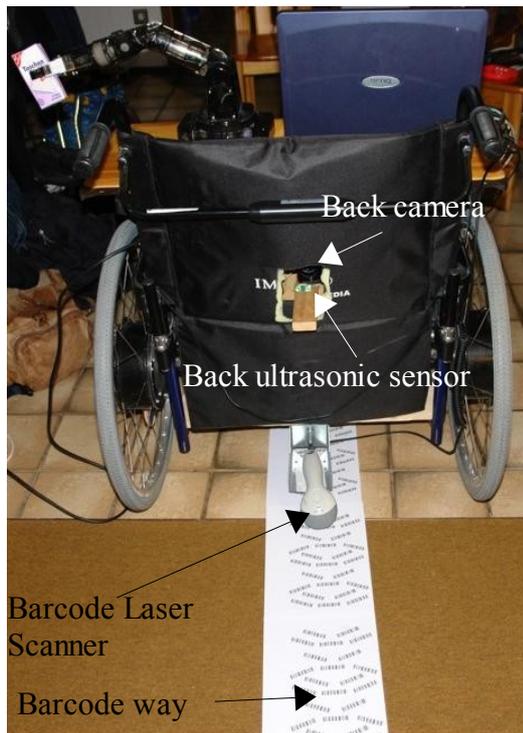


figure 4: Back view of the wheelchair

Robot Arm

The robot arm „Movit Robot Arm MR-999E“ (see figure 1) is controlled via the serial interface using the controller „MRAI-999HB“ (see figure 2). The controller is connected to the notebook via a USB-to-serial adapter.

Control software for the wheeltable/wheelchair, the barcode scanner, the ultrasonic detectors and webcams

Usage

For starting the manual control server, you can enter the COM Port (identifier of the serial port, e.g. COM1 or COM12) of the relais interface into the text box „COM Port“. After that you can select Simulation/Reality in the field „Simulation/Reality“ and then press the button „Start server“. To access to a already started server, you have to enter the host name of the server computer into the text field „Server name“. After that you can control the wheelchair/wheeltable in any direction.

On the server two of connected cameras can be selected after clicking on „List cameras“ and fetch images from these cameras on the client. First the user has to ensure that the correct server name is entered in the text field „Server name“. To display an image then, you've to press the button „Start connection“. After that one can either retrieve images manually or retrieve images periodically.

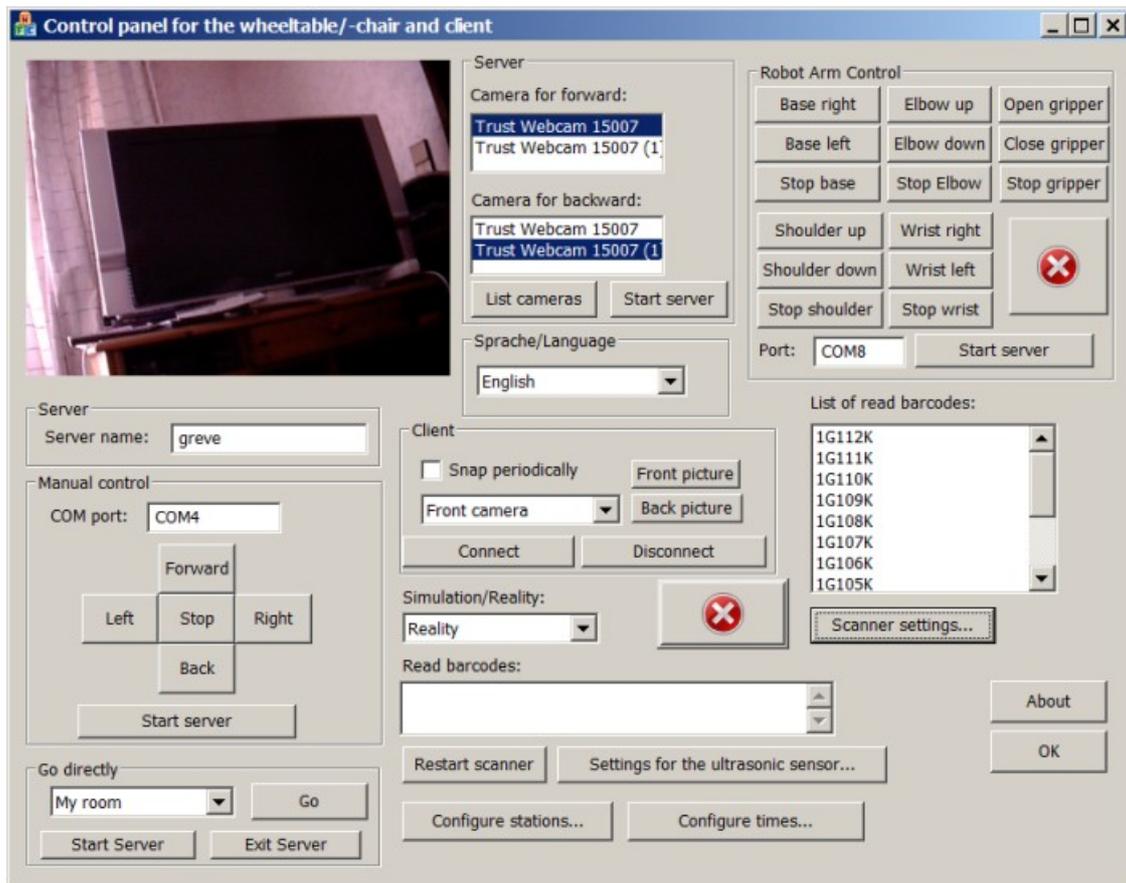


figure 5: Server, Client for Windows XP/Vista and control software

The server for the robot arm can be started after entering the COM Port (name of the serial port, e.g. COM2) of the robot arm by clicking on „Start Server“ in the group box „Robot arm control“. After entering the correct host name of the server notebook into the text box „Server name“, you can move the robot arm by clicking on the various buttons of the robot arm control. All actions of the robot arm can be stopped with the emergency stop button.

Design of the Software

The software was developed with the IDE Microsoft Visual Studio 2005 in the programming language C++. On the notebook, which controls the wheelchair/wheeltable, five servers are running, which can be accessed by any client (PC, Notebook, Pocket PC) in the home network. These five servers are:

- server for going to a station directly (see subsection "Driving the vehicle to a station directly" in chapter "Autonomous Driving in the Control Application with the Aid of Barcode Ways")
- manual control server
- camera server

- robot arm control server
- emergency stop server

In the following sections, I'm going into detail with this and the remaining software. The double quotes with the descriptions of the server protocols won't be sent. The software can be divided into the following modules:

Manual Control

With the manual control the wheelchair/wheeltable can be controlled via a client PC by clicking. The two to the host notebook connected USB cameras can be a help with that (see section "The Cameras"). The server listens on TCP port 2346 and receives the string „1“ for going left, „2“ for going right, „3“ for going forward, „4“ for stopping and „5“ for going backward.

Cameras

The images the selected of the two cameras takes are displayed in my client software. The camera server runs on the control notebook and transfers, depending on the commando it has received, an image taken by the first camera („1“) or the second camera („2“). The server listens on TCP port 3457. The images are transferred in the JPEG format.

It can be selected which cameras connected to the notebook should be used.

Ultrasonic Detectors

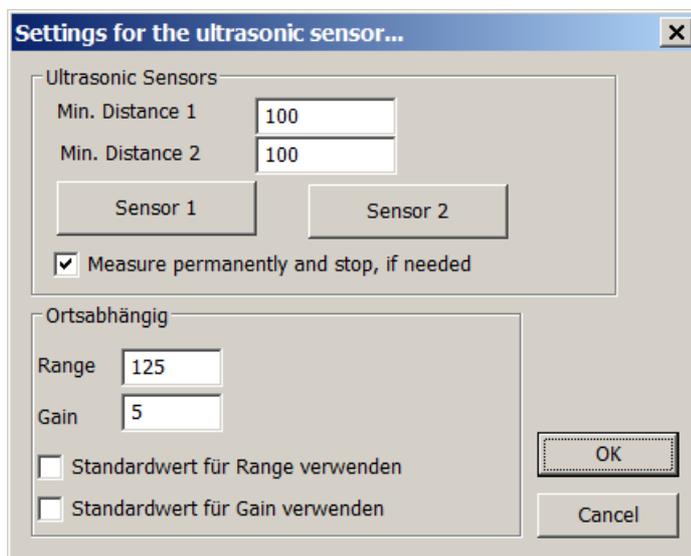


figure 6: Other settings for the ultrasonic detectors

The ultrasonic detectors of the type SRF10 are connected to the microcontroller board RN-Control 1.4. The board receives the signals of the ultrasonic detectors and sends the measured values (distances) measured by the ultrasonic detectors to the CompuLAB Interface, which is connected to the control notebook via USB. My program receives the measured values via the CompuLAB Interface and analyses the data.

The wheelchair/wheeltable is stopped automatically if the measured distance (in cm [centimetres]) is below a specific distance (in cm). This distance can be set up in my program, but the measurement can also be fully stopped.

The values „Gain“ and „Range“ are depending from the current location ("Ortsabhängig") and can be set up in a text box. The values filter out echoes in small rooms or in rooms with many large objects. There are standard values for Range and Gain predefined by the SRF10 sensors that can be used if the checkboxes "Standardwert für Range" bzw. "Standardwert für Gain" are checked.

Simulation



figure 7: Simulation

In the control software you can set up whether you want to use the real hardware (wheeltable/wheelchair) or a simulation. If you choose the simulation, a rectangular window is displayed which states the current state, e.g. „Forward with speed 100“ or „Stop“.

Robot Arm

The robot arm server listens on TCP port 4568 and is controlled by the following commandos which are transferred as a string:

| | | | |
|----------------|-------------|-------------|------------|
| Base | Right: „1“ | Left: „2“ | Stop: „3“ |
| Shoulder | Up: „4“ | Down: „5“ | Stop: „6“ |
| Elbow | Up: „7“ | Down: „8“ | Stop: „9“ |
| Wrist | Right: „10“ | Left: „11“ | Stop: „12“ |
| Gripper | Open: „13“ | Close: „14“ | Stop: „15“ |
| Emergency stop | „99“ | | |

At the client PC the robot arm can be controlled by clicking on buttons.

Emergency stop

The emergency stop server listens on TCP port 9989 and stops the current wheeler (wheelchair or simulation) if it receives the string „0“. For safety reasons, it runs independently from the other servers, because if the manual control server isn't started to stop the vehicle, it can be stopped nevertheless.

Software for manual control via Pocket PC (Devices running Windows Mobile 5.0)

The Software for manual control via Pocket PC (running the operating system Windows Mobile 5.0) is developed with the IDE Microsoft Visual Studio 2005 in the programming language C#.

Usage

The wheelchair/wheeltable can be controlled into any direction by clicking on any of the 5 buttons (see figure 8). The host name of the computer that controls the wheelchair/wheeltable can be entered into a text field.

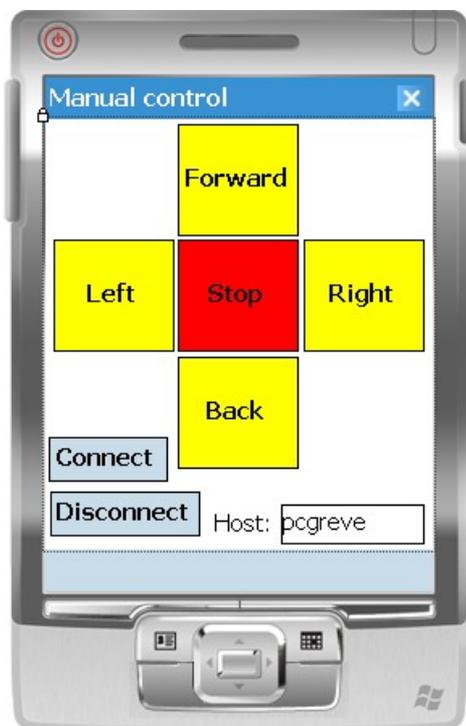


figure 8: Screenshot of the Pocket PC

Software for Creating Barcode Ways

I've developed the software for creating barcode ways with the programming language C#.

Layout of the Barcode Ways

Because a GPS system, a rail system, or pattern recognition (insufficient recognition rate because of light factors) can't be considered – especially in private households – I've decided to use positioning with the aid of barcodes.

For that, I've developed a software for creating such barcodes. The barcodes are arranged in a specific layout, so that slight deviations of the vehicle, i.e. if the barcodes at the positions 0, 2, 3 or 4 (see figure 10) are read in, can be corrected. Due to time reasons, the correction of deviations are only implemented rudimentary, but it is necessary for the fully automatical driving, as autonomous driving from position A to position B.



figure 9: Sample
barcode

A sample of the information encoded in such a barcode of the type Code39 as in figure 9 is:

1G100K

The „1“ means the position in the collocation, which consists of five barcodes. The disposed barcode left (see figure 10) shows the barcode at position 0, the medium barcode stands at position 1, the right disposed barcode at position 2, the bottom disposed barcode left is at position 3 and the bottom disposed barcode right is at position 4.

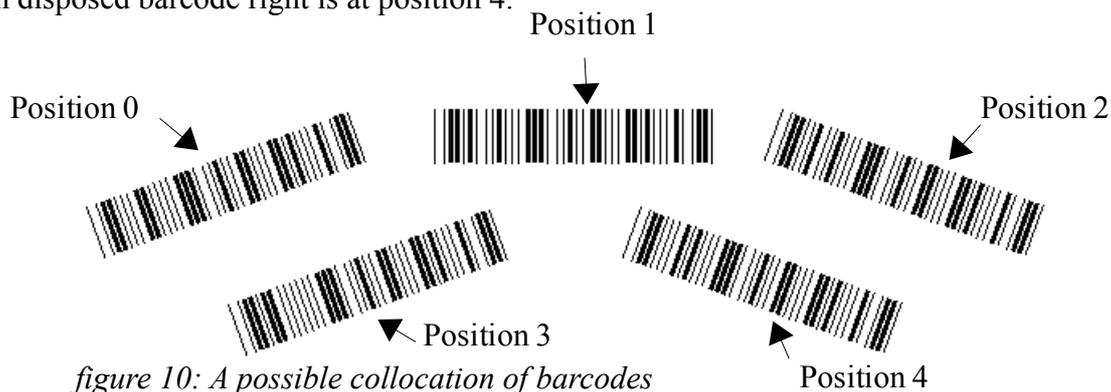


figure 10: A possible collocation of barcodes

The next letter is the room indication letter. It shows in which room the wheelchair is at the moment. The next 3 digits are a definite ID for every barcode collocation. The ID has always 3 digits and starts at 100 and ends at 999. So there are 900 possible barcode collocations in one room = 4500 barcodes. Because there are 26 possible room indicator letters, in one house there can be even 117 000 barcodes.

After that, there is, also only as an enhancement for the control software, a letter to recognise if the wheelchair is at a branch connexion.

The letter K means „no branch connexion“ and the letter A „branch connexion“. In my program, the modus „no branch connexion“ is fixed, but can be changed easily.

In the second collocation from the top in figure 11, the barcodes at the positions 0 and 2 are turned round clockwise. When the wheelchair comes from the opposite direction and deviates, its deviation can be recognised by the computer, too.

Usage

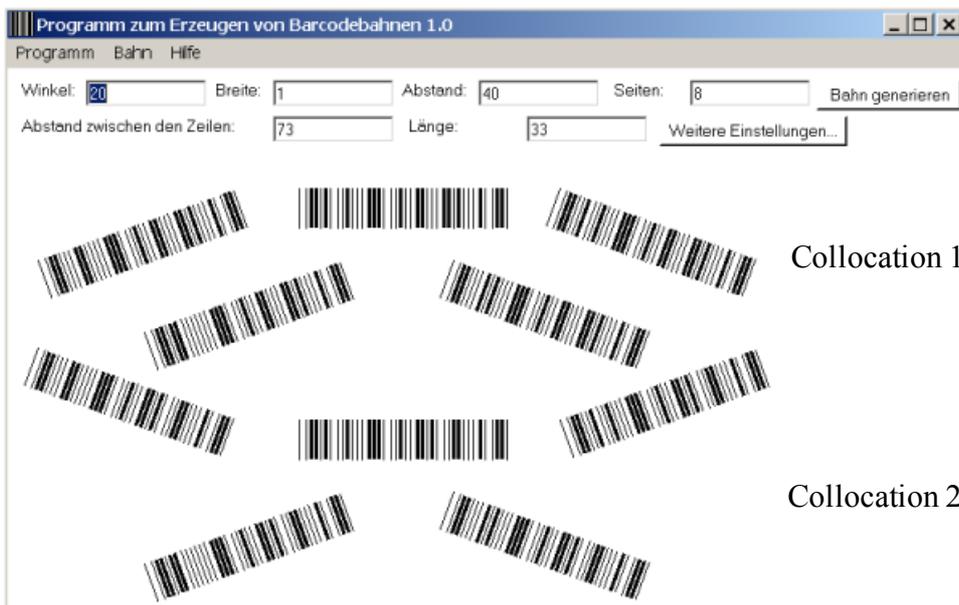


figure 11: Program for creating barcode ways



figure 12: Other settings

In the program there are various settings:

- The angle of the large barcodes at the positions 0-2 (see figure 11, text field „Winkel“)
- The width of the barcodes (see figure 11, text field „Breite“)
- The distance between the barcodes (see figure 11, text field „Abstand“)
- The distance between the collocations (see figure 11, text field „Abstand zwischen den Zeilen“)
- The length of the barcodes at the positions 0-2 (see figure 11, text field „Länge“)

- The angle of the small barcodes (positions 3 and 4) (see figure 12, text field „Winkel (klein)“)
- Manual adjustment upwards, downwards, leftwards and rightwards of the small barcodes at the positions 3 and 4 (see figure 12, text field "Verschiebung oben/rechts (1/2)")
- Length of the small barcodes at the positions 3 and 4 (see figure 12, text field „Laenge (klein)“)
- Number of pages which should be printed later (5 collocations of barcodes on each page) (see figure 11, text field „Seiten“)

There is always a preview displayed in the program. The barcodeway can be printed by the shortcut Ctrl + P or by clicking on Bahn – Drucken.

Autonomous Driving in the Control Application with the Aid of Barcode Ways

If wanted to drive the wheelchair/wheeltable to a station directly, a station can be defined. That happens if you click on „Configure stations...“ (see figure 13) and define the range of the station. Therefore, the button „Add station...“ must be clicked (see figure 14).

If you would like the wheelchair to drive to a station directly, just select the station you want it to drive to from the combo box in the group box „Go directly“.

The wheelchair/wheeltable starts driving when you click on „Go“.

The wheelchair/-table can drive to a station auto-scheduled by defining a time and a station. Therefore, click on „Configure times...“ and on „Add time...“ and define a time (see figure 15 in section "Auto-Scheduled Driving to Stations").

For a time a station a must be defined first (see figure 13 in section "Driving the vehicle to a station directly").

Driving the vehicle to a station directly

On the control notebook you can define stations by entering exact positions (which relate to barcodes) (see figure 13 and dialog „Add stations...“ in figure 14). I have introduced the possibility to drive the wheelchair/-table to a station from the client directly, which was defined on the client first.

The server for the direct driving to a specific station listens on TCP port 6780.

The client sends the range of the barcodes that the wheelchair/-table should stop in as a string divided by a hyphen „-“.

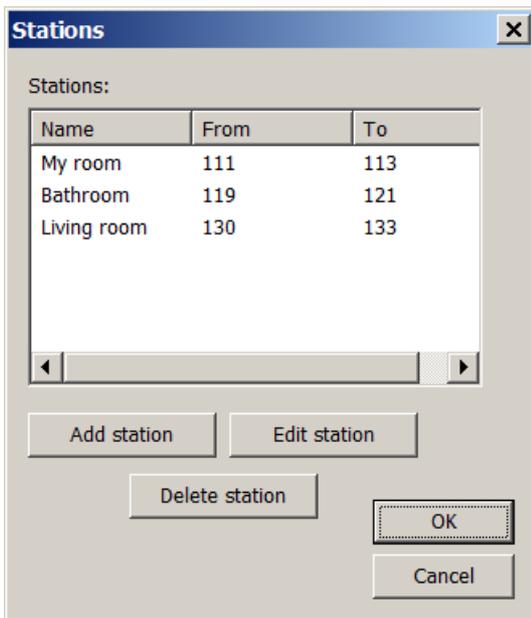


figure 13: Define stations

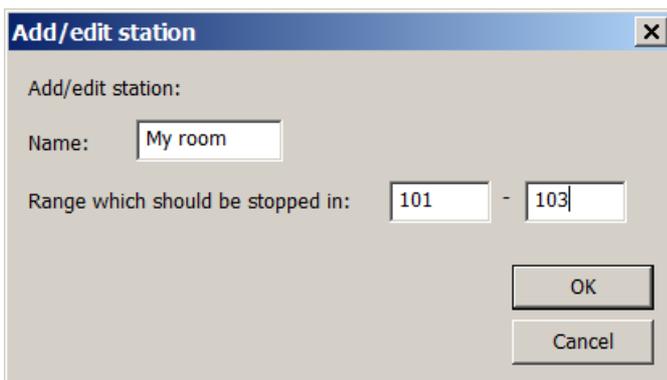


figure 14: Add/Edit station

Auto-Scheduled Driving to Stations

The computer can control the wheelchair/wheeltable in such way that it drives to a station at a specific time. The times and the referring stations are defined on the server (not on the client). An example can be seen in figure 15. An own time and station can be defined in the dialog „Add times...“ (see figure 16).

It is also possible to set the computer into the standby mode or into the idle state, which it wakes up out at a defined time.

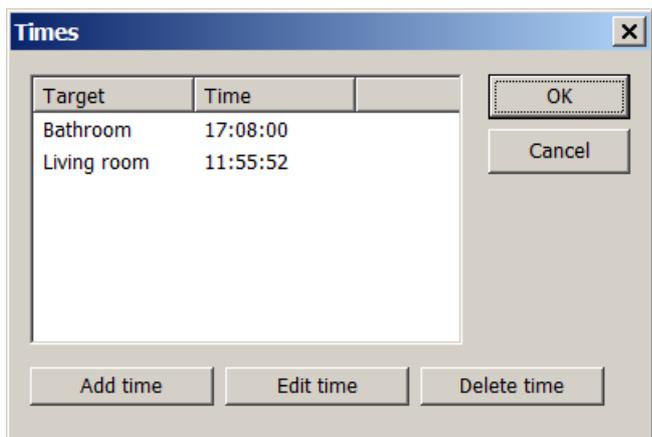


figure 15: Configure times

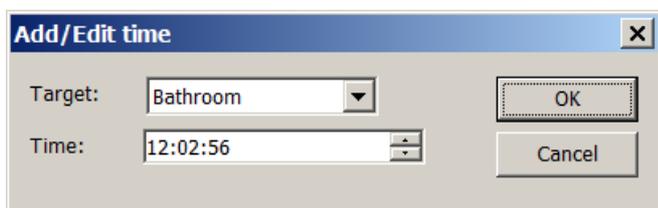


figure 16: Add/Edit time

Scanner Settings

Before driving, the scanner has to be initialised, because the laser is turned off automatically after 3 seconds without reading in a barcode. The initialising last approximately 8-10 seconds. The delay that should be allowed to the scanner can be set up in the dialog „Scanner settings...“ (see figure 17) after clicking on the button with the same name.

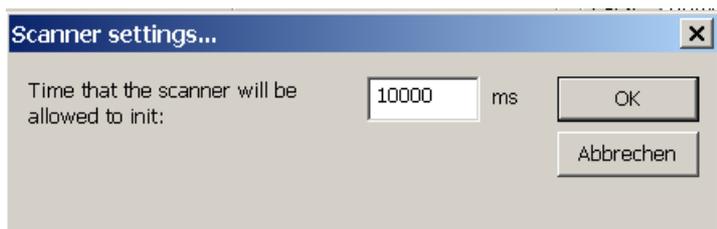


figure 17: Settings for the barcode scanner

Discussion

All hardware should be made more compact.

The lifting magnets used by me are a temporary solution only, because there wasn't, due to the age of the wheelchair, information enough for controlling the control electronics directly.

Because I couldn't deal with the correction of deviations and the autonomous driving of branch connexions enough, also because of time reasons, these things should be much improved in the software. A condition for that would be the possibility to control the control unit of the wheelchair directly, and not mechanically via the joystick.

The project is, because of the amount of work, rather suitable for a project team than for a single person.

My opinion is that fully automatical wheeltables/wheelchairs in households will establish in the future – also for reasons of economy.

Acknowledgement

I thank my parents for their appreciation for the project.

Picture credits

All pictures in this document are © by David Greve (2008).

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