T³ EUROPE

Teachers Teaching with Technology™

Alexandre Gomes

Rover, a Sm@rt Wheelchair

Electric wheelchair steering control through head movements

www.t3europe.eu

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Electric wheelchair steering control through head movements

1. Context of activity

This project consists in developing a robotic prototype for controlling the movement of an electric wheelchair, only with head movements. This is especially relevant for people who can only move their head in a controlled way, due to a tetraplegia or similar condition.

Despite there are already some commercial systems designed for this situation, they have significant disadvantages, namely in terms of technological complexity (and consequently high prices), or because they require the use of any kind of accessory (e.g. helmet, glasses, objects inserted in the mouth, among others), much more intrusive and uncomfortable for the user. In addition, these devices generally involve specific eye movements, face expressions or voice commands, which are usually complex to learn and to use.

The device proposed in this project transforms smooth head movements into controlled motion direction situations. The wheelchair will be simulated by the use of a programmable robotic vehicle (TI-Innovator ROVER), so its extrapolation to the full-scale model is extremely simple, by simply using relays to connect the control unit to each of the electric motor of wheelchair wheels.

2. Learning outcomes

- **a.** Learners will be able to conceptualize simple computer algorithms;
- **b.** Learners will be able operationalize simple computer algorithms in coded programs, using TI-Basic Language;
- **c.** Learners will be able to identify and mathematically manipulate physic variables evaluated by sensors, in order to control project outputs;
- **d.** Learners will be able to design and create a functional simulator of an electric wheelchair, driven from head movements;
- **e.** Learners will be able to judge and compare the advantages and disadvantages of technological development.

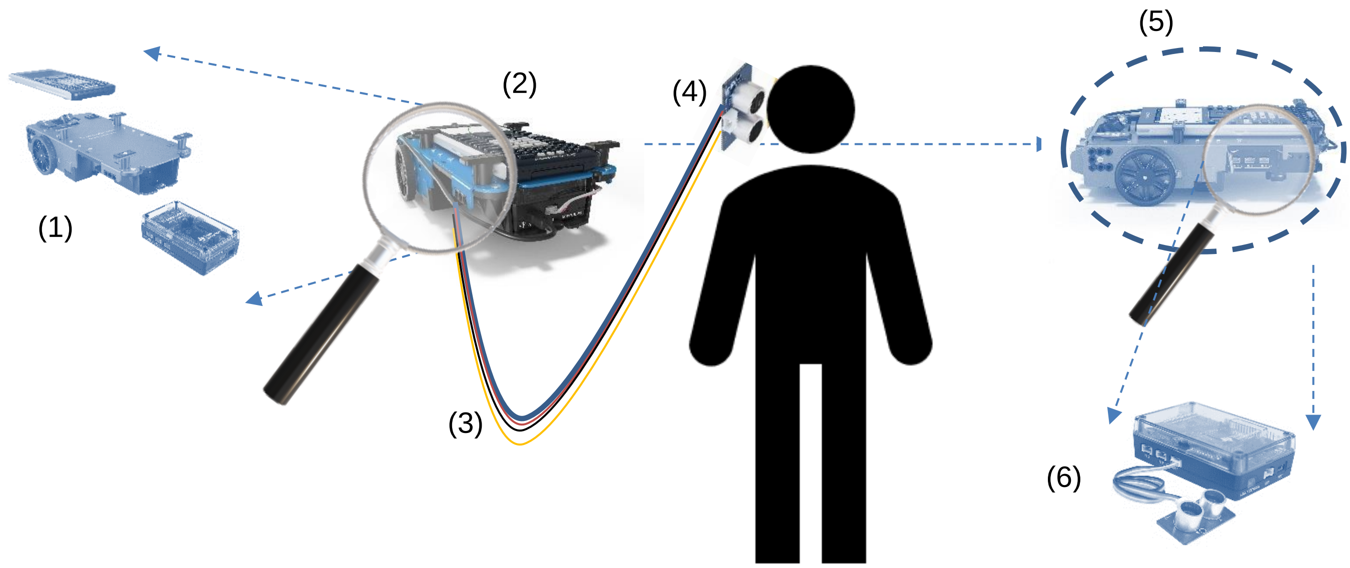
3. Experiment notes and instructions

In this project, the electric wheelchair will be simulated by the robotic vehicle TI-Innovator™ Rover. Therefore, it will be installed in the back of “wheelchair user” a backpack, in which will be fixed a motion/ position sensor (Ultrasonic Ranger). This sensor should evaluate user’s head position in order to send driving commands for the simulated wheelchair – Rover. It’s something like if the head of the user would act as kind of a joystick, that would control the movement of the robotic car. Special care should be taken to correctly fix the sensor related to user’s head, and to convert head distance from sensor in turning information. Teachers could explore the mathematical relations between these two variables, in order to define appropriate range, sensibility and accuracy of this “human remote control”.

TI Technologies and Materials (per group of students)

- 1 TI-Nspire™ CX II;
- 1 TI-Innovator™ Hub;
- 1 TI-Innovator™ Rover;
- 1 Ultrasonic Ranger;
- 3-meter electronic wire x 4 (used to extend the length of Ultrasonic Ranger’s connecting cable);
- 1 Backpack (or similar, used to fix the Ultrasonic Ranger near user’s head);
- Duct Tape;
- Ice cream sticks (or similar, to build Ultrasonic Ranger’s support on backpack);

System General Layout



Legend:

(1) – Rover setup, components view (TI-Nspire™ CX, TI-Innovator™ Rover, TI-Innovator™ Hub).

(2) – Rover setup, perspective view.

(3) – 3-meter electric wire,

(4) – Ranger Sensor

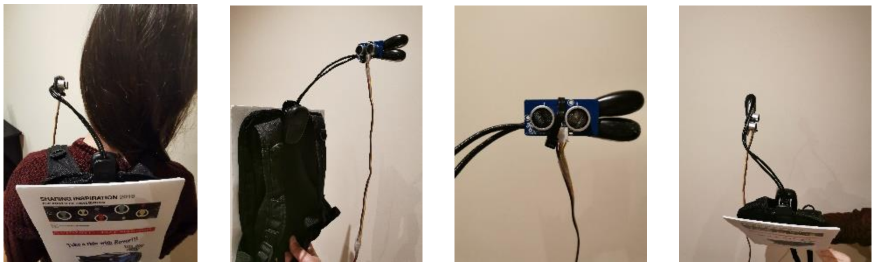
(5) - Rover setup, lateral view

(6) - TI-Innovator™ Hub, detailed Ranger connection view

Application overview

The following pictures show a possible configuration of this project, in a real application.


(general view)



(detailed ranger sensor view)

It can be also seen in the following link a working application of the project, presented as a national Science contest, by Portuguese students, who won a trip to NASA for it!

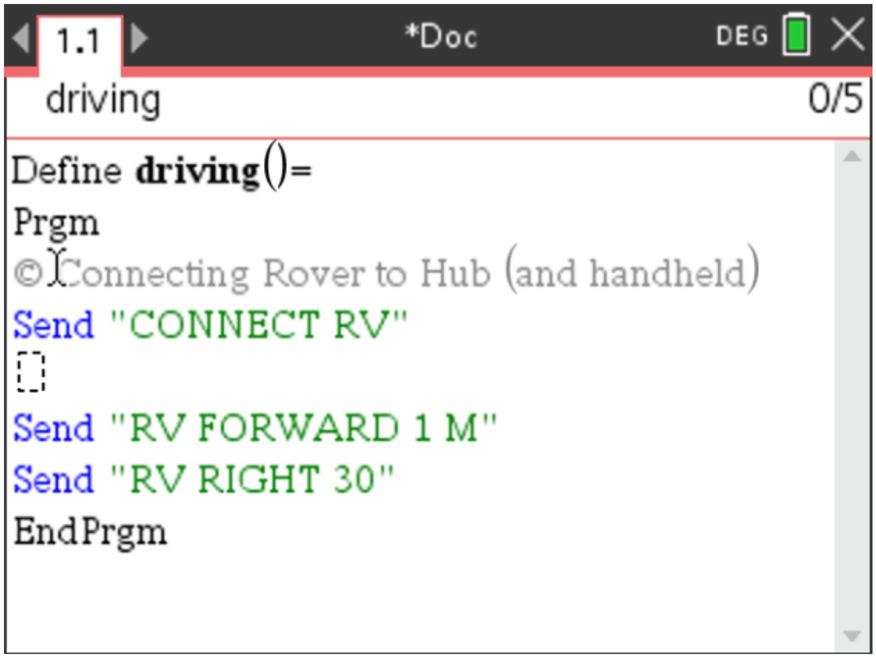
https://www.youtube.com/watch?v=Sbe5jqTemuo&feature=youtu.be

First steps

To see how to connect Rover (with Hub) to TI-Nspire please refer to https://education.ti.com/html/webhelp/EG_Innovator/EN/content/eg_splash/eg_innovroversug.HTML

1. Let's command some simple driving instructions to Rover, for instance, "Go forward for 1 meter, then turn right 30 degrees"

   The program to execute the above instructions should be similar to this (implemented in file *driving_Rover.tns*):



To see other commands and configuration information, please refer to TI Innovator Technology Guidebook, https://education.ti.com/download/en/ed-tech/9682D7EC137E48798E3B250EFD65983D/2E21B21360CC46A094E86AF33192E471/TI-Innovator_Technology_Guidebook_EN.pdf.

2. With TI-Innovator Hub inserted in Rover, connect Ranger sensor to IN 1, as shown in next figure:

Now, let's try to read and display the distance information acquired by this sensor. The program could look something like this (implemented in file *ranger_distance.tns*):

```
Define ranger_distance()=
Prgm
© Connecting Rover to Hub (and handheld)
Send "CONNECT RV"

© Connecting Ranger Sensor to IN 1
Send "CONNECT RANGER 1 TO  IN 1"

© Reading sensor information
Send "READ RANGER 1"
Get dist

© Displaying sensor information
Disp "The distance is ",dist
EndPrgm
```

- From one test to another, please change hand distance from sensor and check that the readings are consistent.
- (how about using a cycle ***For… EndFor*** to do several tests at once?

3. In this challenge, the movement of Rover will be dependent on the reading of the sensor, i.e. the distance of the hand (in the final design, from the head of the system operator) to the sensor. For that, we'll use an ***If...Then…Else…EndIf*** control statement, and turn right or left according to distance information. Something like this (implemented in file *ranger_distance_driving.tns*):

```
Define ranger_distdrive()=
Prgm
© Connecting Rover to Hub (and handheld)
Send "CONNECT RV"

© Connecting Ranger Sensor to IN 1
Send "CONNECT RANGER 1 TO  IN 1"

© Reading sensor information
Send "READ RANGER 1"
Get dist
© Turning right or left according to sensor distance
If dist<0.5 Then
  Send "RV RIGHT 30"
Else
  Send "RV LEFT 30"
EndIf
```

4. We're almost there! In this simplified version of the wheelchair with remote control (simulated by Rover), we will just add the instruction for it to move generically forward, turning left or right according to the distance information read by the sensor. In this startup phase, it is easier to vary the distance read by the sensor by approaching or moving the hand, or any other object that we want to use as control. You can find an example of this program below (implemented in file *Rover_Wheelchair_STEM_Project_Simple.tns*) .

```
Define rover_stem()=
Prgm

Send "CONNECT RV"
Send "CONNECT RANGER 1 TO  IN 1"

For i,1,100

     Send "RV FORWARD TIME 120"
     Send "READ RANGER 1"
     Get d

     If d<0.5 Then
       Send "RV STOP "
© turn right
       Send "RV RIGHT 30"
       Cycle
      EndIf
      If d>0.7 Then
        Send "RV STOP "
 © Turn left
        Send "RV LEFT 30"
        Cycle
     EndIf
EndFor
Send "RV STOP "
Text "Thank's for driving me!"
Send "DISCONNECT RV"
EndPrgm
```

5. In order to make the wheelchair control a little more realistic, it will be interesting to fix the position sensor (Ranger) next to the "operator's" head (for example, fixing it to a backpack, with a flexible support), so that the head position is the direction indicator. To do this, it is necessary to extend the cable connecting the sensor to the

Hub, up to about 3 meters. Get help from your teacher if you are not comfortable with this.

4. Questions

1. What are the physiologic causes for human paralysis? Are there different types? How different is the life of someone who is paralytic? What could be done to promote the well-being for someone who is paralyzed?
2. Are there developed technical solutions to control an electric wheelchair without using the hands? What are the *pros* and *cons* of each solution?
3. What are the damages to the planet of the crescent technological advances? Do these technological advances also influence all the inhabitants of the planet, as do their harmful consequences?
4. What´s an algorithm? How can one control a robot’s movement?
5. How to code? How to use TI-Innovator Hub to interact with the world