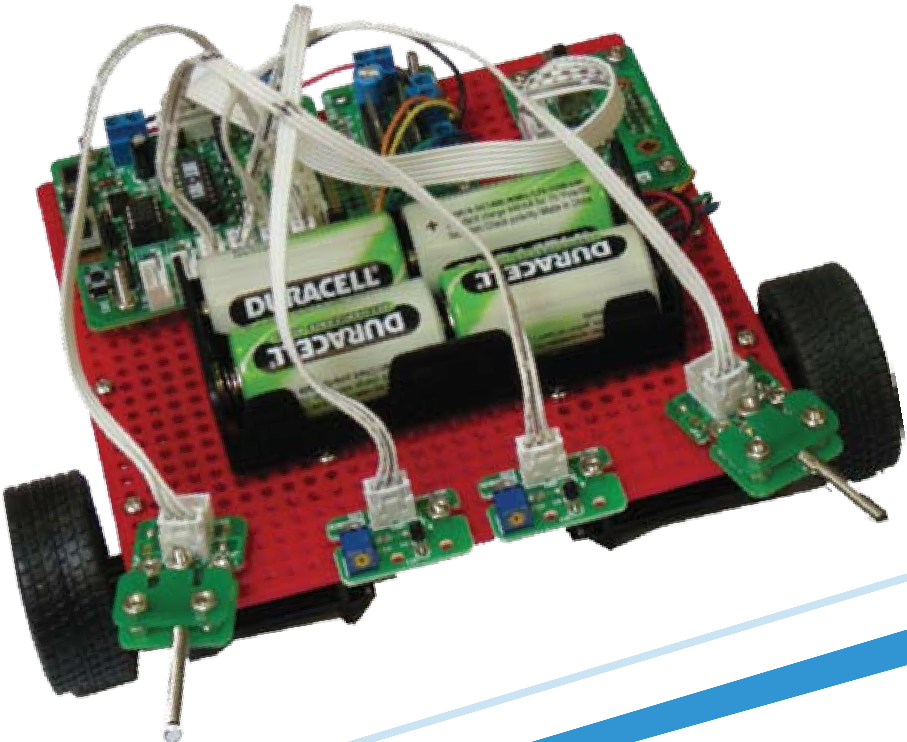
ROBO didactics



Education and Culture

Socrates
Minerva

Teacher's Guide

Conceptual level

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Contents

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This RoboDidactics Teacher's Guide builds on work previously carried out by a number of partners in the RoboCup Junior competition.

RoboDidactics has further developed the content of the Guide, improving the arguments and original English style and adding a completely new section containing suggestions on possible ways of structuring lessons at school, including procedures, materials, exercises and ways in which the topic of robotics can be used in non-technical subjects such as Literature, Philosophy, etc.

It is important to acknowledge the organizations that have contributed to the evolution of the Teachers' Guide over the years. These are:

- **ComLab 2** – ComLab is an EU project in which course material is developed for science and technology education. It is part of the EU Leonardo Da Vinci Community Vocational Training Action Program project SL-05-B-F-PP-176008

  http://e-prolab.com/comlab

- **Edict** – Stichting Educatie in ICT supports the development of course material for ICT education.

  www.edict.nl

- **Amstel Instituut/CMA** – An organization that conducts additional education for teachers in the middle- and higher educational institutes and also develops course material.

  www.cma.science.uva.nl ***www.science.uva.nl/amstelinstituut/***

- **muVium** – The organization developing JelloBot, the muVium Java technology and is the developer of roboPAL.

  www.muvium.com

- **MultiMotions** – The developer of JoBot, JoBot Junior, the Java Processor Board and various simulation programs for RoboCup.
www.multimotions.com

- **BetaPartners** – An organization that assists schools with a dedication towards more extensive Beta education in the secondary schools.
www.betapartners.nl

- **The Management School of the University of Edinburgh** – An organization working among other things in innovation and knowledge management.

- **Robotech srl –** The Italian company distributing the RDS-X01 from Robotech Japan.

Information on the RoboCup Junior can be found at *www.robocupjunior.org*, *www.robocupjunior.nl*, or you can contact it by writing an email to *info@robocupjunior.nl*

Introduction

This Teacher's Guide accompanies the Basic Course and the Rescue Course at Conceptual Level. It is organized in two parts.

The first part (Part I) of the Guide follows the educational premises set out in the Robodidactics Manual, particularly, the importance of learning by discovery in a practical and entertaining way that allows children to reach their first results quickly.

For this reason, the content of Part I seeks to offer teachers information about what actually needs to be 'discovered,' along with additional information about things that are likely to go wrong.

In practice, each lesson will contain the following four aspects:

1. **Ideas to be discovered**, defining clearly what concepts are supposed to be discovered.

2. **Common problems and pitfalls**, sharing practical lessons learnt by others on how to prevent problems or offer help in guiding students who get stuck.

3. **Background information**, containing some more detailed information for teachers to help students in gaining a better understanding.

4. **Additional exercises**, containing suggestions for additional exercises for students who are bright and may find the original assignments too simple.

The second part (Part II) of the Guide contains suggestions on possible ways of structuring lessons at school, including procedures, materials, exercises and ways in which the topic of robotics can be used in non-technical subjects such as Literature, Philosophy, etc.

Of course, teachers are free to decide their own way of structuring lessons but the material in this Part II may help trigger ideas on how this can be done.
Each lesson in Part II of the Guide contains the following specific items:

1. Learning Objective
    - Knowledge
    - Life Skills
    - ICT skills
2. Material
3. Time
4. Class organization
5. Procedure
6. Exercises or Homework
7. Suggestions for Further Activities

Of course, not all items need to be present and one must remember that the discovery process should always be central to the setup of the lessons.

Part I

Basic Course

Introduction

RoboPAL stands for Play and Learn and has been designed to allow children to achieve rapid familiarization with the robot and the programming environment while getting their first results quickly.

As explained in the Robodidactics Manual, the RoboDidactics lessons are conceived at three major levels of increasing complexity: the Conceptual level, the Physical level and the Programming level.
This Teacher's Guide focuses on the simplest Conceptual level, particularly, the Basic Course and the Rescue Course to start the process of building the gradual familiarization of students with robots.

Every lesson teaches at least one new idea and explains what will be achieved. Since we would like students to discover these important ideas by themselves, the role of the teacher is to make sure the discovery process actually happens.
Sometimes students either do not discover the principles or discover some other fact.
Sometimes they will acquire a wrong idea and it is very important for the teachers to identify this and prevent such wrong ideas from spreading further into the student's learning process.

As indicated in the Introduction, the Teachers' Guide contains the following topics for every lesson:

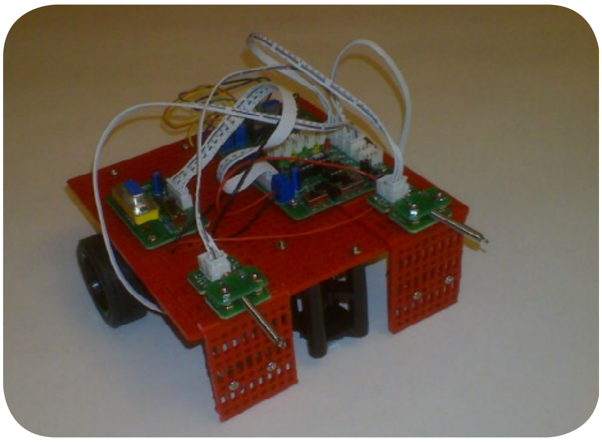
1. Ideas to be discovered
2. Common problems and pitfalls
3. Background information
4. Additional exercises

We also introduce some optional exercises. For instance, the lessons in which the table is cleared can be played with the circle field but also with the rescue field.

The actual selection between these two possibilities will depends on the availability of the field and, also, on the interest of the students.
In addition the purpose is not to constraint you, the teacher, to follow rigidly the material presented here.

Indeed, **you can use this material to create your own package of lessons.**

Lesson 0 – Introduction to Robotics



The first step in getting started is to prepare the robot. When using the RDS-X01 robot, this robot first needs to be assembled. To do this, you should follow the instructions from the booklet delivered with the robot kit.In this picture you see a version that is not actually described in the booklet. The picture shows a robot with forward-pointing sensors.
In this picture you see a version that is not actually described in the booklet. The picture shows a robot with forward-pointing sensors.
These are primarily used to start the robot in these lessons. We also need them for calibration purposes.

The forward-pointing sensors need to be assembled manually, as also do the down-facing reflection sensors.
The robot should have been assembled by the teachers before the lessons start. If a schools lacks technical capacity, the assembly could also be done by an external party linked to Robodidactics.

1. Ideas to be discovered

An important lesson for students is to actually see the various parts of the robot and see how they are inter-connected while the robot is assembled.

However, since the assembly of a robot can be done only once and it is not an easy task, especially for young students, we suggest that teachers or at least older

students assemble them.
See Appendix 1 for details on the parts of the RDS-X01 robot and its process of assembly.

Even though the students will not assemble the robots, it is good practice to first point out to them the various parts of the robot, explaining the working of the sensors, motors and gears.
The working of the touch sensors can be easily shown.

Simply move the springs left and right and see how they make contact. Then you can move on to explain the reflection sensors used to look at the surface the robot is moving over. Finally, you can show the motors with gears and point out to the processor board, switches and interface board.

When assembling the robot, experience tell us that it is a good idea to mount the motors and battery box underneath and all the electronics on top of the red plate where the robot pieces are connected.

To achieve this, the motors must be placed on some spacers, provided with the robot. You should also make sure the reflection sensors are facing down.

The second aspect that needs explanation is the use the software roboPAL. For this, it is best to give a demonstration first, so that the children are able to work on their own thereafter. During the first two lessons they will only use the RoboPAL simulator and, after, they will also learn by using the real robot.

Make sure you explain the function of the processor board and the interface. The roboPAL program runs inside this board but is created on the computer and needs to be transferred from the computer into the memory of the small computer on this robot.

2. Common problems and pitfalls

Assembling the robots takes about one hour per robot and requires following the instructions accurately. Attaching the components using nuts and bolts sometimes creates an unstable robot, if these nuts and bolts are not connected tightly.

Make sure to assemble one complete robot first and test it, before assembling the other robots.

The transference of the roboPAL program from the computer into the memory

of the small computer on the robot makes use of a cable. Make sure that it is connected properly. The switches also must be in the right position.
Also make sure the batteries are fully charged, otherwise the robot will start behaving erratically.

3. Background information

Although the touch sensors are not used directly as sensors in the programs, they are used as a switch in the program to start the calibration procedures.

The field sensors are reflective (reflection sensors), this means that the large LED sends out infrared light like the remote control of your TV. You cannot see this light but if you use the camera on you phone, you will be able to see the light go on or off.

4. Additional exercises

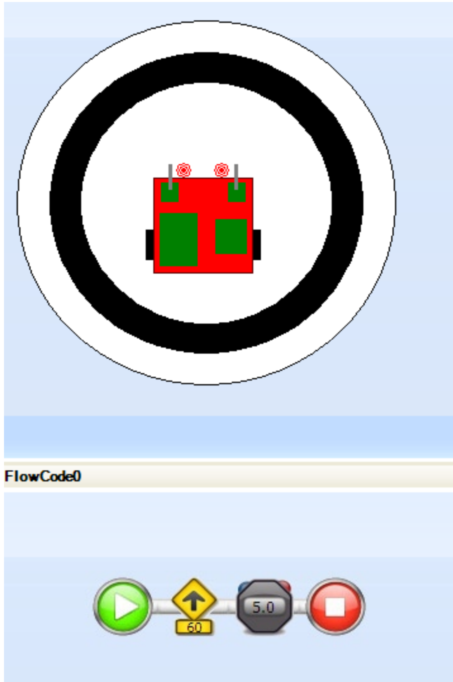
Show the gearboxes and explain that, because they are mounted mirror-like, one motor needs to spin forward and the other one backward to make the robot move in the same direction. If both wheels were to run in the same direction, the robot will spin around its own axis.

Lesson 1 – Making your robot move forward

In this lesson the robot moves forward for a fixed period of time.

1. Ideas to be discovered

This is first lesson in which children see the robot in operation. It is very important that they experience the joy of making a small program that actually works. This is the simplest program imaginable, but it will show the robot moving in response to student's small program. It should set the stage to want to find out more.



2. Common problems and pitfalls

Generally there are not many problems with this exercise. Once it runs using the simulator, however, switching over to the robot is more involving, since the program needs to be uploaded etc. The necessary time should be considered to take care of this.

3. Background information

It is important to realize that the green "go" command actually tells the robot to start moving and that the stopwatch will wait until the 5 seconds are over.
It then stops the program which will also stop the robot.

It is important to know that the motors will continue to run. This is an indication of the parallel activities that are going on in the robot. The robot is moving the motor and counting down at the same time.

4. Additional exercises

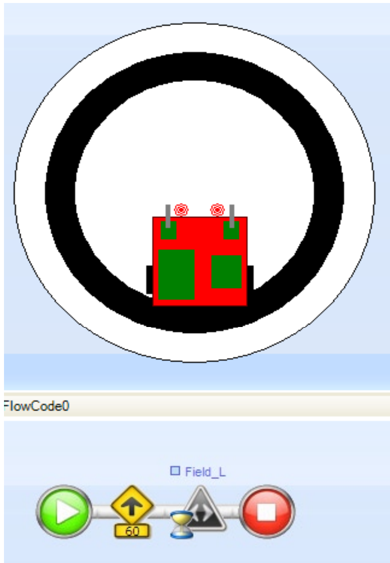
As the exercise has fixed settings for the speed and length of time, the student can now experiment with these settings and change them into faster/slower movement and longer/shorter times.

An interesting addition to this is to have the robot kick a ball and create a table that lists how far the ball has been kicked on the field, using these parameters.

Lesson 2 – Detecting a dark area

Instead of moving forward for a fixed amount of time, the stopping condition for the robot is now the detection of the line.

1. Ideas to be discovered



The sensors at the bottom of the robot continually scan the surface. When a darker area is detected, the sensor now plays the same role as the stopwatch and ends the program.
It is important to let the students find out that the *line thickness* and *robot speed* play an important role in this activity.

2. Common problems and pitfalls

Light conditions could play a role here. Since we are looking for a change in brightness, too much daylight (for instance direct sunlight) could influence the ability of the sensor to detect the black line.

3. Background information

Although the sensor is scanning the surface continually, this will typically be done in short bursts.
If the robot moves too fast or if the line is made too narrow, the robot may not have enough time to detect the line.
It may then either overshoot the line and stops later, or it may not detect the line at all and does not stop until it bumps into something.

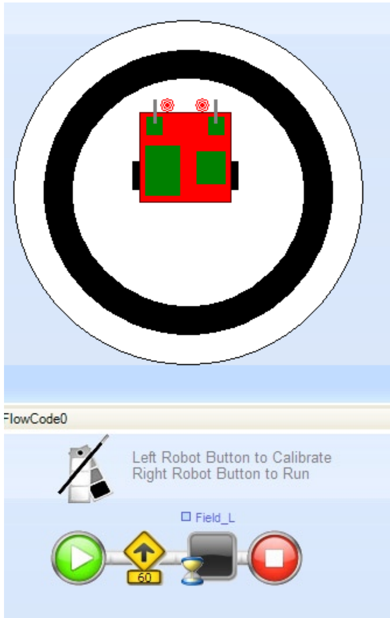
4. Additional exercises

Make the speed higher and the line thinner and find out at which point things start to go wrong.
Have the students make a table and determine when the robot overshoots and when it misses the line.
Can they determine from that how fast the robot is able to detect the black line ?

Lesson 3 – Finding out the color

In the previous exercise the robot was scanning for a change in light level. But because the light conditions may differ between locations, it is safer to measure what the actual value of black is. This program reads that value and stores it for later reference. The process is called 'calibration' and is very important.

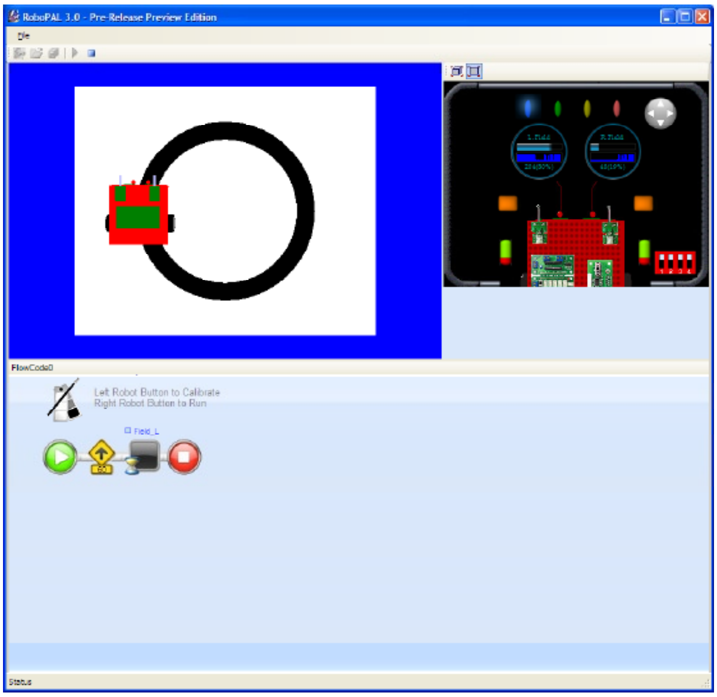
1. Ideas to be discovered



When the light conditions differ, the robot may not be able to detect the black line. This may be demonstrated by sticking a different color over part of the circle and have the robot drive over it.
The simulator gives feedback about the actual light readings and the student may check this by manually moving the robot over the field.
The sensor gauges show the difference between light and dark.

2. Common problems and pitfalls

In this program it is not entirely clear what is going on when it runs. So it is important to explain clearly what the idea is.The two switches are used to tell the robot what to do. The left switch is used to start the calibration program. This makes the robot drive forward until it detects a color change and it will then record this value for later reference.
ot has 'remembered' the correct value and will now respond as expected.



Then the right switch is pressed and the robot executes the small program that now does the same as the previous one, but instead of using a fixed value for the sensor, it now uses the calibrated value.

This is best demonstrated on the real robot, using a strip of a different color that does not react to the default sensor value. After calibration the rob

3. Background information

One of the most important ideas with autonomous robots is that of adaptability. When the external circumstances change, the program must be modified manually. Adaptive behavior means that the robot is able to register these changes by itself without the need to change the program manually. Calibration is just one example of such adaptive behavior that animals display all the time. Calibration is very important for all succeeding lessons and it is a theme that will comes back again and again.

4. Additional exercises

Use different colors like Green and Gray and have the students recalibrate for each of these colors and see how the robot adapts itself.

Lesson 4 – A small game

On the table we set up a field with a black circle and place a number of plastic cups inside the circle. The idea is that the robot will move inside the circle pushing out of it all the cups.

This exercise may also be done using the rescue field and becomes a bit different as a result of the other colors involved. You can select which one you would like to use.

If you intend to run the Rescue Course accompanying the Basic Course, it is better to skip this exercise and select the one in the Rescue Course.

1. Ideas to be discovered

This is the first significant program where all the previous ideas are combined. It is also useful to introduce the concept of "loop", that is, an action executed repeatedly for a fixed number of times, before stopping.

It is important that the students recognize the strategy followed. The robot drives back and forth making a small turn every cycle. This can be followed in the simulator, looking at the arrow.

2. Common problems and pitfalls

The important point here is to ensure that the students really understand what is going on. The strategy followed should be clear and students are always happy when it works. Let them experiment a bit with the angle.

The only parameter given here is the speed. When this is varied the angle will automatically change. When the angle is small, scanning the field takes longer, when it gets too big it will miss the cups.

3. Background information

This is the first 'real' program, where the sensors are used to detect the line and also to check if the line is cleared again. There is a fixed amount of time to drive backward. When the speed is altered this time is also influenced. We do not check for the black line on the way back, since the robot could make a turn and move out of the circle and get lost.

4. Additional exercises

Have the students experiment with the angle, speed and distance traveled inside the circle. You could set up a small competition to see who clears the table the fastest. Also the differences between the attempts are an indication of how well a certain combination works. Let students also experiment with different numbers of cups and different placements.

What would you do if there is just one cup? Is this a good strategy then ?

Rescue Course

Lesson 0 – Introduction to rescue

The rescue mission is played on the rescue field. Because the InfraRed sensors are not very sensitive to the different colors we need to use a special version of the rescue field that uses dithered color. Dithering colors is a technique of mixing pixels of several colors on a computer display to create the illusion of extra colors or shading. These appear to us as real colors, to the sensors they appear as different gray rasters.

1. Ideas to be discovered

The main idea is built around a number of line followers that do most of the work. The students will have to discover how these line followers work and find out how they can modify and improve their behavior.

By changing some of the parameters (or properties) of these line followers they can achieve better performance.

2. Common problems and pitfalls

The biggest problem is that the line followers work so well that it seems they do not need any improvement. Yet the example programs can definitely be improved upon and students should be challenged to try this.

3. Background information

The line followers have a number of important properties. First of al, one or two sensors may be used. The turn angle and speed of change may be altered. Furthermore, there may be differences between left and right.

Last, there is a stop condition. If no stop condition is used, the line follower acts as a *fall-thru*, that is, as a motor command that starts the motor and then goes on to the next step. Nothing is changed until an external stop condition is triggered. When the internal stop condition is used, the fall-thru is not and the line follower stays running until it finds the stop condition.

4. Additional exercises

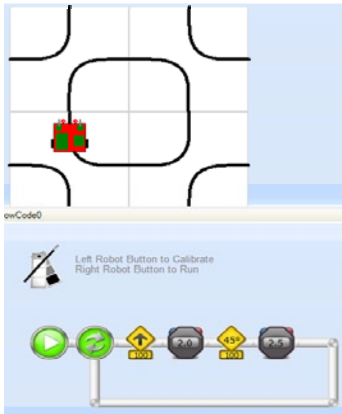
The exercises are designed to allow the students to experiment. The main goal is to let them discover as much as possible about ways to improve the use of the line followers.

Lesson 1 – The first line follower

Following lines is an important part of the Rescue mission. The teacher first introduces a very simple way of following a line that does not work very well and asks the students to find out why it does not work so well. The teacher then takes another approach and show how line followers generally work.

Because this exercise works best with a square, the new tiled rescue field is used here, but only for the first two lessons. *For this reason, it is better to do this exercise only with the simulator*.If you think that it is nicer to work also with the robot then, of course, you can make your own version of the field or try to get the tiled rescue field instead.

1. Ideas to be discovered



Many people will attempt at first to have the robot follow a path (here a simple rounded square) by telling it where to make a turn. This only works well if you are able to find out exactly what turn and speed to select and how fast you should drive. When this parameter is off, it will not work.

It is important that students notice this difficulty. If the exercise works well, it will not show the difficulty, thus contributing little to learning.

2. Common problems and pitfalls

When selecting the right starting position, speed and angle, the square will be followed perfectly. That is actually not the learning idea. Following the square should be very hard, requiring counting, making a turn, counting again etc. This is much harder.The *key point to stress is that 'telling' the robot what to do is not a good idea. The robot should use its sensors to find the line itself and then follow it.* That is the subject of the next lesson.

3. Background information

If this lesson were to be skipped, going directly to the next, the students might not even realize the significance of the difference between "telling the robot what to do" and "letting the robot to find by itself what to do", using its sensors. It is therefore important to let students experience how hard it is to get this exercise done well. Using the square will illustrate the point since it is difficult and will result mostly in failure, unless it is started at exactly the right position.

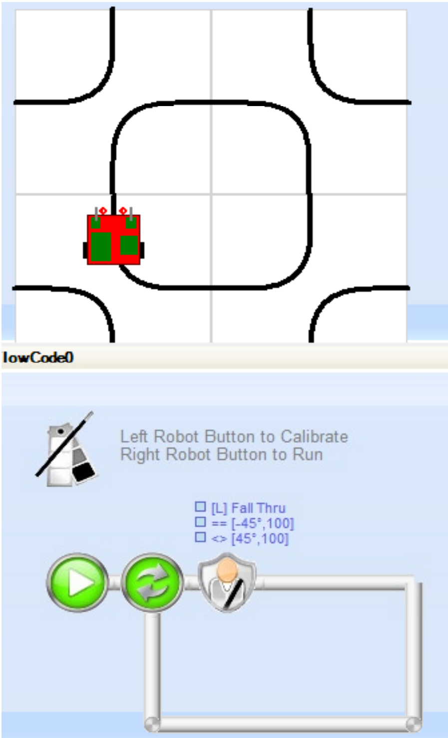
4. Additional exercises

Students could also try to make the robot using its sensors to follow the rescue field, which is even more difficult.

Lesson 2 – A better line follower

In the previous example the robot was not following the line, it was following its program, which was supposed to tell the robot where the line was.
A much better strategy is to have the robot find the line by itself. This is an example of adaptive behavior.

1. Ideas to be discovered



Using information from the light sensor, the robot must now follow the line. Most children (and adults too) would like to follow the center of the line. This is impossible here. When the line is wide enough you could try that, but the risk of overshooting is very large. So the robot meanders around the edge of the line. It is important that students detect this behavior, since it is relevant as an introduction to line following with two sensors.
First however you start with a single sensor line follower, which is the default situation unless you specify something different.

2. Common problems and pitfalls

Placement of the robot is critical. Following the program, it will turn right until dark and left until light, so it should start on the outside of the circle. When placed on the inside of the field, the robot will make a turn and start circling the field until it finds the line again.

3. Background information

It may not be obvious at first, but a robot following a fixed pattern is the most common way newcomers try to solve this kind of problem. Another issue is that the motors of a robot typically show small differences, making it very difficult for the robot to drive a straight line. Most people will try to solve these problems by selecting motors that are exactly the same.
In robotics this is not the best way to solve problems. Animals do not work this way either. When a dog hurts its leg, it easily switches from walking on four legs to walking on three legs.
So students must work to see the robot using its sensors, checking what it should do and adapting itself to what it finds. By using the reflection sensor, the robot is able to detect and follow the line.

Following a line with one sensor is fairly simple but not very fast. The line followers we will see later on will use two sensors and some even use three.

4. Additional exercises

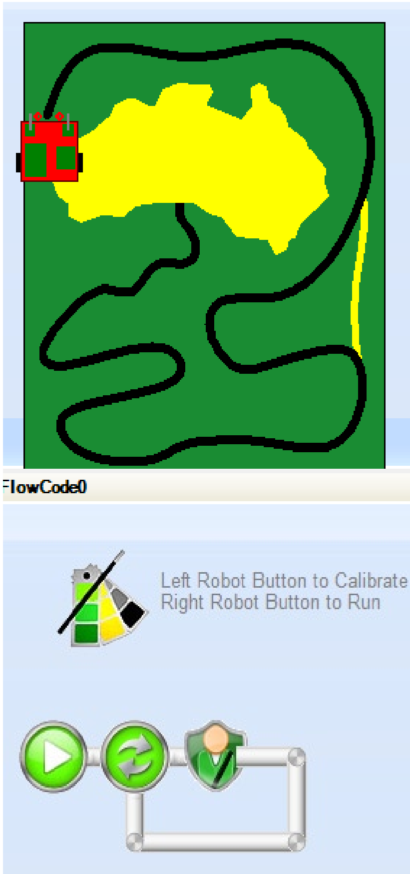
Let the students try various speeds and angles and determine what the main differences are.

Lesson 3 – Rescue autocalibration

This is the same exercise as in the Basic Course but on the rescue field. This exercise adds an extra dimension since the calibration now involves more colors.

1. Ideas to be discovered

The robot again drives over the field and, by doing so, it automatically passes over yellow, green and stops on black.



This is a progression from light to dark.
If the robot is initially placed on the green part of the field, will it work?
This is a way to ask students to find out how calibration works.

2. Common problems and pitfalls

Lighting is important when the real field is used. Please note that the RoboTech robot has IR sensors that are not sensitive enough to distinguish the various colors.

Thus, you may have to resort to a black-and-white field only or use a rescue field with dithered colors that have different shades of gray.

3. Background information

Calibration is very important for the success of the exercises. Therefore students should understand well what is happening.
Having the robot calibrated under various circumstances will show the performance of the robot.

4. Additional exercises

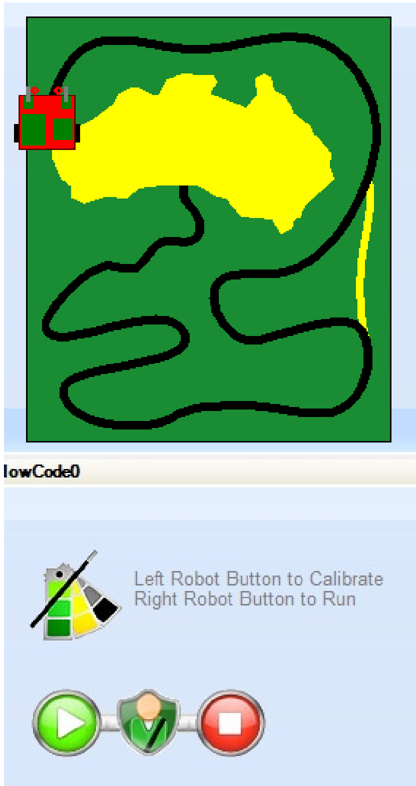
Try to calibrate from different positions on the field. Do the same with the real robot.

What happens ?

Lesson 4 - The rescue line follower

1. Ideas to be discovered

By providing some standardized line-following icons (B/W, B/G and Y/G) the entire field can be traversed.
This is an easy way of solving the problem, unless some difficulty is introduced. In the more complicated Soccer competition we will see the same approach but with more icons.



2. Common problems and pitfalls

The line following icons solve the entire problem, but here they have been made not to permit the robot to follow immediately the fastest way of completing the road.
This helps in traversing the shortcut and also in negotiating well the steep corners. However the speed is limited.

So for a real competition something more is required. This is dealt with in the later 'physical level' courses.

3. Background information

The pre-programmed B/W and Colored line followers capture the most important aspects of the programming of the rescue mission.
To build a full rescue program from this requires just a few icons. Students have to tweak the parameters in such a way that the robot actually follows the lines in each of the sections.
Look in the student's Basic Course to find the various icons' properties that may be changed.

4. Additional exercises

A single line follower is capable of doing the entire field. However, using the stopping criteria, a more complicated game can be played. For example, in the first part the robot is going fast and stops on yellow.
It then takes the yellow line, using the yellow/green line follower in which different colors are used and, this time, stops on black.
Then, in the third part, the robot goes slower and again stops on yellow.
Then it closes with the clearing exercise.

Lesson 5 – A faster line follower

1. Ideas to be discovered

Using the standard icons the entire field can now be traversed. Students should note the repetition but also the differences created by using the line followers on different positions of the field.

They should experiment with different speeds, angles and accelerations.

2. Common problems and pitfalls

There is a tendency to accept quickly the program as good enough. Therefore, it is important to state the challenge. Other students have been able to perform the mission in less than 36 seconds. So it can be done faster.

Students should try to find out how they can improve the program. The experimentation phase where they find out what works best is very important.

3. Background information

Providing complete, running line followers is a way of achieving results very quickly. They also invite to experimentation and, in this way, the students should discover how the line followers work. In the Physical Level the students will be asked to develop their own line follower.

4. Additional exercises

Let the students try different speeds and maybe introduce a new step where the speed can be set higher or lower for a specific part of the trajectory.

Lesson 6 – Clear the rescue field

This is the same exercise as 4 but now on the rescue field. It is actually the last step in the process that combines line followers from previous lessons

1. Ideas to be discovered

This exercise does the same as the circle exercise but the border is now the green part of the field. The distances are different and thus the values for the backward movement may have to be modified.

2. Common problems and pitfalls

Faulty calibration is usually the biggest problem with this part of the rescue mission.

3. Background information

Finding the victim in the rescue mission is similar to this exercise, but only a single cup is used. If the robot is able to detect the cup, it can go directly to the location where the cup is. This however requires additional sensors that are not in the standard package.

The robot enters the field at the black line and then it must decide if it needs to go left or right. This could be programmed into the robot.

4. Additional exercises

Make a program that only scans left and another that only scans right. Here again the goal is to clear the area as quickly as possible. For the rescue mission, a can wrapped with reflecting foil is used as the object to be "rescued" or cleared.

You may use a sensor to detect the reflecting can and use this knowledge to your advantage.

Part II

ROBO didactics

Introduction

This Part II of the Guide contains suggestions on possible ways of structuring classroom lessons on the theme of *Introduction to Robots – Conceptual Level*. It is composed of three lessons: "What is a Robot," "Programming the Robot," and "Let It Move."

A final section also provides suggestions on ways in which the topic of robotics can be used in non-technical subjects such as Literature, Philosophy, etc.
Each lesson contains the following specific items:

1. Learning Objective
   - Knowledge
   - Life Skills
   - ICT skills
2. Material
3. Time
4. Class organization
5. Procedure
6. Exercises or Homework
7. Suggestions for Further Activities

Of course, teachers are free to decide their own way of structuring lessons but the material in this Part II may help trigger ideas on how this can be done, remembering that the discovery process should always be central to the setup of the lessons.
Other examples of lessons may be added later on by teachers as the experience of using this Guide grows.

Lesson 1 – What is a robot

This module presents two didactic activities relevant to the introduction of the concept of robot.
The first is group activity and role-playing, while the second activity comprises the assembling of the robot used in this course: the Robotech RDS-X01.

The actual assembling of the robot is not recommended for the youngest students (9-10 years old), since it is delicate process and can be done only once, so you got to make sure that it will be fine first time. Some basic knowledge of use of a personal computer is assumed**.**

Didactic Activity 1
Group discussion and/or role-playing about robots

Learning Objective

To familiarize students with the concept of robot, while stimulating their curiosity and motivation about the subject. To make students reflect about robots, assessing their initial assumptions and understanding,

Knowledge

Learning of basic concepts (vocabulary) such as robot, hardware, software, sensors, control, and simulation.

Life Skills

Stimulation of communication skills, creativity, problem-solving skills and personal and social skills through teamwork.

ICT skills

Preparation to work with robots and computer hardware and software.

Material: Pictures of different robots either on paper or on slides for projector (a short video may also be appropriate), slide projector, blackboard or paper pad and felt pen, (video projector).

Time: 15 minutes or more

Class organization: Plenary and groups of five students

Procedure:

The activity begins with the teacher asking the students: "What is a robot?"
The answers are written on the blackboard or paper pad for all to see. The teacher rapidly classifies the key words in the answers and points them out as characteristics

defined by the students.
If the teacher feels that the discussion is animated it might wish to ask other questions, for instance

- Have you ever seen a robot?
- What kind of robots do you know?
- Do you know the meaning of the word robot?
- Why do people use robots?

With younger students, it is probably best to discuss "what is a robot" through role-playing. Students can get together in groups of five and decide on a type of robot and task they will perform or simulate to the class.

Or the teacher can assign types of robot and task to be performed at random by having pieces of paper with the assignments inside a bag. All groups can simulate a robot and receive the applause of the rest of the class, thus to stimulating reward and fun. The teacher should be alert to support any group that may have difficulty.

Following the discussion or role-playing, the teacher can show the students the pictures, or slides, or short video of some robots and their current applications (e.g., toys, space explorers, industrial robots, bomb disposers, etc).
During the discussion and role-playing, and while showing the pictures, the teacher can gradually introduce the basic robotics concepts of the lesson. To facilitate understanding of a robot's main components, the teacher can make a comparison with the human body:

- Brain = main control board
- Leg = gear box & tire
- Eye = light sensor
- Hand = touch sensor
- Ear = sound sensor
- Etc.

The role-playing is particularly effective to introduce the concept of simulation and program of instructions.
If made possible by the content of the activity, after this lesson, the students will be able to identify the three most important parts of a robot:

- *sensors* (devices for sensing the environment, such as cameras, ultrasound, infrared, etc.),
- *actuators* (devices for carrying out physical tasks, such as electrical motors), and
- *control unit* (the small computer that contains the program of instructions guiding the behaviour of the robot in response to the data coming from the sensors)

Didactic Activity 2 – Assembling the robot

Learning Objective

Reinforce students' understanding of the concept of robot by familiarizing them with the robot kit RDS-X01. Learning how to assemble the robot.

Knowledge

Reinforcing learning of basic concepts such as robot, hardware, sensors, actuators, control unit, gearbox.

Life Skills

Stimulation of communication skills, problem-solving skills, visual and manual skills and personal and social skills through teamwork.

ICT skills

Working with robots

Material: Robotic kit RDS-X01, Appendix 1 in this Guide "Parts and Steps to build the RDS-X01 Robot." Manual of the RDS-X01 robot, screwdriver, batteries, multimeter, projector if slides are used. It is also important to point out that schools need to have a laboratory or classroom large enough for robot development, testing, and storage.

Time: 40 minutes or more

Class organization: Plenary and groups of students.

Procedure:

The activity begins with the teacher introducing the robotic kit to the students. The teacher gives students, individually or in groups, the document "Assembling the RDS-X01 Robot" and draws their attention to the checklist of the robot's components. The number of groups of students will depend on the number of kits.

If only one kit is available, the teacher takes each components out of the kit, and ask the students to guess what it is, checking it on the list.

The teacher briefly explains each component and its function. If several kits are available, the teacher names a component and asks the student groups to find it and take it out of the kit, ticking the corresponding box in the checklist. Again, the teacher explains briefly the function of each component.

Now it is the time of assembling the robot. As said before, for younger students the assembling activity is not recommended.
If only one robot kit is available for assembly, this operation should be done by the teacher or one or two students showing at all times every step to the class.

Preferably, if several kits are available for assembly, the teacher shows the students either a physical model or a good picture of an assembled robot and asks them to build a similar one using the pieces they have in their boxes (some of the parts may be pre-assembled in order to speed up this phase, according to the students' age level and expertise).

This lesson does not include the assembling of the sensors since the robot without sensors can be programmed to move, although not to react to the environment. At the end, each group of students will have an identical robot ready to be programmed to move.

During the last five minutes or so of the lesson, the teacher may find it useful to sum up the main threads of the lesson on the blackboard, going back to the definitions and examples of robots given by students.

At this final stage, the teacher asks the students whether there is something missing in their robot and, if so, what. The teacher with the help of students will point out that a program and the sensors are missing, and the batteries, of course!

Exercises or Homework

The teacher asks students to work in group/pairs or individually and to make a web search to find robots and to identify sensors and actuators

Suggestions of Further Activities

If each student or group of students is keeping a lab book with notes and information on their efforts, then

The student or group of students may seek to define relevant robotics vocabulary, discussing these with each other and sharing their observations with the class.

Each student or group of students may make notes of new things learned and if they change their ideas they should write down why they have done so.

These types of notes will come in very handy as students build more and more robots. In this way students will deepen their understanding and use their findings to solve future problems.

Lesson 2 – Programming the robot

Learning Objective
To familiarize students with the concepts of software program, programming, simulation and other relevant vocabulary, while stimulating their curiosity and motivation about the subject. Learning how to program a robot using the roboPAL programming environment.

Knowledge
Learning basic concepts (vocabulary) of software program, programming, simulation, roboPAL, icon. Basic knowledge of use of a personal computer is assumed.

Life Skills
Stimulation of communication skills, creativity, problem-solving skills and personal and social skills through collaborative teamwork and self-assessment skills

ICT skills
Basic programming and computer skills, robotics

Material: Examples of different programs either on paper or on slides for projector (a short video may also be appropriate), slide projector, blackboard or paper pad and felt pen, RoboPAL software (included in the robot kit), Robodidactics Basic course, personal computers (video projector)

Time: about 60 minutes

Class organization: Plenary and groups of students

Procedure
The first 25 to 30 minutes can be used to introduce the main concepts of the lesson through a combination of didactical techniques.
The teacher may start by pointing out that the computer is not a magic box that decides by itself what to do and how to do it. The computer to work must be given instructions that it will follow or execute.

The full set of instructions followed by the computer is called program and to make a program is called programming. To reinforce the learning of these concepts, the teacher can use the brochure of a program of events, for instance, the program of a musical, or a sport event, or a parents meeting at school. These will communicate the message that to achieve a result a series of tasks must be defined and followed. The teacher can ask the students individually or in groups of five to give examples of programs they know.

To bring the discussion quickly down to robotics, the teacher can then go back to the role-playing game of the first lesson when groups of students performed simulation of robots to the class.

This time the teacher can ask the same groups of students to write the small program of instructions they think the robot should be given to do the task they simulated. One student could repeat the simulation while the others in the group decide and write down the instructions. If the class has not done the role-playing game before, then this may be an opportunity to do it.

The second 30 minutes are used to engage students with practical programming. The Teacher opens the software RoboPAL and explains that this software will allow them to make a simple program very quickly, besides simulating the behaviour of their robots on the computer screen like in a computer game. This is important since a program can be tested to see if it works, before actually being loaded onto the real robot.

For details on RoboPAL, please refer to the booklet, Robodidactics Basic Course, sections "You also need some software" and "Making your robot move forward." These are inside the chapters "Building and Programming Robots" and "Programming Your Robot."

The teacher then explains and encourages students to use roboPAL's building blocks and basic steps to make the first simple program, and run it on the simulator. Seeing the robot moving on the screen is rewarding and instructive for the students, who will be stimulated by having done in just one lesson. Students will want to program the robot to do other exciting things, writing ever more complicated programs, and, of course, they will want to see the real robot moving with their programs.
During the last five minutes or so of the lesson, the teacher may find it useful to sum up the main threads of the lesson on the blackboard, going back to the definitions and examples of programs given by students. Finally, the teacher asks the students whether the real hardware robot needs something to make it move and, if so, what. The teacher with the help of students will point out that a program is missing and it should be downloaded from the computer into the small computer in the robot.

Exercises or Homework

The teacher asks students to work in group/pairs or individually to use roboPAL and write a program to make the robot move straight.

Suggestions of Further Activities

If each student or group of students is keeping a lab book with notes and information on their efforts, then

Each student or group of students may seek to define relevant programming vocabulary, discussing these with each other and sharing their observations with the class.

Each student or group of students may make notes of new things learned and if they change their ideas they should write down why they have done so.

These types of notes will come in handy as students build more and more complex programmes.

Lesson 3 – Making a robot move

Learning Objective

Deepening the learning of robot programming by making and running gradually more complex programs written, simulated and tested in the roboPAL programming environment. Experiencing how to make real robots move forward, backward, to the right and to the left, making connections with the concepts of time, distance and velocity.

Knowledge

Knowledge of roboPAL programming and concepts and vocabulary of its major components such as The World, FlowCode and Toolbox. Linking the concepts of time, distance and velocity to the movement of the robot.

Life Skills

Stimulation of creativity, problem-solving skills and personal and social skills through collaborative teamwork and self-assessment skills, visual and manual skills.

ICT skills

Computer skills and roboPAL programming, simulation and testing of robots.

Material: Robotic kit RDS-X01, RoboPAL software, Robodidactics Basic Course, personal computers, blackboard or paper pad and felt pen, or slides and slide projector, ruler

Time: about 60 minutes

Class organization: Plenary or groups of five students

Procedure

Teacher asks students to write, simulate and test in the computer a roboPAL program that will instruct the robot on the screen to move forward for 5 seconds. If the program does not test right, then the students must discuss and find where is the problem. If the program tests right then the students can proceed to download from the computer to the robot and look carefully at the actions of the robot.

Does the robot perform in accordance with the instructions in the program? If the robot does not behave as expected, the students must examine the situation and find what is the cause of the problem. This will teach them by experience the

difference between the simulated world of the computer and the real world of hardware robots.
Once the robot has performed well, the teacher can ask the students to measure with the ruler the distance travelled forward by the robot. Then they can be asked to find out the speed with which the robot has travelled by using their knowledge of the distance and time travelled.

Once this exercise is completed, the teacher asks students to modify the program by changing the fixed time, or the speed of the motor. Again the students may be asked students to reflect on the concepts of time, speed and velocity of the robot.
The following additional exercises can also suggested:
Try to program the robot run backwards
Try to program the robot to make a turn

During the last five minutes or so of the lesson, the teacher may find it useful to sum up the main threads of the lesson on the blackboard. Finally, the teacher asks the students whether the robot needs something to make it move adaptively, that is to say, reacting to its surroundings and not just following rigid instructions. If so, what is needed? The teacher with the help of students will point out that what is required is a program that takes the information from the sensors and make the robot respond to it.

Exercises or Homework

The teacher asks students to work in group/pairs or individually to write a program to make the robot run faster or slower or another program that makes the robot run inside the circle of the roboPAL world.

Suggestions of Further Activities

If each student or group of students is keeping a lab book with notes and information on their efforts, then
Each student or group of students may reflect on new relevant vocabulary, discussing these with each other and sharing their observations with the class.
Each student or group of students may make notes of new things learned and if they change their ideas they should write down why they have done so.

Extensions to non-technical school subjects

Robotics is a subject with multiple educational implications and can be used by school subjects other than information and communication technologies. The following are examples of the relevance of robotics for Literature, Arts, Philosophy, Sociology and Cultural Studies

LITERATURE & LINGUISTICS

Carel Capek was the first to use of the word *robot* in his play *R.U.R (Rossum's Universal Robots*), published in 1920. The word "robot" comes from the Slavonic languages "robota" meaning *slave, slavery*.

Didactic activities may include requesting students to read and analyse selected passages of novels such as R.U.R. *(Rossum's Universal Robots*) and novels about new technologies such as Asimov's sci-fi novels, but also novels written by more classical authors such as A. Huxley's *Brave the New World* (1932), Mary Shelley's *Frankenstein* (1818) or Samuel Butler's *Erewhom* (1872) and then discuss the author's view of scientific and technological progress.

The debate between utopians and dystopians in the UK, which started at the beginning of the XX century, can be considered as a reference.

ARTS

(History of Art) Didactic activities here may include the study the various automata built in Europe, mainly as clocks or toys, for instance, Leonardo da Vinci is supposed to have designed a humanoid robot, called "The Knight" in 1495.
But automata were also built in other Eastern countries, such as the automata made by the 12th century Arabian engineer Al Jaziri or the Karakuri ningyo dolls in Japan.

(Cinema): There are many movies about robots and new technologies that can serve for didactic activities related to robots, from Fritz Lang, *Modern Times* (1936) to more recent movies such as *Blade Runner* (1982) or *I Robot* (2004)

Likewise, the relationship between, on the one hand, the arts and, on the other, robotics or scientific and technological progress at large can also be studied with reference to painting or sculpture. Consider for instance, the Futurist Movement and its relationship to machines and technologies.

PHILOSOPHY and SOCIOLOGY

Didactical activities may include students having to reflect about some of the current ethical and societal implications of robotic technologies and systems.

They may also be requested to study the relations between philosophical theories and robotics, from the mind-body dichotomy to the current debates on consciousness and artificial intelligence.

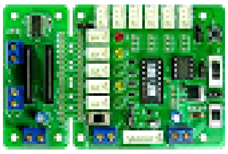
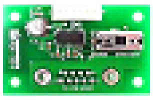
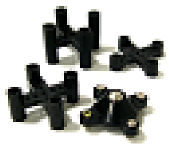
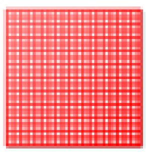
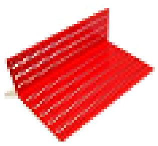
For instance, to describe a robot by referring to the parts of the human body as has been suggested at the beginning of Lesson 1 can be debatable, as it assumes a mechanistic approach to the human being, a way of thinking very popular in the philosophy of XVIII (e.g., Descartes).

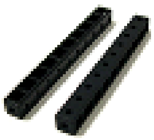
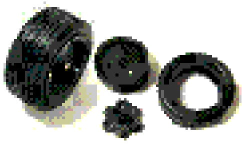
CULTURAL STUDIES

Robotics can be used to have students reflecting on their own cultural background and to foster a positive relationship among different cultures, for instance, by considering the different approaches to robots in Western and Eastern countries.

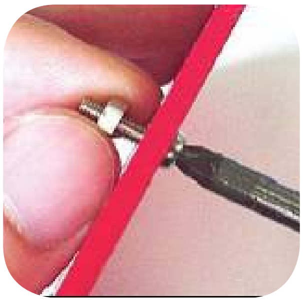
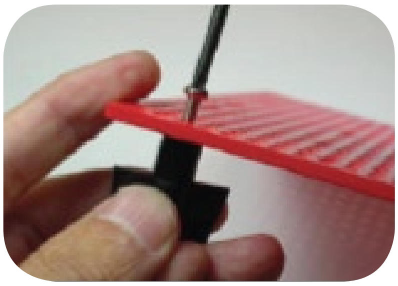
APPENDIX 1 - PARTS AND STEPS TO BUILD THE RDS-X01 ROBOT

RoboDesigner RDS-X01 Check List

	Name of the component	Picture of the component	Note
☐	**Main Control board RDC-101 with Muvium board**		Quantity: 1
☐	**Touch Sensor RDI-201**		Quantity: 2
☐	**Infrared Sensor RDI-202**		Quantity: 2
☐	**Communication board RDI-301**		Quantity: 1
☐	**Serial Cable**		Quantity: 1
☐	**Motor and gearbox RDO-501**		Quantity: 2
☐	**Universal Caster RDP-806**		Quantity: 1
☐	**Universal Plate RDP-801**		Quantity: 2
☐	**Universal Plate RDP-802**		Quantity: 1

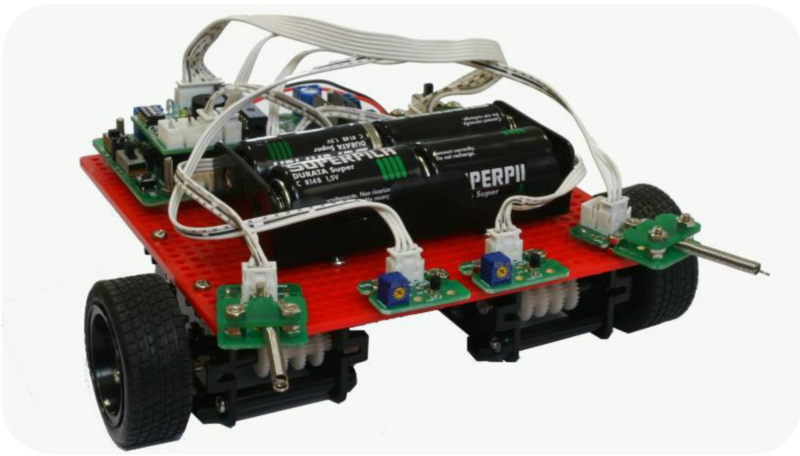
☐	**Universal Pillar RDP-803**		Quantity: 5
☐	**3-pin cable RDP-804**		Quantity: 3 Length 20 cm
☐	**3-pin cable RDP-805**		Quantity: 2 Length 30 cm
☐	**6-pin cable RDP-808**		Quantity: 1
☐	**Wheel and tyre RDP-807**		Quantity: 2
☐	**Battery Housing RDP-809**		Quantity: 1
☐	**RDS-X01 Manual**		To open the Manual, on your PC follow menu Start, Programs, TiColla and click on RDS-X01 Instruction Manual
☐	**Screws and Nuts**		Screw type: M3
☐	**Screw Driver**		Quantity: 1 For M3 screws
☐	**Battery**		Size C battery Quantity: 4

How to fasten screws and nuts:


Assembling the first robot

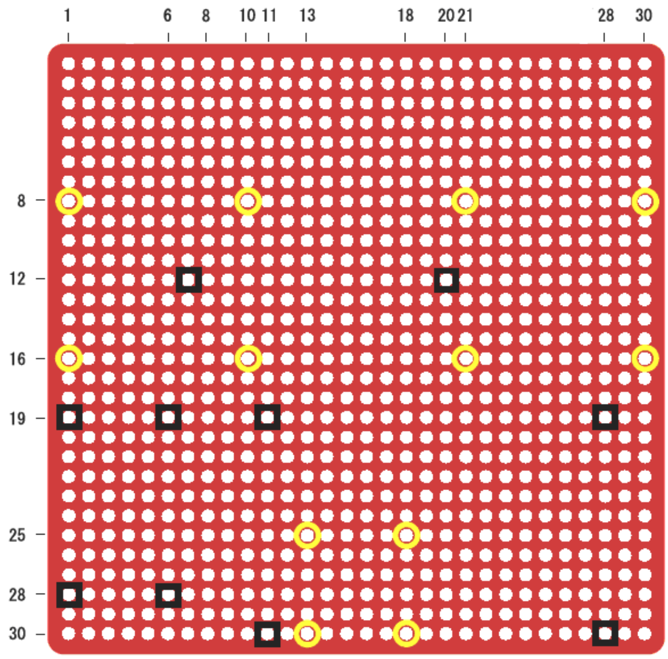
This section shows how to assemble a robot consisting in a mobile base with two actuated wheels with the help and following the instructions reported in the RDS-X01 manual. The following picture shows the final assembling of the robot. The next paragraphs report the steps to build the robot.



Step 1: Assembling screws for hosting battery housing, serial and control boards

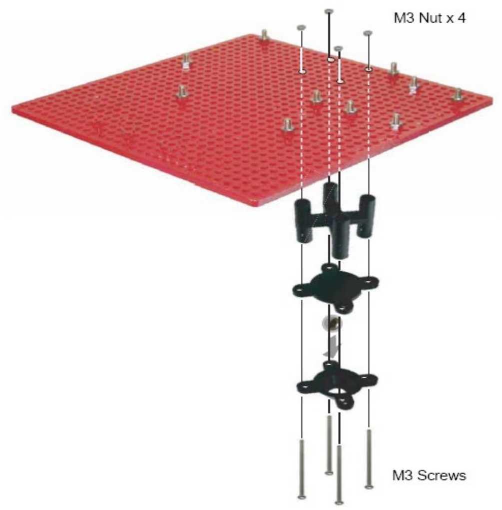
Insert 10 screws and screw nuts where black squares are printed on the universal plate in the following figures. These screws will be used to host respectively the battery housing, the control board and the serial communication board. Assemble double nuts on the screws hosting the control board to prevent contact and short circuit. Do not insert screws into the yellow circles. Yellow circles shows where the gearboxes and caster will be assembled.

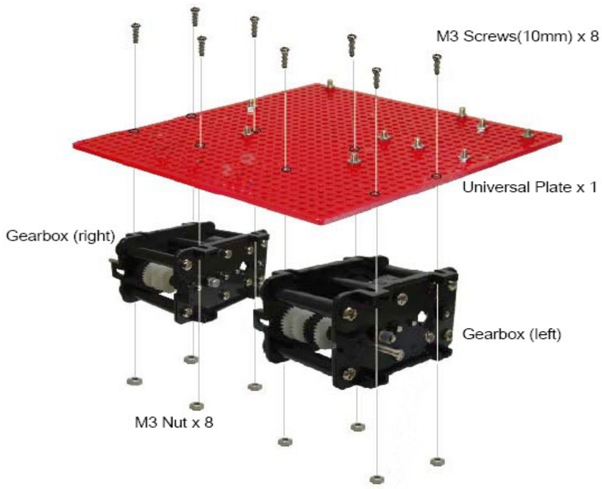
- ■ Top side: screws for control board, communication boards and battery housing
- ○ Under side: screws for caster and gearboxes

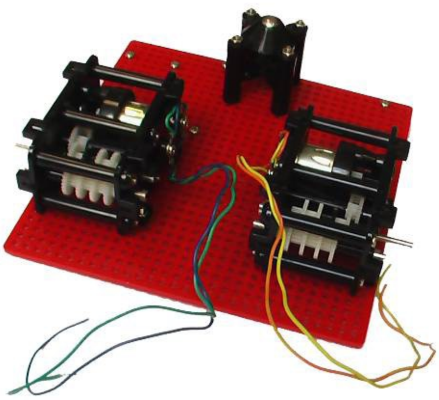


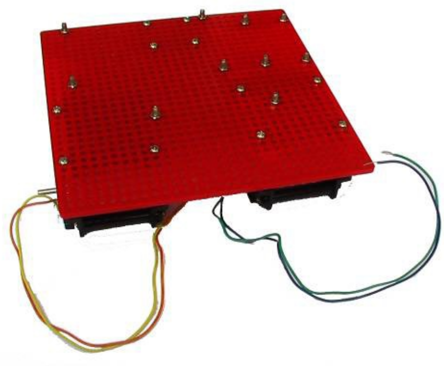
Step 2: Assembling motors and universal caster

On the opposite side where nuts have been assembled, mount the motor gearboxes and the universal caster (use the support 3 cm height) in correspondence of the yellows circles as shown in the following figure. Mount as left motor the motor with blue and green cables, and as right motor the motor with yellow and orange cables.



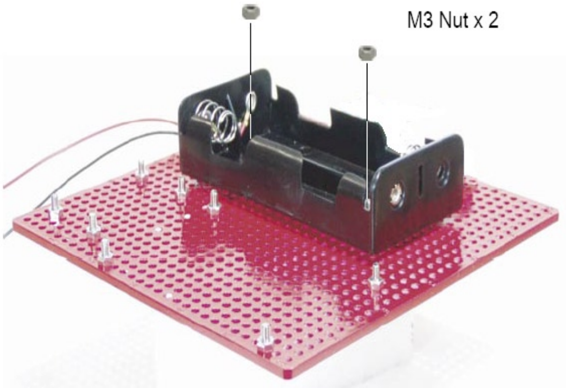


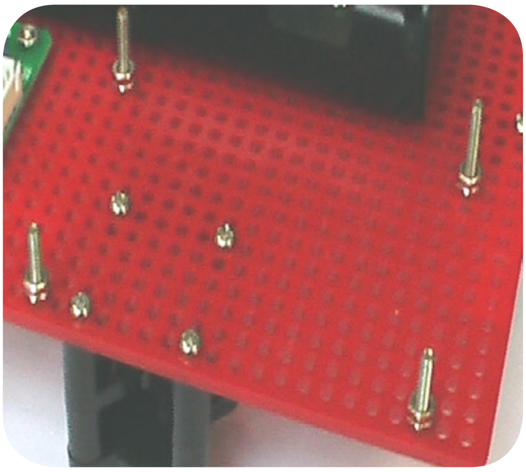


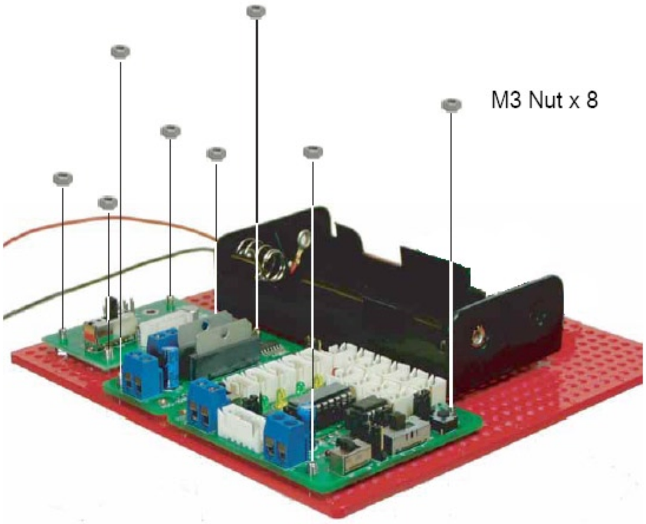


Step 3: Assembling control board, communication board and battery housing

On the opposite side where motors and universal caster have been assembled, mount the control board, the communication board and the battery housing as shown in the following figure. Be sure that double nuts are assembled on the screws hosting the control board to prevent contact and short circuit.

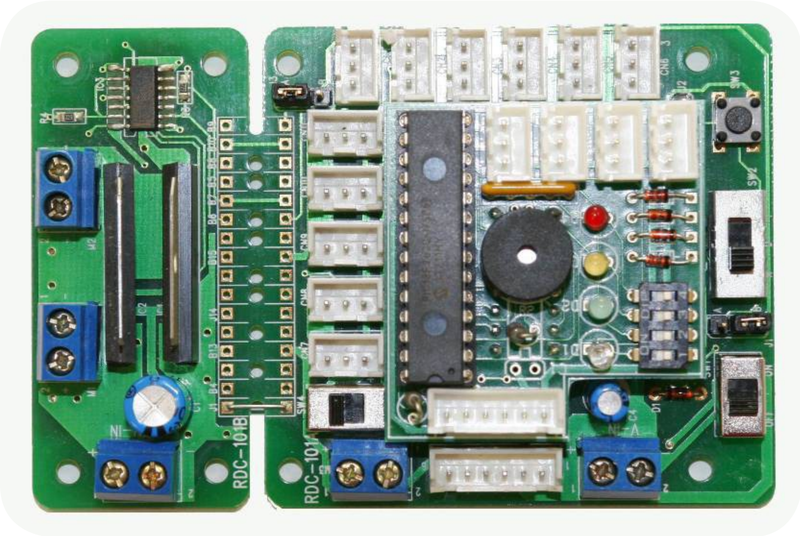


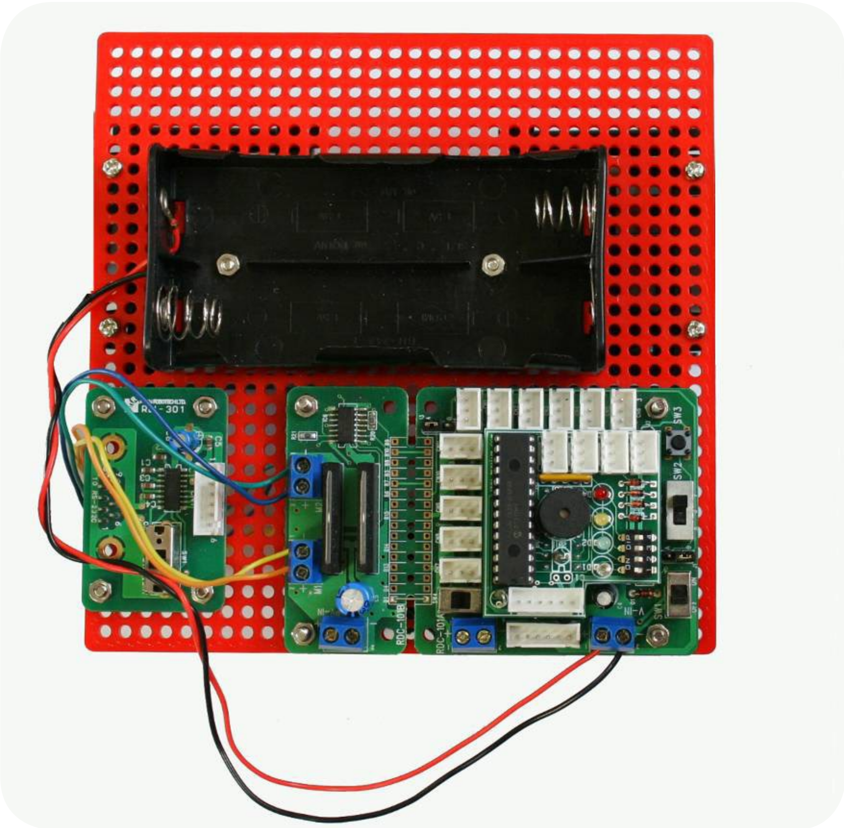




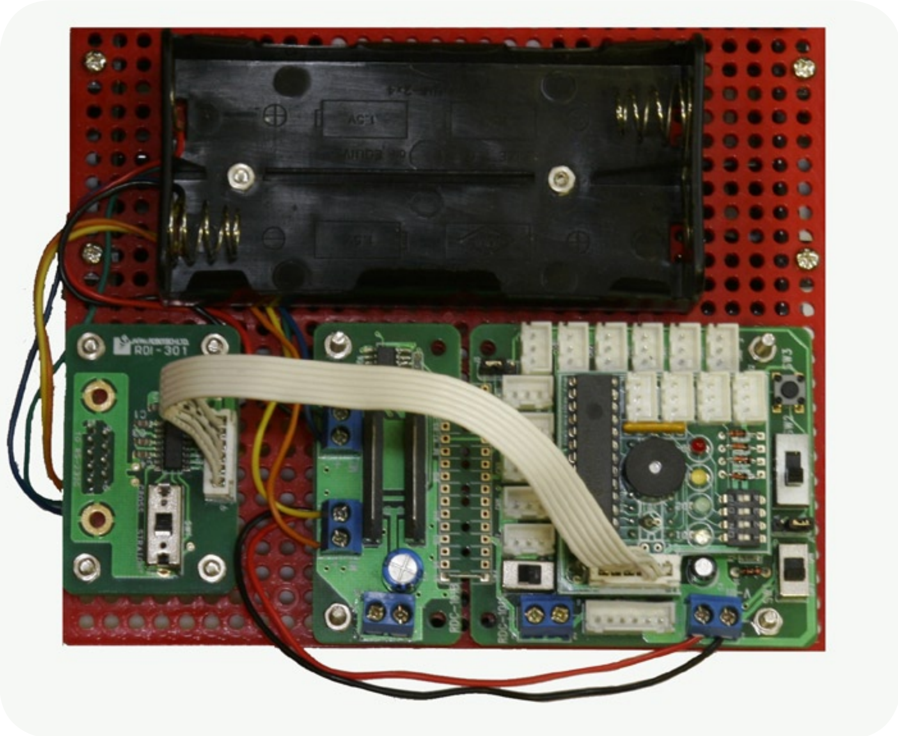
Step 4: Cables connection

Connect the cables of the motors and battery housing to the control board according to the schemes shown in the following figures.



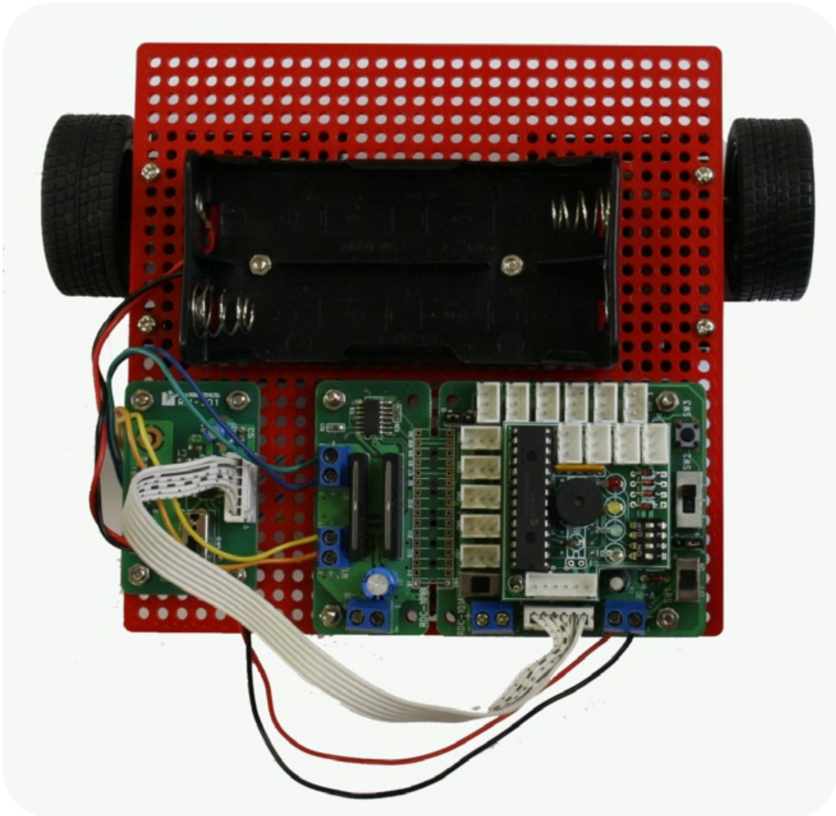


Finally, connect the serial communication board to the muvium board with the appropriate cable.



Step 5: Assembling the tyres

Assemble the tyres according to the instruction reported in the manual to complete the robot as shown in the following figures.



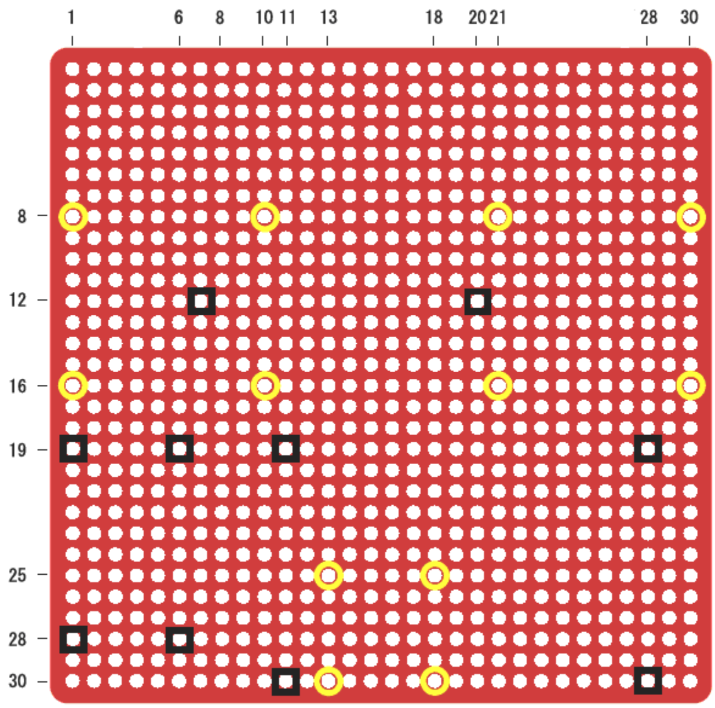
Assembling the touch sensors

With the help and following the instructions reported in RoboDesigner RDS-X01 manual, assemble the two touch sensors. The following picture shows the final assembling of a touch sensor.

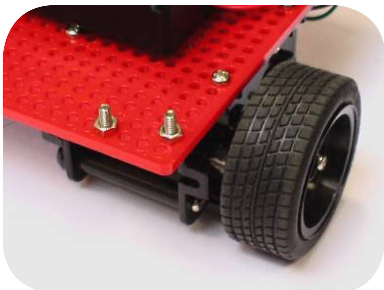
The following pictures show the position of the contact sensors on the grid. Insert 4 screws and 4 screw nuts where green squares are printed on the universal. These screws will be used to host respectively the left and right touch sensors.

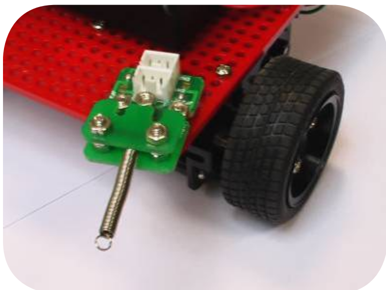
Top side: screws for touch sensors. Nuts are on the top

.

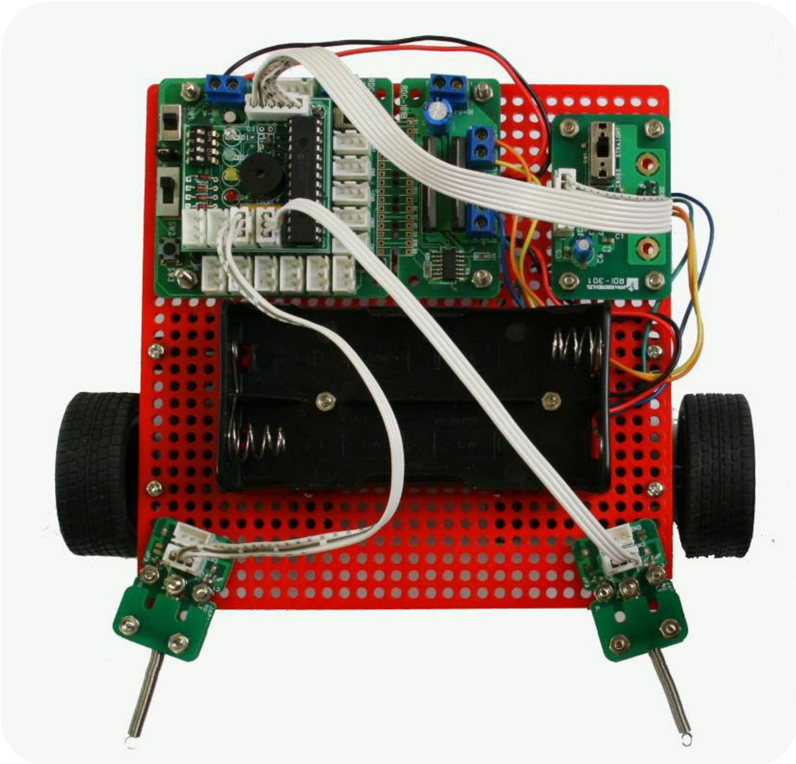


The following pictures shows the steps to assemble the left touch sensors on the robot.

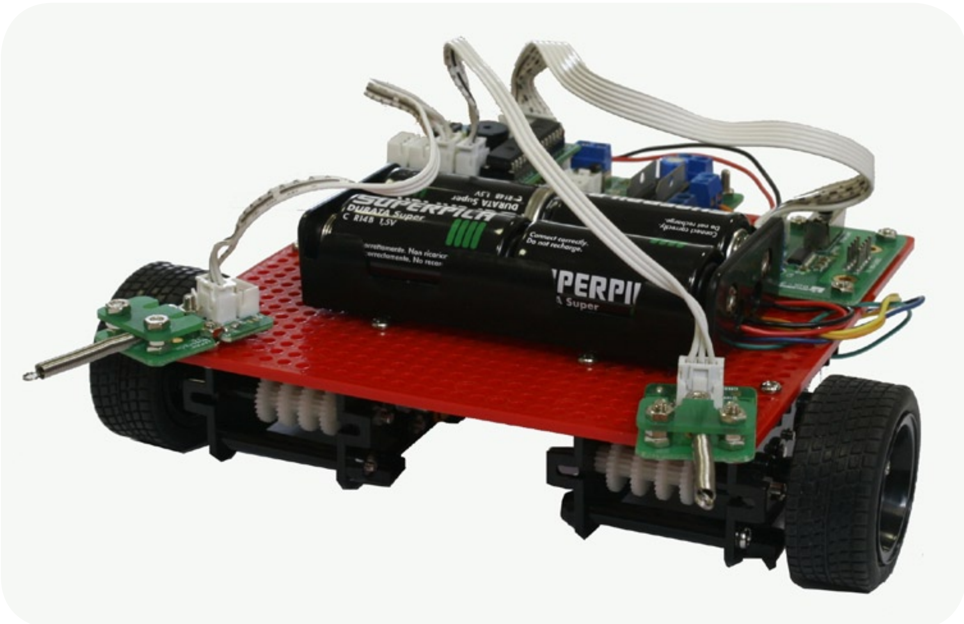




Finally, assemble both left and right touch sensors and connect with the proper cable left sensors on connector DI00 and right sensor on connector DI01 of the Muvium board as shown in the following figure.



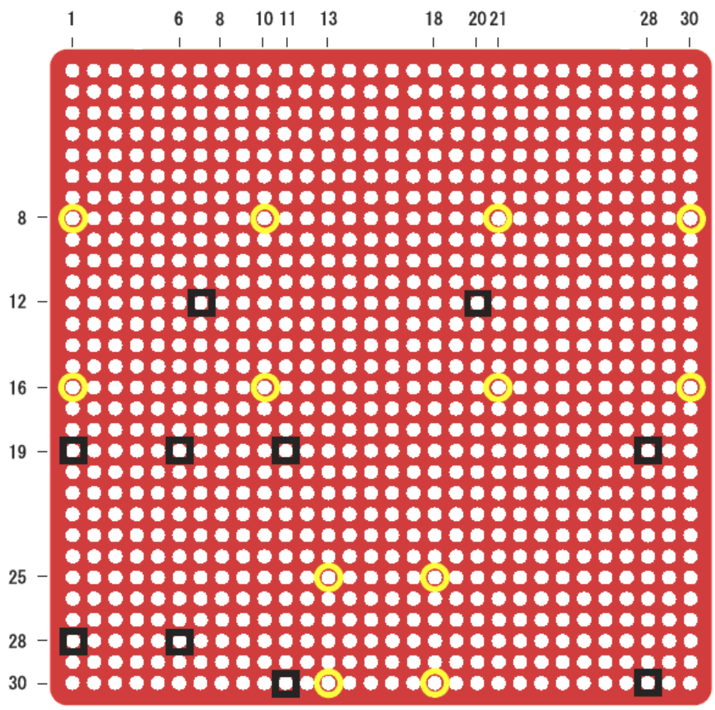
The following picture shows the final configuration of the robot.



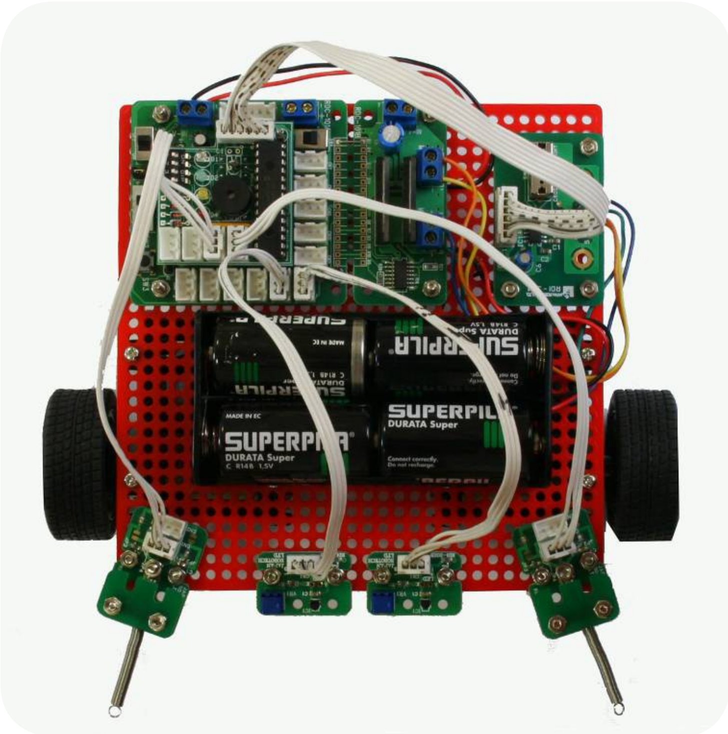
Assembling the infrared sensors

The following pictures shows the position of the infrared sensors on the grid. Insert 4 screws and 4 screw nuts where blue squares are printed on the universal plate. These screws will be used to host the infrared sensors.

Top side: screws for infrared sensors. Nuts are on the top.



Assemble the infrared sensors on the universal plate in the same way you did for the touch sensors and connect with the proper cable left sensors on connector CN1 and right sensor on connector CN2 of RC-101 board. The following picture shows the final configuration of the robot.



Next picture shows the final configuration of the robot