

Ministry of Education and Culture

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**Physical
level Course**



ROBODIDACTICS
PROJECT
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Robodidactics Teacher's Guide **Physical level - Structured Lessons**



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Introduction

This Teacher's Guide is part of the Physical Level of the three-level Robodidactics Methodology (see the Robodidactics Manual).

It uses the TiColla software environment. TiColla is the standard icon-based language that comes with the RoboTech RDS-X01 robot but does not contain a simulator.

At the Physical level, children learn how the commands at the Conceptual Level are actually executed.

This is made clear in the form of an iconic language a little more technical than the iconic language of the conceptual level.

The Teacher's Guide is organized into two Units with corresponding supporting material presented in the Appendices.

Unit 1 of the Guide contains suggestions on possible ways of structuring classroom lessons on the theme of *Introduction to Robots – Physical 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.

Unit 2 of the Guide contains suggestions on possible ways of structuring classroom lessons on the theme of *Sensing and Acting – Physical Level*.





It is composed of four lessons: “Exploring sensors – Touch sensors (Part One), “The infrared sensors (Part One),” “The infra-red sensors” (Part Two), “ and “Sensing, thinking and acting” Again a final section in this Unit also provides suggestions on ways in which the topic of robotics can be used in various subjects such as, etc.

Each lesson in the two Units 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 these Units 1 and 2 may help trigger ideas on how this can be done. Other examples of lessons may be added later on by teachers as the experience of using this Guide grows.





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UNIT 1

Introduction to Robots Physical level



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 so you got to make sure that it will be fine first time.

Some basic knowledge of use of a personal computer is assumed.

This lesson makes use of the Supporting Material, Unit 1/Lesson 1, found in Appendix 1 of this document.


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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:

- The brain corresponds to the robot main control board, that is, where intelligence is located.
The muscles that move our legs, hands, etc. can be considered the actuators of the robot, that is, the mechanical devices that are used for moving or controlling the robot, such as the motors that moves the robot wheels, legs, hands, etc.
The sense organs of human beings correspond to the robot sensors, that is, devices that respond to physical stimulus from the environment. Sight is provided by cameras, touch by contact or touch sensors, hearing by sound sensors etc. Cables connecting sensors, actuators and control board can be compared to the human nervous system.

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, “Supporting Material” in Appendix 1 of this Guide” (showing the component parts of this robot and explaining the steps of its process of assembly).

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” (see Appendix 1, Lesson 1) 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

This lesson makes use of the Supporting Material, Unit 1/Lesson 2, found in Appendix 1 of this document.

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 TiColla programming environment.

Knowledge

Learning basic concepts (vocabulary) of algorithm, software program, programming, TiColla, 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, TiColla software (included in the robot kit), 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.

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 TiColla and explains that this software will allow them to make a simple program.

For details of TiColla, please refer to the RDS-X01 handbook and also to the Appendix 1 in this Teacher's Guide.

The teacher then explains and encourages students to use TiColla's building blocks and basic steps to make, download and execute their first program. The teacher explains the basic commands to activate and stop the motors.

Moreover, the teacher explains the importance of the concept of time in programming the robot.

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



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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 TiColla 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

This lesson makes use of the Supporting Material, Unit 1/Lesson 3, found in Appendix 1 of this document.

Learning Objective

Deepening the learning of robot programming by making and running gradually more complex programs written and tested in the TiColla 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 TiColla programming and concepts and vocabulary of its major components. 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 TiColla programming and testing of robots.

Material:

Robotic kit RDS-X01, TiColla software, 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, download and execute a TiColla program that will instruct the robot on the screen to move forward for 5 seconds. If the robot is not executing the program correctly, then the students must discuss and find where is the problem. Is the problem in the program?

Or is the problem in the interaction between the robot and its environment?

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 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.

For more advanced students, the teacher may ask students to program the robot to behave according to physical laws, such as uniform rectilinear motion or uniformly accelerated rectilinear motion. In addition, different weights can be placed on top of the robot and see how its speed is affected by friction.

Moreover, a robot can be used to describe the trajectories learned in math classes, for instance, straight line, parabola, circumference, ellipse.

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 and 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.

For instance, the *luddite movement* originated in the XIX century in England as a movement of social protest against the changes brought about by the Industrial Revolution, and especially against all mechanical devices.

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 strong relationship between the Futurist Movement and technology.

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.



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UNIT 2

Sensing and Acting







Lesson 1: Exploring sensors

The touch sensors

This lesson makes use of the Supporting Material, Unit 2/Lesson 1, found in Appendix 1 of this document.

Learning Objective

Deepening of students' concept of sensor and introduction of the concepts of conditional and loop statements.

Familiarizing students with the RDS-X01 robot's sensors, experimentally testing the functioning of touch sensors by applying the conditional and loop statements.

Stimulating curiosity and motivation to learn more about robots.

Knowledge

Concepts (vocabulary) of sensors, touch sensors, infrared sensors, conditional and loop statements.

Life skills

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

ICT skills

Computer and robotic skills (including adaptive robots) and TiColla programming.

Material

Blackboard (BB), slides with pictures of sensors and their applications, slide projector, RDS-X01 robot kit and Manual, Appendix 1 in this document, PC, TiColla software, Touch and infrared sensors; Screwdriver, Nuts, Screws.

Time

About one hour

Class organization:

Plenary or in groups



Procedure

For the first 15 minutes or so, the teacher prompts students or groups of students to tell what a sensor is, giving examples that draw on their personal experience. If necessary, the teacher may suggest, for instance, lift sliding doors, remote control systems, etc.

Going back to the introductory discussion on sensors in Lesson 1 of Unit 1, the teacher may explain that, broadly speaking, sensors are physical devices that provide information about the world. For instance, a light sensor is a kind of primitive eye; it measures the variation of light around us.

Different kind of sensors can be distinguished according to the physical property they are “sensing/measuring”: Switch sensors, for instance, are used for contact; ultrasound, radar and infrared for distance; microphone for sound level; encoders and potentiometer for rotation; altimeter measures altitude; thermal and infra red sensors are for temperature, etc.

To complete the discussion the teacher should ask students: Why are sensors important both for biological systems and for robots? And what examples come to mind. For instance, bats use the physiological process of echolocation, that is, they can find a location using sonar system (they emit sound waves that are reflected back to the emitter by the objects). The cat uses whiskers like a radar system (i.e. whiskers are sensitive to air movement)... and what about human beings?

For the next 20 minutes, the teacher introduces to the class the sensors in the RDS-X01 robot. In this robot there are two kinds of sensors: an infrared sensor and a touch sensor. The teacher points out that the first sensor students will learn to use is the “touch sensor”.

The teacher also introduces the concept of testing the value of a sensor in a program through conditional statements (*if...then...else*) and loop statements.

The teacher then divides students in groups and asks them to program the robot so as to turn right or left when the corresponding touch sensor is activated. The students are invited to assemble the touch sensors, using the user guide provided with RDS-X01 (to speed up classes, sensors can be given to students already assembled). Then the teacher asks each group to show the performance of their robot to the rest of the class.

For the last five minutes, the teacher may wish to sum up the main points of the lesson on the blackboard or in one slide: definition of sensor and conditional and loop statements.



Exercises or Homework

The teacher asks students to work in groups or pair to program the robots for an obstacle avoidance task.

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 Various School Subjects

Philosophy

The perception of the external environment by means of senses introduces the problem of how human beings perceive the external world. In philosophy this can be related to epistemology, ontology, phenomenology, etc.

Biology

Vibresse are contact sensors similar to those used by cats.

Lesson 2: The infra-red sensors (Part I)

This lesson makes use of the Supporting Material, Unit 2/Lesson 2, found in Appendix 1 of this document.

Learning Objectives

Learn how to calibrate an infrared sensor using a multimeter, to understand the concept of threshold and to program a sensor using TiColla.

Familiarizing students with RDS-X01 infrared sensors by experimentally applying the conditional and loop statements.

Knowledge

Concepts of calibration and threshold.

Life skills

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

ICT skills

Computer and robotic skills, programming with TiColla.

Material

RDS-X01 infrared sensors (with and without led emitter), TiColla software, PC, multimeter, flash light, blackboard, slides, slide projector, RDS-X01 robot kit and Manual, Appendix 1 in this document.

Time

About one hour

Class organization

Plenary or in groups.

Procedure

For the first 20 minutes the teacher explains the calibration process, that is, the process of adjusting a mechanism so as to optimise its performance. The teacher

introduces the concept of threshold and explains how to calculate a threshold. The responsiveness of the infrared sensors can be adjusted by changing the position of the trimmer on the sensor and can be measured by using a multimeter.

For the next 35 minutes, the teacher helps each group of students to calibrate the infrared sensors to respond to a light source. Finally, the teacher explains how to program the RDS-X01 infrared sensor to respond to light.

Then the teacher asks students to calculate the ambient light level of infrared light. As we know, ambient or background light may interfere with the infrared sensors measurement.

By taking two readings of the detectors, one with the emitter on and the other with the emitter off, and then subtracting them, it is possible to know the level of infrared light in the environment.

For the last five minutes, the teacher may wish to sum up the main points of the lesson on the blackboard or in one slide: calibration and threshold.

Exercises or Homework

The teacher asks students to work in groups and make a program to move the robot towards a light source perceived by the infrared sensors.

Suggestions of Further Activities

Simulate a program by devising a short and easy performance with students. 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 Various School Subjects

Anatomy

The teacher can make a comparison between sensors in artificial and biological systems.

Bionics or Biorobotics

Drawing on the examples given during the explanation of sensors, the teacher can introduce the meaning and purposes of bionics or biorobotics: the discipline of looking at how nature works to find engineering solutions to be applied to artefacts.

Electronics

How to teach the difference between a digital and an analog signal (for high schools students!)

The teacher asks students to think about an object that is digital or analogue. The teacher takes as an example the clock.

There are analogue and digital clocks. The teacher asks students to think about the difference between a digital and an analogue clock and draw it or describe it on the blackboard. By looking at the differences students can start proposing possible explanations.

The teacher explains that a digital clock changes its number every second and shows time, but an analogue clock shows time with clock hands making a circle. The main difference between an analogue and a digital clock is that the former can tell the detailed time. It can show 12:00 1.5 seconds, 1.25 seconds, or even 1.125 seconds. Of course, it is not known whether we can read these times or not.

A digital clock changes every second, so detailed times in between are not known (although a stop watch can show till 1/ 100 seconds, it cannot measure for 1/1000 seconds). That is, a digital clock shows the time roughly and an analogue can show the minute changes in time.

There are analogue and digital also in the electric circuits. As we have seen, we could only tell whether the sensor was activated or not until now. That is, we can only judge roughly, so it is digital. The infrared sensor which we will study from now on is a sensor that measures the amount of infrared light.

This explanation is taken and adapted, with permission from 'RoboDesigner – Teacher's Manual. Robot Technology 1' written by Norio Kumamaru and Kenji Noda, translated by Junko Kamachi and published by Japan Robotech Ltd., 2005.

Why do you have to measure quantity? How much is quantity? The infrared light is also present in sunlight. If you investigate whether there is any infrared light, you will need to measure it using a sensor which reacts to infrared light. That is, we can measure how much infrared light there is, so it is an analogue. Yes or no is digital and a measure expressed in a detailed number may be seen as analogue.

Biology

The teacher can explain the evolution of the primitive eye. Originally, the primitive eye functioned as a light sensor; it could only detect a variation of light.

The teacher can explain the working of the sonar (sound navigation ranging) etc.

Physics

The RDS-X01 robot's sensors can detect infrared light. The teacher can take advantage of this to explain physical phenomena such as the spectrum of light, colours, light wave etc.

Lesson 3: **The infra-red sensors (Part II)**

This lesson makes use of the Supporting Material, Unit 2/Lesson 3, found in Appendix 1 of this document. It draws also on some of the exercises designed by Valentino Braitenberg in his book *Vehicles - Experiments in Synthetic Psychology*, The MIT Press, Cambridge, Massachusetts, 1986 (however, the reading of the book is not a required assumption).

Learning Objectives

Consolidation of students' understanding of the concepts of calibration and threshold. Provide students with new vocabulary, for instance, robot "character", sensory-motor connection.

Knowledge

Consolidation of concepts of calibration and threshold. Vocabulary: robot "character", sensory-motor connection

Life skills

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

ICT skills

Computer and robotic skills, programming with TiColla.

Material

RDS-X01 with IR sensor assembled, TiColla software, PC, multimeter, flash light, blackboard, slides, slide projector, RDS-X01 Manual, Appendix 1 in this document.

Time

About one hour

Class organization:

Plenary or in groups.

Procedure

The teacher asks students to use the same program and robot configuration developed at home (i.e. light follower), and observe the robot behaviour while they operate it under two different conditions: with the light source straight ahead and with the light source on one side.

The teacher invites students to reflect on the robot “character”: Do robots like or dislike the light source? Then, the teacher asks students to modify the connections between motors and sensors. This can be done either by hardware, switching the connector of the infrared sensors, or, by software, changing the connection between motors and sensors.

At this point, students will realize that two types of sensory-motor connections are possible: (a) robots with straight connections, and (b) robots with crossed connections. The teacher invites students to compare the behaviour of robots with straight and crossed connections and tell the differences. The teacher points out that both robots dislike sources of light.

However, their “characters” are different: while the robot with straight connections dislikes the source of light (i.e. is a “coward”) because it “becomes restless in their vicinity and tends to avoid them, escaping until it safely reaches a place where the influence of the source is scarcely felt” (Braitenberg, 1986:6), the robot with crossed connections shows an aggressive behaviour. As a matter of fact, “it, too, is excited by the presence of sources, but resolutely turns toward them and hits them with high velocity, as if it wanted to destroy them” (Braitenberg, 1986:9)

Exercises or Homework

Teacher asks students to write a program to have the robot slow down its speed in correspondence of a light source.

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.

Lesson 4: Sensing, Thinking and Acting

Learning Objectives

Consolidation of students' understanding of concepts of calibration and threshold learnt in previous lessons, making use of exercises proposed by Braitenberg (1986).

Knowledge

Consolidation of concepts learnt in previous lessons. Introduction to Braitenberg's exercises.

Life skills

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

ICT skills

Computer and robotic skills, programming with TiColla.

Material

RDS-X01 with IR sensor assembled, TiColla software, PC, multimeter, flash light, blackboard, slides, slide projector, RDS-X01 Manual, Appendix 1 in this document.

Time

About one hour

Class organization

Plenary or in groups

Procedure

The starts the lesson by refreshing the concepts learnt in the previous lesson. Then the teacher proposes to students an exercise that follows Braitenberg's Exercise 4: to change the robot behaviour into a positive one, like love. The teacher asks students "How can this be done"?

According to Braitenberg this is possible by introducing "some inhibition in the connections between the sensors and the motors, switching the sign of the

influence from positive to negative. This will let the motor slow down when the corresponding sensor is activated. ” (Braitenberg 2000: p.10).

The teacher asks students to test this “inhibition” – namely, the program they have written for homework – in two kinds of robots: i.e., with straight and with crossed connections. Students must observe the robot behaviour: the robot with straight connections will come to rest facing the light source while the robot with crossed connections will come to rest facing away from the light source.

Braitenberg explains the robots behaviour in this way: “These vehicles LIKE the source, you will say, but in different ways.” The vehicle with straight connections “LOVES it in a permanent way, staying close by in quiet admiration from the time it spots the source to all future time.”

The vehicle with crossed connections, “on the other hand, is an EXPLORER. It likes the nearby source all right, but keeps an eye open for other, perhaps stronger sources, which it will sail to, given a chance, in order to find a more permanent and gratifying appeasement” (Braitenberg 2000:12).

The teacher invites students to reflect on the robots’ characters and on the words used to describe their behaviour (i.e. coward, aggressive, love). The robots have been compared to very simple animals and psychological language has been used in describing their behaviour.

Further Activities

The teacher may introduce the concept of *flow chart*. This is particularly useful as the procedure of a program becomes complicated to express in icon form due to proliferation of conditional branches etc. These more complicated programs can be more easily expressed by a flow chart.

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.

The teacher may introduce the concept of *synthetic psychology*, as used by Braitenberg, and invites students to reflect on the robots' characters and on the words used to describe their behaviour (i.e. coward, aggressive, love).

The robots have been compared to very simple animals and psychological language has been used in describing their behaviour. As observed by Braitenberg: "I have been dealing for many years with certain structures within animal brains that seemed to be interpretable as pieces of computing machinery because of their simplicity and/or regularity.

At times, though, in the back of my mind, while I was counting fibres in the visual ganglia of the fly or synapses in the cerebral cortex of a the mouse, I felt knots untie, distinctions dissolve, difficulties disappear, difficulties I had experienced much earlier when I still held my first naive philosophical approach to the problem of the mind" (Braitenberg 2000: p.1)

Extensions to Various School Subjects

Biology

The teacher can propose a simple test to show how sensors may change their "resolution" depending on the purpose they have. By pressing two tips of pencil on your finger, lip and shoulder, it is possible to be aware of the different resolution proper to sensors.

Neuroscience

Drawing on Braitenberg's Exercise about sensory-motor connections, the teacher invites students to reflect or study the role of human beings' crossed connections, i.e., the crossed representation of the world in the (vertebrate) brain.

English as a Foreign Language

The teacher can take advantage of robotics to improve motivation for learning a foreign language. Participating to an international competition of robotics, for instance RoboCup Junior, can be a good excuse to collaborate with the English teacher and/or teachers of other languages. For instance, designing the rule for a competition can be done in the foreign language.





Education and Culture

Socrates
Minerva

Appendix 1

Supporting Material

Unit 1 & 2



UNIT 1: Introduction to Robotics

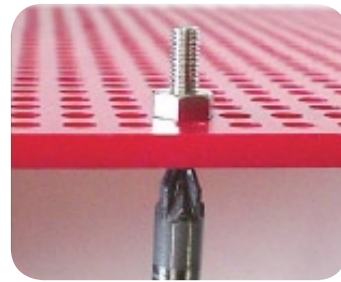
Lesson 1: What is a Robot

RoboDesigner RDS-X01 Check List

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

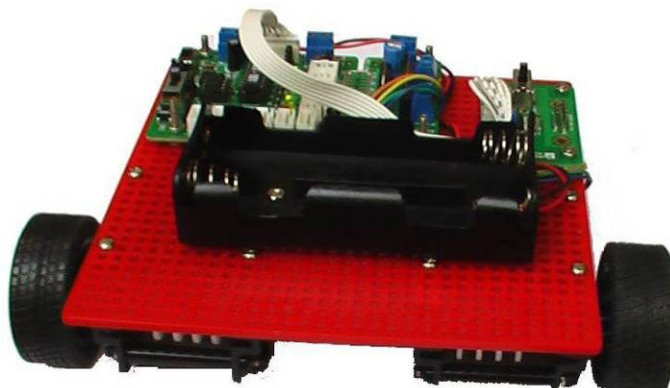
<input type="checkbox"/>	Universal Pillar RDP-803		Quantity: 5
<input type="checkbox"/>	3-pin cable RDP-804		Quantity: 3 Length 20 cm
<input type="checkbox"/>	3-pin cable RDP-805		Quantity: 2 Length 30 cm
<input type="checkbox"/>	6-pin cable RDP-808		Quantity: 1
<input type="checkbox"/>	Wheel and tyre RDP-807		Quantity: 2
<input type="checkbox"/>	Battery Housing RDP-809		Quantity: 1
<input type="checkbox"/>	RDS-X01 Manual	 <small>Instruction book</small>	To open the Manual, on your PC follow menu Start, Programs, TiColla and click on RDS-X01 Instruction Manual
<input type="checkbox"/>	Screws and Nuts		Screw type: M3
<input type="checkbox"/>	Screw Driver		Quantity: 1 For M3 screws
<input type="checkbox"/>	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

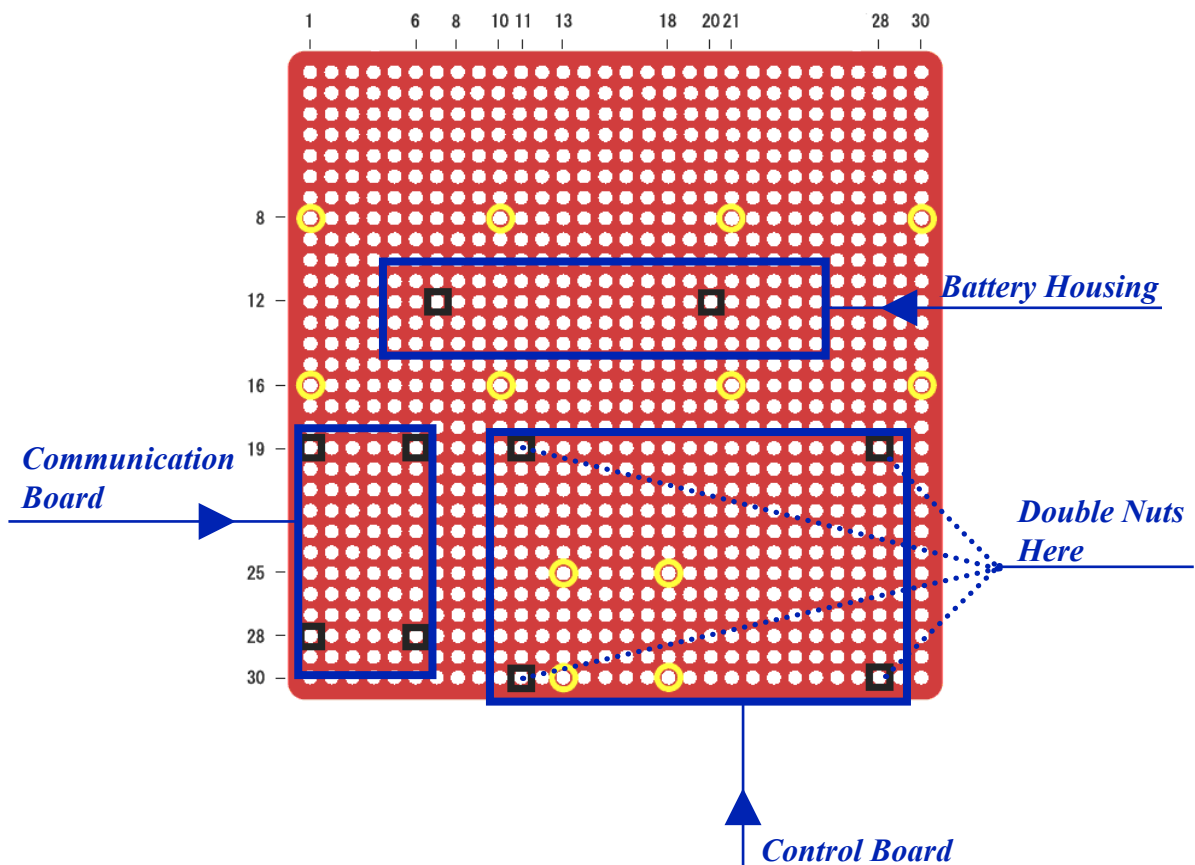
Insert 10 screws and screw nuts where black squares are printed on the universal plate in the following figures.

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.

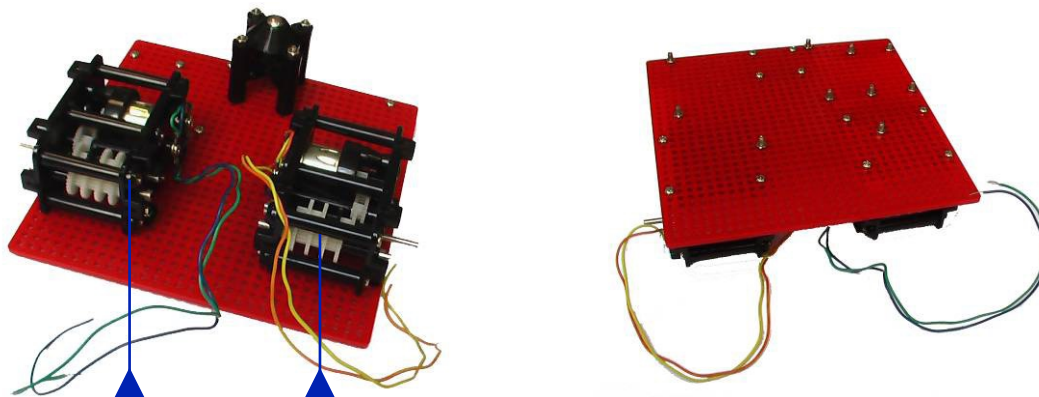
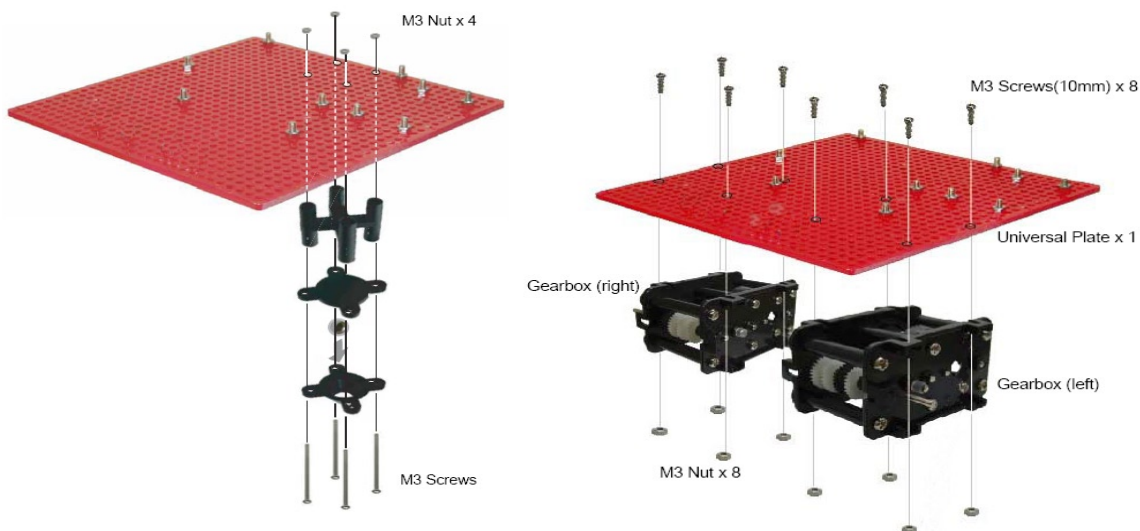
Do not insert screws into the yellow circles. Yellow circles shows where the gearboxes and caster will be assembled.

- 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 with the yellow 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.

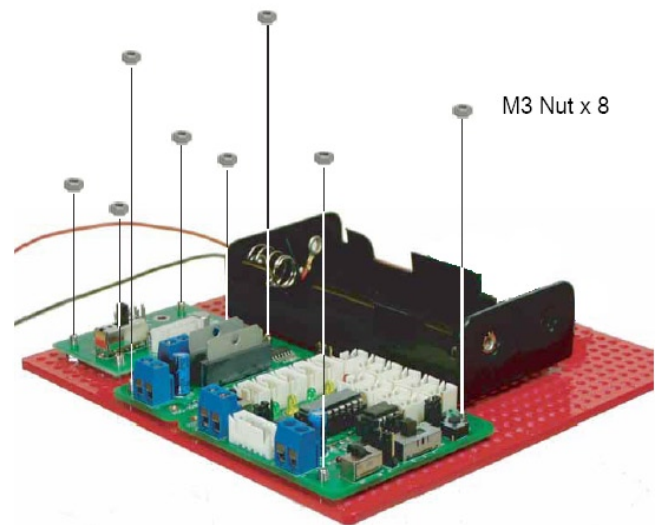
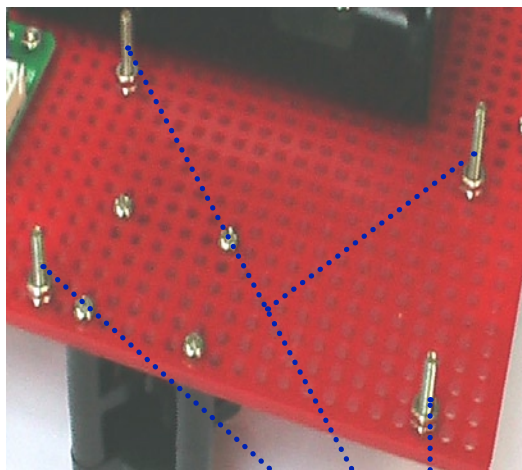
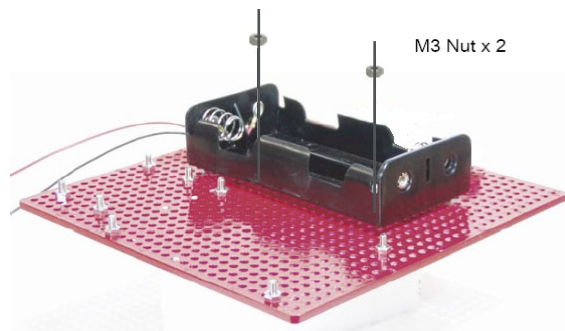


Left Motor:
blue and green cables

Right Motor:
yellow and orange cables

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

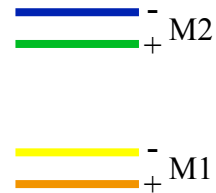
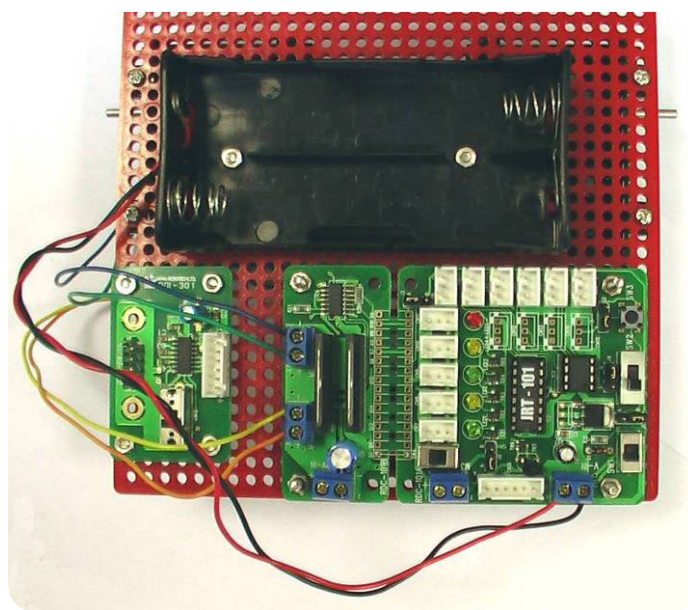
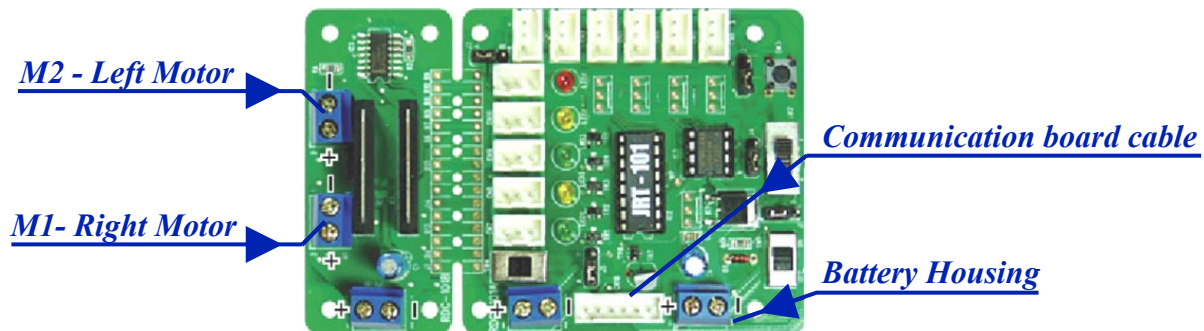
On the opposite side where motors and universal caster have been assembled, mount the control board, the communication board and the battery housing as shown in the following figure. Be sure that double nuts are assembled on the screws hosting the control board to prevent contact and short circuit.



Double Nuts

Step 4: Cables connection

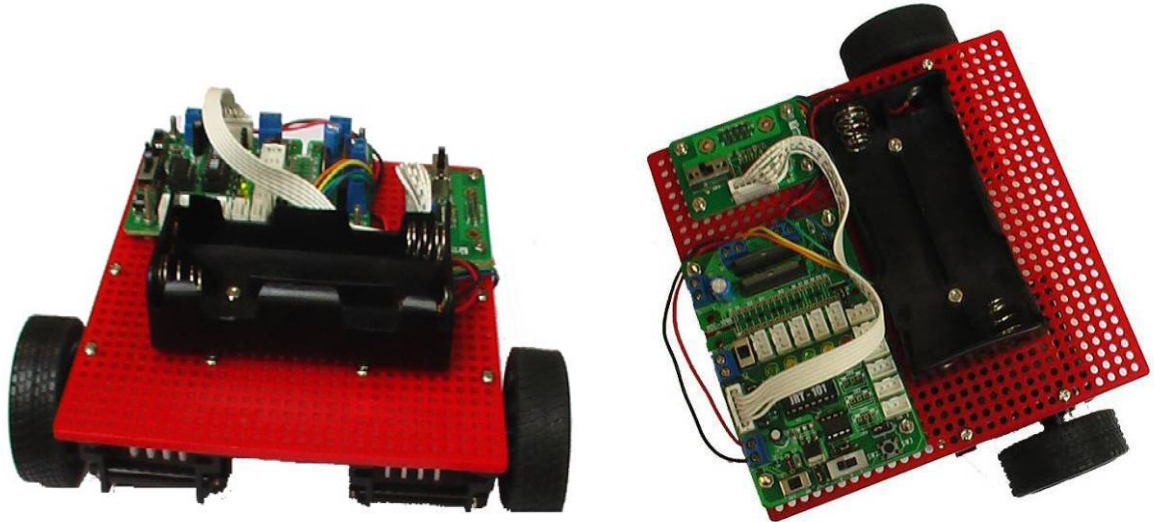
Connect the cables of the motors and battery-housing to the control board according to the schemes shown in the following figures.



Finally, connect the serial communication board to the control 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.



Lesson 2 – Programming the robot

This section shows how to use TiColla to make, download and execute a program with the help and following the instructions reported in the RDS-X01 manual. In particular, the basic commands to activate and stop the motors are explained as well as how to make a program that move the robot forward. Finally, the concept of time in programming the robot and how to make a program that move the robot forward for a finite time are introduced.

Step 1: Description of TiColla

Refer to RDS-X01 manual to describe how to start TiColla and to the content of the main window, i.e. the Project Explorer Window, the Property Area, the Toolbar and Menu Commands and the Programming Area.

Describe also how to:

1. create a new project;
2. save the project;
3. close the project;
4. open a saved project.

Then describe that to program the robot the following step are needed:

1. configure the hardware;
2. write the program;
3. compile the program;
4. download the program on the robot;
5. run the program.

Note that for the robot built in lesson 1, the default configuration, i.e. the one automatically created by TiColla, is appropriate.

Step 2: Create a simple program to move the motor

This section explains how to create a simple program to move the robot forward for a finite period of time (i.e., 5 seconds).

First explain how to drag and drop a tile from the Tiles Area into a box in the program grid. Also explain how to delete an icon from the program grid, referring to the RDS-X01 manual for these explanations.

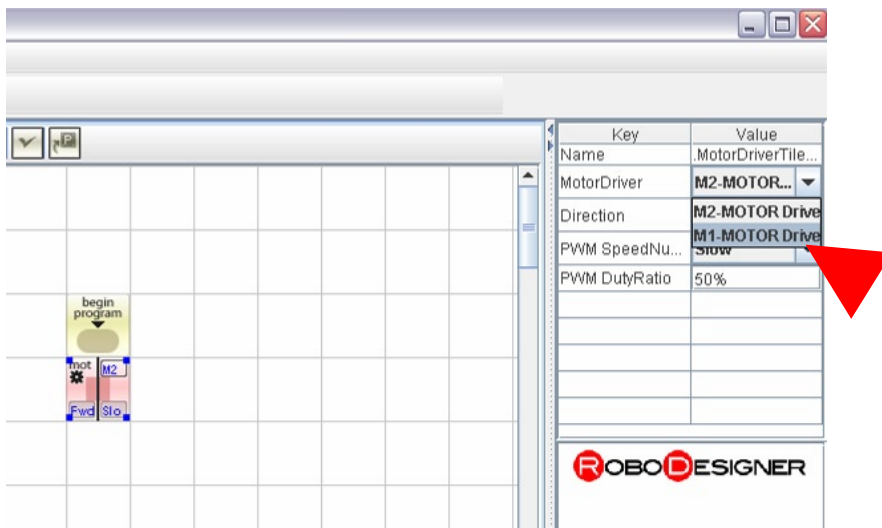
Then explain that a program has to start with the icon “begin program” and show how to drag and drop the “begin program icon” on the program grid.



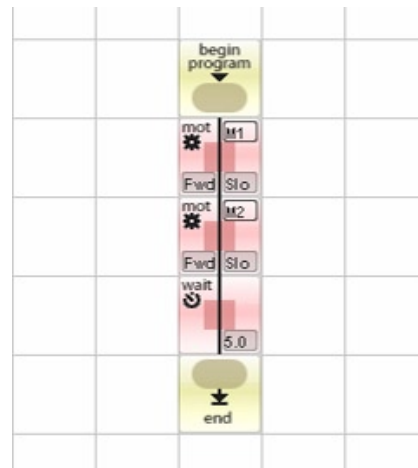
Explain the meanings of the icon “mot” to command the motors and drag and drop the icon “mot” in the program grid under the “begin program” icon. Explain also the content of the icon “mot” showing that this icon means that motor M2, corresponding to the left wheel on the robot built in lesson 1, is commanded to move forward at slow speed.



Then explain how to change the property of the icon “mot” by acting in the Property Window and setting the Motor Driver property to M1, corresponding to the right wheel in the robot built in lesson 1.



Add the icon to move the second motor, the icon “wait” and the icon “end” to terminate the program. Explain the meaning of the icon “wait”, i.e. it stops program execution for the time specified in its *Waitvalue* property. Modify the property Waitvalue of the icon “wait” by setting it to 5 seconds.



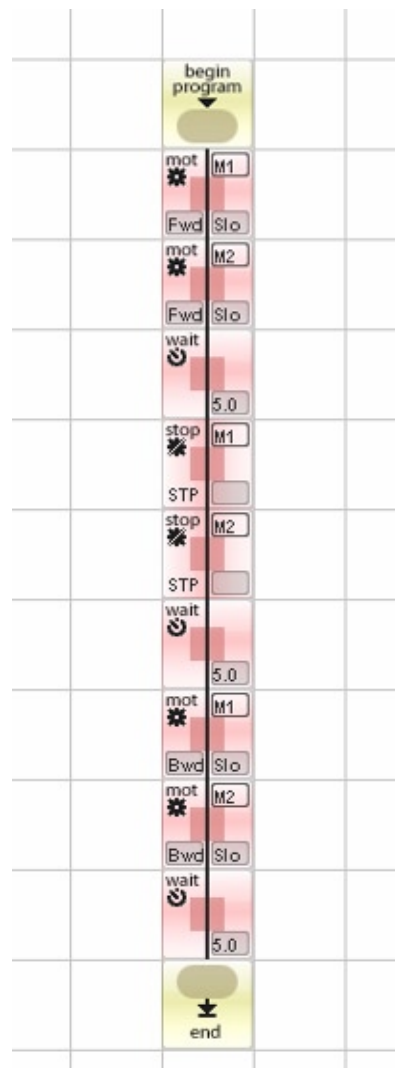
Step 3: download and run the program on the robot

Explain how to verify the correctness of the program and how to download and run the program on the robot by referring to RDS-X01 manual.



Step 4: modify the program to move the robot forward and backward for 5 sec

Show the meaning of the icon “stop” and modify the previous program to move the robot forward for 5 seconds, stop the motor for 5 seconds and move the robot backward for 5 seconds.



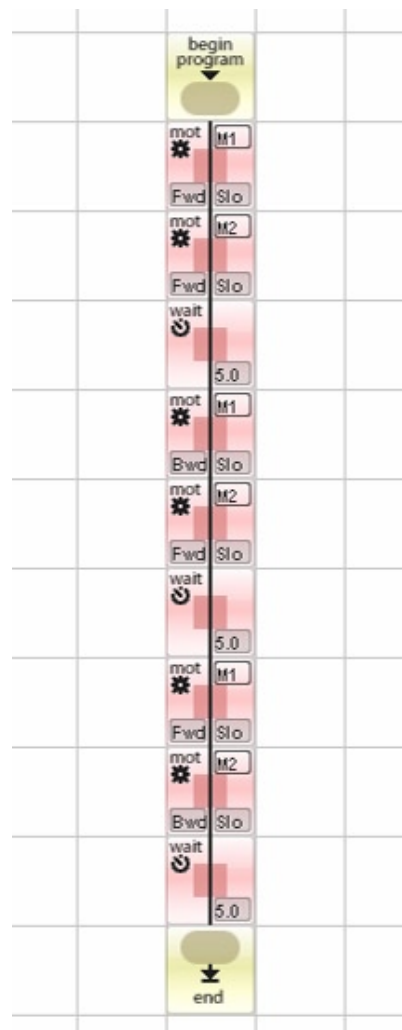
Exercise or Homework

Using TiColla make a program to move the robot forward for 5 seconds, to turn the robot on the right for 5 seconds and turn robot on the left for 5 seconds.

Lesson 3: Make a robot move

Homework Solution

The homework solution is shown in the figure below. Explain that the robot moves to the left if the right wheel moves forward and the left wheel moves backward and that, conversely, the robot moves to the right if the right wheel moves backward and the left wheel moves forward. This program has been prepared for the robot built in Lesson 1.

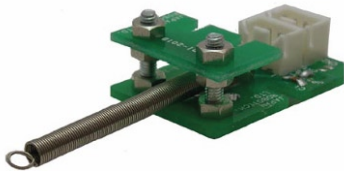


UNIT 2: Sensing and Acting

Lesson 1: Exploring Sensors – The touch sensors

Assembling the touch sensors

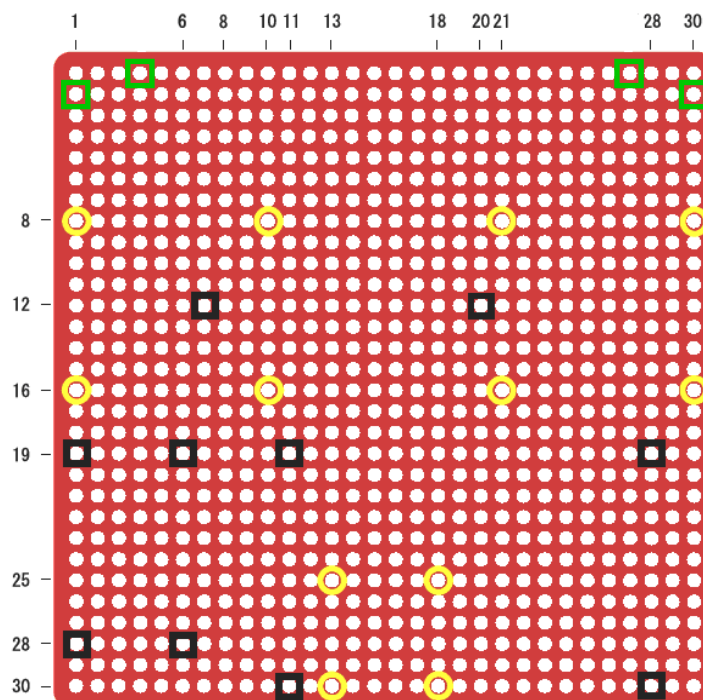
With the help and following the instructions reported in RoboDesigner RDS-X01 manual, assemble the two touch sensors. The following picture shows the final assembling of a touch sensor.



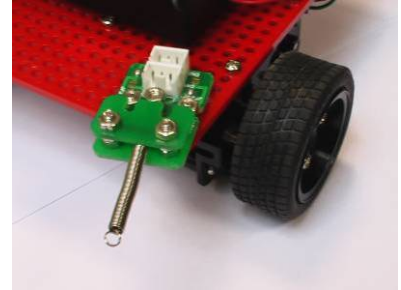
The following pictures show the position of the contact sensors on the grid. Insert 4 screws and 4 screw nuts where dark (green) squares are printed on the universal. These screws will be used to host respectively the left and right touch sensors.



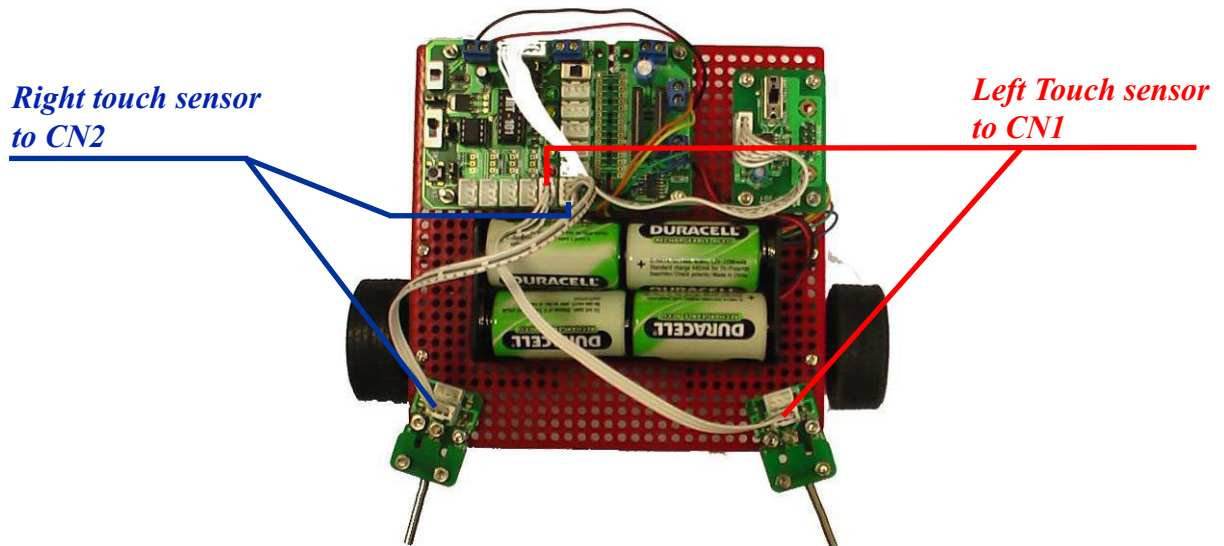
- Top side: screws for touch sensors. Nuts are on the top.



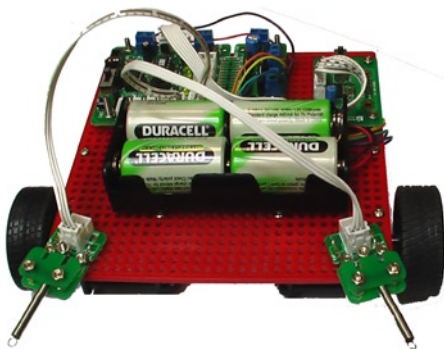
The following pictures shows the steps to assemble the left touch sensors on the robot.



Finally, assemble both left and right touch sensors and connect with the proper cable left sensors on connector CN2 and right sensor on connector CN1 of the control board as shown in the following figure.



The following picture shows the final configuration of the robot.



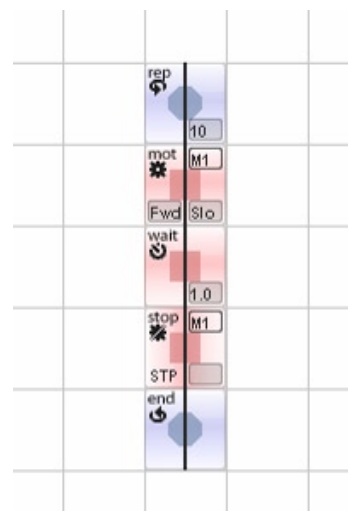
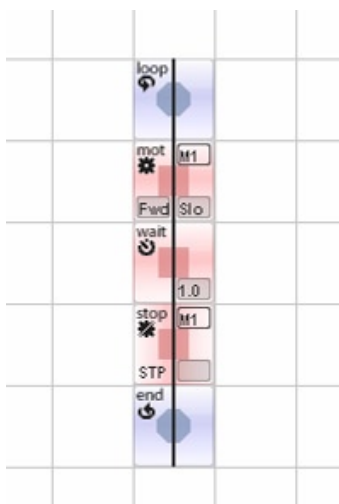
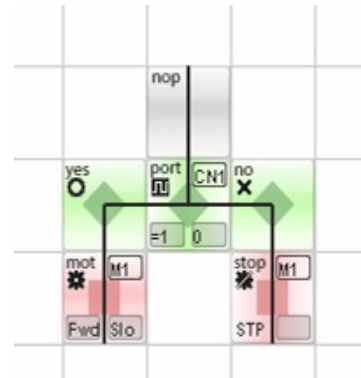
The conditional statement in TiColla

Explain how to implement the conditional statement in TiColla, i.e. conditional statements are implemented on the values of the input/output ports. In particular, it is possible to test the value of a digital port, such as the port of infrared sensor, and performing different actions depending on its value (1 or 0). The following diagram shows the testing of digital port 1 in TiColla.

The loop statement in TiColla

Explain how to implement the loop statement in TiColla. In TiColla there are two loop statements: the infinite loop statement (*loop*) and the repeat statement (*rep*). The *loop* is a loop statement whose Boolean condition evaluate always to true, thus the program perform repeatedly the block instruction following the *loop*. The *rep* statement repeat the block of instruction for a finite number of times as specified in his *RepeatCount* property.

The following diagram shows how to implement the *loop* and *repeat* statement in TiColla. The block of instruction repeated is the one enclosed between the *loop/rep* icon and the *end* icon.

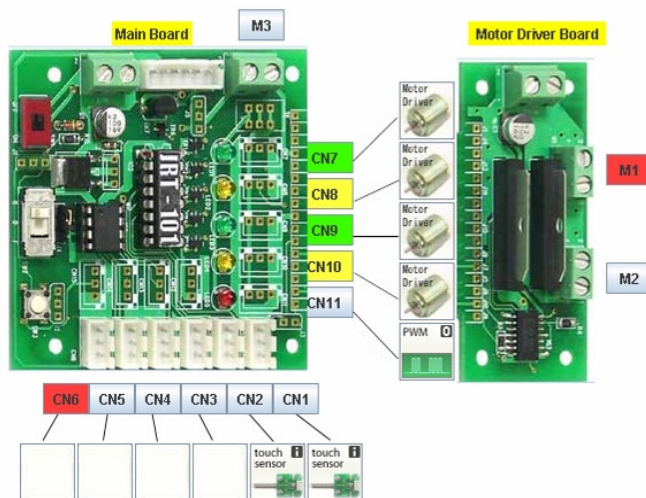


Making the robot turn right or left

This section explains how to program the robot to turn right or left when the corresponding touch sensor is activated.

Configuring the hardware

In TiColla, open a new project and call it TouchSensors. Configure the hardware of the new project by dragging and dropping two touch sensors in correspondence of the CN1 and CN2. The configuration of the hardware is shown in the following picture.

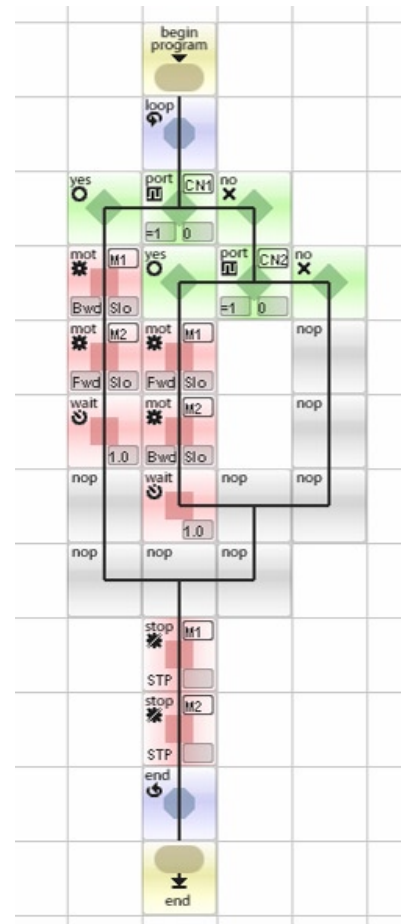


Programming the Robot

Show how to program the robot to turn right for 1 second when the right sensor is activated and turn left for 1 second when the left sensor is activated. Recall that:

- the right-motor is connected to motor M1 in TiColla and the right sensor is connected to port CN1.
- The left-motor is connected to motor M2 in TiColla and the left sensor is connected to port CN2.

Explains that to repeat the behaviour of the robot, the test of the condition should be done repeatedly, i.e. the block of instruction should be enclosed in a *loop* statement. Moreover, explain also how to use the *nop* statement and how to connect the icon in a proper way. Refer to the RDS-X01 manual for these explanations. The following picture shows the final program.



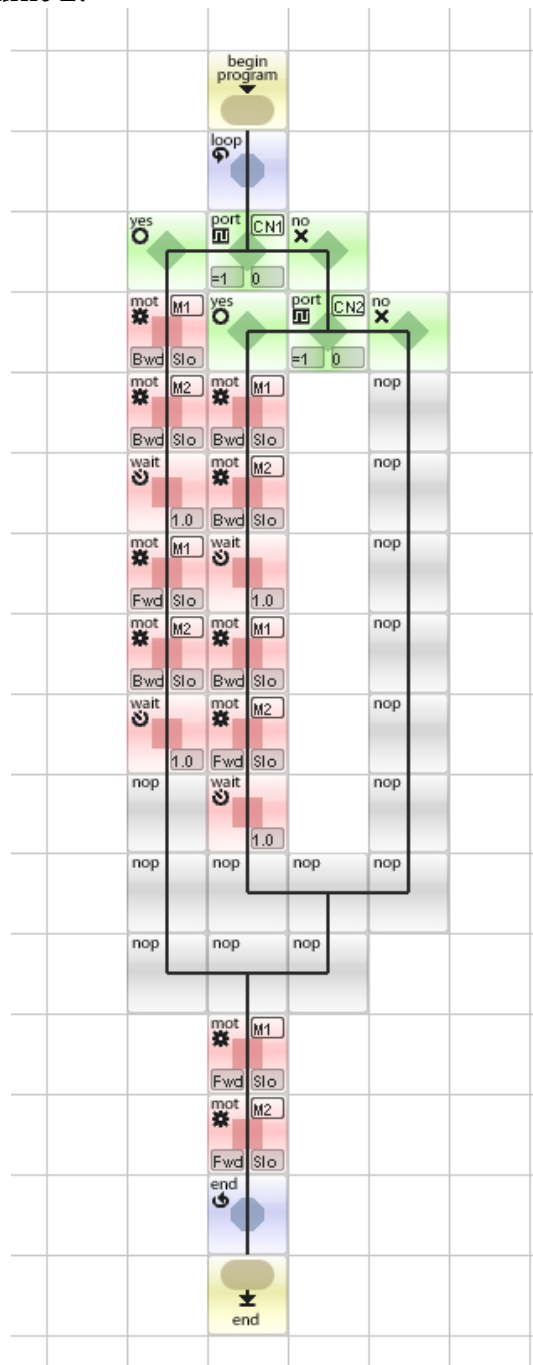
Exercise or Homework

Using TiColla make a program to move the robot forward continuously and avoid obstacle during motion.

Lesson 2 – The infra-red sensors (Part I)

Solution of Lesson 1 Homework

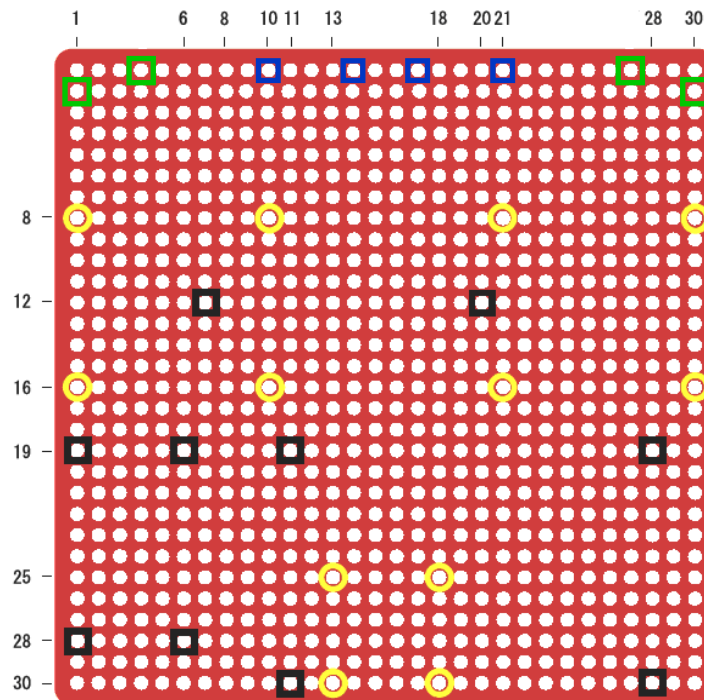
Obviously there are different ways to do the homework. The figure below shows one of these solutions. When the robot hits an obstacle with a touch sensor, the robot moves backward for one second and turn left or right depending on the touch sensor (right or left) activated. Then the robot move forward again. These programs have been prepared for the robot built in unit 1 with touch sensors added in lesson 1 of unit 2.



Assembling the infrared sensors

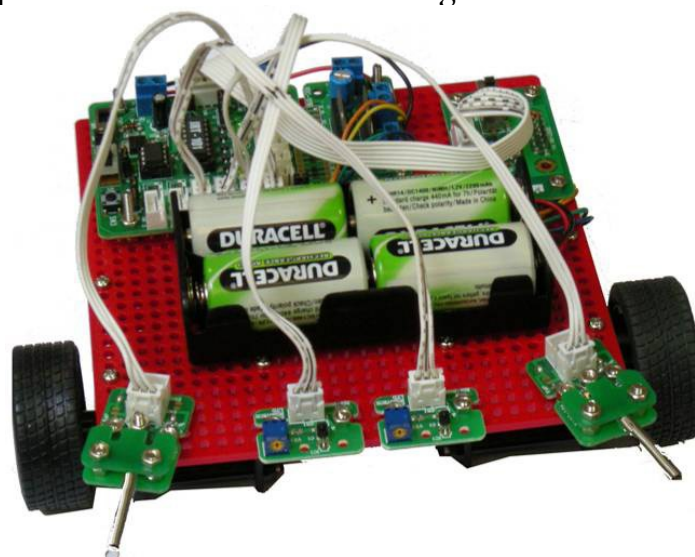
The following pictures show the position of the infrared sensors on the grid. Insert 4 screws and 4 screw nuts where blue squares are printed on the universal plate. These screws will be used to host the infrared sensors.

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



Assemble the infrared sensors on the universal plate in the same way as you did for the touch sensors and connect with the proper cable the left sensor on connector CN4 and the right sensor on connector CN3.

The following picture shows the final configuration of the robot the robot.

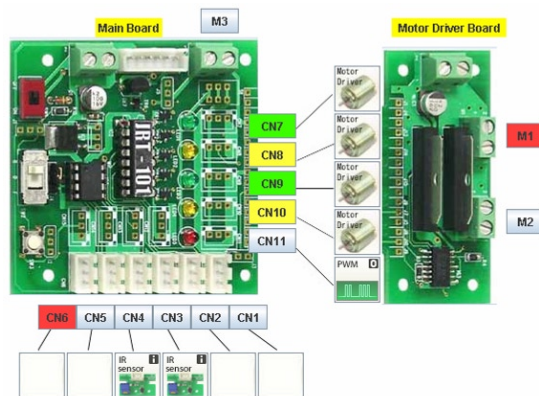


Following a Light Source

This section explains how to program the robot to follow a light source perceived by the infrared sensors.

Configuring the hardware

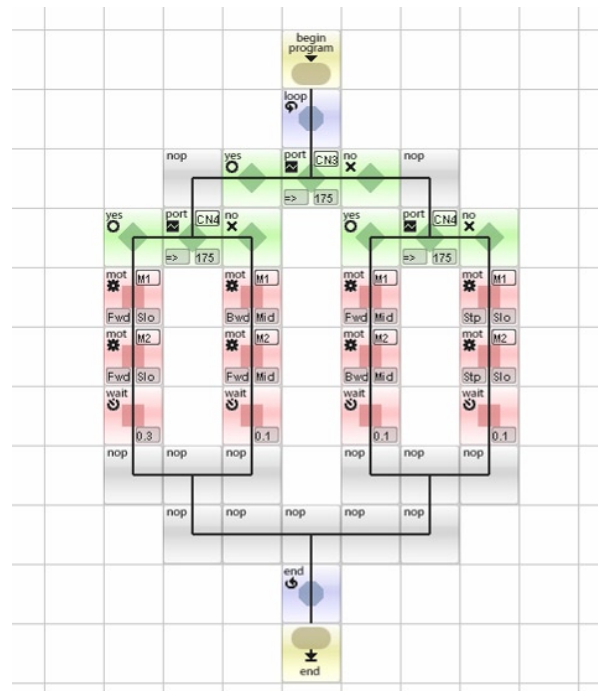
In TiColla open a new project and call it InfraredSensors. Configure the hardware of the new project by dragging and dropping two infrared sensors in correspondence with the CN3 and CN4. The configuration of the hardware is shown in the following picture.



Programming the robot

Show how to program the robot to accomplish the desired behaviour. Explain that the infrared sensor is an analogue sensor that perceives the light in the environment and transforms this light into an output that ranges from 0 to 5 volts. Explain that this analogue signal is converted by the control board into a digital signal that ranges from 0 to 256.

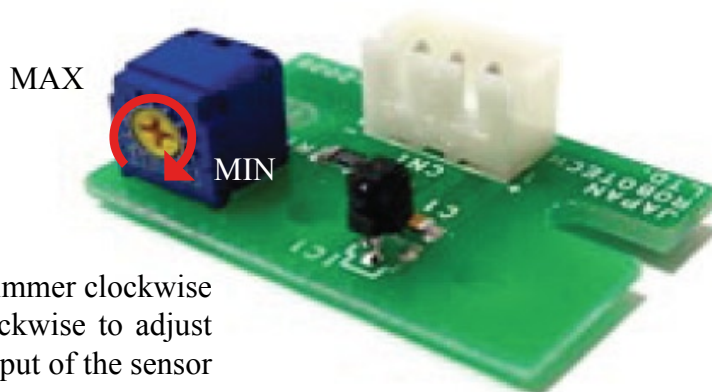
Then explain how to test the value of an infrared sensor and performing different actions depending on its digital value. Show how to set the *ValueNumeric* property of the analogue test icon and the meaning of this value. The following picture shows the final program.



Note: this program implements the cross connection of the experiments mentioned in Lesson 3.

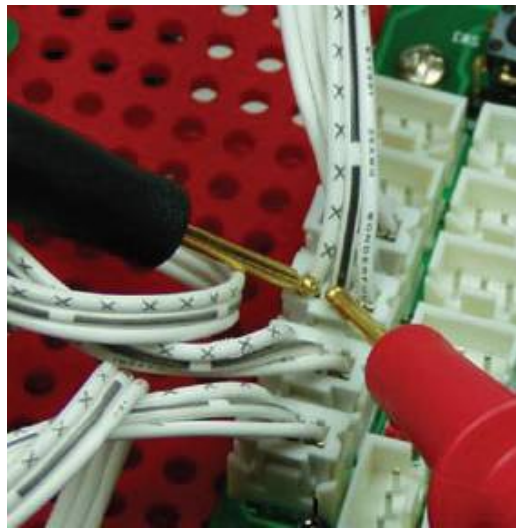
Adjusting the sensitivity of the infrared sensor

An important issue is to set properly the *ValueNumeric* property of the analogue test icon. The discriminating value depends on the light condition of the environment and should be set experimentally. Moreover, the sensitivity of the infrared sensor to the light could be modified by acting on the trimmer on the infrared sensor. By turning the trimmer clockwise, the sensor is less sensitive to the light, so you need an intense light to activate the sensor. On the contrary, by turning the trimmer anti-clockwise, the sensor is more sensitive to light, so you need a slight light to activate the sensor.



Turn the trimmer clockwise
 or under clockwise to adjust
 the output of the sensor

With the help of a tester you can measure the output of the sensor in normal light condition and turn the trimmer so as to adjust the outputs of both sensors to an intermediate value (i.e. 2V). It is important that both sensors have the same output in the same condition of light to facilitate the programming of the robot. The previous and the next examples has been realised by setting the sensitivity of the infrared sensors to its minimum value.

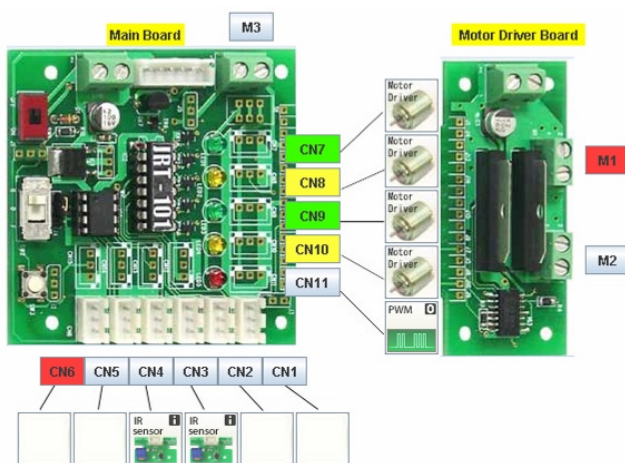


Lesson 3 –The infra-red sensors (Part II)

This section shows how to program the robot to implement the “Love Experiment” of Braitenberg vehicles. In this experiment the motor slows down when the corresponding sensor is more activated, i.e. it perceives more light.

Configuring the hardware

In TiColla open a new project and call it Love. Configure the hardware of the new project by dragging and dropping two infrared sensors in correspondence with CN3 and CN4. The configuration of the hardware is shown in the following picture.

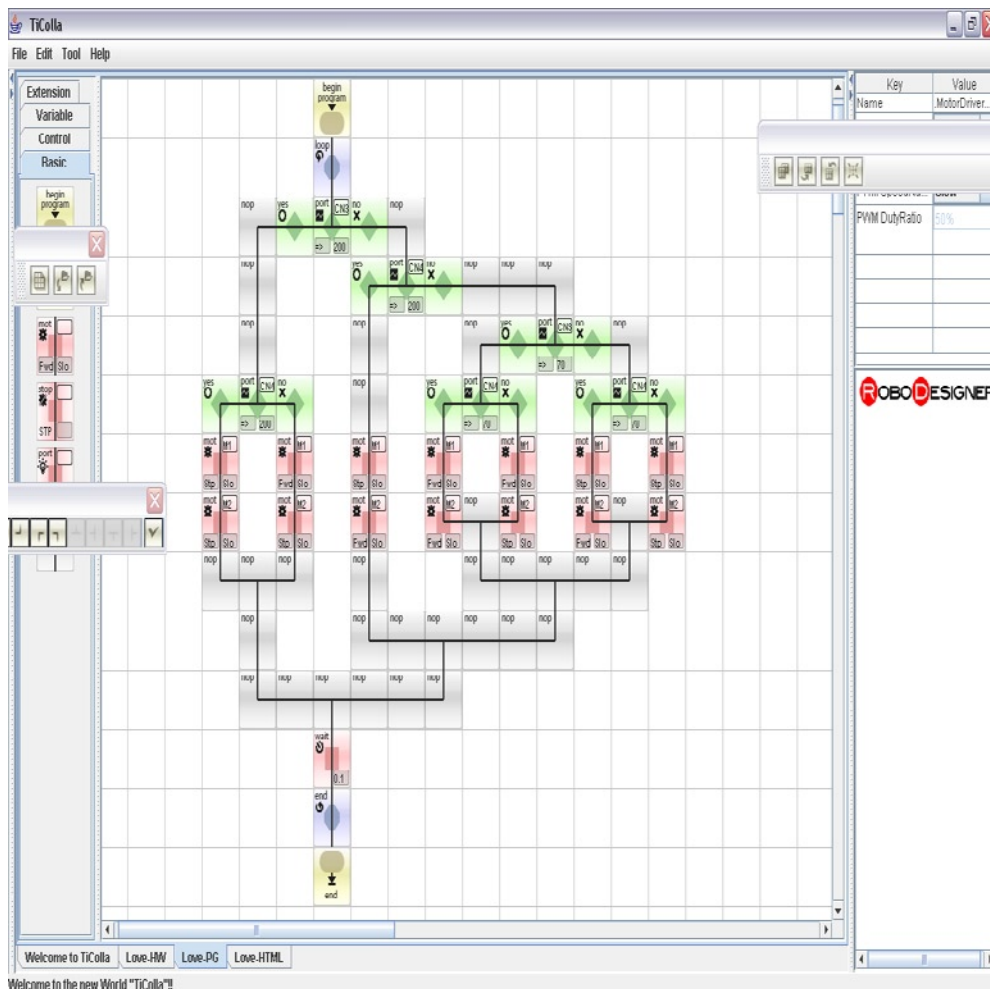


Programming the robot

Show how to program the robot to accomplish the desired behaviour. Obviously there are different ways to solve the problem: the figure in the next page shows one of these solutions.

If both sensors perceive a high quantity of light (i.e. their digital values are greater than 200) the robot is in front of the light and the motor are stopped. If only one of them measure a high quantity of light, the robot turn in that direction (i.e. left motor is activated when right sensor is activated and vice versa) so that the robot face the light.

Otherwise, if both sensors perceives an intermediate quantity of light (i.e. i.e. their digital values is between 70 and 200) the robot is in front of the light but not enough closer, thus the robot moves forward. If only one of them measure a intermediate quantity of light, the robot turn in that direction (i.e. left motor is activated when right sensor is activated and vice versa). Finally if both sensors measure a low quantity of light the robot stops.





Education and Culture

Socrates
Minerva



