« Mission On Mars »
Robot Challenge

Robotics programming competition

MathWorks®

« Mission On Mars » Robot Challenge

MathWorks is organizing the third "Mission On Mars Robot Challenge" robotics programming competition at the Innorobo Exhibition in Paris (France) on May 25th 2016.

Your mission: Rover robots will carry out the following mission, with two objectives: to explore the planet Mars while identifying specific site locations and avoiding any obstacles!

MathWorks will send you a robot operating simulation model. You can use this to carry out the mission, but you will need to improve it to win the competition! The aim is to optimize the Rover's MATLAB and Simulink algorithms, so the exploration mission is as short and smart as possible.

A 3D-printed robot using Arduino® and Raspberry Pi® boards will be made available on the day of the competition. The teams will be provided with the MATLAB/Simulink software. You don't need any prior technical know-how to take part in the competition.

MathWorks

Les Montalets – 2 rue de Paris
92196 MEUDON
http://fr.mathworks.com/

Contact : competition@mathworks.fr

Contents

The competition

All set for Mars! This competition is a chance to relive the preparatory phase of the Mars exploration mission, by programming “Mars Rover” type robots, using MATLAB and Simulink software.

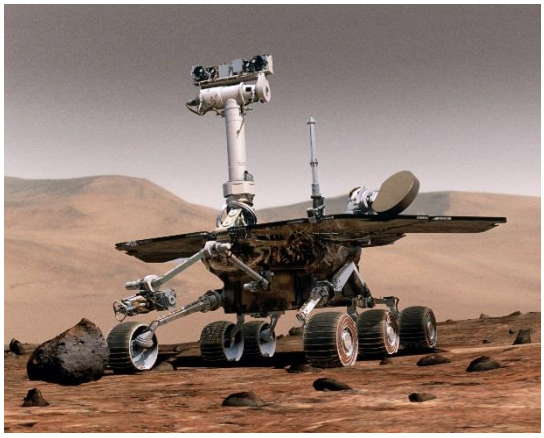
Your mission: Explore the planet Mars while identifying specific site locations and avoiding any obstacles, in the shortest possible time!

The aim is not to build the robots, but to optimize the algorithms they use to carry out their mission. Demonstrate your programming know-how to optimize the simulation model that your robot will use, and win the competition!

When you register, you will receive:

- Limited-time free versions of the MATLAB and Simulink software.
- A Mars Rover robot operating simulation model.

The MATLAB/Simulink simulation model is designed to perform the Mars mission in certain length of time. Between your registration and the day of the competition, your job will be to optimize the model by demonstrating your bold and creative programming know-how. Your aim: to make your robot as fast and smart as possible so it can explore the maximum number of Mars locations in the shortest possible time!



On the day of the final, 3D-printed and laser-cut out Mars Rover Robots with Arduino® and RaspberryPi® boards, will be made available to the competing teams. You will be able to test your optimized programming model on the robots and compete with the other teams in the rush to explore the planet Mars. An electronic judge will time the different robots.

The winner will be the team that has managed to visit the greatest number of sites in the shortest possible time, while avoiding all the obstacles.

To meet this challenge, we invite you to form teams of 2 to 4 participants. The 12 finalist teams will compete face to face in Paris on May 25th, in the special arena at the Innorobo Exhibition.

The mission

A team of scientists wants to identify all the sites on Mars where water may have been present in the past. A robot is being sent to these sites to look for possible life forms that may have developed there.

The main constraints that have been identified for the mission are as follows:

- **Budgetary constraints**: These are crucial and mean that there is no room for mistakes! The robot's program must be simulated and improved from Earth, because only one robot can be sent to Mars.
- **Robot autonomy:** Once on Mars, the robot will have only limited power. The robot needs to be able to explore the maximum number of locations as quickly as possible, while it still has enough power left. This means that the path the robot will follow must be optimized, or its efficiency improved. The robot must be able to identify and avoid any obstacles it might encounter.
- **Communication with Mars**: Due to communication interferences between Earth and Mars, the robot has to be able to perform its mission and move about completely autonomously.
- **Time needed to carry out the research**: The robot needs to stop at each location for a minimum amount of time, to perform the analyzes required. If it simply passes the location without stopping, it will not be able to perform the analyzes required and will be of no use to the scientists.

A competition has therefore been launched to find the teams capable of implementing the most efficient simulation within the constraints set for the mission. The most talented team, that has managed to visit the greatest number of locations in the shortest possible time, while avoiding all the obstacles, will be chosen to program the robot for the mission.

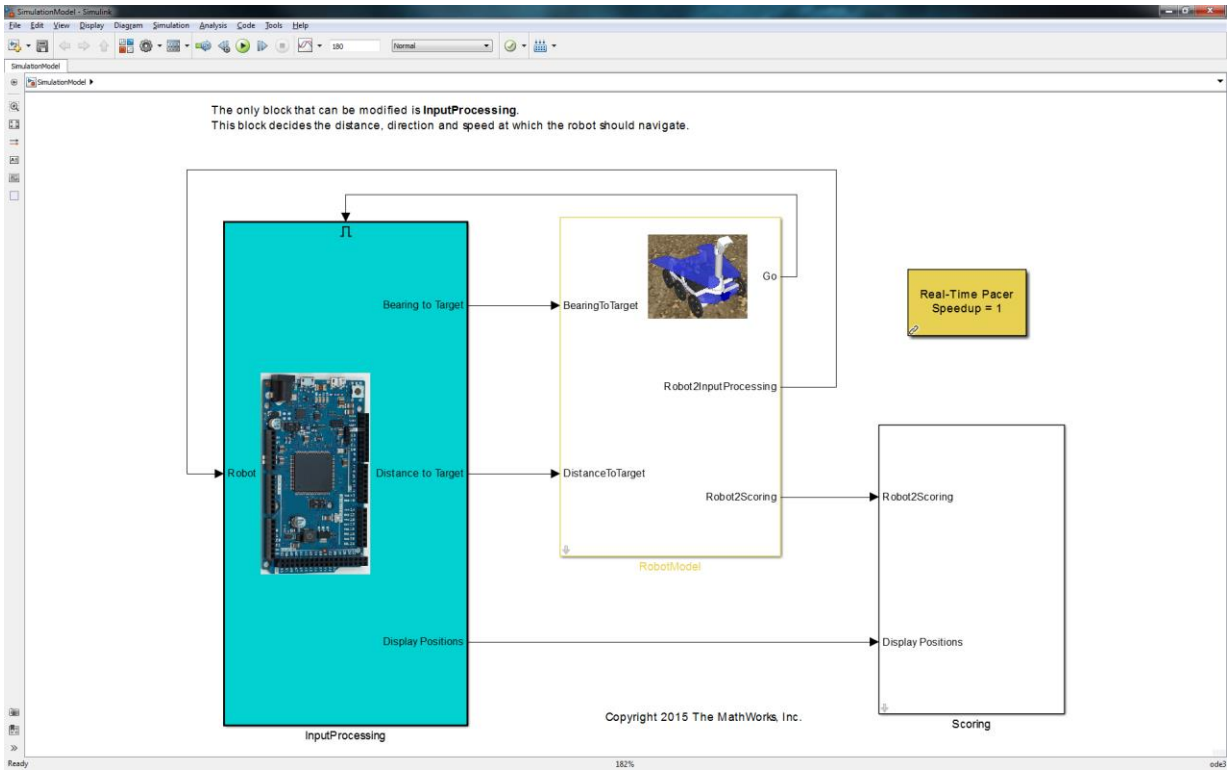
The scientists wanting to be part in the project must be able to pre-program the robot on Earth so that it can be remotely controlled and perform as efficiently and quickly as possible during the mission.

Simulation model

All participants will receive an operational but non optimized simulation model.

Prior knowledge of MATLAB and Simulink is not a prerequisite! Simulink is a system simulation and modeling software application with a simple, user-friendly graphic environment that can be mastered easily. We will also provide additional resources to help you understand and use these tools as effectively as possible.

The figure below shows the system simulation model. It includes the program designed for the robot and a model of the environment.

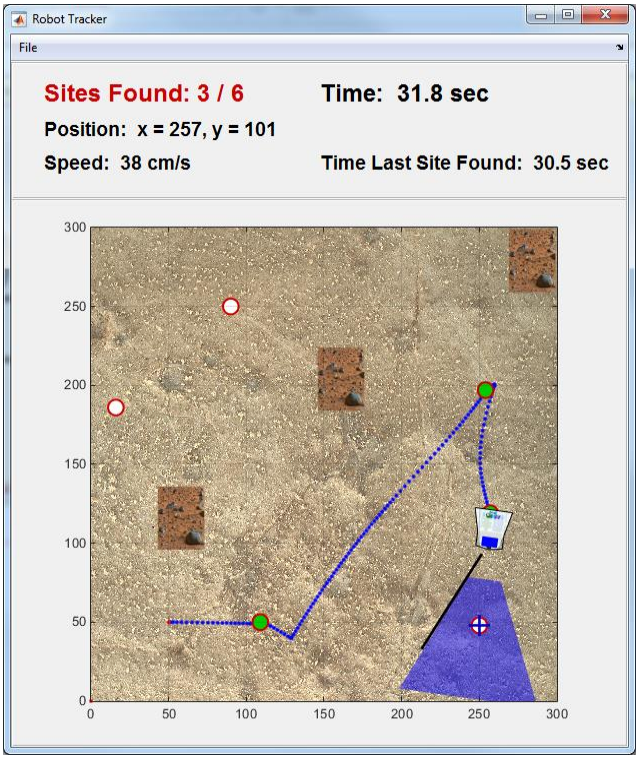


There are three main parts to the model:

1. **The blue "InputProcessing" unit:** This implements the robot movement strategy. Given the robot's estimated position, the information supplied by the camera and the distances measured, this unit determines the direction the robot will travel in and the distance covered. This is the only unit that you will need to optimize.
2. **The "Robot Model" unit:** This unit models the robot's physical behavior and its sensors. You must not modify this unit.
3. **The "Scoring" unit:** This models the electronic judge and manages the graphic simulation window. You must not modify this unit.

The following figure shows how the robot travel simulation works:

- The locations to visit, i.e. the sites on Mars where the robot has to stop at least for 3 seconds, are shown by circles.
- The obstacles the robot needs to avoid.
- The robot camera's field of vision is shown by the blue outline. The robot can detect the sites within its field of vision.
- The path followed by the robot is shown by the blue dotted line.
- This window also displays the robot's travel time and the number of sites it has visited.



Once you have started the simulation and observed your robot's behavior, you can modify the model and re-launch the simulation to see how its behavior changes.

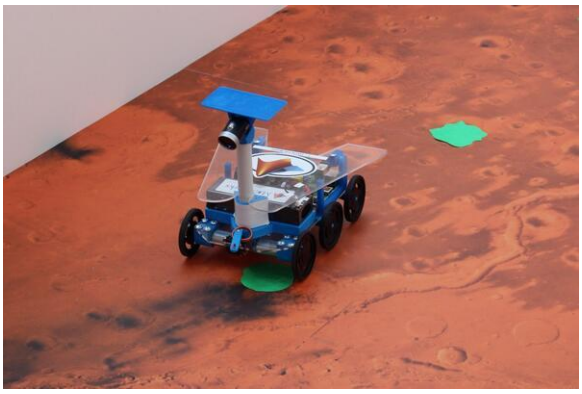
There are several ways of optimizing the model:

- You can improve the existing exploration-based strategy
- You can change the navigation strategy so as to keep a log of where the robot has been and avoid revisiting the same areas of Mars twice, but be careful not to get lost...

The « Mars Rover » Robot and arena

1. The robot

The “Mars Rover” robot you will use in the competition will be provided by MathWorks on the day of the final, on May 25th. You are not allowed to compete with your own robot.



Each team having reached the final will test their model for the first time on the robot on May 25th. It is a 3-wheel robot with 2 driving wheels and a free wheel. This means it can move in a straight line or turn round on the spot.

The robot navigates on Mars with three main sensors:

- A Webcam, which provides the localization of the sites identified, after processing.
- Two encoders which provide information on the distance covered by the wheels.
- A distance sensor mounted on a servomotor, which provides information on the distance between the robot and obstacles or the side of the arena.

The prototype and the robots have been manufactured using:

- 3D print-outs for all the blue parts
- Laser cutouts for the plexiglas part

The Mars Robot is 24 cm wide, 24 cm long and 22 cm high.

The robot consists of the following parts:

- An Arduino DUO board
    - This is the board that will use your algorithms.
    - The Arduino DUE board controls the navigation and the movement strategy used to reach the sites.
    - It is equipped with a daughter board controlling motor power: DFRobot motor Shield.

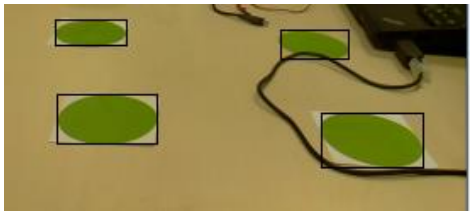
- A Raspberry Pi board
    - Using the image flow from the connected camera, this board will identify any sites within the camera's field of vision. These are represented by colored markers on the ground.
    - It will compute the distance in centimeters of the detected sites and their angle in relation to the robot (0° facing, positive angle left and negative, right).
    - This information will then be sent to the Arduino board via I2C interface.
    - This assembly will be provided and requires no modifications.

- A Webcam
    - The webcam is directly connected to the Raspberry Pi to provide vision.

- Two CC motors
    - The motors are equipped with 70 mm dia wheels.
    - They are fitted with encoders with a 636 step resolution per wheel revolution.
    - The wheels are 165 mm apart.
    - The Arduino board will use this information to estimate the distance covered and the robot's angle.
    - Please note that the robot's wheels may slip and that it is not foolproof. A navigation algorithm based solely on the localization provided by the encoders is not a realistic proposition.

- A 6000m AH battery can power the robot for a whole day.

This shows the Raspberry Pi board camera's viewpoint



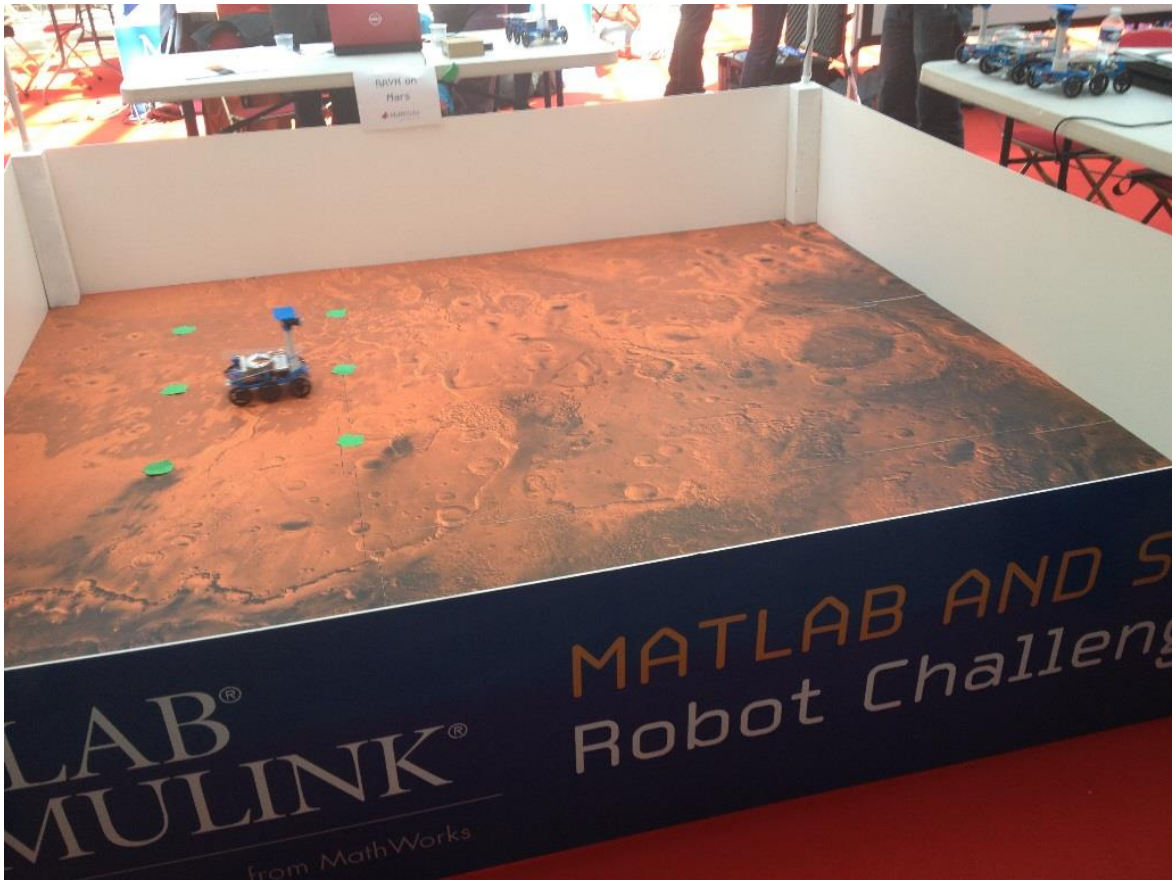
2. The arena

The planet Mars is represented by a 3 meter by 3 meter arena. The arena will contain:

- Green dots: they stand for sites on Mars that the robot has to pass over and where it must remain stationary for 3 seconds to validate their exploration.
- Obstacles to avoid.

An electronic judge will follow your Mars Rover thanks to a Webcam overlooking the arena. This system will confirm the sites that you have visited while timing your performance, including the times recorded at different stages when you pass over the sites. You can follow the electronic judge's validations and the estimated times on the PC screen allocated to your arena.

A separate large screen will display your robot's path, the number of targets achieved and the time recorded.



Software and resources

The “Mars Rover” robots must be programmed exclusively using the MATLAB and Simulink software provided and the MathWorks Toolboxes Version R2015a.

We will email you a temporary free version of the software you will need to prepare for and take part in the competition. We recommend a “64-bit MATLAB” installation.

Please note: To take part, you will also need a laptop under Windows 7 (required on the day of the final) with all the software installed. Apple and Linux platforms will not be supported on the day of the competition.

Here are some resources you can use to find about MathWorks solutions:

- Introduction to MATLAB
- Introduction to Simulink
- Arduino powered by MATLAB and Simulink
- Raspberry Pi powered by MATLAB and Simulink
- Simulink tutorial

Registration

You can only register for the competition on the MathWorks site. Each team captain must register all the team members, with their names, age and contact details.

Registration for the competition will be open from February 2016 to April 15 2016.

Team members:

- Each team must have at least 2 members and a maximum of 4.
- All the team members must be aged 15 and above.

Registration for the “Mission On Mars” Robot Challenge is free of charge. Access to the Innorobo Exhibition will be free for finalists on the day of the final. MathWorks will not cover any travel and accommodation expenses for the participating teams.

Competition rules and judging

1. Competition rules

The aim of the competition is to visit all the designated planet Mars sites in the shortest possible time, while avoiding obstacles.

Passage over a site will only be validated by the electronic judge providing the robot has remained stationary for at least 3 seconds on the site.

The maximum time allowed for the mission is 3 minutes.

If several teams manage to validate the same number of sites, the time taken to reach the final target site will be the deciding factor.

2. Judging the competition

The competition will be judged by MathWorks engineers. An automated system will decide on the winner on the basis of total time taken to complete the course. Full instructions and assessment criteria will be provided during the preparatory phase and on the day of the event.

The judges' decision will be final.

Competition organization

1. Pre-qualifying

A pre-qualifying phase will be organized to select the 12 teams that will take part in the final in Paris on May 25th.

The qualifying teams will be selected on the basis of their optimized models, which must be sent to the jury by midnight on April 24th 2016 at the latest.

The 12 teams that have produced the fastest and most innovative simulations will be selected to take part in the Innorobo challenge.

2. On the day of the competition

Competition schedule:

09.00 - 09.30	Welcome and installation
09.30 – 12.00	Robot testing
13.00 – 15.00	Qualifyng pools
15.00 – 17.00	Semi-final
16.00 – 17.00	Final
17.00	Awards ceremony

Equipment the teams need to bring:

- No more than one or two laptop computers under Windows 7, with MathWorks software installed.
- The model you designed before the event.

Equipment provided by the organizers:

- Tables and chairs
- The “Mars Rover” Robots
- The arenas
- The power supply

a. Test phase

During the test phase, you will be able to test your simulation for the first time in real-life conditions on the Rover robot provided.

The aim of this phase is to allow you to adapt your simulation model according to the way your robot behaves. The time performances at this stage are for information only and are not taken into account for the competition results.

b. Pool phase

A new set of sites and obstacles to explore on Mars will be set up in the arenas. From now on, every second counts! All your times will now be recorded and your best times will be used to rank all the teams. The four teams with the best times will go through to the semi-finals.

c. Semi-final

The Mars sites and obstacles will again be changed. The 2 teams that have visited the most sites in the shortest time will go through to the final.

d. Final

A new array of sites and obstacles will be installed in the arena. The winner of the 2016 competition will be decided on the basis of the best time recorded by each of the finalists.

e. Awards ceremony

The winners must be present to receive their award. If the winning team is not present at the awards ceremony, the first prize will go to the second finalist.

The 3 best teams will receive a prize, as follows:

- The winning team will receive the robot with which they competed in the final.
- Each of the 3 top teams will receive MATLAB and Simulink licenses.
- And many other surprises!