A ROBOTIC SYSTEM POWERED BY SOLAR ENERGY

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ABSTRACT

This paper describes the process of constructing a robotic system from scratch, using Lego bricks as constructing blocks and solar panels as energy source. The product is a robotic system (car) on 4 wheels powered by 32 small 0,08W solar panels. The paper describes the possibilities of using renewable energy sources, such as the solar energy, as driving energy for robots. Furthermore, this paper gives some ideas on how can this model be upgraded with more functionalities.

I. INTRODUCTION

Mobile robots are capable of performing many useful tasks, such as exploration, rescue, entertainment or cleaning the floor [5], but they are quite limited with the energy supply. For these robots, using the environmental power, such as the solar energy, is the best solution for refilling the battery. Solar energy is most efficient when used by robots floating on water or in the space, but it is not so efficient in urban, cluttered areas [1, 3]. Many robotic vehicles, such as the Mars exploration rovers Spirit and Opportunity [2], Husky A100 form Clearpath [1], the Polar Cool Robot [9] or the mobile exploration rover Solero [10], use solar panels as main source for energy supply. Many flying robots [6] and many tiny robots [7, 8] also use the solar energy as the main energy source. The use of solar energy for supplying robots grows constantly and becomes more and more popular. Many researchers invest in energy efficient, low polluting electric vehicles, such the UltraCommuter [4]. Many ideas for optimization of harvesting the solar energy have taken place already [1].

Building a robotic system from scratch requires not only mathematical computations, but also lot of testing in every stage of development. Modular robots that can easily change their shape [2, 11] are very useful during the construction and testing phase because some small modifications can be made whenever it is necessary. Finding the right driving power for a robot with a particular weight is another thing that requires precise computations and testing. This problem is highlighted when renewable energy source is used, such as the sun. In this paper an overview of the constructing process of the robotic system is given (Figure 1). The paper further explains the problems encountered during the construction.

Figure 1: A robotic system made of Lego bricks and solar panels.

The paper is organized in several sections. The next section discusses the Lego bricks as a (suitable) solution for building modular robots and controlling the robot weight. Then finding the right electromotor that can move the robotic system is discussed. Next, the solar panels that are used in this robotic system are presented, observing the electrical circuit they form and the power they give. At the end some ideas on how this circuit can be upgraded with different functionalities is given and the paper is concluded.

II. LEGO BRICKS FOR BUILDING ROBOTS

Turning a robotic idea into reality requires a fairly big investment. This includes making some special pieces which will build up the robotic system. The problem occurs if some of those pieces are not built properly. Then they have to be redesigned again and again until satisfactory pieces are assembled.

Using bricks model, on the other hand, enables the constructor to start building the robot without a perfect plan. Many changes can be made during the constructing process and even after that. Moreover, it enables the construction of the different modules of the robot separately (for example the wheels frame or the motor frame), which can be merged all together later. Lego bricks [11] are also suitable for changing the weight of the robot (simply by adding or removing bricks) which can be very useful in the process of testing.

The most suitable bricks for building such robots are Lego Technic bricks. Figure 2 shows some of the pieces that are used in the robot presented. Combining the Lego Technic bricks there can be made many possible solutions for constructing the main frame of the robot. Lego Mindstorm is the ultimate Lego robotic system made of Lego Technic bricks, Lego sensors, Lego actuators and Lego controller called "NXT Intelligent Brick".

For this robot, Lego Technic bricks as well as some Lego System bricks are used. The design consists of the wheels frame module, which holds the wheels and gives space to change the wheels; the frame that holds the electromotor; and the brick columns that hold the solar panels.

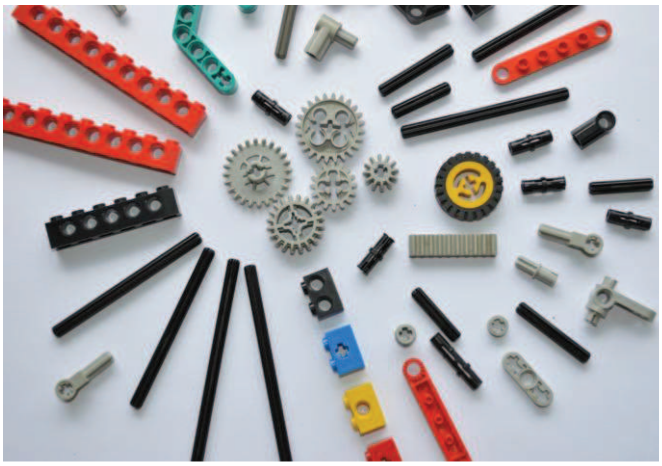

Figure 2: Some of the Lego Technic bricks.

III. Electromotor that moves the system

After building the main frame of bricks, the process of selecting the proper motor is required. In the design presented here, which required incorporation of the electromotor with the bricks, there were two possibilities: using cogs or using rubber belt. A rubber belt was chosen since it offers a simple way to connect the electromotor with the bricks. If cogs were chosen, a tiny precise hole in a brick should have been made, which is difficult since it requires proper tools and is imprecise.

For the robot's motor that can move the wheels, a 4 V (volts) direct-current electromotor was used with a reduction 4:1. The robot was tested with a proper battery. After it was successfully moved using commercial, but not renewable power source, the final part of the construction took place. The most challenging part of the design was to be able to move this simple robot using the solar source of energy.

IV. Solar panels as the main energy source

The energy in a robotic system is a valuable resource. Using only battery for supplying autonomous robotic system is not good idea because batteries have to be recharged after some time. The best solution for such robot is to be able to drain the energy from the surrounding environment. For this robot a solar energy is used.

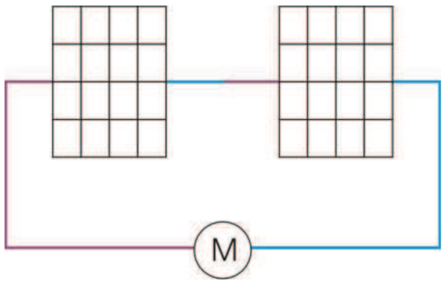

Figure 3: Connection between the panels and the electromotor.

A solar panel was chosen, with dimension 3 cm X 4 cm which produces 0.08 W. This seems to be a good solution for the problem because the panels are small and can be implemented on the top of the robotic system. Measuring the voltage that the panels produce, 2 volts per panel were got. Computing the current as the power divided by the voltage, 0.04 A per cell were calculated. Because the battery requires 4 V we need a serial connection between two panels. In this way, 4 V are produced but still 0.04 A. After some testing the decision was to make a serial connection between two sets of cells, each containing 16 solar cells connected in parallel. On Figure 3 one can see the scheme of this system. As a product, voltage of 4 V is obtained giving 0.64 A. That is equal to 2.56 W.

V. Testing the system

This paragraph elaborates on the different tests that have been done to the robotic system. This includes how much power the robotic system produces and how much weight can this system carry during full light intensity. The answers to these questions are important since they give insight of the environment conditions needed in order to move the robot. There is a need to know whether the robot could perform well in not so favourable conditions, such as cloudy weather.

As mentioned before, another important question is the question of variable weight of the robot. In creating platform-like robots, it is good idea to enable the robot to move and carry different weight form one point of the environment to the next.

The following tests were made on a sunny day, at around 12:30 PM.

First, the voltage produced by the solar panels needs to be measured. Measuring the voltage with a digital multimeter one can see that the panels produce 4.2 V (volts). At this point the panels are facing the sun. That is, the angle between panels and the sun rays is 90 degrees. Changing this angle by ±45 degrees does not change the voltage drastically, but decreases it from 0.1 to 0.2 volts. When the robot is not exposed to sun, the voltage decreases to 0.71 ± 0.02 volts.

Second, the current produced by the solar panels needs to be observed. Unlike the voltage, the current changes drastically when the angle of the solar panels is changed. By measuring the amperage with a digital multimeter it can be seen that maximum current is gained when the angle between the sun rays and the solar panels is 90 degrees. At this point around (± 0.02) 0.76 A (amperes) are produced. If the angle is increased by 45 degrees (making the panels parallel with the ground) the amperage is reduced on 0.65 A (amperes). Similarly, when the angle is reduced from the best position (that is when the panels face the sun) by 45 degrees, the amperage is reduced but now on 0.55 A. When the solar panels are set parallel with the sun rays, a small amount of current is gained – 0.15 A.

The last thing tested is how much weight the robot can carry. The solar panels weigh 320 g. The Lego parts, together with the electromotor weigh 180 g, and together with the panels make a total of 500 g. Furthermore, this robotic system can carry additional 120 g (± 10 g).

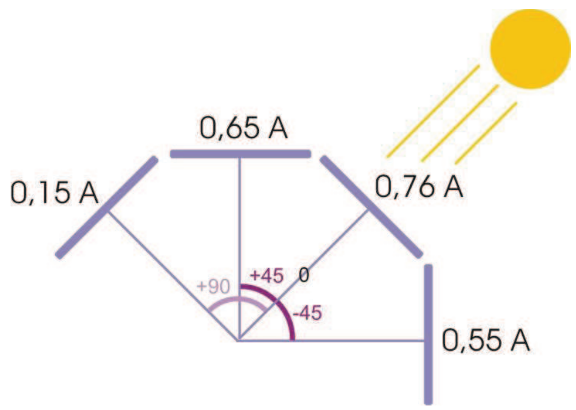

Figure 4: Change of the amperage when changing the angle.

VI. UPGRADING THE ROBOTIC SYSTEM

This robotic system is a basic frame that can be upgraded in many different ways, depending on the functionalities needed. Here we present some basic ideas that can be implemented on this system.

Since this robotic system requires light as the main energy source, the query is asked - what will happen if there is no light at all? In this case the robotic system should still remain functional. This can be achieved by adding a rechargeable battery that will charge itself when the robot is hit by light and supply the robot with energy when there is no light.

Even with the rechargeable battery the robotic system presented in this paper is not intelligent. So the next thing to do is adding a controller in the system with a particular functionality as shown on the Figure 5. For example, the controller can decide when the robot should charge and when the robot should move. Adding additional sensors to the controller will make the robot even smarter.

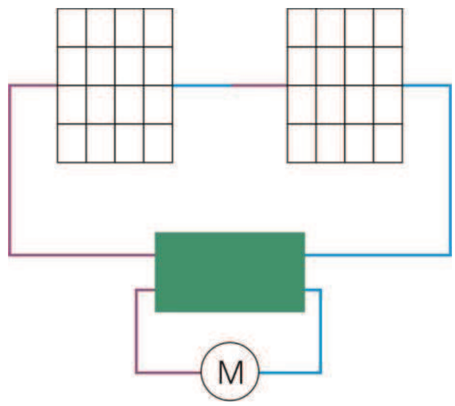

Figure 5: Scheme of upgraded robotic system with a controller.

VII. CONCLUSION

Making a self-sustainable human-independent robotic system develops two main ideas. The first one is creating a robot that can work on some projects without any human help. The second one is using a renewable power source as main energy supplier. Combining these two concepts, very powerful robotic systems can be assembled contributing to the whole aspect of the life in future.

This paper describes the beginning of the process in which a self-sustainable robotic system is created. This is a very stable platform which can be easily modified and upgraded. Adding new features, such as controller and sensors, will make this robot more intelligent and adaptive to the human needs.

VIII. ACKNOWLEDGEMENT

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