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Minirobot controlled by means of an external sensorial equipment

ABSTRACT

In the case of a minirobot without embarked sensorial equipment there are 3 entities will exist in this situation: the operating scene; the minirobot; the sensorial equipment. A pneumatic minirobot and an optoelectronic sensorial equipment ware design by the authors in different stages. For the control of the minirobot it was used the parallel port of the computer and the Labview Software, independently with the sensorial equipment who was controlled using a computer by the intermedium a acquisition board and the Labview Software, in different first stages. Thereafter the first steps were taken in order to perform the interaction between the optoelectronic equipment of surveillance and control with the minirobot. The final aim is to draw up a single interactive programme that must control both pieces of equipment based on the two existent independent programs. The authors aim to approach this subject by means of a gradual development, ranging from simple module programmes to complex module programmes. This would enable the reuse of this subject in other stages too, with contributions based on previous experience.

INTRODUCTION

IN THE MINIROBOTS CASE, THE SENSORIAL EQUIPMENT EMBARKED ON these fills in many situations a great volume comparable with the gauge of the minirobot. The displacement of the minirobot (fig. 1) with sensorial equipment on a independent tracking and control plant (fig. 2) simplifies the minirobot construction and its handling, diminishes its price and allows its miniaturization. Thus, 3 entities will exist in this situation: the operating scene; the minirobot; the sensorial equipment, unlike the commune situation with only 2 entities, when the minirobot has the sensorial equipment on its structure. For the new situation, the (real) operating scene must be apriori known, by means of a mapping process, for instance. She must have an informatics equivalent, which will be created by means of several programmes: the virtual operating scene for the evolution of a virtual minirobot. The sensorial equipment for tracking and control determines every moment the position of the real minirobot in the real operating scene. Any control of the real minirobot must be preceded, at a given moment, by a control of the virtual minirobot in its motion in the virtual scene. If the virtual minirobot motion in the virtual operating scene is possible, then that particular control may be applied to the real minirobot. If the ordering of the virtual minirobot, which moves in the virtual operating scene, leads to a impossible situation in the real operating scene, then the computation unit attached to the optoelectronic sensorial equipment analyses the solutions according to programmable criteria, which must find the possible solution in the virtual operating scene in order to execute the correct command in the real scene.

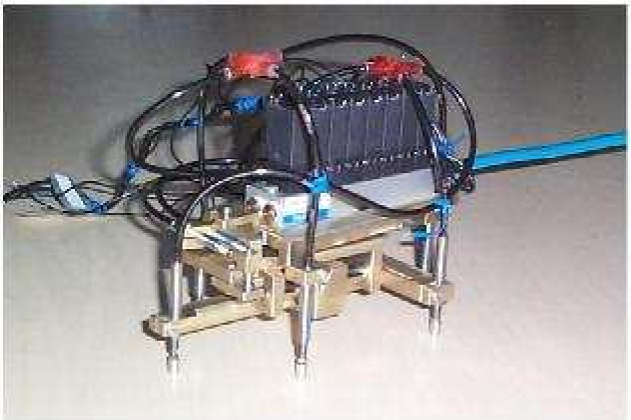

Fig. 1. View of the walking minirobot.

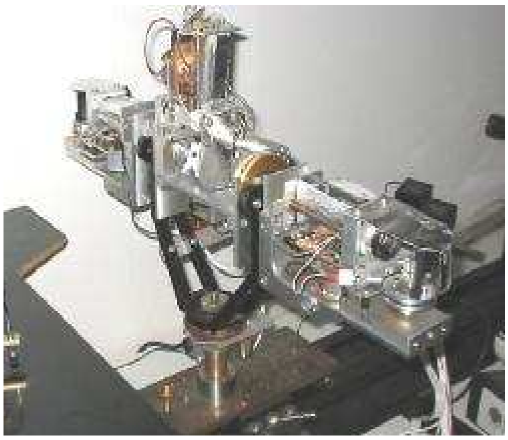

Fig. 2. Photo of the optoelectronic equipment.

In order to control the minirobot by means of the optoelectronic equipment, in the context of the two coexisting independent programmes for the two entities (minirobot and equipment), the following steps are taken:

1. Completion of the existing programme that controls the optoelectronic equipment with the programme controlling the minirobot and which can be operated in two ways:

- manual control for the exemplification of the 9 elementary moves of the minirobot;
- control for a programme sequence, which can be developed by the programmer.

The result of this step is the fact that the programme of the minirobot, included in the programme of the optoelectronic equipment, would be supplemented by the location co-ordinates of a light beam source which is attached to the minirobot.

The design of a simple programme for a straight line back and forth movement, within the limits established by the user. In this way, the minirobot movement will be controlled by the optoelectronic movement within the ambit established by the user and not through the setting of a certain number of steps to be executed by the minirobot.

THE MINIROBOT

FOR THE CONTROL OF THE MINIORBOT IT WAS USED THE PARALLEL PORT of the computer and the labview software. An interface was used as a power amplifier. The power amplifier has been made using an ULN2803 Darlington transistor array which consists of 8 npn Darlington pairs with a collector-current rating of each pair of 500 ma, being a very good choice as an interface between the low level logic circuits and the power circuits.

The pneumatic minirobot can be controlled in two ways, as follows: by manual controls (step by step) or by groups of controls in the form of a program. Fig. 3 shows the panel for the case in which the robot is controlled by a sequence of commands in the form of a number of steps and a direction of motion.. The controls sequence is specified in the left part of the panel. In order to start to perform the commands the button OK has to be pressed.

To each direction corresponds a group of 2 letters showed in the right central part.

After the commands are initiated, in the upper part are shown some fields in which there are indicated the number of the current command line, the command content and the state of the current command.

When the specified command is not among the indicated ones or when it is reached the end of the commands set, the program stops and the user is informed of this by the last field. In order to start the program again is necessary to press the Ok button again, just after the wrong command has been corrected.

The control of frequency, similar for the two panels, offers the possibility of setting the delay time for the component movements of each command. This time is set depending of the application. A very short time results in a heavily mechanical loading of the robot while a long one in low speed displacements.

Fig. 4 represents the diagram corresponding to the time command of the program. This modality is based too, on the step by step actuation logic to which has been added the possibility of recognition and interpreting of the command lines from the working sequence indicated by the user and also the signalling of a line which is not part of the possible commands and of the end of the program.

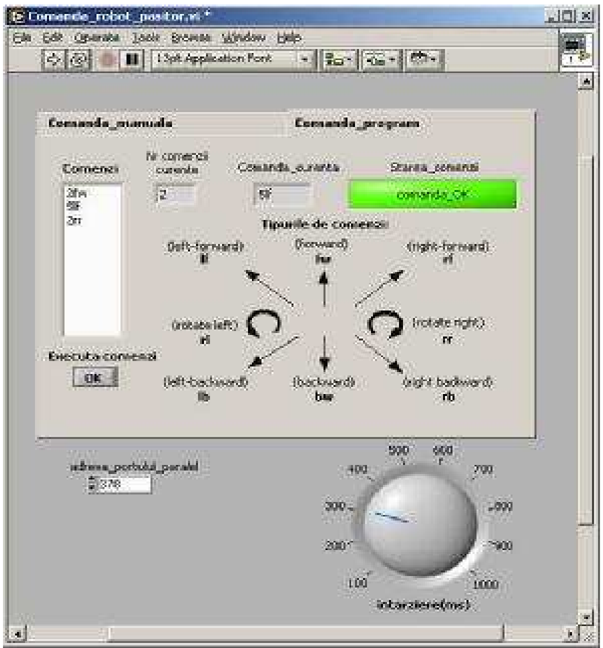

Fig. 3. The frontal panel for sequence control.

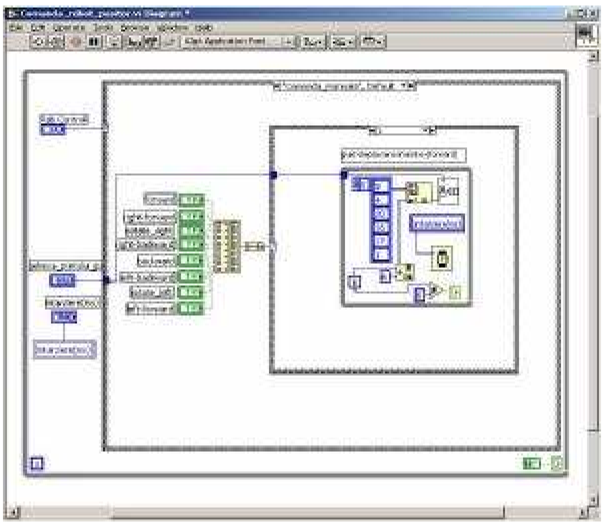

Fig. 4 The diagram for manual control.

THE OPTOELECTRONIC SENSORIAL EQUIPMENT

THE OPTOELECTRONIC SENSOR DETERMINES THE SPATIAL POSITION OF A number of p_j light sources, placed on a movement object (e.g. on a minirobot that must be controlled). The photo of this sensor is shown in fig. 2 and its drawing is shown in fig. 5.

The optoelectronic sensor is in fact an installation based on three identical modules, named M_1, M_2 and M_3, which materialized a three-dimensional coordinate system at which the controlled displacement of a mobile object (minirobot – mr) is referred.

The characteristic element of each module is a rotating mirror. By means of an objective, the mirror places the light source image on a linear photosensitive sensor, whose axis is parallel with mirror axis. Also, each module has three coplanar photo-collimators placed perpendicularly on mirror axis. The angles between the photo-collimators are known. The first photo-collimator represents an IR LED and the other two are receiving IR sensor each. Three counters start when the perpendicular on the rotating mirror coincides with the bisector of angle between first and second photo-collimator. The first counter stops when the mirror perpendicular coincides with the second receiver collimator axis. The next two counters stop when the images of the other two light sources "touch" the linear photosensitive sensor. The electric pulses countered by the counters allow computing the rotating mirror angular velocity and the angle between the plane defined by mirror axis and light source P_1 and the plane xOy of the spatial orthogonal reference system.

Reference [2] presents the mathematical model of a module and is shown that the ratio of geometrical angles is equal with the ratio of time periods able to be measured by the module. Also, is shown that the ratio of measured time period does not depend of the angular velocity of the rotating mirror, variable in time of motor cause. Thus, each module can transform the geometrical angle into a time period, which can be easier analyzed. The three identical modules, which materialize a spatial orthogonal reference system, build an optoelectronic installation able to determine by triangulation the position of a light source from space coordinates of the two light sources, as shown in Fig. 6. For three light sources attached to the movement object, which are not placed in straight line it is possible to calculate their spatial position and therefore the normal direction on the plane determined by the three light sources.

An acquisition board NI-DAQ 6602 connected to a PC is used in order to determine the position in space of a punctiform source of light, situated on a minirobot. The data acquisition programme is developed in the LabView Programming Environment. The user panel of the application is shown in fig. 7. In the right corner, in windows that were created in this purpose, the angular speeds of the three modules are indicated, whereas the coordinates of the luminous source are shown in the upper part.

Table 1 presents a series of data, which were gathered by means of the application LabView determining the position of a luminous source (x, y, z, in conformity with fig. 5).

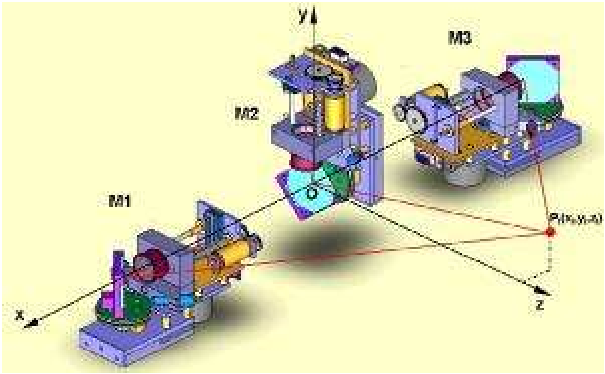

Fig. 5. The Optoelectronic sensor, which materialized a three-dimensional coordinate system.

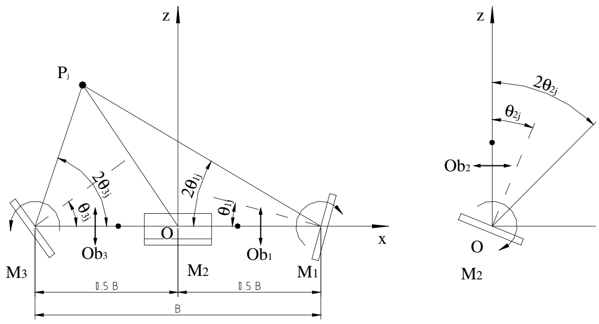

Fig. 6. Calculus schema for the triangulation method.

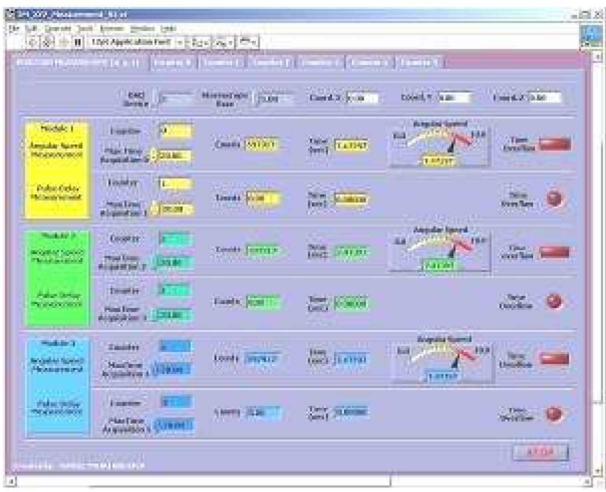

Fig. 7. The user panel for application with a single light source.

The experiments that were realized enabled the determination of the position of the luminous source on the three axes, with a precision of ± 1,5 mm.

Table I. The coordinates of a light source, which were acquired with a Labview application

	Basic stereo	X [mm]	Y [mm]	Z [mm]
1	529	27.22224	64.29427	853.14961
2	529	28.33222	65.51634	854.58815
3	529	27.92919	64.09133	854.64330
4	529	27.99536	63.61816	852.56374
5	529	26.13143	65.30944	853.52481
6	529	26.41362	64.24659	852.91797
7	529	28.04854	65.26615	854.24497
8	529	25.90209	62.87971	854.03430
9	529	27.55185	65.37757	851.78131
10	529	27.22224	64.29427	852.14961

The utilization of optoelectronic equipment in the minirobot navigation is limited by the appearance of some three-dimension obstacles in the working space. In this aim, the authors focused on conceiving some sensorial equipments which should not be affected by such type of limitations.

CONTROL OF THE MINIROBOT WITH THE OPTOELECTRONIC EQUIPMENT

THE TWO INDEPENDENT PROGRAMMES FOR THE CONTROL OF THE minirobot and of the optoelectronic equipment were developed in such a way that they might be divided into subprograms. This approach enables any changes or developments to be carried out in the initial programmes. In LabView programming environment, in order to develop a subprogram based on a programme, the connectors of the Virtual Instruments (VI) module must be linked and an icon must be created. Eventually, it only takes to call upon the VI module in another programme.

The minirobot can be operated by the optoelectronic equipment with the help of the created subprogram. For the beginning, in order to test the subprogram, a simple application was taken into account: the monitoring command of the straight line movement of the minirobot along axis Z of the optoelectronic equipment (see fig. 5) confined in between two points. Actually, the minirobot moves in between the two straight parallel borderlines A and B, in a straight angle on axis OZ of the optoelectronic equipment. A simple click on the Run button will operate the minirobot. The current movement is signalled by enabling one of the LEDs “Backward” or “Forward”. The screen (display) indicates the exact location of the minirobot in connection with the two border lines. It is used as subprogram in the minirobot control programme. The box called “Sub-program” (lower left hand corner in front panel, image 8) is used by the main program, when this program is used as a subprogram.

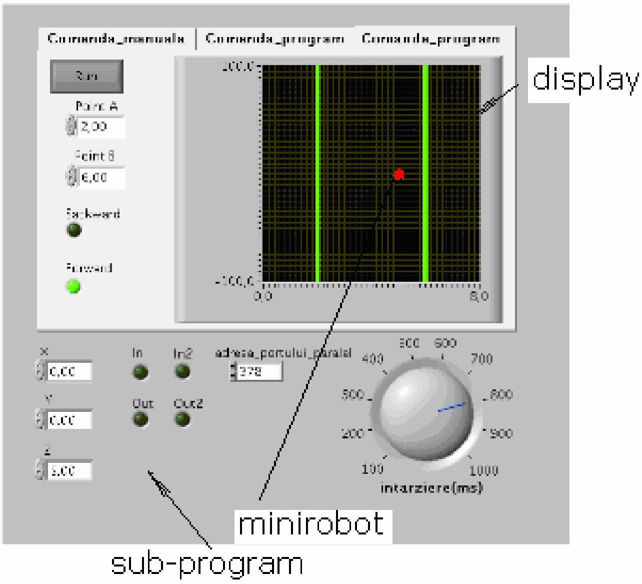

Fig. 8. The user panel for control of the minirobot
by optoelectronic equipment.

Integrating the above mentioned subprograms into the same program, one can control the autonomous minirobot, spotted in the working space by the optoelectronic equipment.

CONCLUSION

The paper aimed to create in a Labview environment a program enabling the operation and control of a minirobot in the working space by means of an optoelectronic equipement. The minirobot does not have any built in sensors. It only has a light beam source.

Initially, the two pieces (the minirobot and the optoelectronic equipment) used to function with two separate independent programmes developed in Labview environment, as part of previous research projects. Eventually, a single interactive program was designed in order to operate both pieces of equipment based on two existing independent programmes.

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[2] Panaitopol, H., Bacescu, D., Petrache, S., Iashiu, D., “Walking minirobots” , 50. Internationales Wissenschaftliches Kolloquium 19.-23.09.2005; Mechanical Engineering from Macro Nano, Technische Universität Ilmenau, Proceedings, ISBN 3-932633-98-9, p.405- 407;

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