Algorithms for Control of a Line Robot

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***Abstract* – The paper introduces authors' research on movement algorithms of a line robot on a preset trajectory. A scale model of the robot based on a single-board microcontroller was created. The paper outlines the apparatus and devices as well as the implemented control algorithms.**

***Keywords* – robot, control algorithms, sensor, single circuit board microcontroller, motor.**

I. Introduction

The last few years saw a number of new highly technological products with an optimal life cycle developed in the area of mechatronics. Robots incorporate:

- precise mechanics and mechatronics;
- highest level of information technologies designed for processing digital and analogue data [1];

Robots feature intelligent action control depending on the kind of tasks that have to be accomplished. This can be achieved by receiving feedback from sensors.

The tasks of controlling a mobile object can be divided into several groups according to the methods and resources used for collecting information.

This paper studies algorithms for controlling a robot on a trajectory predetermined by means of a line.

II. Technical implementation

The modular scheme of the technical implementation of the system is shown on fig. 1. The system uses the following modules:

- single-board microcontroller;
- data processing module from analogue sensors;
- data processing module from digital sensors;
- communication module (interface module);
- operator interface module;
- motor command module;
- real-time clock module;

There are two alternate ways of powering up the system – either by an external 9V source or by an accumulator battery. The external dimensions of the robot are 20x12 cm.

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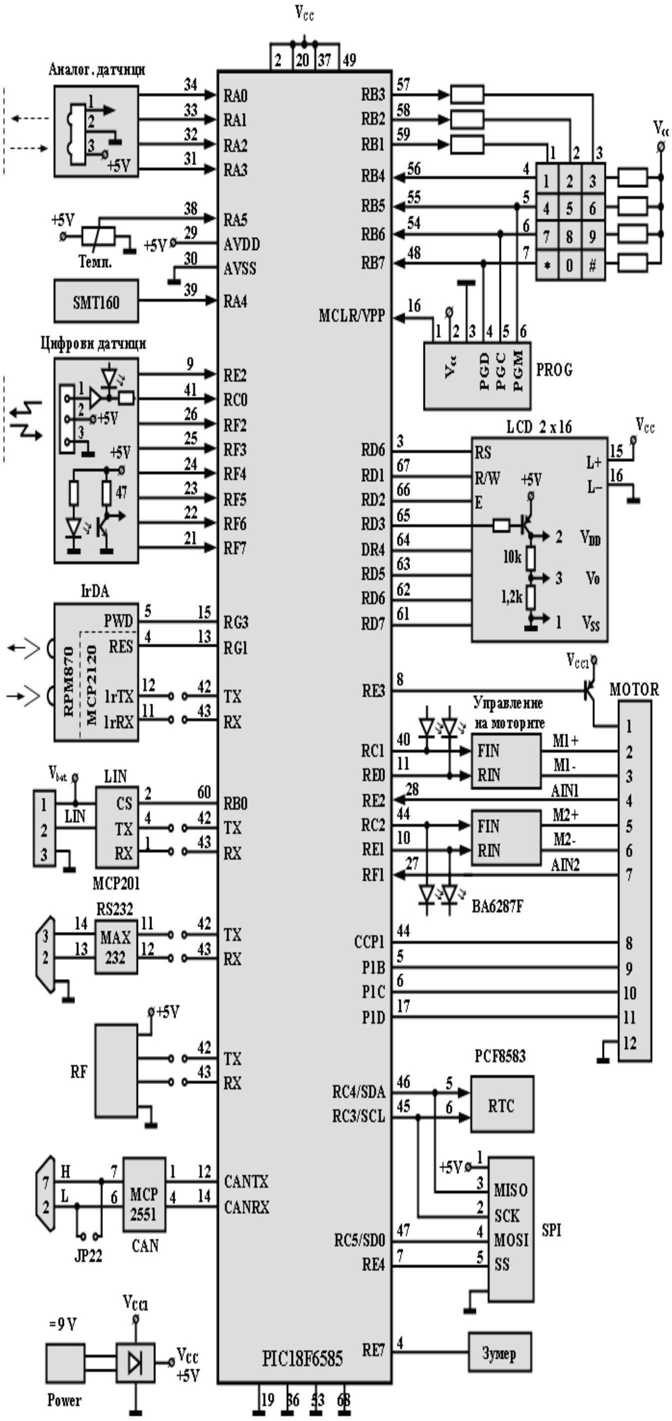

Fig. 1 Technical implementation

III. Control Algorithms of a Line Robot on a Preset Trajectory

The type of the robot control algorithm depends mainly on:

- the data processing modules from the analogue and digital sensors;
- the DC motor command module.

The sensors used in the system are analogue and ON/OFF sensors. The type and the number of the sensors as well as their location in the system determine the algorithm used for controlling the object as they provide information about the position of the object in relation to obstacles or the preset track. The platform utilizes two analogue sensors – one measuring the distance in front of the robot and another measuring the distance to the left. The sensors work on the principle of measuring reflected infrared light. The distance to the object is determined on the basis of reflected light readings.

When the track is marked by a line (black or white) the ON/OFF sensors come into play. The number of the ON/OFF sensors is five. They are placed in a straight line at 2 cm intervals 5 mm above the surface of movement. They work by measuring reflected infrared light recognizing the surface colour beneath the sensor. If it is white the reading of the sensor is 1 and respectively, the reading is 0 when the colour beneath the sensor is black.

The DC motor command module consists of two similar circuits based on the BA6287F chip. The chip allows the motors to function in one of the following modes:

- forward movement;
- stop motion mode;
- reverse movement;
- stand-by mode.

The single-board microcontroller controls the direction and speed of rotation of the motor. Alterations in the speed are achieved by means of signal with wideband impulse modulation generated respectively by PWM1 modules for the first motor and PWM2 modules for the second. The saturation coefficient of the impulse is programmable and proportionate to the rotation speed of the motor and therefore to the speed of movement of the robot.

A. Contour following algorithm based on special points

A sample contour of robot's movement is shown on Fig. 2.

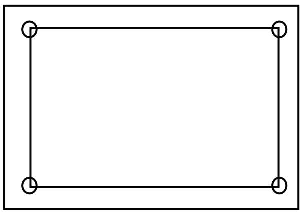

Fig. 2 Movement contour with special points

This particular movement contour is closed. It has a rectangular shape. The main difficulty in this algorithm is maintaining continuity of velocity and acceleration in the special points. The trajectory set by each side of the rectangle is reduced to a Bezier function with six supporting points. Starting and pulling off is achieved at zero velocity and acceleration. The problem is solved by doubling the supporting points. Each section is described by a 5^{th}-degree polynomial. Nevertheless, the movement follows a straight line. [2]

B. Straight line movement algorithm

The robot is set in motion by two DC motors with reducers. The classic design motor is controlled by changing the voltage. The momentum of the high speed revolution motor cannot be applied directly to the wheels. The use of reducers is indispensible. The control is accomplished by changing voltage. The need for corrections in velocity is induced by various disturbances as:

- unevenness of the track;
- wheels do no spin with the same speed, etc.;

These disturbances lead to diversions from the perfect trajectory of movement. The possible diversions are shown on Fig. 3.

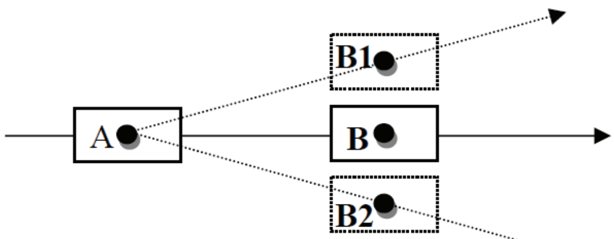

Fig. 3 Types of deviations

A smooth-surface track should be used in order to test the straight line movement of the robot. In the straight line movement the velocity back and forth is fixed. If diversions from the movement line occur, the algorithm is adjusted by increasing or decreasing the speed of one of the motors.
If the robot has to move with maximum speed, 5V current is supplied. If lower speed is desired, the voltage is decreased accordingly. For achieving average speed of movement the robot is supplied with 5V current at first and then the voltage is decreased to 0V. The voltage values [0, 5] corresponding to the robot's movement has to be represented using a table.

C. Movement along a line set trajectory

Labyrinth movement algorithms can be used for achieving movement along a preset trajectory. Information about object's orientation and position is received by reflective sensors placed on the bottom side of the robot. They are placed at 5 – 6 mm intervals. There are two possible scenarios:

- following a white line on a dark surface;
- following a dark line on a light surface.

The difference between the two scenarios is the choice of active value.

The arrangement of sensors is shown in Table 1.

TABLE 1
THE ARRANGEMENT OF SENSORS

L2	L1	C	R1	R2
1	1	0	1	1

Left Centre Right

The represented system comprises five information components. Their position in relation to the line is as follows:

- 1 1 1 1 0 → the line is in rightmost position
- 1 1 1 0 1 → the line is slightly to the right
- 1 1 0 1 1 → central position
- 1 0 1 1 1 → the line is slightly to the left
- 0 1 1 1 1 → the line is in leftmost position

The graph is shown in Fig.4

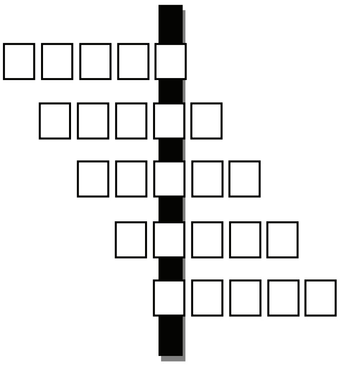

Fig.4 Position on five sensors

The sensor reads 1 when it is on a light surface and 0 when it is on a dark surface.

The received information is used for a pattern to define:

- the current position of the robot;
- subsequent actions (follow-up);

The presence of five sensors determines 32 possible combinations. Some of them are less likely to happen for the purposes of the current task. With inputs such as 0 0 1 1 0 ,1 0 1 0 1, etc. robot's behaviour is hardly determinable.

When the robot reaches a barrier the readings of the sensors change from „11011" to „11111". In this situation the robot has to stop.

IV. CONCLUSIONS

Practical testing of the proposed algorithms is carried out with two options available to reflective sensors - straight line and triangle. In both versions are achieved the objectives, as 32 commands in both cases are different. It is envisaged to situate markers in the form of white spots inside the wheel with directed at them additional reflective sensors. This will allow for feedback on speed and apply the algorithms for speed control of each of drive wheels, which will improve the management of the robot. A significant moment in the control algorithms is driving the robot to the final goal overcoming the existing obstacles in the environment.

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