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Production Workspace Obstacle Avoidance Mobile Robot Trajectory Modeling

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Abstract. *Abstract. The paper describes a method for determining the trajectory of a mobile robot inside a production workspace among obstacles. To determine the path of movement, a navigation system is used, which determines the robot's own coordinates, plans the trajectory at the current time and controls its movement. A software tool for modeling the behavior of a mobile robot taking into account the properties of its mechatronic platform is proposed. The model of the adaptive control system of the mobile platform is described. The block diagram of the program for modeling the method of finding the optimal way to move a mobile platform among uncertain obstacles is considered. The simulation results are given.*

Keywords: *Keywords: mobile robot, navigation system, optimal way, model, program, C#.*

I. Introduction

To implement the concept of Industry 4.0 in production, the use of mobile robots to combine industrial equipment into one integrated production process is of particular importance. The task of using robots in a human environment is very difficult. First, it is necessary to pave the way for mobile vehicles to move among objects whose positions are changing dynamically. Secondly, it is necessary to ensure the safety of workers who service the equipment through the use of intelligent sensors.

This paper considers the solution of an important problem - determining the method of optimizing the trajectory of the transport robot in the production workspace among the inhomogeneous obstacles to reduce the duration of transport operations [2 - 4].

II. Method of Determining The Traction of Motion in An Undefined Environment

The proposed method is a combination of the method of finding the optimal trajectory of movement, when all obstacles are identified, and the method of visual odometry to determine changes in the surrounding space [3]. By combining these two methods, we get the opportunity to constantly search and analyze the location of new obstacles that appear in the surrounding space, and quickly respond to changes in real time.

Tasks of the adapted visual system [6]: determination of the location of the robot in the initial position and when moving; orientation of the work in space and relative to the starting point; identification and tracking of objects in the workspace; allocation of impassable areas.

For the analysis of the environment the method of visual odometry is used, the essence of which is stated in the previous sections. This method allows you to link obstacles to a local map. The found changes are immediately applied to the map and then used to lay the optimal route [2-5, 8]. Laying the route according to the map is done using the algorithm A * [5].

Thus, we have three independent processes: obstacle search, map modernization and route planning. The proposed method is similar to the well-known principle of moving robots in space, which is called SLAM (method of simultaneous navigation and mapping). The difference is that in the traditional method, the robot has no idea about the surrounding space and the first step is to study space and build a map.

In our method, the map is already known and loaded into the mobile device's memory. For example, this is very often the case when the robot is working on a production workspace where the location of the equipment is known in advance.

At the first stage there is a fast paving of a way from a starting point to the set purpose. In the process of moving the work, he constantly scans the simple and monitors changes in the surrounding space. Changes can be caused by the appearance of a person in front of a mobile device, the appearance of another mobile robot, or the movement of products.

Thus, having determined the location of a new obstacle or its disappearance, the robot control module adjusts the trajectory of movement, and determines the optimal route for this current situation. The proposed algorithm is embedded in the following model of the adaptive control system of the mobile platform in an indeterminate environment, shown in Figure 1.

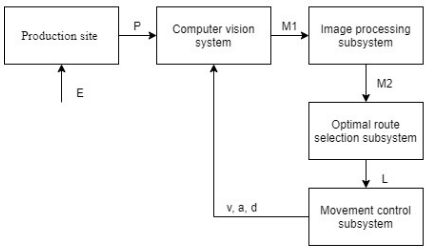

Figure 1. Model of adaptive mobile platform management system

The environment consists of objects that do not move and are elements of equipment (O) or room structures, as well as moving objects such as humans or other mobile robots (U).

Thus, each point in space can be represented:

$$P^* \{[O1, O2...], [U1, U2...]\}. \quad (1)$$

The environment can be described by a set of reference points that make up the spatial background that hinders or does not hinder movement:

$$P = \{P^*1, P^*2, \dots P^*n\}, \quad (2)$$

where P^* – is coordinates of reference points of objects in the room; n – is the number of reference points in space.

$$M1 = \{S, W\}, \quad (3)$$

where S - is method of determining visual coordinates; W – is method parameters.

The parameter L is described as:

$$L = \{\Delta X, \Delta d\}, \quad (4)$$

where X – is the localization of the mobile platform; d – is the direction of movement of the platform.

At the output of the motion control subsystem we get the parameters of influence on the movement of the mobile platform, and hence on the displacement of the computer vision system, which is rigidly connected to the platform (v, a, d). The parameter v describes the change in platform speed. Parameter a describes the angular displacement, and parameter d is the direction of motion.

III. Program For Modeling an Adaptive Mobile Platform Management System

Based on the preliminary analysis, the software tool for modeling the method of finding the optimal way to move the mobile platform among uncertain obstacles has the following independent processes: a) TraceRoute, which is used to build a trajectory based on data about the obstacles found; b) TimerProces – an independent complex process that runs the following functions: space scanning and obstacle search; visualization of the effect of the scanner of the surrounding space; restructuring of the virtual map; c) moving the digital duplicate on the virtual map of the production environment in the found way.

Figure 2 shows the structure of the software.

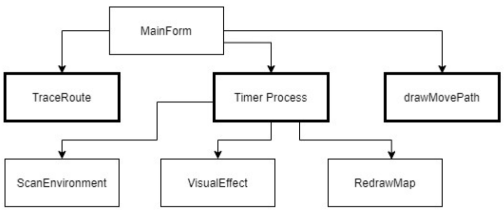

Figure 2. Block diagram of the program for modeling the method of finding the optimal way to move the mobile platform among uncertain obstacles.

The drawScan () function is used to visualize the space scanning process. To combine all processes, a timer model time calculation function has been developed.

When the movement of the mobile platform is completed and the end point is reached, the timer is turned off and the drawMovePath function is called to visualize the path traveled.

The path is drawn from the data stored in the MovePath array. In this array are entered all the points at which the mobile robot was in the process of movement. The MovePath array changes the mobile platform offset feature. Figure 3 shows an example of the algorithm in the first steps and the result of paving the way.

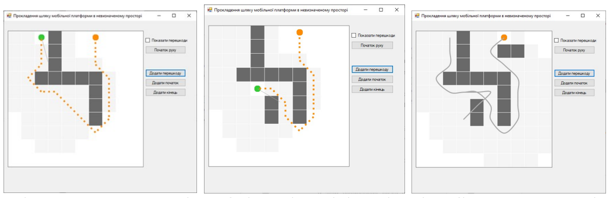

Figure 3. Example of the algorithm in the first steps and the result of paving the way

The path may pass through existing obstacles because at the time of the previous passage they did not exist, but they appeared when changing the trajectory and were taken into account when laying a new path.

IV. Conclusions

In this work, experimental studies of the practical use of the proposed method of laying the optimal path of movement among uncertain obstacles were performed. Simulation (software) modeling was used for this purpose.

The block diagram of the program for modeling of a method of search of an optimum way of movement of a mobile platform among uncertain obstacles was developed. The program is written in the C # programming language in Visual Studio. The developed method of finding the optimal trajectory was tested in practice and the result of the simulation model showed its efficiency. Algorithm A * is used to route.

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