USAGE POSSIBILITIES OF MOBILE ROBOTS WITH MANIPULATION BODY IN COURSE OF PRODUCTION PROCESSES AUTOMATIZATION

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A***bstract:*** *The article presents the description of mobile modules (chassis) with manipulation body for the automatization of production processes. From this point of view their basic classification according to different standpoints is mentioned and the possibilities of practical usage are shown. The more detailed attention is devoted to the description of designed mobile robots with the manipulation body and possibilities their use for concrete applications. We can achieve an universal usage by suitable combination of manipulation body and mobile module.*
Key words: *mobile robot, chassis, manipulator, transportation.*

1. INTRODUCTION

The sphere of engineering and non-engineering production bear wide possibilities for the application of industrial robots and manipulators. Except this group of robotic means also the mobile robots can find an exercise in many cases. The mobile robots may realize series of service tasks, which can link to the production operations performed by industrial robots. They will find applications also in other service activities in course of the automation production processes realization.

2. REQUIREMENTS ON MOBILE ROBOTS IN PRODUCTION PROCESSES

The requirements on mobile robots in the production process are different from requirements on industrial robots. They follow from principles of performed activities. Industrial robots practice the same or similar repeated activities in closely defined working space [4]. On the other hand mobile robots are intended for practice of activities, which do not repeat and their working space can be erratic. They vary also in this that they realize almost entirely service processes and have to respond to moving obstacles in terms of their translocation from starting to the objective point. They may move in doing so into indoor or outdoor environment [2, 3]. The mobile robots exploited in the production can be classified in accordance with different standpoints like e.g.:

- according to the type of locomotive mechanism on: a) wheel
  b) belt
  c) hybrid
- according to the body of locomotive mechanism on: a) without body
  b) with manipulation body
  c) with technological body
- according to the control method: a) autonomous locomotive robots
  b) mobile robots guided by an operator
  c) automatic traffic trucks
- according to the loading capacity a) up to 10 kg, 100 kg, 500 kg
  b) over 500 kg
- according to performed activities:
  a) handling - in interoperational transports for material handling,
  in store economy, work pieces inspection and sorting,
  b) assembly - parts withdrawing from containers and their assembly,
  c) environment identification - moving in dangerous environment, e.g. crashes
  d) service activity - inspection activity for removing the failure possibility e.g.
  in stores with dangerous waste,
  e) transport - material and equipments transfer on the requisite place,
  f) inspection activity - inspection and verification of dangerous processes,
  g) other activities
    - according to the environment characteristic where robots will move,
    - other.

The mobile robots with the manipulation body can be used for the manipulation, assembling and transport activities. It may be the question of autonomous robots or robots guided by an operator. From the point of view of the load capacity for the manipulation body and whole robot all the mass categories of these robots may be included [1]. The considerable requirement scatter influences the chassis construction and the manipulation body. Mobile robotic systems with a manipulation body may be solved for activities in partially known or unknown environment with variable scenes etc. In the case of autonomous robots the information from the outer and inner sensorial subsystem has to be processed.

Their activity unwinds from processing exact mathematical models for the defined environment and the time of activities. The robot navigation in the environment is realized by data processing of outer sensors and by position evaluation in dependence on the robot trajectory speed. Data processing and all calculations have to be compiled in real time.

3. MOBILE ROBOT WITH MANIPULATION BODY

For handling, service activities or transport also the mobile robot construction with the manipulation body designed in the Department for Robotics, Faculty of Mechanical Engineering, Technical University of Ostrava. The model robot scheme compiled in Pro/ENGINEER system is shown on Fig. 1.

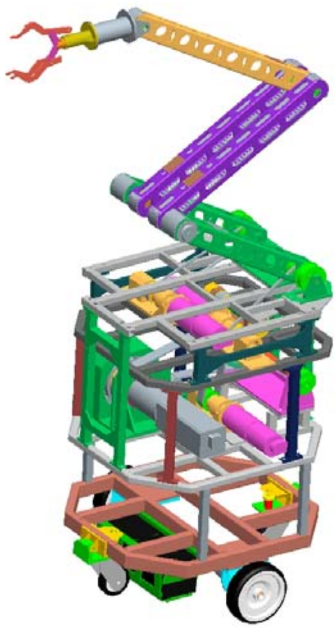

Fig.1 *Designed mobile robot construction*

The chassis of the mobile robot is designed as four-wheel with difference method of the control. The trajectory control of robot movement is realized by different rotation of driving wheels, eventually by reverse direction of their rotation. This solution makes possible to turn the robot in place around its vertical axis what can be an advantage especially during its maneuvering in close spaces or corners. On this account the circular shape of grand plan projection was selected. The chassis includes several levels. The control computer will be located under the basic frame in the space beside batteries. By this solution the certain compactness of the chassis construction is achieved and at the same time the chassis centre of gravity is moved down. The operation security will be ensured by contact segments located in the under part of the chassis [5]. The electro motors for turning all joints of the manipulation body with three degrees of freedom are placed in the upper levels. The transformation of the rotary movement in all joints is solved by means of belts and pulleys. On the interface of the manipulation body the gripper head or an anthropomorphous gripper can be fixed. For driving the chassis as well the manipulation body the MAXON motors are used. The operating range of the manipulation body takes 1,2 m with its load capacity of 5 kg.

The robot movement on the required trajectory is given by a mathematical model of the chassis. The kinematic scheme is shown on Fig. 2.

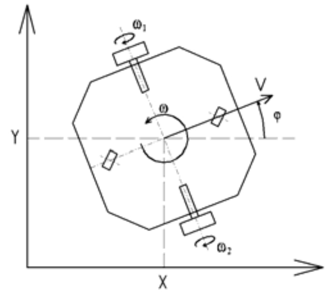

Fig.2 *Position and orientation designation of the chassis*

According to the mentioned designation on the Fig. 2 it can be written:

$$\dot{x} = v.\cos\varphi ,$$
$$\dot{y} = v.\sin\varphi , \qquad (1)$$
$$\dot{\varphi} = \omega ,$$

where x, y and φ - are positions and orientation of the chassis,

v and ω - are peripheral and angular rotary speeds of the whole chassis.

The formulation of peripheral speeds v_1 and v_2 is given by angular speeds of driving wheels ω_1 and ω_2 and their radii R_1 and R_2 and can be gained by gradual substitution:

$$\dot{x} = \frac{\omega_1.R_1 + \omega_2.R_2}{2} \cdot \cos\varphi ,$$
$$\dot{y} = \frac{\omega_1.R_1 + \omega_2.R_2}{2} \cdot \sin\varphi , \qquad (2)$$
$$\dot{\varphi} = \frac{\omega_2.R_2 - \omega_1.R_1}{l} .$$

Integrating the system of equations (2) the chassis position regarding to the origin of the coordinate system (x_0, y_0, φ_0) can be defined. This model can be schematically presented by the scheme shown on the Fig. 3 where (x, y) are functions of angular speeds (ω_1 and ω_2).

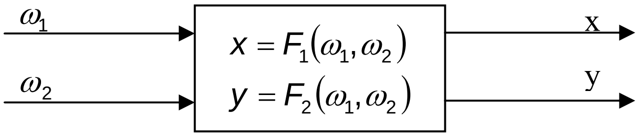

Fig.3 *Block diagram of the position determination*

Inverse functions to the F_1, F_2 functions are G_1, G_2 functions that can be expressed again from the equation system (2) for angular functions ω_1 and ω_2:

$$\omega_1 = \frac{1}{R_1} \cdot \left(\frac{\dot{x}}{\cos\varphi} - \frac{l.\dot{\varphi}}{2} \right),$$

$$\omega_2 = \frac{1}{R_2} \cdot \left(\frac{\dot{y}}{\sin\varphi} - \frac{l.\dot{\varphi}}{2} \right), \qquad (3)$$

$$\varphi = arctg\left(\frac{\dot{y}}{\dot{x}} \right).$$

This model can be schematically expressed by the scheme shown on the Fig. 4 where ω_1 and ω_2 are the position functions of x and y.

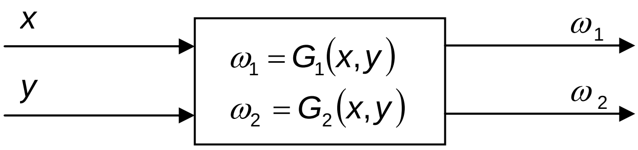

Fig.4 *Block diagram of the angular speeds determination*

The robot movement trajectory given by time functions x and y can be determined by controlling angular functions of both driving wheels ω_1 and ω_2. With respect to the difference control of the designed variant it will be valid $\omega_1 = -\omega_2$ for turning with the zero radius (turning around the centre of the driving chassis wheels common axis). The $\omega_1 = \omega_2$ relation is valid for the direct movement direction.

The designed mobile robot with the manipulation body can be used in production processes for example for following applications:

- manipulation with work pieces and tools up to the load capacity of 5 kg in terms of interoperational transport and in stores,
- realization of service activities for production sections,
- manipulation with objects in the dangerous environment
- other service activities.

The example of an alternative type of the manipulation body suitable also for the manipulation and transport is shown on Fig. 5. It is the question of the manipulation body, which has four degrees of freedom with the load capacity of 3 kg. It can be used in connection with the wheel or belt chassis. The MAXON motors are used again to drive all joints.

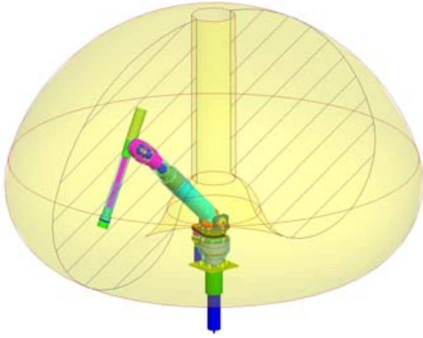

Fig.5 *Manipulation body of a mobile robot*

4. CONCLUSION

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