Chapter 37
Control System for Designed Mobile Robot – Project, Implementation, and Tests

Stanisław Kozłowski and Jarosław Majchrzak

37.1 Introduction

Thanks to highly sophisticated control techniques, modern mobile robots are capable of accomplishing advanced tasks. Briefly, mobile robots can be dived into two main branches: research devices and consumer devices. The firs class usually consists of prototypes used for testing and verification of various control algorithms. The latter is represented by efficient, dependable and fulfilling industrial safety requirements robotic vehicles, often distributed as closed systems. During the design and test phase, the imperfections of a completely custom design may not allow to perform advanced tests, thus lengthening the construction phase. In order to eliminate this problem, the authors have designed the robot so that its crucial parts were previously known, tested and proved to be reliable. The control system consists of distributed pieces of software and hardware, each of which accomplishes precisely defined tasks. A fast serial communication bus is used to exchange information, what makes possible the use of module elements of control system. The modularity of the control system in range of hardware and software allows easy modification of components of the control system (the exchange), the diagnostics of drives as well as the introduction of an alternative controller or a measuring sensor in case of breakdown. Moreover the presence of a communication bus makes it possible to integrate the control system with measuring devices and drives. The utilization of independent arrangements of control drives makes it possible to use synchronous drives with position or speed control, independently from the main driver, which enlarges control precision [3]. The robot served as a testbench for various control algorithms thanks to which it was possible to determine the effectiveness of the design.

Stanisław Kozłowski and Jarosław Majchrzak
Chair of Control and Systems Engineering, Poznań University of Technology,
ul. Piotrowo 3a, 60-965 Poznań, Poland
e-mail: `uisats@gmail.com`, `jaroslaw.majchrzak@put.poznan.pl`

K.R. Kozłowski (Ed.): Robot Motion and Control 2009, LNCIS 396, pp. 401–410.
springerlink.com

The kinematics of mobile robot is a subject to nonholonomic constraints. In the paper a lateral constraint of the kinematic model was considered. A kinematic model is described by nonlinear differential equations. Therefore, the steering of such vehicle requires the use of suitable techniques, for example dynamic linearisation. Moreover the system of 2-wheeled mobile robot is underactuated system, what results from its feature, that number of state variables $\boldsymbol{q}$ is larger than number of control signals $\boldsymbol{u}$. Considering these problems it is possible to use the control technique dependent upon time, e.g. a time-varying control [4]. The control in trajectory tracking task is executed usually with minimal variable error, which was bounded of admissible range.

The set point control depends on execution of robot to set point with set orientation after generated path. In an underactuated system with nonholonomic constraints, it is not possible to stabilize in zero with the help of static state-feedback (Brockett's condition). A solution exists applied in practice which requires the disconnection of steering in sufficient closeness to the point set. The Pomet's algorithm itself was chosen because it was previously evaluated in simulation and was fairly well known.

37.2 Robot Construction

The robot is a modular construction based on a welded frame and a rocker suspension system [1]. *LeoPart2* is equipped with two castor-type stabilizing wheels which will, in the future, have their own suspension system. The robot is equipped with high-torque synchronous motors integrated with wheels. The robot's drive system has been designed to be as simple as possible, yet very powerful. It consists of two units, one o them is presented on Fig. 37.1. The direct drive synchronous motor is mechanically coupled with the encoder using a rubberized shaft with a ratio of 1:9.53 (Fig. 37.1(a)). The local feedback loop includes analog Hall sensor data as well as digital encoder output. The entire assembly (Fig. 37.1(b)) is connected to the CANbus™[1] and powered from the battery pack. This pack comprises ca. 60% of the robot's mass. It supplies power to the drive system, motor controllers, sensoric circuits and the on-board computer controller. The robot has been designed to accomplish indoor (flat, levelled surface) tasks carrying a maximum load of 100 kg.

Assuming no skid, kinematics in the base coordinate system can be described by the following equations [5]

$$\dot{x} = v_x = v\cos\varphi, \qquad \dot{y} = v_y = v\sin\varphi, \qquad \dot{\varphi} = \omega. \tag{37.1}$$

All symbols are described in Fig. 37.2. Denoting the state vector as $\boldsymbol{q} \triangleq [\varphi \quad x \quad y]^T$ and the control vector $\boldsymbol{u} = [u_1 \quad u_2]^T = [\omega \quad v]^T$, where ω and v are the robot's angular and linear velocity in the base coordinate system, respectively, the following equation is obtained:

[1] CANbus Toolset™ CANopen is a registered trademark of CAN in Automation (CiA). CAN in Automation (CiA). is a trademark of ExpertControl GmbH, Germany.