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Cost-Oriented Mobile Robot Assistant for Disabled Care

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Abstract: This abstract describes briefly how mobile robot assistant system for disabled persons can be cost-effective. This is done by using a widely available on the market robot parts and a web based user interface. So this system can easily be controlled even over the Internet. To be a user-friendly the robot firmware and software implements various control algorithms – like PID based motor control and collision avoidance. This results in achieving a very smooth and precise movement and a control tolerant to operator's mistakes. Different methods for sending movement commands to the mobile robot system are proposed and evaluated. The robot will be able to remind disabled persons to take medications, it will serve pre-prepared food and drinks, will turn on/off electronic devices, will alert when his/her health is getting worse and will connect to his physician, relatives or with the emergency services.

Keywords**:** mobile robot, PID algorithm, web user interface, obstacle avoidance, Internet, ROS

1. INTRODUCTION

Control of mobile robots is a complex process that requires coordination and cooperation between many subsystems. When the robot is oriented and designed for helping elderly or disabled persons, its control becomes even more difficult and responsible task. It is important that the movement is executed with higher precision. Also, the control logic must be very tolerant to mistakes made by the operator. In this research we wanted to build an inexpensive and cost-oriented mobile robot assistant system for disabled care.

1.1 Mechanics

Our robot is based on a differential drive platform. This particular design has two motors mounted at fixed positions on the left and the right side of the robot *(Bräunl, 2008)*. They are independently driving one wheel each. Since three points are required to define a plane and our system is operating in a two dimensional plane, this design requires at least one additional passive caster wheel or a slider, depending on the location of the driven wheels.

We chose design with two passive wheels or sliders, one placed in the front and one at the back side of the robot. This allows rotation about the centre of the robot. However, this design can introduce surface contact problems, because it is using four contact points. The driving control for differential drive type mobile platforms is complex, because it requires coordination and cooperation of two separate driven wheels.

Figure 1 demonstrates the driving actions of a differential drive type robot. If both motors run at the same speed, the robot drives straight forward or backward, if one motor is running faster than the other, the robot drives in a curved trajectory along the arc of a circle, and if both motors are running at the same speed in opposite directions, the robot rotates around its centre on the spot.

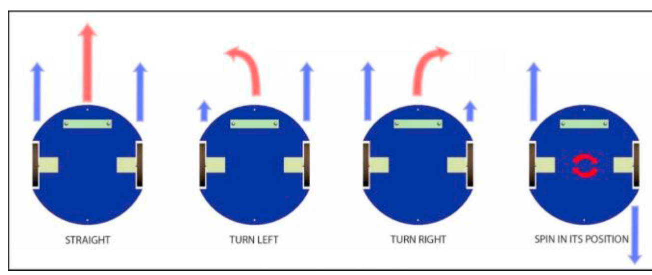

Figure 1. Driving and rotation of differential drive

- Driving straight, forward: $v_L = v_R$, $v_L > 0$
- Driving in a right curve: $v_L > v_R$, e.g. $v_L = 2v_R$
- Turning on the spot, counter-clockwise: $v_L = -v_R$, $v_L > 0$

Odometry is the most widely used method for determining the momentary position of a mobile robot. In most practical applications odometry provides easily accessible real-time positioning information in-between periodic absolute position measurements. The frequency at which the (usually costly and/or time-consuming) absolute measurements must be performed depends to a large degree on the accuracy of the odometry system.

Odometry computes the robot's relative horizontal displacement and change in orientation as a function of the incremental horizontal displacement of the drive wheels *(Borenstein, 1996)*. The latter is found from incremental wheel encoders as follows: Suppose that at sampling interval I the left and right wheel encoders show a pulse increment of N_L and N_R, respectively. Suppose further that

$$c_m = D_n/nC_e$$

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where

c_m - Conversion factor that translates encoder pulses into linear wheel displacement.

D_n - Nominal wheel diameter (in mm).

C_e - Encoder resolution (in pulses per revolution).

n - Gear ratio of the reduction gear between the motor (where the encoder is attached) and the drive wheel.

One can then compute the incremental travel distance for the left and right wheel, $U_{L,i}$ and $U_{R,i}$ according to

$$U_{L/R,\,i} = c_m\, N_{L/R,\,i}$$

We omit here the detailed development of the well-known odometry equations for differential drive vehicles. By improving the odometry we will have good positioning and localization.

1.2 Electronics

The mobile robot electronics consist of computer, robot control board, battery, camera, Kinect sensor, infrared and ultrasonic sensors, DC motors, wheel encoders, microphone and speakers. This is a short description of some of the components:

1.2.1. Robot controller: The Eddie Control Board provides a complete single-board solution to control the Eddie Robot Platform. Designed to be flexible and expandable, the Eddie Control Board is also well suited for other mobile robot platforms. While the board has a wide input voltage range, it is primarily targeted to 12 VDC battery-powered applications (*Control Board*).

Key Features:

Powered by the Propeller P8X32A with eight 32-bit cores opens a world of multi-processing possibilities.

Integrated high-current motor drivers, eight-channel 10-bit ADC, and 16 general purpose digital I/O allow for a range of robotic applications.

Three auxiliary power ports provide switchable battery voltage for accessories.

Application Ideas:

Telepresence robots

Two-wheeled balancing robots

Manufacturing automation equipment

1.2.2. Infrared sensor: The Sharp GP2Y0A21YK0F infrared distance measuring sensor uses a beam of infrared light to reflect off an object to measure its distance. Because it uses triangulation of the beam of light to calculate the distance, it is able to provide consistent and reliable readings which are less sensitive to temperature variation or the object's reflectivity. The sensor outputs an analog voltage corresponding to the distance of the object, and can easily be read using an inexpensive analog to digital converter (ADC) chip (*Infrared sensor*).

Key Features:

Distance measurement range: 10 to 80 cm (3.9 to 31.5 inches)

Analog output voltage corresponds to distance

Operates on 5 V supply

3-pin JST connector

Two mounting holes spaced 1.46 inches (37 mm) apart

Application Ideas:

Distance sensor for autonomous robots

Non-contact optical switch

Industrial automation and controls

1.2.3. Sonar sensor: Interfacing to a microcontroller is a snap. A single I/O pin is used to trigger an ultrasonic burst (well above human hearing) and then "listen" for the echo return pulse. The sensor measures the time required for the echo return, and returns this value to the microcontroller as a variable-width pulse via the same I/O pin (*Sonar Sensor*).

Key Features:

Provides precise, non-contact distance measurements within a 2 cm to 3 m range

Ultrasonic measurements work in any lighting condition, making this a good choice to supplement infrared object detectors

Simple pulse in/pulse out communication requires just one I/O pin

Burst indicator LED shows measurement in progress

3-pin header makes it easy to connect to a development board, directly or with an extension cable, no soldering required

Application Ideas:

Security systems

Parking assistant systems

Robotic navigation

1.3 Control

A proportional-integral-derivative controller (PID controller) is a control loop feedback mechanism (controller) widely used in industrial control systems. A PID controller calculates an error value as the difference between a measured process variable and a desired setpoint. The controller attempts to minimize the error by adjusting the process through use of a manipulated variable (*PID Controller*).

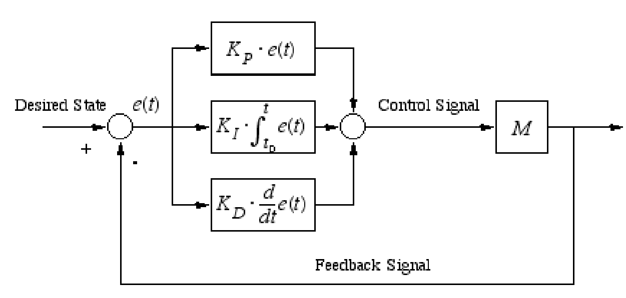

Figure 2. PID Controller schematic diagram