Line Tracking with Pixy Cameras on a Wheeled Robot Prototype

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***Abstract*-- In this paper, an algorithm is proposed for line tracking and object recognition by using an Arduino controller and a Pixy camera. With the application of a differential-driven wheeled robot, it is possible to track lines and recognize objects, which can all be implemented in the industrial application such as AGVs. The proposed algorithm takes central points by a forward facing Pixy camera, in order to perform the movement of tracking successfully with the correlation of a wheeled robot. By tracking the red color, the Pixy camera can identify which path to follow, distinguishing the bright hue over the contrast color of the floor, which avoids confusions. Labeling the objects with a specific color allows Pixy camera to understand which object is the target one.**

I. INTRODUCTION

The topic presented in this paper, line tracking, and object recognition, are techniques which can be used in many areas. Automated vehicles are gaining importance in manufacturing, transportation and even in medicine. With enough research, automated vehicles can work with zero mistakes. This is important because when human is in charge of a certain task, there is always a possibility of some sort of an accident, which may cause loss of time and money, and on the other hand, automated vehicles can make processes foreseeable.

The Pixy camera is an effective tool for combining the experiences of individual robots in a group, in order to increase the precision of the localization of that group of robots, such as the research presented by Lee et al. in[4].In another research presented by Nashaat in [3], Pixy camera is able to track animal behavior in both head-fixed and freely moving animals in real time and offline.

In the last mentioned research, a color-based filtering algorithm at 50 Hz was used to track objects, the method developed shows the versatility of the Pixy camera by using it in many lighting conditions such as infrared (IR), making behavioral monitoring possible in virtually any biological settings. Another of the many Pixy applications are the automated vehicles, as presented by Carrillo in [4], to prevent collisions and estimate the driving conditions of surrounding vehicles like velocity and distance to the camera.

Dynamics is the study of the motion of a mechanical system by taking into consideration the different forces that may affect it. Pacheco et al. [5], showed a model predictive control (MPC) as an accurate nonlinear methodology to minimize the cost of tracking an exact trajectory, by reducing the error between the robot and the desired path. When planning a trajectory for a wheeled robot, the robot´s dynamics play an important role in order to maintain the desired path, planning safe and accurate trajectories and avoiding any colliding obstacle, to reach the final desired coordinates with a good performance. In his research, Pacheco et al. presents a differential driven mobile robot (DDMR), which has a free rotating wheel. To plan a path, a strategy with local monocular visual perception data was used by a local model predictive control, which trajectories with safe obstacle avoidance can approach the robot to the goal. Consequently, it can be used to test the control performance.

II. SYSTEM ARCHITECTURE

A. Design of the robot system

For this research, a Sumo differential driven mobile robot (DDMR) is selected in order to perform the line tracking, considering that the DDMR´s efficiency and most of its dynamical problems have already been understood and fixed by the robotics community during the early years of development of mobile robots. Thus, the use of a Sumo robot becomes a possible strategy if the reduction of tracking path error is achieved. The pictures of the Sumo DDMR are shown in Fig. 1, and the hardware architecture is shown in Fig 2.

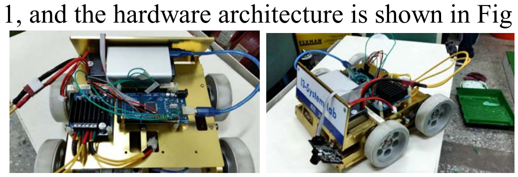


Fig. 1 The pictures of Sumo robots

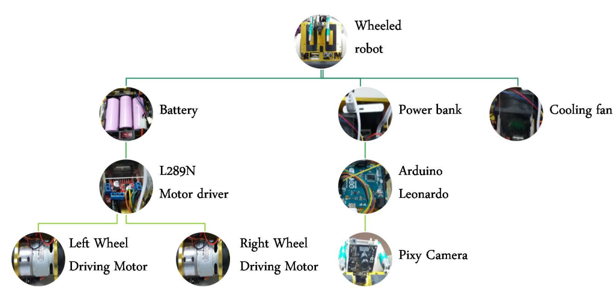


Fig. 2 The hardware architectures of Sumo robots

B. The Pixy module

A pixy camera, which is shown in Fig 3, implements an algorithm used to detect objects of a specified color. Pixy is a low cost designed camera and it is fully programmable. It is suitable for real-time processing and flexible for connecting to microcontrollers without a need of additional components. The associated specifications of Pixy camera modules are described in Table I.

Fig. 3 The Pixy camera module [1]

Table I. Technical specifications of Pixy camera [1]

Processor	NXP LPC4330, 204 MHz, dual core
Image sensor	Omni vision OV9715, 1/4", 1280x800
Lens	75 degrees horizontal, 47 degrees vertical
Power consumption	140 mA typical
Power input	USB input or unregulated input (6V to 10V)
RAM	264K bytes
Flash	1M bytes
Data outputs	UART serial, SPI, I2C, USB, digital, analog
Dimensions	2.1" x 2.0" x 1.4
Weight	27 grams

III. LINE TRACKING CONTROL OF DDMR WITH PIXY CAMERA

A. The utilization of Pixy camera module

The utilization algorithm of Pixy camera module in the application of line tracking control for the DDMR is shown as Fig 4. We firstly test the performance of color detections with Pixy cameras to know that the color of lines can be successfully detected and tracked. The Pixy camera can totally detect seven colors, and associated performances are shown as Table II. The color of the line must be distinct to the ground for preventing any confusion for Pixy cameras.

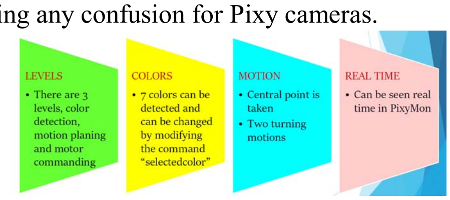


Fig. 4 The algorithm of Pixy utilization

Table II. The performance of color detections

RED	BEST
YELLOW	SECOND BEST
ORANGE	IMPLEMENTABLE
PURPLE	IMPLEMENTABLE
FUCHSIA	IMPLEMENTABLE
GREEN	LEAST SUCCESFUL
BLUE	LEAST SUCCESFUL

B. The line tracking control with Pixy camera modules

In the beginning, it is useful to examine the library of the Pixy for Arduino. In this research, the software application is summarized within three parts: Color detection, line tracking and the motor control. In color detection part, Pixy understands and distinguishes different colors. When a specific color is assigned to be followed, Pixy performs it successfully. The line detection process is performed by taking the central point value according to the sight of the Pixy camera. The motion of the wheeled robot is assigned as follows: if the position of central point in X in the Pixy camera´s sight is lower than 130 pixels, the wheeled robot should turn left and when it is lower than 100 pixels, it should turn far left. Oppositely, the wheeled robot must turn right if the position of X is higher than 180pixels and to far right if the position of X is higher than 200 pixels. The DDMR will go forward when the value of the central point is between 130 and 180 pixels. The coding ends by the control function of the motor. The software flow chart is shown in Fig. 5.

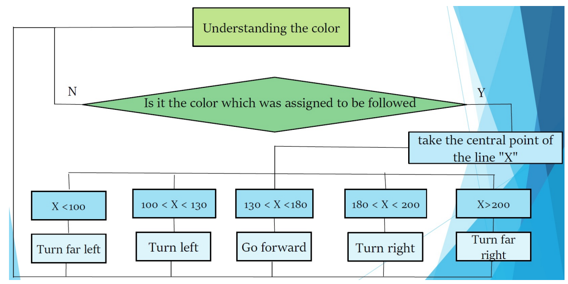


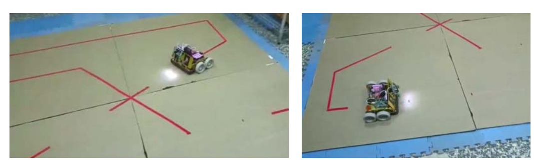
Fig. 5 The strategies for the line tracking with pixy cameras

IV. EXPERIMENTS RESULTS

The experimental results, shown in Fig. 6 and Fig. 7, demonstrate that the line tracking control of DDMR with Pixy cameras are successful for detecting and following a single line.

(a) (b) (c)

Fig. 6 Basic functions of the line trackong control, (a) Turn Right, (b) Turn Left, and (c) Turn in Diagonal



(a) (b)

Fig. 7 Advanced functions of the line trackong control, (a) Finding the Continuation of the Line and (b) Following Segmented Line

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