AUTONOMOUS TRACKING MOBILE ROBOT

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ABSTRACT

The autonomous tracking mobile robot described in this paper was developed at Control laboratory at ESIEE University in Paris in collaboration with Brno Technical University. The main objective was to develop a mobile robot with relative navigation to surrounding object. To implement such feature the machine vision method was used. To keep effective operability of the robot a digital signal processor has been chosen to process 2 dimensional image from a camera. A known object was detecting by implemented machine vision and his relative position was used to navigate the robot against the object. The robot was based on small four-wheel drive chassis and powered from accumulators through high efficiency DC/DC power supply.

1 INTRODUCTION

During evolution of life on our planet the one of most decisive factor is orientation in environment of each organism. As it can be seen in the nature, animals (all organisms can be included) use various type and level of self-localization and orientation what determines their position in hierarchy and ability to survive. In this meaning behavior complexity of robots (as objects affecting their environment) created by human is mostly given right by level of their ability to self-localization and orientation.

An environment is sensed by robots using various types of sensors. It should be noted that only some information from environment are exploitable for current purpose. In this project we are trying to substitute human vision by machine vision at object tracking – relative navigation to an object. This feature is very important in everyday life, also when more units are cooperating.

2 RELATIVE NAVIGATION METHOD

Used relative navigation method is based on machine vision. This method come out of human vision and is intuitively intelligible.

A scene in front of our robot is scanned by 2D camera as shown on figure 1. In this image we search known objects and those position against our robot. Analogue video signal from camera is being converted to its digital representation by TMSC6711 IDK card that includes video grabber, digital signal processor Texas TMSC6711 and fast data memory. The dsp localizes target pattern in each digital video frame by using machine vision methods (described below). In respect to target position in image its relative position against the robot is evaluated. At this moment the robot can be navigated to move as desired. In our experiment we have programmed the robot to follow the target within fixed distance.

Object/pattern used for relative navigation

To be able to process quickly all captured video data by TMSC6711 dsp we have chosen one very simple target pattern. This pattern consists of three black rectangles on a white background. Due to its high contrast and geometric simplicity can be easily found in image by using simple and fast mathematical methods. Handicap of such pattern it that can not be identified with any real object. Anyway to find desired object in the image this one can be "marked" by our pattern as shows figure 1.

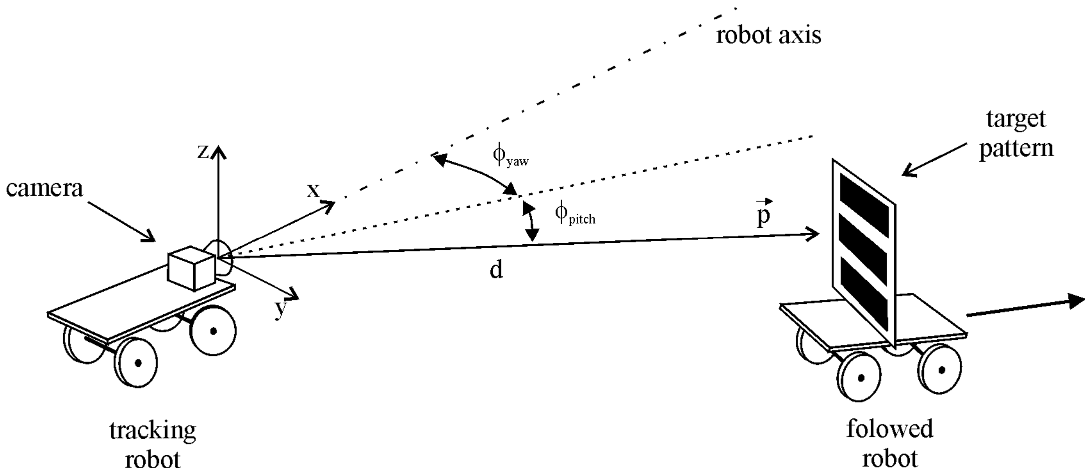

Fig. 1: *Object tracking*

Object/pattern localization

Pattern localization is performed by TMSC6711 IDK, respectively by implemented machine vision method. Our simple pattern can be easily found by sequence of common method mentioned in [1]. Figure 2 indicates the used sequence. Captured and digitalized image is being filtered by Sobel filter, which finds edges. After that, the resolution of already filtered image is being reduced because of high data quantity. Finally, the pattern is being searched in processed image.

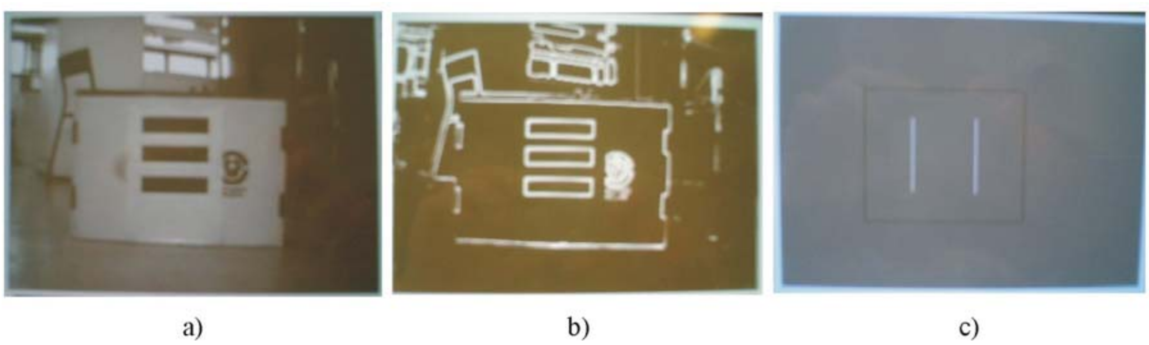

Fig. 2: *Image treatment - a) raw image, b) Sobel filtered image c) localized pattern*

When the pattern is found its position in the image, respectively against the robot can be determined. As shows figure 1 to evaluate real position the pitch, yaw angles and distance of object/pattern is needed. Pitch and yaw angles are evaluated from linear dependence on the position in image. The distance is evaluated from size in image. The resulting relative position in respect with figure 1 is given by equation 1.

$$\vec{p} = d \cdot \begin{bmatrix} \cos(\varphi_{yaw}) \cdot \cos(\varphi_{pitch}) \\ \cos(\varphi_{yaw}) \cdot \sin(\varphi_{pitch}) \\ \sin(\varphi_{pitch}) \end{bmatrix}^T \qquad (1)$$

Where φ_{yaw} and φ_{pitch} linearly depend on pattern position in captured image.

Here should be noted that the TMSC6711 IDK card (together with 2D camera), which process video data from camera, serves only as a sensor of the object relative position for a movement controller. The position is measured in range from 0,3 m to 4,0 m within view angle 45° with average delay 1/6 s.

3 MOVEMENT CONTROL

As a movement controller another microcontroller, exactly the LF2407, was used. Into this microcontroller were implemented two P, later PSD controllers for speed and direction control. The output from the system is the measured object position. Another input into the closed loop is desired position against the object. Due to unstable measuring period of object position the positional form of PSD regulator had to be used. Outputs from the regulators (action) are being converted to pulse-wide modulated signal (PWM).

Both actuators (the speed controller of gear motor and steering servo) are controlled by PWM signal (see figure3).

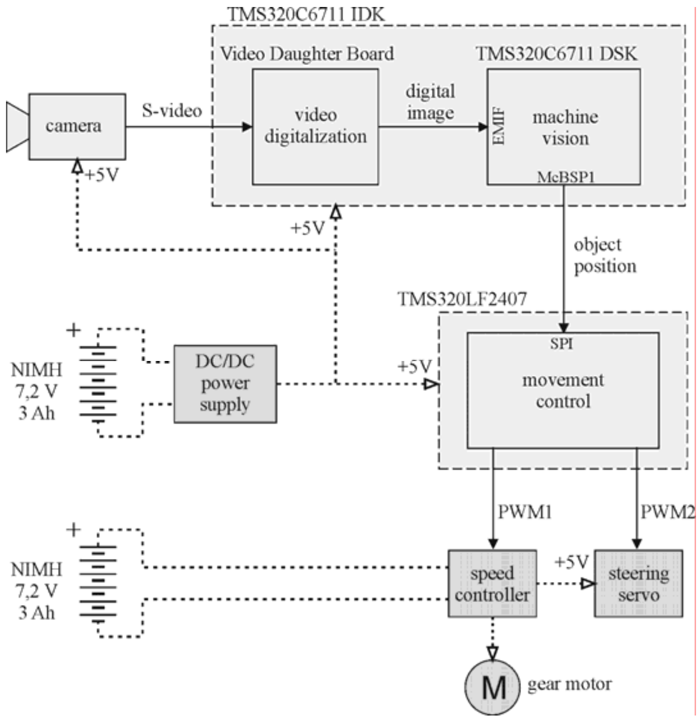

Fig. 3: *Robot scheme*

4 CONFIGURATION

Entire configuration indicate figure 3. All parts are carried by four-wheel drive chassis with high surmount ability and clearance. The robot movement is provided by two DC motors. The steering axle is turned by one servo. These actuators are fed from a single accumulator. Another accumulator is used to feed high efficiency (94%) switching supply based on "buck" topology. This supply has been developed especially for this purpose to provide low weight of accumulator and long operation time. Power losses have been reduced by 25 % (with 7.2 V accu.) against linear voltage regulator what in effect has increased operational time.

All signal circuits are placed on a support (see figure 4). Such solution is expedient for developing and testing. The analogue camera is attached to chassis at front axle. Above mentioned accumulators are fixed to the middle of chassis around the two gear motors.

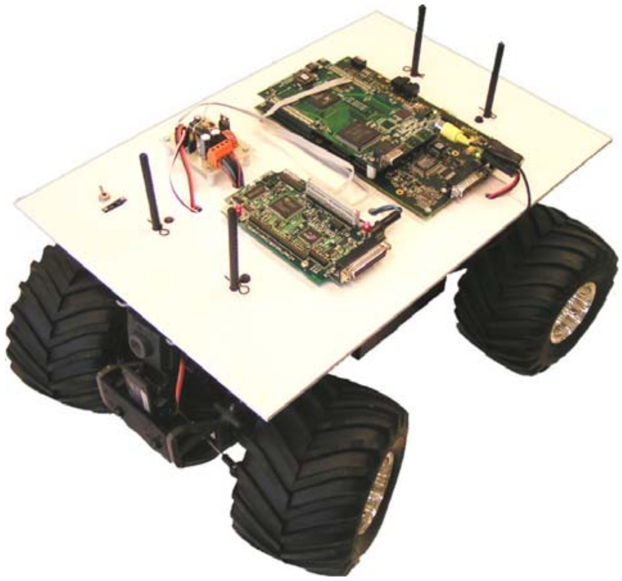

Fig. 4: *Robot*

5 CONCLUSION

An autonomous tracking mobile robot has been developed. The implemented machine vision allows the robot to recognize one specific object in front of it and determine its position against the robot. Determined position is used to navigate relatively the robot by desired way.

Shown solution proves viability of relative navigation using machine vision. In addition also serviceability at small robots is proved. Such system can be used in various type of application, where human activity can be fully or partially substituted. For instance in improved version can serve as a car collision detection system, auto/smart-toter (as human's carrier) and so on.

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