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CONTROL AND STEREOVISION SUBSYSTEMS FOR REMOTE CONTROLLED MOBILE ROBOT SURVEYOR

ŘÍDICÍ A STEREOVIZNÍ SUBSYSTÉM DÁLKOVĚ OVLÁDANÉHO PRŮZKUMNÉHO MOBILNÍHO ROBOTU

Abstrakt

Příspěvek popisuje řídicí systém spodní úrovně řízení mobilního robotu, který je určen pro činnost u hasičské jednotky. Úkolem robotu je dálkový sběr dat a průzkumná činnost v nebezpečném prostředí. Popisovaná řídicí systém ovládá všechny subsystémy – akční (pohony), senzorický (kamery pro stereovidění, orientaci (GPS a náklon) a komunikaci. Řídicí systém je schopen činnosti v nepříznivém prostředí – teplota, agresivní chemické vlivy a další. Součástí článku je také stručný popis implementovaného subsystému stereovodění.

Abstract

The article describes a low level embedded control system for mobile robot. This robot is to be used for the assistance to fire brigade. The robot will provide the remote data acquisition and a survey of the dangerous places. The presented control system operates all robots' subsystems as actuator – drives and sensory subsystem – cameras (stereovision), orientation (GPS, tilt of robot) and communication including data acquisition of the special sensors – as detection of chemical warfare agents and toxic industrial gases. The control system fulfils specialities of the given mission as unfavourable working environment (temperature, aggressive chemical influences etc), self monitoring and others.

A stereovision system for the robot is also described here. For the operator of the remote controlled device the 3D sensing of the environment is very advantageous. This sensing can be achieved using the 3D helmet if a corresponding image capture device is used on the mobile robot. The device concept, mechanical design, hardware and software resources are described here.

Introduction

The presented control system controls the mobile robot's actuators, stereovision positioning and the sensor data acquisition. Due to the high computing demands the microcontroller C8051F120 has been chosen. This microcontroller can handle multiple communication lines such as RS232, RS485 and I2C. It can also generate the PWM signals for the servo drives control. Other reason for choice of this chip is, that we own the software development system KEIL. The chip is derived from x51/52 family microcontrollers and it is completed with others peripherals and managed 100times higher computing power compared to the standard x51 core.

For the remote control of the mobile robot we have developed a 3D cameras system, which uses two cameras on a positioning mechanism, which are connected to a 3D helmet. The helmet is equipped with a 3 axis position sensor which we use to position the cameras according to the helmet movements. The cameras optical axes are also pointed to the object of operator's interest. This function is done automatically. The device also carries a low wattage laser marker which helps the operator to aim the helmet and the device on the observed object.

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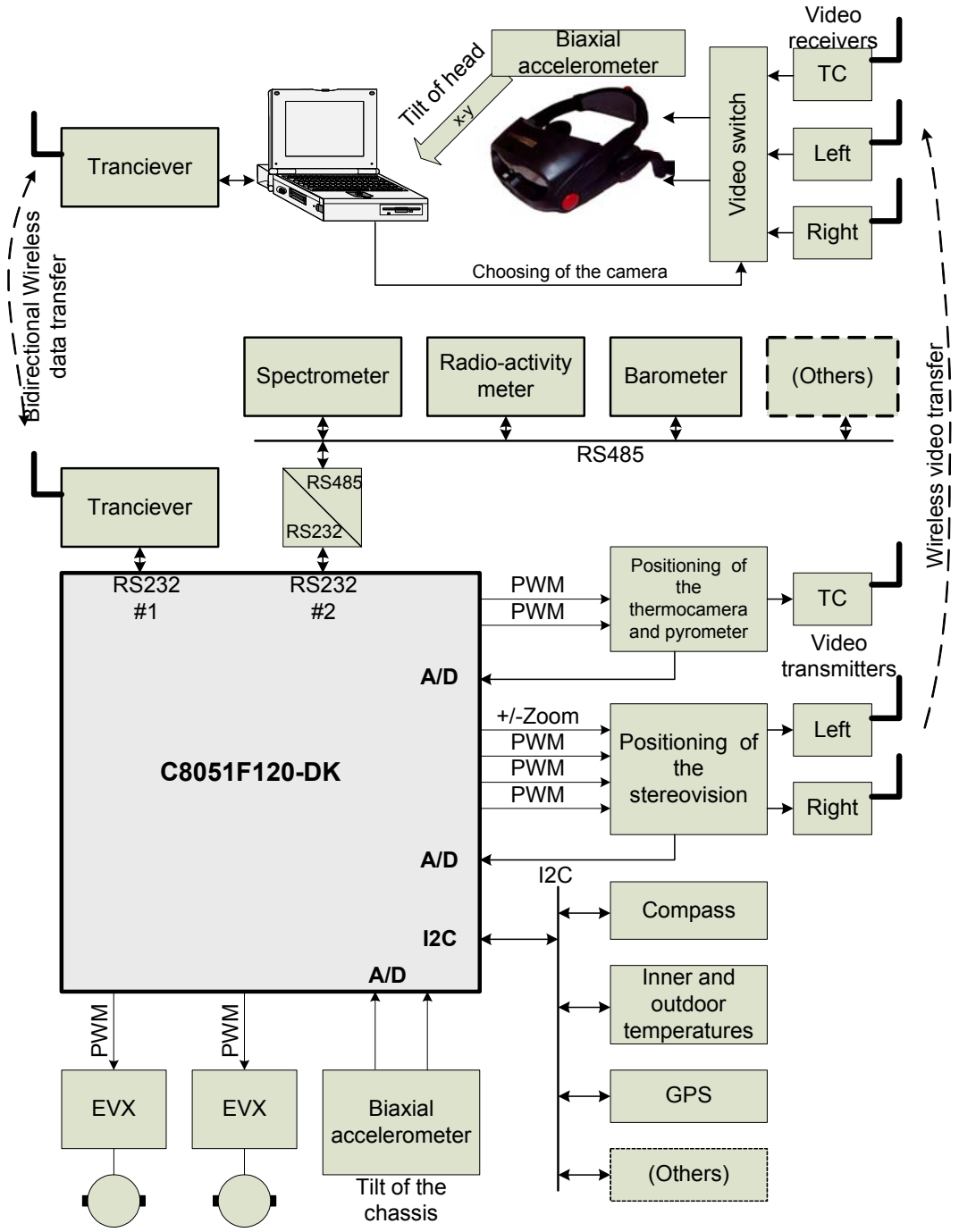

Fig. 1 Diagram of the mobile robot control system

The control system

The main purpose of the robot is the operator-driven survey of human dangerous areas, such as areas after industry accidents or chemical or nuclear disasters, etc. The sensoric subsystem is modular and can be therefore combined to suit best the kind of the present dangerous matter. The sensor modules communicate via the RS 485 bus.

By one of task of the low level control system is control of the positioning of the stereovision cameras and their automatic synchronising with operator's head turning. For this task, the 3D helmet and stereovision unit are completed with the biaxial static accelerometers. On the board of the mobile robot are two positioning systems – first for stereovision unit and second one for positioning of the thermo camera unit. The corresponding video signals are transferred wirelessly into the video switch unit.

Next task there is the remote control of the locomotion of the mobile robot by operators. The locomotion subsystem of the robot consist of pair of 70 Watts DC motors, powered by "EVX-Speed Control", witch are controlled with PWM signals – similarly as cameras positioning above.

Important part of the mobile robot there is sensor subsystem. It is divided to two parts: first consist sensors for positioning and navigation – GPS and digital compass. Second one is sensors modular system for measuring and/or detecting of the chemical matters etc. Detached sensors – as spectrometer, radio-activity meter are controlled via RS485 bus.

For safety of the mobile robot – avoiding of the overturning there is used pair of static accelerometers, which look about the maximal allowed chassis tilt.

The mobile robot allows semiautomatic or automatic building of the map of the chemical and/or radioactive contamination. On this account, the robot is equipped by GPS unit and digital compass. The concrete type of the sensor(-s) depend of the kind of the mission. The Czech fire departments often use products of the DRÄGER and OLDHAM companies. The DRAEGER Multi IMS is chosen as a simply spectrometer. The Dräger Multi-IMS is a portable ion mobility spectrometer for detection of chemical warfare agents and toxic industrial gases (TIC's).

The stereovision system

The device is constructed as follows: the cameras are mounted on 220mm high pylon – see. The top part is turning around its horizontal axis and the whole device can turn about its vertical axis. The mechanism is driven by three servo drives HITEC. The vertical axis servo drive is connected directly via the Oldham type clutch.

The horizontal rotation is provided by second servo drive also connected via the Oldham clutch. The torque is transferred by the spur belt and a pair of bend wheels. The belt is tensed by single pulley so the precise movement is achieved.

The cameras axes are turned by the last servo drive using a leverage mechanism.

The device is constructed mainly from aluminum alloy which helped to lower the devices weight to about 1.5 Kg. The usage of stainless steel material for the shafts together with bronze self-lubricated sliding bearings and encapsulated ball bearings made the device almost maintenance-free.

The video signals from the cameras are wirelessly transferred to the 3D helmet. The video signals are also transferred to frame-grabber, which digitizes the signals and the software detects the laser marker spot in the two pictures and ensures that the cameras CCD chips centers are aimed on this spot.

The computer processed signal from the 3D helmet sensor and from the 'spot searching' software if transferred wirelessly again by the pair of external radio modems Advantech ADAM 4550.

The servo drives use the PWM rotation control signal. The servo drives are controlled by the C8051F120microcontroller, which can generate the PWM servos control signal.

The main problem was to automatically aim the optical axes of the cameras at the object of interest. Due to the low resolution and the overall quality of the images, the detection must be done in a number of steps. The lonely points are first detected via the convolution mask. The points are tested to fit the assumed color. Then the cross correlation of the chosen points neighborhood is performed.

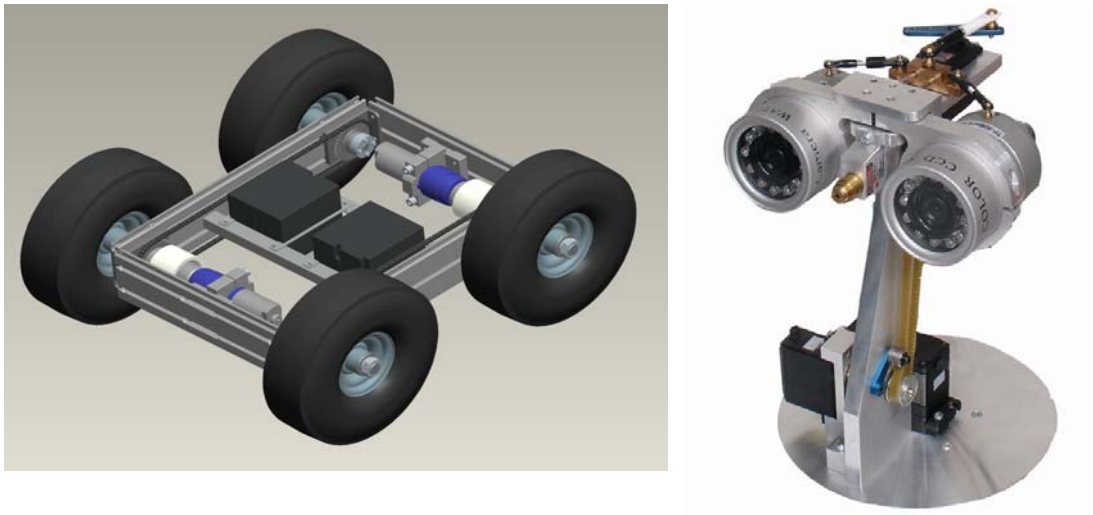

Fig. 2 The image on the uncovered mobile robot chassis and the stereovision system

Conclusion

The usage of the robots in the dangerous situations is the current course of the development worldwide. The presented control system fulfils the demands of robot that can be put into action in areas after industry accidents with presence of chemical and nuclear plague. The control system can operate the subsystem such as: actuators, communication, cameras, orientation systems and other dangerous agents detection devices. These systems can be combined to suit best the momentary situation.

The developed robot can be also used to build the map of the density of chemical and radial contamination.

To ease the work of the robot's operator the stereovision system has been developed. The system transmits the images from two cameras to the operator's 3D helmet. The operator therefore gets the 3D perception of the robot's scene.

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