VISION SYSTEM FOR MOBILE ROBOT

1. INTRODUCTION

Machine vision can be seen as the scientific investigation of artificial systems for perception from images or multi-dimensional data. Examples of applications of computer vision systems include systems for controlling processes, detecting events, organizing information or modeling objects or environments. The systems are nowadays intensively developed in science. Systematic expansion of computer related technologies allows to decrease vision systems prices, and makes them much more popular [1,3].

Robots generally can be divided into two classes, linked manipulators and mobile robots. Mobile robots have the capability to move around in their environment and are not fixed to one physical location. In contrast, industrial manipulators usually consist of a jointed arm and gripper assembly, that is attached to a fixed surface.

The most common class of mobile robots are wheeled robots, which armed with a video camera can be used in military applications. The obvious examples are detection of enemy soldiers or vehicles and missile guidance. Everyday applications of such devices include video surveillance and objects tracking [4,5].

2. CONSTRUCTION OF THE MOBILE ROBOT

A mobile robot called ROBOT is an object which was used to put a construction of vision systems on it. It was built basing on a caterpillar construction, utilizing two DC Motors with planar gear. It allows the unit to operate at high performance, i.e. 40 r/min rotary velocity and nominal torque of 1 Nm at 12V power source and 860 mA nominal current. The drive has very good wheel bearings and clutches, which protect it from damaging after a collision. The control unit of the mobile robot was built using an AVR ATmega128 microcontroller, which is responsible for generating correct signals to control the movement of the mobile robot. A wireless module, a RF modem, has been added to ensure a wireless communication with a computer. The second RF modem is attached to a computer. Using a program called “Mobot Rider” it is possible to control the movements of the mobile robot. The modem connected to a computer receives data on a RS-232 serial interface and using FSK modulation emits the wave to the air. The second modem installed on the mobile robot demodulates this signal and sends proper instructions to the microcontroller. Several instructions were implemented, like driving forward, backward, left/right rotation, speeding up, down and stop [2,6].

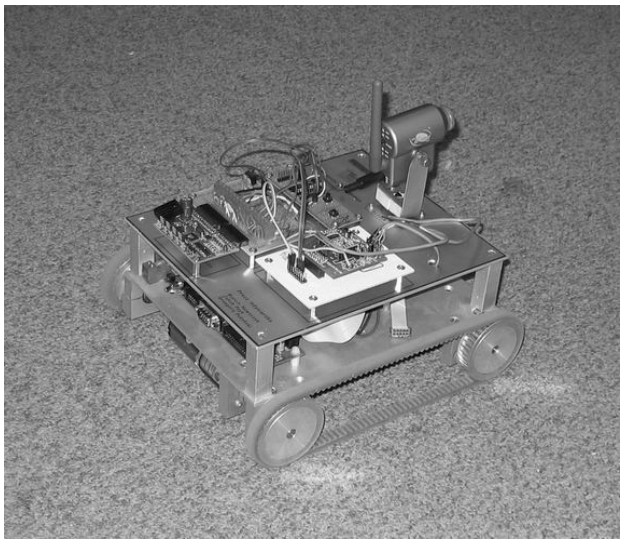

Figure 1. The vision system

To expand the robot’s functionality, several parts were added, to allow the operator to see, what is in the surroundings of the robot. The vision system uses a RF video camera - GRANDTEC Grand RF CMOS USB kit operating on 2.4 GHz frequency.

The kit is made up of a small color wireless video camera and a receiver, which has several outputs that allow to connect it to a computer or to separate devices like television, video recorders and others. Additionally it is possible to change the channel in case of interferences or other devices working on the same frequency. CMOS based video cameras consume less power then CCD type cameras, thus making them perfect to use on mobile units. The CMOS sensor has a

resolution of 330 lines which are enough to get a clear and sharp picture. The device was put on a small stepper motor, to allow the operator to look not only in front of the unit, but also to look around.

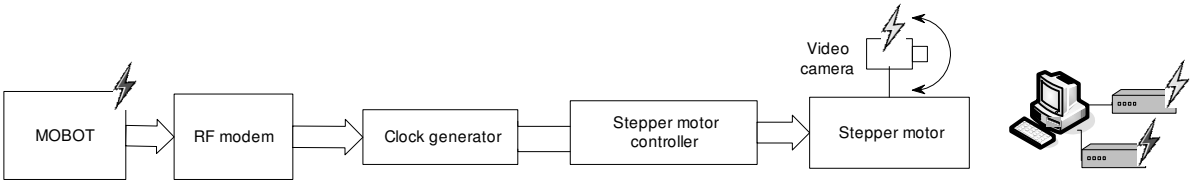

Figure 2. Transmission diagram

The stepper motor positions the video camera very precise and its high holding torque ensures that it will stay firmly in one place. Its construction enables rapid stopping and starting of the motor which is important at such systems. To control the stepper motor there was used a separate controller, which rotates the motor according to the signals given by the RF modem. It allows to rotate the motor with 7 level of frequencies (40 - 100 Hz) and change the direction of rotation. The rotation is possible in the range of 180 degrees. The software "Mobot Rider" allows to see the picture of the video camera and to control the rotation of the stepper motor.

3. SOFTWARE APPLICATION

To control the mobile robot and receive video stream from a camera, a custom application has been designed. The program establishes connection with radio modem through a serial port in a computer and sends move commands in the form of simple characters. The commands are next transmitted to the module installed on the robot and executed. Apart from changing moving direction of the robot or the camera, user can choose between several speeds of both devices, which increases the control precision.

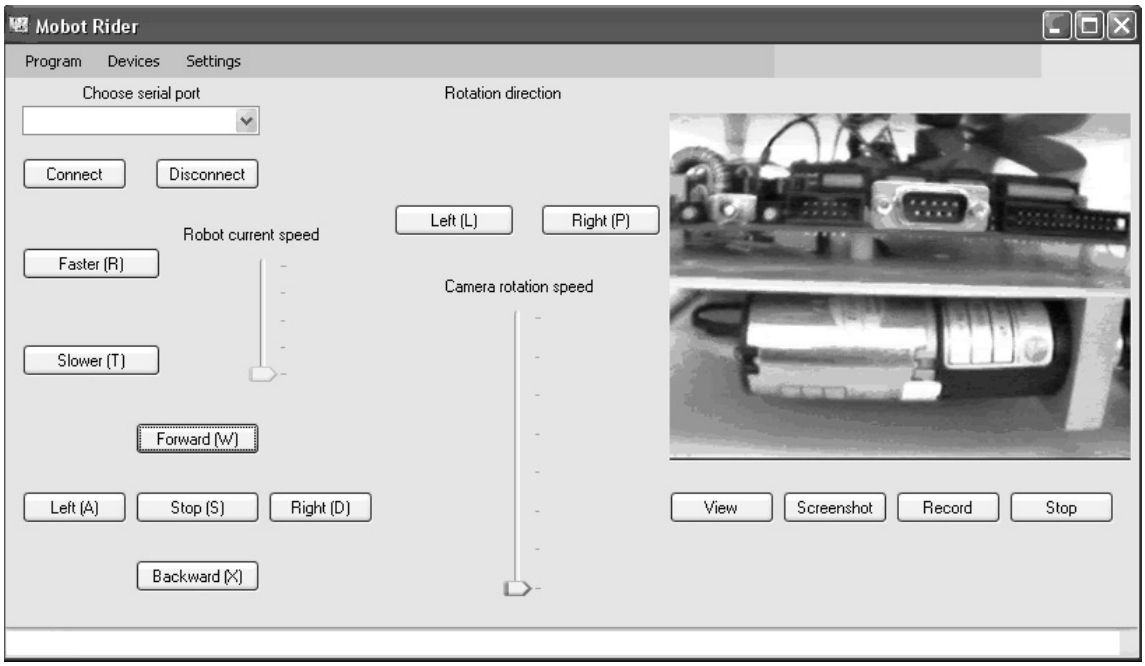

Figure 3. Main window of the "Mobot Rider" application

To acquire both video and audio data from the camera the program uses DirectShow architecture, which provides advanced support for multimedia applications on various Windows platforms: WinXP, Windows 2000 NT. It includes a set of filters that implement most known multimedia standards encoding formats as well as a Software Development Kit (SDK) easing the addition of custom filters.

Application layout and controls ensure easy navigation even for inexperienced users. After few steps including choosing video source (optionally audio source) and clicking "View" button, a video feed should be visible in the right part of the main window. Image properties, such as brightness, contrast or even video standard can be easily changed using "Property Pages" options in the "Settings" menu.

The results of settings manipulations are instantly visible on the viewing screen, which helps to adjust the image options precisely. Video stream can be saved on a hard drive as screenshots or movie files. The screenshots are taken on demand, by clicking "Screenshot" button and stored as *.jpg images. The recorded video file contains every frame of video feed as well as optional audio sound. It's saved in *.avi format and can be later viewed using most of the popular multimedia players.

4. VISION SYSTEM ANALYSIS

The frequency range of the video camera enables fast transmission of large packages of data, but only in a small distance. Indoor tests show, that the effective range of the device is about 25-30 meters. Further than that the video stream interferences make the image unwatchable. The below pictures show a view from the camera at maximum distance of 40m, where picture quality remains acceptable [fig. 4]. Further increasing of the distance between the robot and the receiver results in major decrease of the picture quality [fig. 5].

`

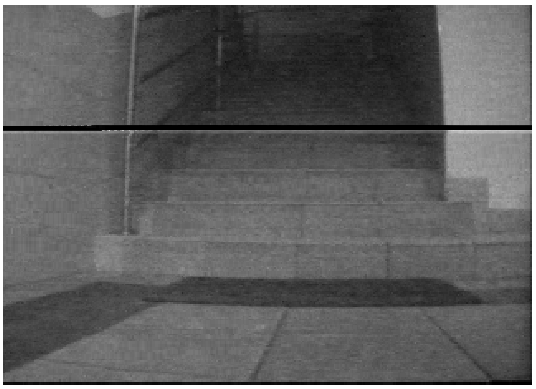

Figure 4. Picture quality at maximum range

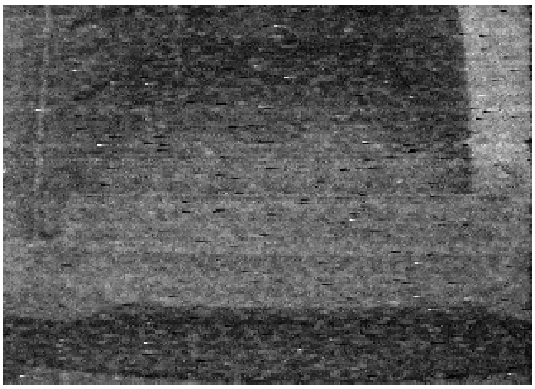

Figure 5. Picture quality beyond maximum range

Data analysis shows, that maximum vertical range of video transmission reaches the third floor of a building. Further distance increase results in loss of video signal. Average range radius of good quality video in an open area reaches 104 meters. Gathered data allow to estimate average signal dampening for walls and each floors of the building, where the system was analyzed.

5. CONCLUSIONS

The main goal of the project was to build a vision system that will allow a user to remotely control a mobile robot with installed video camera, that can be used in surveillance of difficult to reach places. The construction meets the requirement and thanks to a user-friendly program can be operated by anyone. The project does not exhaust the subject and will be continued to add more functionalities. Future research will include installing another motor that will allow the video camera to look up and down, adding small controllable lights which will allow to get a good picture in dark places and writing additional algorithms that will allow the robot to follow a object seen by the video camera.

REFERENCES

[1] Y. Nagaonkar, B. Call, S. Cluff, J. Archibald, D.J. Lee, *Autonomous mobile robotic system with onboard vision using configurable logic,* Industrial Electronics Society, IECON 2005. 32nd Annual Conference of IEEE, 6-10 Nov. 2005

[2] H. Kezhong, S. Haihang, G. Muhe, W. Hong, *Research of intelligent mobile robot key techniques*, Industrial Technology, 1996. (ICIT '96), Proceedings of The IEEE International Conference on 2-6 Dec. 1996 pp. 503 – 507

[3] K.-C.H. Fok, M.R. Kabuka, *A flexible multiple mobile robots system*, Robotics and Automation, IEEE Transactions on Volume 8, Issue 5, Oct. 1992 pp. 607 – 623

[4] J. Castellanos, J. Tardos, *Mobile Robot Localization and Map Building. A Multisensor Fusion Approach*. – Dordrecht: Kluwer.

[5] J. L. Crowley, *Mathematical foundations of navigation and perception for an autonomous mobile robot*, In: Reasoning with Uncertainty in Robotics (L. Dorst, Ed.). – Berlin : Springer.

[6] S.Trzcieliński, *Managing advanced manufacturing and automated systems. Some concepts and results of their implementation*, Proceedings of the third international workshop on robot motion and control, RoMoCo'02 Nov. 9-11 Bukowy Dworek, Poland, pp.261-269