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Low Cost Target Recognising and Tracking Sensory System Mobile Robot

Hedefleri Tanıyan ve İzleyen Düşük Maliyetli Sensör Sistemli Mobil Robot

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Abstract

In this study, the prototype of a mobile robot or unmanned ground vehicle was produced which can identify each mine buried in the ground, can be controlled using the simulator goggles as if in the vehicle, incorporates the electromagnetic wave distorting system, obtains its energy from the sun; can recognise moving objects such as tanks, aircraft or missiles and determine the trajectories of these objects.

Özetçe

Bu çalışmada, yere döşenen her bir mayını tespit edebilen, aracın içindeymiş gibi simülatör gözlüğü ile kumanda edilebilen, elektromanyetik dalgaları bozucu sistemi üzerinde barındıran, enerjisini güneşten temin eden; tank, uçak, füze gibi hareketli cisimleri tanıyıp bu cisimlerin yörüngelerini tayin edebilen mobil bir robot veya insansız kara aracı prototip olarak yapılmıştır.

Keywords: Mobile Robots, Unmanned Ground Vehicles (UGV), Target Recognition, Target Tracking, Sensory Systems.

Anahtar Kelimeler: Mobil robot, İnsansız kara aracı (İKA), Hedef tanıma, Hedef izleme, Sensör Sistemleri.

1. Introduction

Three types of sensor were developed, namely: infrared (IR), ultrasonic and image based sensors. The information coming from the infrared and ultrasonic based sensors are evaluated in the micro-controller, thereby performing target identification. In the image based target recognition operation, the pixel groups of the image received from the camera are compared with those of target images previously stored in the computer. The processor identifies the image and determines the speed and direction information belonging to the target. The mobile robot tracks the recognised target.

2. Mobile Robot Design

Unmanned ground vehicles are designed to be used on land for assignments which are difficult or risky for people to perform. Such vehicles are generally used in reconnaissance and surveillance, bomb/mine disposal work, fire intervention, for damage assessment purposes in war zones, in physical attack and destruction, NBC (nuclear-biological-chemical) work and scientific research. The increasing number of terrorist incidents have boosted the interest in mobile robots.

Fig.1. Mobile vehicle controlled by laptop computer and joystick.

The need for mobile robots in the areas of military and civil defence is increasing by the day and the areas of usage are broadening rapidly [1].

As seen in Fig. 1, the movement/control of the mobile land vehicle designed as a prototype can be controlled by laptop computer and joystick. Images are taken and recorded via an RF wireless camera on the turret. The mobile land vehicle was remotely controlled from a separate location using the simulator goggles as if inside the vehicle. In order for the mobile land vehicle to function for a long period of time, a solar panel was used to re-charge the batteries. The prototype can easily ascend gradients of up to 50º. The command and control of the mobile land vehicle was enabled by an interface program developed in Visual Basic 6.0.

3. Infrared/Ultrasonic Sensory Systems

Infrared and ultrasonic sensors used in object-detection work on the principle of a light or ultrasonic signal with a specific frequency, which is transmitted from a source, being reflected back by the object and being detected by the receiver. Infrared sensors are frequently used in the identification of close targets [2], counting operations [3], ground detection and position control [4] and identification of obstructions.

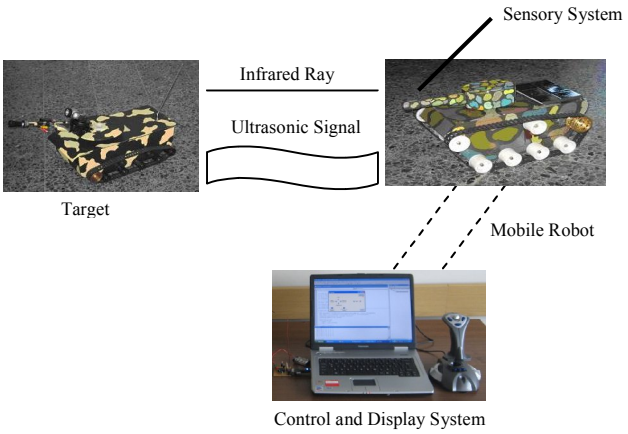

Fig. 2. Mobile robot with sensory system.

Furthermore, using infrared sensors, the positions of people in a room was identified and it was possible for various superfluous data and error-correction routines to be evaluated automatically [5, 6].

Ultrasonic systems are used in distance, level, security systems and mobile robots [7, 8].

In Figure 2, a mobile robot with a simple sensory system, target and control/display system are shown. The command and control of the mobile robot is performed via an ARX-34 RF transmitter at a working frequency of 433.92 MHz. through the serial port on the laptop computer. The mobile robot has infrared, ultrasonic and image based sensory systems.

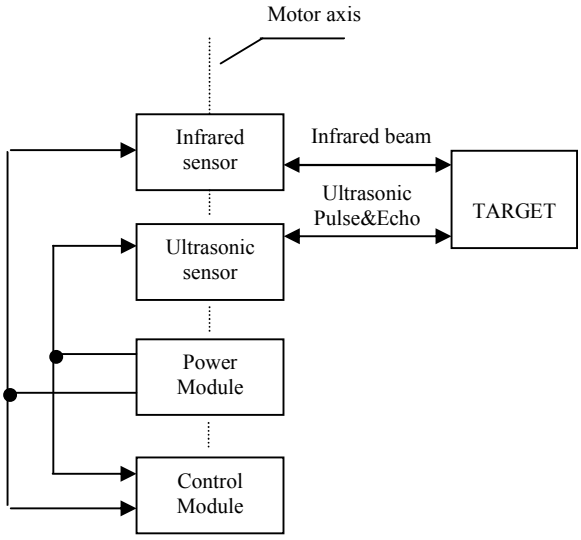

Fig. 3. Block diagram of the mobile robot with sensory system.

The block diagram of the connections of the infrared and ultrasonic sensors used for target recognition is seen in Figure 3. These sensors work independently of each other and are fed from a single battery. Information from both sensors is evaluated in the control module.

3.1 Infrared Sensor

IR LEDs, which are similar to normal LEDs in appearance, operate at a frequency which cannot be detected by the human eye. The human "visible spectrum" ranges between 0.4 microns (blue) and 0.75 microns (red). The cellular structure of the human eye cannot detect light with a wavelength above 0.75 microns i.e. beyond red. Since this area comes after red, it is called beyond red or infrared (Infra Red). IR generally has the same characteristic properties, beginning from 0.76 microns up to 1,000 microns wave length. Beyond 1,000 microns, the microwave region begins.

As seen in Figure 4, the infrared sensor comprised of two IR LEDs and one IR receiver. IR LEDs were modulated at approximately 36-40 KHz and thus it was possible to project beams up to a distance of three metres.

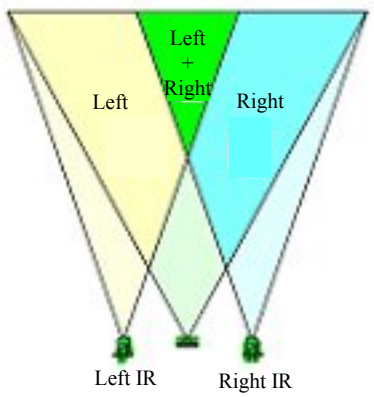

Fig. 4. Infrared sensor.

As seen in Figure 4, the infrared sensor comprised of two IR LEDs and one IR receiver. IR LEDs were modulated at approximately 36-40 KHz and thus it was possible to project beams up to a distance of three metres. Upon capturing a target in the left range, the LED connected to the relevant IR LED will illuminate, when a target is captured in right range, the the right LED will illuminate and when a target is captured in the left+right

range, both LEDs will illuminate. The rays are reflected from the target to the IR receiver which has a photodiode that provides digital output. The modulation of the IR LEDs and evaluation of the information coming from the IR receiver was performed with the integration of a PIC 16F628 micro-controller.

3.2 Ultrasonic Sensor

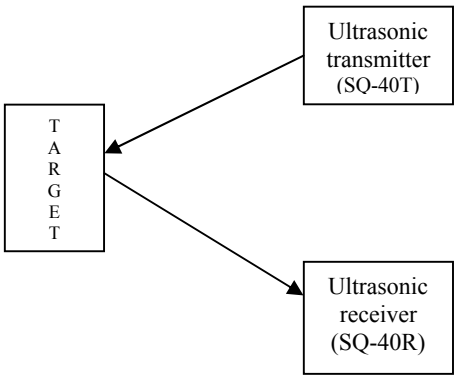

Fig. 5. General working principle of the ultrasonic sensor.

The general working principle of the ultrasonic sensor, is shown in Figure 5. The ultrasonic signal transmitted by SQ-40T is reflected from the target to the SQ-40R ultrasonic receiver.

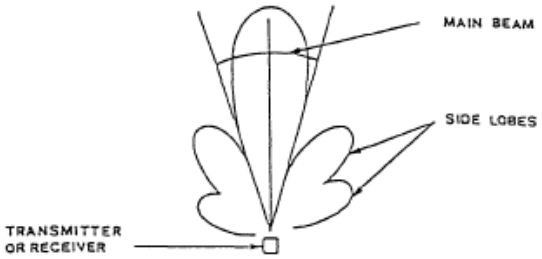

Fig. 6. The wave structure of SQ-40 ultrasonic transmitter and receiver [9].

The 40 KHz. ultrasonic signal was produced with the integration of a PIC 16F628 micro-controller. The ultrasonic signal is reflected from the target to the ultrasonic receiver after a period of time. The received signal is amplified using an LM 324 operational amplifier.

The ultrasonic transmitter and receiver used have a 30º angle, 2 nF capacity, -70 dB sensitivity and operational temperature between -20 ºC and 60 ºC [10].

3.3 Power Module

Re-chargeable, dry-cell 12 Volt batteries were used to power the sensors, the motors and the RF receiver module used for the command and control of the mobile robot.

3.4 Control Module

The information received from the infrared and ultrasonic sensors is evaluated in the PIC 16F877A processor. In the coding of the software in the micro-controller, HEX files were generated using MPLAB–MPASM compilers and embedded in the micro-controller [11].

4. Image Based Sensor System

In the image based sensory system; an RF wireless camera was used, mounted on the mobile robot's turret which has the ability to rotate 360º. The control program which generates the speed/direction information for image comparison and tracking of a potential target, was coded in Visual Basic 6.0. The camera can take 17 pictures per second at a resolution of 628x582 pixels.

As seen in Figure 7, the image received from the camera is compared to the images of known-targets previously stored in the computer. If the image from the camera is un-recognised, the camera rotates 360º and continues to take pictures. If the image from the camera matches an image in the database, the target is recognised. The speed and direction information

relating to the target are generated in the control program. This is applied to the mobile robot's motors via the computer's serial port, in order to track the target.

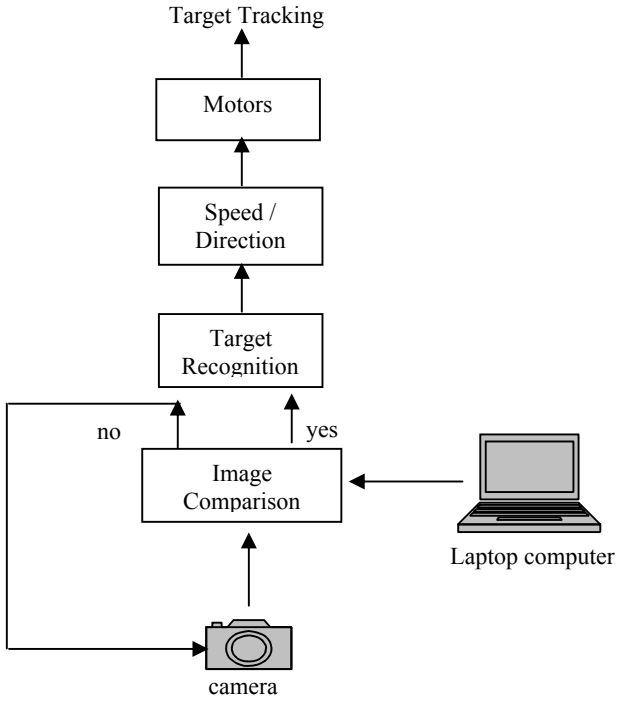

Fig. 7. The block diagram of the image based sensory system.

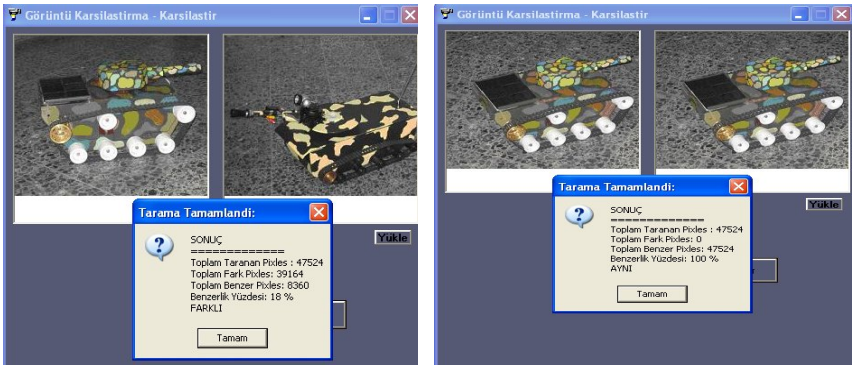

Fig.8. Image Comparison Operation

The image from the camera is compared with pre-recorded target images on the computer the by examining the geometrical shape and pixel groups using the interface program shown in Figure 8. The warning "SAME" or "DIFFERENT" is displayed on the screen, based on a threshold of 75% similarity between the real-time camera images and pre-recorded target data.

The target tracking system software is an I/O (Input/Output) based program where images are input to the program from the external environment via a camera and a digital signal is sent to the mobile robot. The camera and consequently the video stream from the camera is transferred to the program in real time during design and operation. In other words, the CapturePRO component was used in order to be able to add the camera to the form during design. Another component used in the program is Hitime.ocx. This component reduces calculation time, which is a crucial factor in image processing, to the level of microseconds. The program works on the basis of distinguishing the target from the background and then determining the geometrical centre of this identified section.

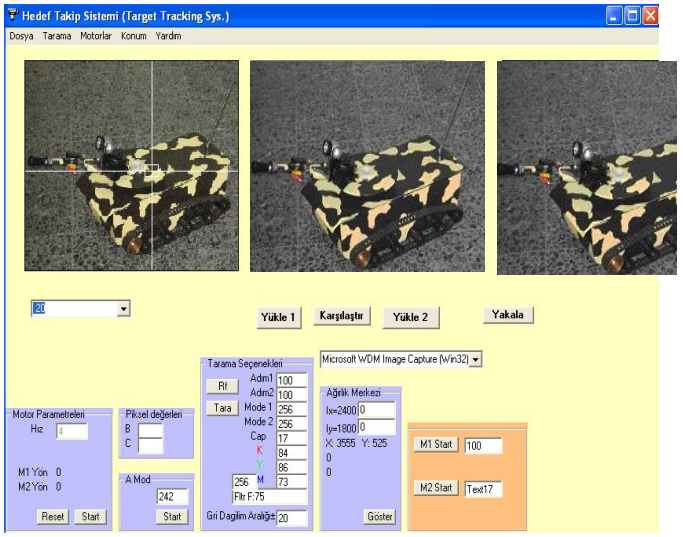

Fig. 9. Interface program of the target tracking system.

As a result of the interpretation of the image, the direction and speed information of the target is generated which is needed for the mobile robot to be able to track the target. The direction and speed information is transmitted from the software to the mobile robot via a serial port.

5. Conclusion

An infrared, ultrasonic and image based sensory system was developed, enabling successful target identification, recognition and tracking. A firing system may also be implemented by attaching a weapon to the mobile land vehicle. Such systems identify and track the target without requiring an operator and, when required, establish the identity of the target by determining its properties. Furthermore, such systems can easily be used in automatic examination of images from satellite or unmanned airborne vehicles, determining possible hostile targets and target classification operations.

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