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On-line Recognition of Autonomous Robot Position via Camera DragonFly

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Abstract: Contribution deals with one possible applications of image processing - recognition of moving object position. Traced object is robot MINDSTORM NXT, which is described in the first part of the paper. The methodology of image processing and object recognition is discussed in the second part of the paper. The third part describes the application example.

1 INTRODUCTION

Signals (in the form of pictures or videos) processing is popular, interesting and widely discussed branch of research which has many applications in praxis:

- transport engineering
- biomedicine data processing
- chemical industry

Video processing is possible to divide into two groups:

- offline - the whole set of images is taken and then processed
- online - each taken image is immediately processed.

Both methods have their advantages and disadvantages. Offline images processing is suitable for astronomical or medical images processing, pollution image processing ect., [Pavelka et all, 2005]. Online image processing is t is rather good for tracking, observing and control.

The contribution describes one of the applications of the second (online) way - online tracking of moving robot.

2 DEVICE DESCRIPTION

2.1 Robots Mindstorm NXT

Robots MINDSTORM NXT are products of LEGO group, more in [www.eduxe.cz] and [Hlinovský et all, 2010]. It is typical LEGO brick box which is equipped by 32-bit microcontroller with three output connectors and four input connectors see Figure 1. Three servomotors are the outputs of the system and inputs are presented by

- ultrasonic sensor,
- sound sensor,
- light sensor
- touch sensor.

Optionally, it is possible to add other sensors as gyroscope, compass, or camera.

Fig. 1. MINDSTORM microcontroller

Lego MINDSOTRM brick box is possible to set as any variant of mobile robot (see Figure 2). Robots can be absolutely autonomous (PC is used only for their programming) or can be depending on PC (robots provides only measuring, control is provided by the computer). Communication to PC is realized via USB 2.0 or Bluetooth.

All programmes were built in MATLAB environment and MINDSTORM NXT Toolbox was used for communication to robot, [www.mindstorm.rwth-aachen.de]. Toolbox includes basic communication functions:

- initialize robot
- get data from defined sensor

- rotate defined servomotor

Fig. 2. Different variants of robot

2.2 Camera DRAGONFLY

Camera DRAGONFLY is standard digital camera (see Figure 3). It features on-camera color processing and auto white balance, see [Kubíček, 2004].

Specification details are:

- CS-mount lens with variable focus and auto iris
- resolution max 1296x964
- Max 30 frames per second
- IEEE-1394 (Fire Ware) connector.

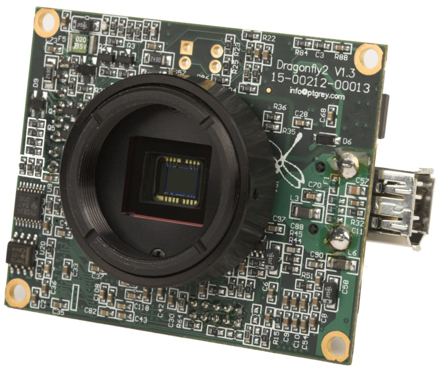

Fig. 3. Camera DRAGONFLY

3 METHODOLOGY OF TRACKING OBJECTS

Generally, object recognition at any background is nontrivial problem. It is necessary to choose the object, find its centre and calculate the position.

If the background has constant colour which is different from the colour of the object, only one object is recognized at the image and one centre position is found.

Otherwise, if the background has a difficult structure and the background colour is similar to object colour, many object are recognized and it is not easy to find out which one is the right one.

One of possible approaches is the frames difference method. Firstly, the image of background (without moving object) is taken. Then (at every sample time) this image is subtracted from the image of moving object. Constant parts of images are black (subtracted each other) and only tracked object remains. Images with and without subtracted background are shown in Figures 4 and 5.

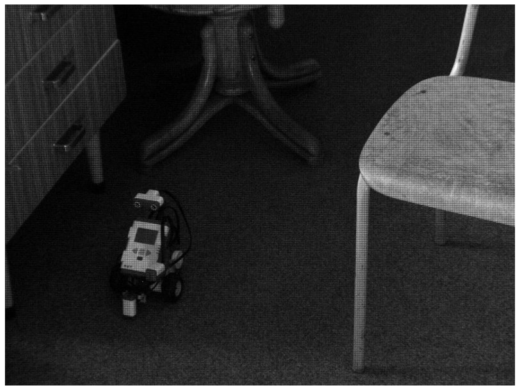

Fig. 4.Object and background with difficult structure

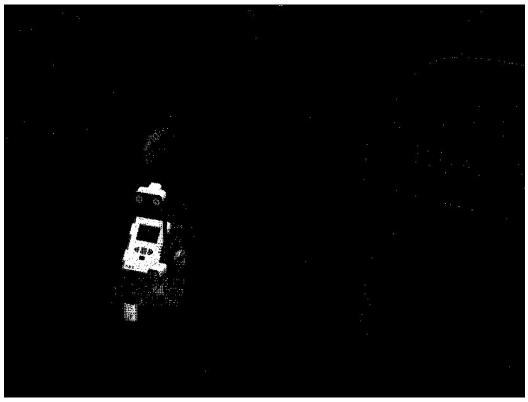

Fig. 5.Image after subtraction of background

After subtraction and the object recognition, it is necessary to find the center and calculate the position (in praxis tresholding and filtration is used too). The object center is possible to find by cutting out the subset bounded by upper, lower, left and right points of tracked object from the image. Object center is given by the center of this new matrix.

For calculation of real object position in 2-D coordinate system, camera calibration is needed. It is necessary to evaluate horizontal and vertical angles of the camera. Using the calibration grid placed in the distance *d* from camera it is possible to find both horizontal *shorizontal* and vertical *svertical* sizes of the figure. These parameters can then be used for evaluation of the limits of angles (using rectangular dark and light triangles).

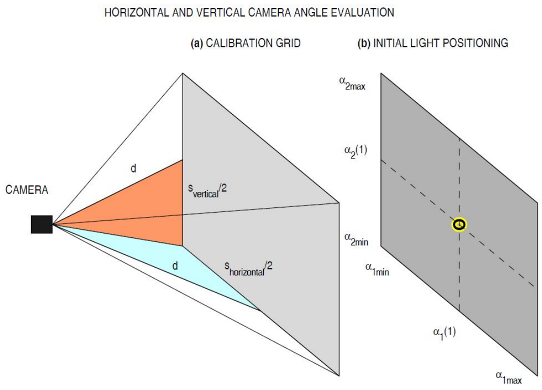

Figure 6 – Camera calibration

$$\alpha_{horizontal} = 2.arctg\left(\frac{s_{horizontal}/2}{d}\right) \tag{1}$$

$$\alpha_{vertical} = 2.arctg\left(\frac{s_{vertical}/2}{d}\right) \tag{2}$$

Finally, it is necessary to calculate calibration straight-lines for horizontal and vertical directions.

Moving object tracking algorithm:

1. Initialize hardware
2. Calibrate the camera
3. Take the first frame of background (without moving object)
4. Take frames of moving object in the cycle
   - *i. Take the frame*
   - *ii. Calculate the difference*
   - *iii. Find the center*
   - *iv. Calculate the position*

4 APPLICATION EXAMPLE

Methodology of moving object tracking was applied to recognition MINDSTORM robot position.

Robot moved randomly in defined space. Its movement was tracked by the camera which was placed above it. Camera setting was one frame per second. Each frame was immediately processed and actual robot position was calculated.

Important parts of MATLAB code are shown in chapter 4.1 and the result- moving object trajectory is plotted in Figure 7.

4.1 *MATLAB code*

Images acquiring and processing

```
obj=videoinput('dcam',1,'Y8_1024x768');
set(obj,'FramesPerTrigger',1);
preview(obj)
start(obj);
[f_pozadi,t]=getdata(obj);

for i=1:1:5
start(obj);
[f_pozice,t]=getdata(obj);
diff=imabsdiff(f_pozadi,f_pozice);
tresh=graythresh(diff);
bw=(diff>=tresh*255);
L=bwlabel(bw);
s=regionprops(L,'area','centroid');
area_vector=[s.Area];
[tmp,idx]=max(area_vector);
Centroid =s(idx(1)).Centroid;
X(i)=centroid(1);
Y(i)=centroid(2);
alfaXh(i)=ah*X(i)+bh;
alfaYv(i)=av*Y(i)+bv;
xposition(i)=alfaXh(i)/alfah*sh*100;
yposition(i)=alfaYv(i)/alfav*sv*100;
end
figure
plot(xposition,yposition,'o-r',)
```

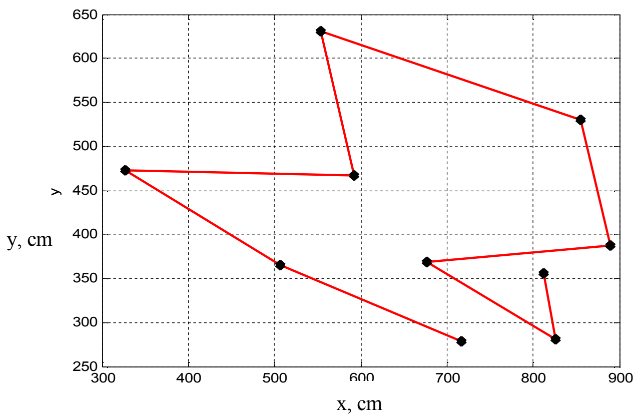

Fig. 7.Moving robot trajectory

5 CONCLUSIONS

Image processing is popular and widely discussed branch of research nowadays.

Contribution deals with one of possible approaches to image processing - moving object tracking (i.e. for control purposes).

One digital camera was used as a sensor of localization of moving robot, thus the trajectory in two-dimensional space was calculated. If two or more cameras were used, 3-D reconstruction could be evaluated.

This methodology of object tracking is usable for one moving object tracking at anystatic background.

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