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Petr ŠPAČEK*, Petr NOVÁK, Vladimír MOSTÝN*****

VIZUALIZACE VZDÁLENOSTÍ URČENÝCH POMOCÍ STEREOMETRIE

VISUALISATION OF DISTANCES DETERMINED BY STEREOMETRY

Abstract

The article describes system, which is determined for visualisation of information about surrounding area. Visualisation is done by picture from camera. Picture is mixed with information about distance of objects, because picture from camera constraints only 2D information. The information about distance is showed as overlapping colour on object pixels. Colour tone depends on distance of object. The information about distance is determined from two pictures. These two pictures are acquired from two parallel cameras simultaneously. The distances of objects are computed using triangulation method. By this way is visualised information about surrounding area.

Abstrakt

Příspěvek popisuje systém, který zobrazuje informaci okolí pomocí obrazu z kamery. Do tohoto obrazu přidává informaci o vzdálenosti objektů. Tato informace je zobrazena tak, že objekty dostávají nádech barvy, která odpovídá vzdálenosti. Informaci o vzdálenosti získá systém pouze ze snímků vzájemně rovnoběžných kamer, pomocí triangulační metody. Tyto data jsou potom zhodnocena, jestli leží v žádaném intervalu vzdálenosti. A pak je jim přidělena barva podle barevné stupnice. Tato barva je následně připojena do obrazu. Výsledný obraz kamery takto zobrazuje i informaci o vzdálenosti.

INTRODUCTION

Nowadays are many robots, which are controlled by operator. The way, which operator getting information about surrounding area, where is robot situated, is in most case done by picture from camera. Camera is usually situated on robot. Here is need to know, that the picture from camera can get only 2D information about surrounding area. Thus, the operator has not information about distances of objects, which are in camera view. This article describes system, which adds this information about distances of objects to the camera picture. Speciality of this system is that the distance is determined only from two images. These two images are captured by two parallel cameras simultaneously. Here is no other measuring tool used.

DESCRIPTION OF SYSTEM

Scene of view is acquired by two parallel cameras. These cameras are connected to the PC via IEEE 1394. The image processing and other computing are computed on PC. The software of this system is written in C++ language, by this is computing speed relative fast. The schema of system is showed on Fig. 1.

* Ing. Petr Špaček, Department of Robotics, VŠB-TU, 17. listopadu 15/2172, 70833 Ostrava-Poruba, Czech Republic

** Doc. Dr. Ing. Petr Novák, Department of Robotics, VŠB-TU, 17. listopadu 15/2172, 70833 Ostrava-Poruba, Czech Republic, ☏+420596993595, petr.novak@vsb.cz

*** prof. Dr. Ing. Vladimír Mostýn, Department of Robotics, VŠB-TU, 17. listopadu 15/2172, 70833 Ostrava-Poruba, Czech Republic

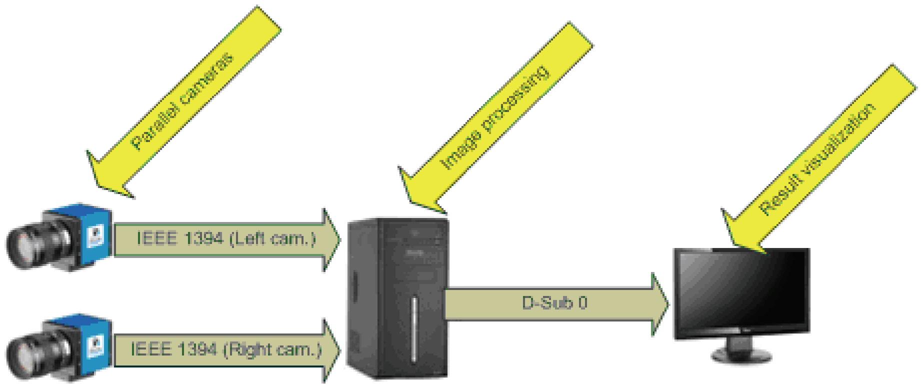

Fig. 1: Schema of the system

The two cameras DFK 31F03 were used in this system. Table below show the parameters of system.

Processor	Intel Pentium 4 dual core 3.2GHz
Memory	2GB
Graphic card	NVIDIA Quatro FX560
Operation system	Windows XP

COMPUTING OF DISTANCE USING TRIANGULATION METHOD

Triangulation method is the way of computing distances of objects, which are in cameras view. Now suppose that, we have two perfect pictures, which is not distorted. These two pictures were acquired by two cameras, which have perfectly parallel optical axis. These cameras have the same focal length and the point, where optical axis intersect projection, plane is on same coordinates. The schema of triangulation is showed on Fig. 2.

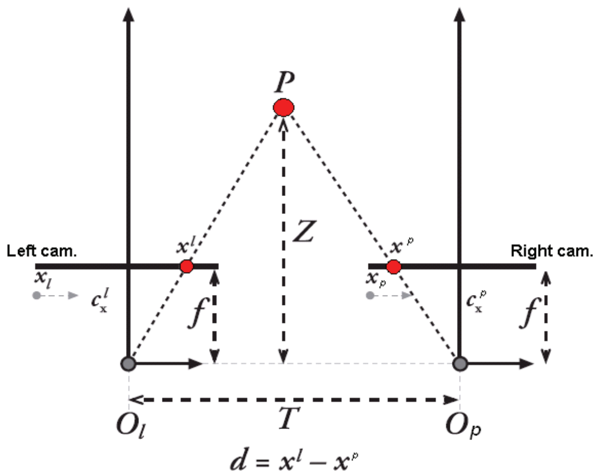

Fig. 2: Schema of triangulation

If the cameras are situated according to figure, we can find the position of point in space. The projection of point P (x^l and x^p) is related to distance Z of this point. The difference $d=x^l - x^p$ is disparity. The relation between Z and projections of point P can be determined from triangle similarity. Next equation describes this relation.

$$\frac{T-(x^l-x^p)}{Z-f}=\frac{T}{Z} \quad => \quad Z=\frac{fT}{x^l-x^p}$$

The relation above can be rewritten to matrix form (reprojection matrix). The computing on system is done by using this matrix form.

$$Q\begin{bmatrix} x \\ y \\ d \\ 1 \end{bmatrix} = \begin{bmatrix} X \\ Y \\ Z \\ W \end{bmatrix}$$

Where d is disparity and matrix Q is:

$$Q = \begin{bmatrix} 1 & 0 & 0 & -c_x \\ 0 & 1 & 0 & -c_y \\ 0 & 0 & 0 & f \\ 0 & 0 & -\frac{1}{T_x} & \frac{c_x - c_x'}{T_x} \end{bmatrix}$$

Values c_x a c_y are coordinates of left camera principal point (the point where optical axis intersect projection plane). T_x is distance of camera coordinate systems in direction of x. The x coordinate of principal point of right camera is c_x‘ and the f is focal length.

Now the 3D coordinates is (X/W, Y/W, Z/W).

VISUALISATION USING COLOUR BAR

Limitation interval can be set in developed software. This interval is limitation for computed distances. The computed distance is ignored, when lying out of this interval. Visualisation of distances can be limited by using this interval. If limitation interval is used, the better results are got. It is, because whole resolution of colour bar is spread only on object of interest.

On Fig. 3 is colour bar, which has been chosen. On this figure is showed the colour space too. The colour bar is defined by broken line in this colour space. If colour components (R, G, and B) be in interval 0-255 then resolution of colour bar will be 500 different colours. The distance limitation interval is equally spread between these 500 values.

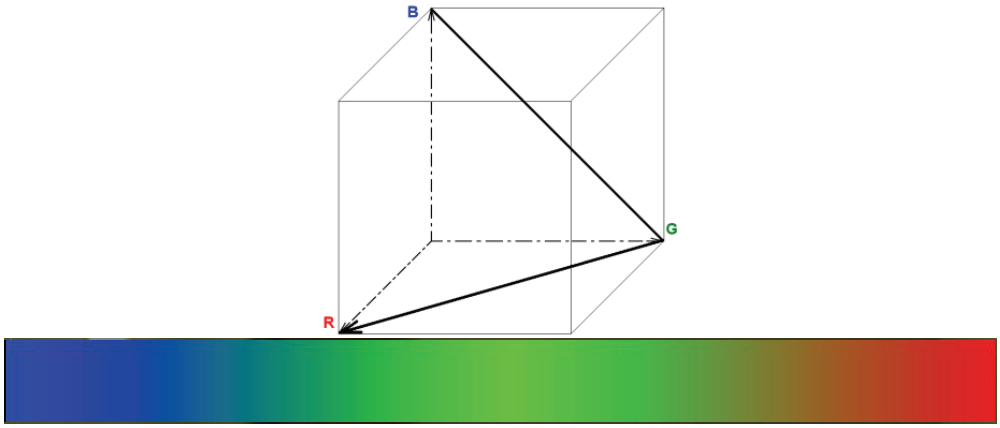

Fig. 3: Colour bar

ALGORITHM RESULTS

Algorithm was tested in several situations. The Fig. 4 shows first situation. This situation deals about alone object of chair. The boundaries of distances limitation interval was set that the first boundary is in front edge of chair and second boundary is at outermost point of this chair. Which part of chair is closer to camera, and which part of chair is far from camera, is evident from this figure.

The Fig. 5 shows photography of scene from another position. This photography was made for better idea about situation.

Fig. 4: Alone object

Fig. 5: Photography of situation

Two objects were tested in next situation. One of these objects was closer and second was distant. The Fig. 6 shows two frames from camera, left frame shows objects without distances, and right frame shows objects with distances. First look at left frame of this figure, if operator does not have any information about scene he don't know if left chair is at higher position or far position. The right frame of figure show colour distances, and question about distance is now solved.

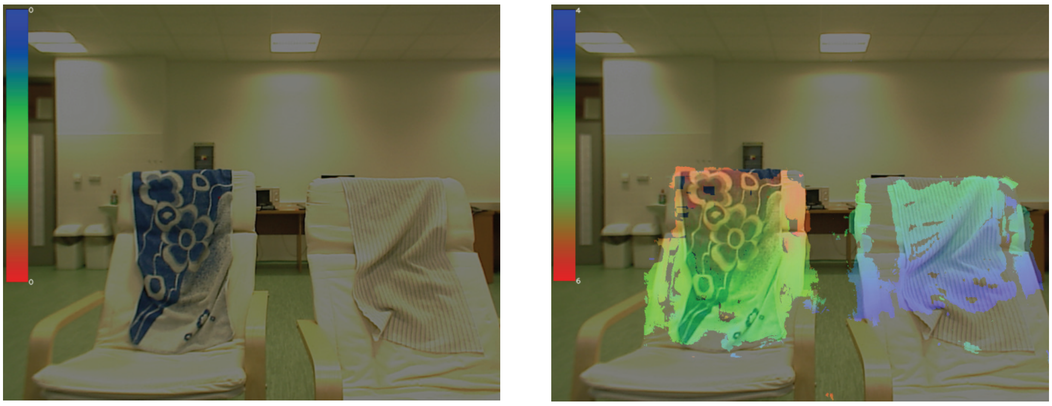

Fig. 6: Situation with two objects

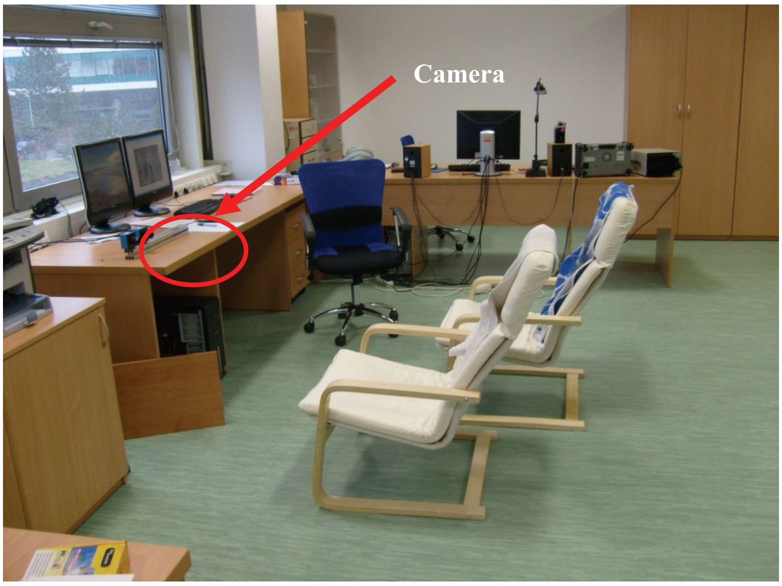

Fig. 7: Photography of scene with two objects

The photography of second scene from another position is on Fig. 7. This photography is here for getting idea about second scene.

CONCLUSION

This developed visualisation system is the result of project that this article describes. This system visualise information about distances of objects in camera view to camera picture. This information can be very useful, when operator navigates robot only by picture, which is acquired by camera, and hi need to get information about distances. The information about distances is computed only from pictures of two parallel cameras. There is no need to use additional tools (such laser scanner, IR scanner, Sonar etc.). The software for PC was written in pure C++ language, because here is need to get maximum computation speed, for all that the system is heavy to hardware configuration. Software has implementation of limitation interval of distances. Only distance in this interval is used. This limitation takes better resolution of distances on object of interest.

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