Image Processing Based Tracking System

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Abstract: Image processing based tracking systems equipped with powerful computing systems have gained vast applications nowadays. In this paper, an image processing based tracking system and its algorithms is described.
In order to separate desired colored patterns or nodes from the background in color image processing, hardware type filters are usually used. Here a software based filter is investigated.

Keword: Image processing, Vision feedback, Tracking systems, adaptive control**,** PC Interfaces

1 Introduction

Image processing has several applications in astronomy, medical science, military, and other fields of technology and science.

An application of image processing include the need for measuring kinematic parameters of moving robot in which by determining the robot joints and its images, these parameters are measured [1].

Another application was the puzzle solver robot in which image processing is used to recognize the pattern by image processing based closed loop control [2].

The main component of an image processing system is shown in Figure1.

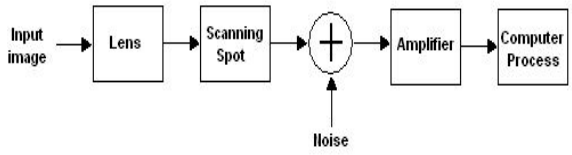

Fig1. The elements of an image processing system

Transfer function of each component can be modeled analytically, determined experimentally, or taken from manufacturers' specifications.

The lenses, for example, can be assumed diffraction limited. The computer operation may or may not be linear, but this is the only subsystem in fureig1 that is directly under the users' control [3].

In simple systems a webcam can be used as sensing unit for image capturing. These cameras are of CMOS and CCD type.

CCD sensors show a higher quality image than other type. Images can be processed by Digital Signal Processor (DSP) or personal computer (PC). The choice depends on the availability and the needed processing speed.

In this paper, first the principles used in some common image processing projects are described. Then, the details will be explained and developed.

2 Image Matrixes

Image capture sensor is formed from some light sensitive elements. The voltage of each element is proportional to the intensity of radiation light.

The image forms on the sensor plane by variating light propagation tools such as convergent lenses (Figure2).

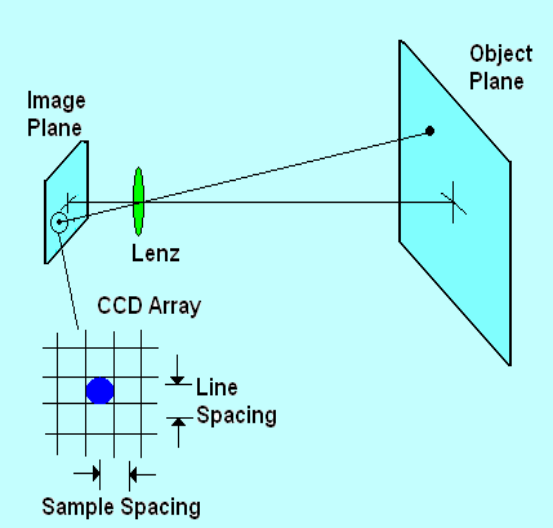

Fig2. Image formation

The voltage of each image plane element is converted to a binary code by an ADC and then transferred to main processor by a communication cable.

The communication protocol is chosen from different S-video, IEEE1394, RS170, or USB type. Based on their application, each of them have their own advantages or drawbacks.

In case of the use of a PC as processor equipped with Microsoft windows as OS, using Video For Windows (VFW) programming technique is recomended. This technique makes a simple communication with all image capturing devices.

At the end, the expected images as RGB or CMYK format and as a 3D matrix which its elements are image pixels color value will be formed.

3. Color separation filters and noise effect reduction

Separating a particular color or color node is common need in various color image processing systems. In most cases in order to separate and pass a particular color colored filters are used.

A less expensive and more flexible solution is the utilization of software filters specially when using webcam as image capturing sensor.

Different digital image saving methods are developed among them, RGB color space have more application in color image processing.

In this system the search space is determined by R, G, and B axis. Each of the amounts of R, G and B for a singular pixel can be in the range of 0 and 255.

For separating of a particular color the amount of B, G, and R is compared to a desired value. For example to identify the yellow color the amount of the R and G must be more than 200 and amount of B must be less than 150.

The color space of these Conditions is shown in Figure3.

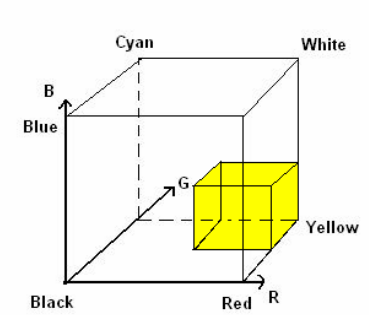

Fig6. Rectangular color space

After separation of desired colored nodes, for noise effect reduction a low pass filter can be used. Matrix coefficients for such a filter are calculated as a moving average filter as follows:

$$\begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix} = \text{LPF Mask}$$

4. Tracking a moving target and laser designation

Tracking moving objects over time is a complex problem in computer vision and has been an important research subject over the last few years [4], [5], [6]. Impressive tracking systems have been developed for some specific applications [7], [8].

In case of selecting one object among several, the subject becomes more complex, especially if the targets are of nearly same color.

In this case, system can track the target more accurately by limiting the search window while zoomed around the target.

In the following project, our goal is tracking of moving target over a plane and turning it on by laser pointer.

This device can be used as image processing algorithm benchmark in laboratories. Figure 3 shows the image of the device.

Fig3. Image processing based laser tracking system

5. Mechanical and electronic sections

For moving the laser point over objects plane, two stepper motors are used. These motors are connected to a gear by a worm gear. The movement of these gears changes the position of laser point.

The necessary control command is given by computer through parallel port to the interface circuit. Power transistor is used in the interface circuit. These transistors can turn off/on stepper motor inductors due to command received directly from parallel port. The interface circuit can also turn the laser pointer off or on.

A web camera with 352x288 pixel resolution is mounted on the device as well. It transfers the images through a USB link to the computer.

6. Computer Programming and Image Processing

The device control program is written by Delphi7 with a total of more than 2300 lines of programs. Different sections of the Program are as follows:

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6.1. Device Driver

This section consists of sub-programs written in assembly language for hardware control and access to the parallel port.

Note is made that Delphi has an internal assembler. So, there is no need to link the main program to other control sections.

6.2. Image Capturing

To capture images Video for Windows (VFW) technique is used.

The Tscap32 component is used to get data from camera driver through VFW. This is a free component on the internet.

The images are given as 352x288 matrix in RGB format and pass to image processing section.

6.3. Image processor

After transferring the images to the computer, they need to be processed. In order to separate the target object from image plane, software color filter is used.

Also the light of laser pointer is seen in the images as light dots. By proper adjustment of color filtering parameters or by using an high pass filter, based on pixels color codes, its coordinates are determined.

The coordinates of laser point through image processing needs to be determined because the distance of object plane to the camera is not known.

7. Determining the necessary control commands for laser pointer movement

After finding the target coordinates and the light of laser pointer, the correct command must be given to the stepper motors trough the parallel port in order to move laser pointer to correct direction.

In order to find the correct movement, the nearest neighbor method is used. According to this method, since the pointer movement in 2D image plane is limited to the eight boxes around the pointer position. To find the right direction, it is enough to find the distance of each of the eight boxes from the target. Then, the proper direction is toward the box which has the less distance to the target (Figure 4).

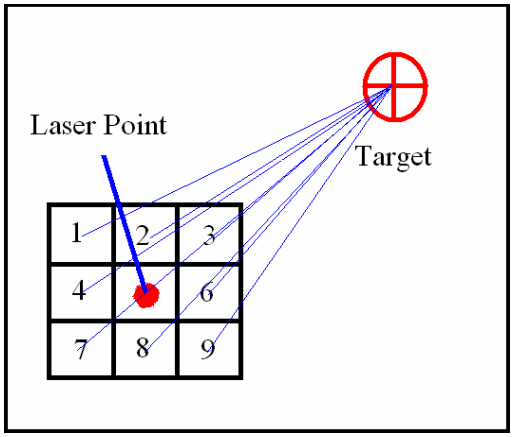

Fig 4. nearest neighbor method

8. Selecting the main moving target

Since the color of the main target can be the same as the other ones, to determine the right ones, the kinematic characteristics of the main moving target must be utilized.

For selecting the main moving target among all another targets, we must use the following notions:
1- The moving object speed is limited.
2- The moving object acceleration is limited.

The first notion tells us that in order to find the main moving target, we don't need to search the whole object plane, and searching only one window around the target which its dimension are in proportion with the maximum speed of the moving target will suffice. This will decrease the image processing time for each frame too.

This will give proper result for the situation when the main moving target has not passed by fake ones. In the case of passing by fake targets, we should use the second notion above.

Therefore, the speed vector for the exiting moving objects in search window is found. Since based on the moving object acceleration limitation, this vector can not have instantaneous change, the main moving target is determined. In fact, we suppose that the main moving target saves its moving direction [9],[10].

9. Conclusion

The detailed of moving target tracking system using an image processing technique is explained. Tracking systems which are based on image processing have found wide applications in man machine relation and are also used in high tech situations.

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