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The Impact Point Detecting System for Photo-electricity Targets

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***Abstract*—according to the requirement of shooting training, the impact point detecting system of photo-electricity target is designed based on laser coordinate orientation method. The principle of detection method based on image process is firstly discussed, then the system design and image processing arithmetic is also detailed, at last the simulation experiment is done, and the result shows that the designed system is stabilized and can reach accurate and reliable detecting and displaying for scoring ring number.**

Keywords-impact point detecting; laser coordinate orientation method; image process

I. INTRODUCTION

In the conventional shooting training, the display, inspection and report of the round target and the record and statistics of training scores is an essential task to ensure the successful operation of shooting training. At present, this work is done in manual and has the character of extensive work quantity, low safety and low efficiency [1][2] [3][4].

To solve above problem, the automatic detecting system of impact point of photo-electricity target is designed based on image processing. The laser coordinate orientation method is adopted for the realization of detecting and automatic scoring round target. The image processing is done by image processor TMS320DM642 to accomplish high accurate and reliable system.

II. THE PRINCIPLE OF DETECTION METHOD BASED ON IMAGE PROCESS

The schematic diagram of calculation for ring number and target is illustrated in fig 1. The rectangular is the field of view of CCD sensor, with the fractional-pixel of 586(elevation) ×720(azimuth), and the left upper angle is the coordinate of reference point (0, 0). The whole round target is divided into six parts by four straight line segments passed through circle centre(288,360), and the slope of this straight line is separately 2.4, 0.41, -0.41 and -2.4.

If the laser chaingun shooting on photo-electricity target, the laser spot coordinate (x,y) will be calculated out, then the slope of straight line passed through laser spot and centre circle is calculated out by the follow formula:

$$k = (y - 360)/(x - 288)$$

The ring number and target will also be checked out according to round target parameter. For example, if laser spot is the point (311,390), the slope can be calculated out and is -0.48. Because the -0.48 is less than -0.41 but more than -2.4, so we can infer that the shooting target should hit the lower right on photo-electricity target. The ring number can be also checked out through the pixel-value differencing between laser spot and circle center.

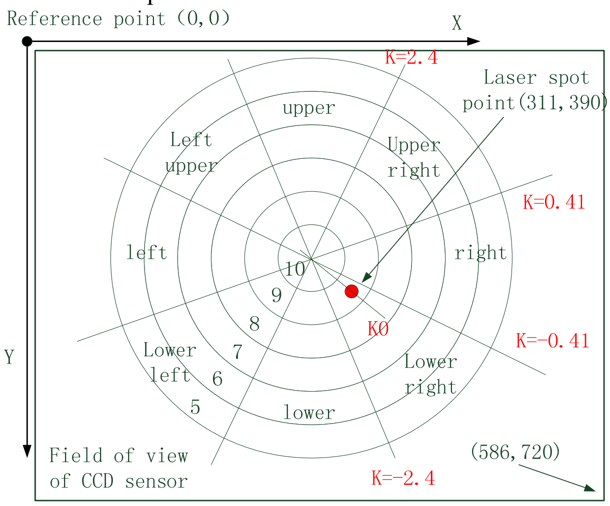


Figure 1 schematic diagram of calculation for ring number and target

III. THE SYSTEM DESIGN FOR IMPACT POINT DETECTING

The impact point detecting system, whose block diagram for impact point detecting system is illustrated in figure 2, is based on image method which process core is the TMS320DM642, the ring number and target is calculated out according to the laser spot position on the field of view of CCD sensor. So in this paper, the TMS320DM642 is in charge of receiving and processing of video from CCD, and transmission of the centroid coordinate of laser spot to other microcontroller. While the other microcontroller STM32F103 is used for further processing and calculation, and the interface between DM642 and STM32F103 is typical serial port RS232.

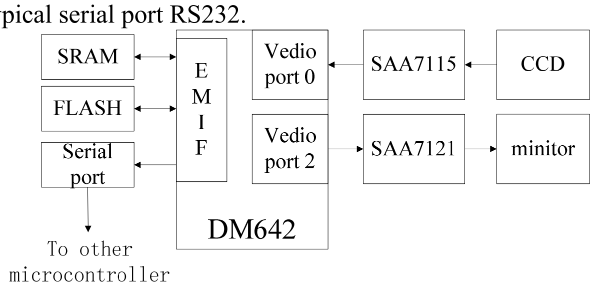


Fig 2 block diagram for impact point detecting system

A. The introduction for TMS320DM642

The TMS320DM642 device, based on the Second-generation high-performance, very-long-instruction-word architecture, is the highest-performance fixed-point DSP generation in the TMS320C6000 DSP platform. With performance of up to 4800 million instructions per second (MIPS) at a clock rate of 600 MHz, the DM642device offers cost-effective solutions to high-performance DSP programming challenges.

The DM642 DSP has application-specific hardware logic, on-chip memory, a two-level cache-based architecture and a powerful and diverse set of peripherals. The peripheral set includes: three configurable video ports; a management data input/output (MDIO) module; a VCXO interpolated control port (VIC); one multichannel buffered audio serial port (McASP0); an inter-integrated circuit (I2C) Bus module; two multichannel buffered serial ports (McBSPs); three 32-bit general-purpose timers; a user-configurable 16-bit or 32-bit host-port interface (HPI16/HPI32); a peripheral component interconnect (PCI); a general-purpose input/output port (GP0) with 16 GPIO pins; and a 64-bit glueless external memory interface (EMIFA).

More important, the three configurable video port peripherals (VP0, VP1, and VP2) provide a glueless interface to common video decoder and encoder devices and it can be directly connect to common analogy cameras through video decoder.

B. Video median filtering algorithm [5][6]

In signal processing, it is often desirable to be able to perform some kind of noise reduction on an image or signal before processing. The median filter is a nonlinear digital filtering technique, often used for signal smoothing and reducing random noise (especially when the noise amplitude probability density has large tails) and periodic patterns, theoretical results on its behavior are nonexistent in the open literature. Considering the real-time task in embedded system, the median filtering algorithm is adopted in the paper to conduct image pretreatment.

Median filtering conduct according the follow formula:

g(x,y)=[f(x-1,y-1)+ f(x-1,y) □1+ f(x-1,y+1)+ f(x-1,y-1)+ f(x,y-1) □1+ f(x,y) □2+ f(x,y+1) □1+ f(x+1,y-1)+ f(x+1,y) □1+ f(x+1,y+1)] □4

Where, □ is shift logical left which means operated object multiplying with 2; Otherwise, □ is shift logical right which means operated object divided with 2. f(x,y) is the image before processing of median filtering, g(x,y) is the image after processing.

C. adaptive threshold segmentation algorithms [7]

In the field of Computer Vision, image segmentation plays a crucial role as a preliminary step for high-level image processing. To understand an image, one needs to isolate the objects in it and find relation among them. A threshold image $g(x,y)$ is defines as

$$g(x,y)=\begin{cases}1, f(x,y)>T\\0, f(x,y)\le T\end{cases},$$

Where 1 is object and 0 is background.

The implementing steps for segmentation are as follows:

- Select an initial estimate for *T;*
- Segment image using *T, Group G1 (values >T), Group G2 (values ≤ T);*
- Compute average gray level values for G1, G2→μ1, μ2;
- Calculate a new threshold value T=1/2(μ1+μ2);

Repeat (2) through (4) until the difference in *T* in successive iterations is smaller than T_0.

D. laser spot centroid algorithm [8]

The finally aim of pretreatment for collected video and the image processor of dm642 is to extract the coordinate of laser spot, and the recent method includes peak location method, matching location method, central projection method and centroid location method. Where the centroid location method with the character of high location precision and a fewer calculation are adopted in this paper.

If the dimension of an image is $M\times N$, then the centroid coordinate is calculated by

$$x_c=\frac{\sum_{i=1}^{M}\sum_{j=1}^{N} x_{i,j}\cdot\left(g(i,j)-T\right)}{\sum_{i=1}^{M}\sum_{j=1}^{N}\left(g(i,j)-T\right)},$$

$$y_c=\frac{\sum_{i=1}^{M}\sum_{j=1}^{N} y_{i,j}\cdot\left(g(i,j)-T\right)}{\sum_{i=1}^{M}\sum_{j=1}^{N}\left(g(i,j)-T\right)}$$

E. Software flow chart

The software flow chart of designed system is shown in figure 3. When the system is switched on, the DM642 enter into system initial state; include system clock and some relative peripherals. Then the analog video is collected from CCD and converted into digital video frames by frames. Finally, the image pretreatment is done in the core of DM642. If there isn't the target, it will return to gather the nest frame of the analog video. Otherwise, the centroid coordinate of laser spot is calculated out and sent to other control microcontroller for next calculation.

IV. EXPERIMENT AND CONCLUSIONS

The simulation detecting experiment of individual firing for laser gun is done based on the designed system. The distance between the gun and target is no less than 3m. The distance between the gun and the detecting device is 2m. Sampling rate of the image sensor is 25 frames per second. The collected image in the course of experiment device through image processor of TMS320DM642 is shown in figure 4. The same condition experiment is done for many times and the result shows that the successful rate of detecting and voice broadcast for ring number is 100%, the system hardware for signal sampling, processing and displaying is accurate and reliable, the system software is correct, and the whole system is stabilized.

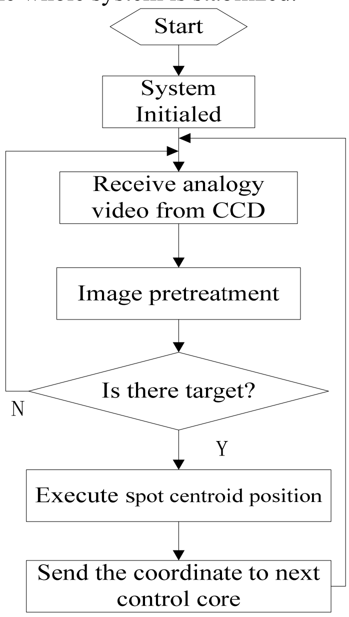
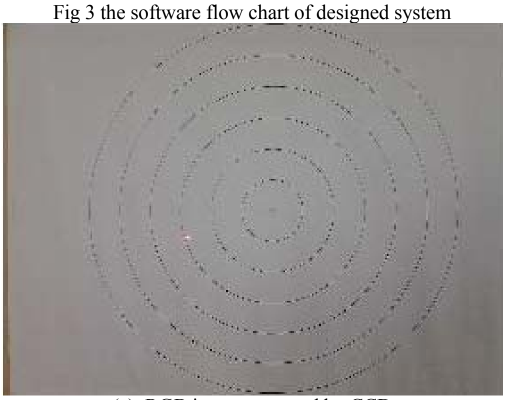
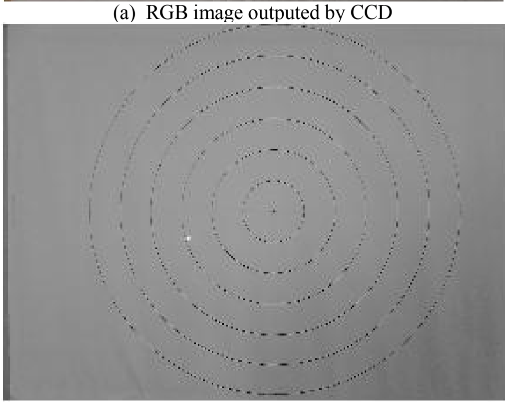


Fig 3 the software flow chart of designed system



(a) RGB image outputed by CCD



(b) Gray image through image processo

(c) Image after binarization through image processor

Figure 4 collected image in the course of experiment device

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