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THE MEASURING SYSTEM OF A MARATHON RUNNER

Nobuyuki SASAKI
Toshiba Corporation
Komukai Works
1,Komukaitoshiba-cho,Saiwai-ku,Kawasaki 210,Japan

Iwao NAMIKAWA
Kansai Telecasting Corporation
5-17,Nishitemma 6 chome,Kita-ku,Osaka 530,Japan

ABSTRACT

The measuring system of a marathon runner by using the realtime image processor - Picot (PICture COmpuTer) and fast graphic processor - HSP has been newly developed. It includes two subsystems, pitch (step frequency) detection and CG display of a runner. Pitch detection subsystem detects the runner's pitch by image processing. CG display subsystem detects the position of the joints of the runner's legs and displays their motion at realtime rate.

INTRODUCTION

To broadcast a marathon program effectively, we have already several conventional ways, such as displaying each 5 km's raptime and expecting the goal time and so on. But all these ways are not related with image processing. So the authors began to try to get some information by using image processing. And this year (1990), we succeded to implement the measuring system of marathon runner's pitch and the displaying system of the runner's legs motion.

Pitch detection subsystem detects the marathon runner's pitch by applying two different ways from the image and the velocitry from a car that follows a runner. And from the pitch and the velocity data, stride data are calculated. By these three data (pitch, stride and velocity), current status of a runner and expecting goal time are explained by a commentator.

CG display subsystem detects the position of the joints of runner's legs and displays their motion at realtime rate. At first, data of runner's legs are stored in the data memory,then skelton lines are detected and positions of the joints are specified. Finally parameters of sine curves which express the motion of leg's joints are obtained and transmitted to the CG controller through LAN, and CG display is generated by the graphic processor.

The results of pitch detection had been broadcasted several times in the 1990's Osaka lady's marathon race and as for CG display, main parts of the process have been already implemented.

CONCEPT

To develop this system, the authors set up the following design targets.

<u>(1) Using the image processing method.</u> All the data should be obtained from only the image transmitted to the broadcast station.
<u>(2) Programmable.</u> Each process should be easily changed by software.
<u>(3) Real-time processing.</u> Each data should be obtained without a large time delay.
<u>(4) Automatic processing.</u> Each data should be processed without a human help.

To realize these targets, we used the Picot system[1]. It is a totally programmable real-time image processing system which can do any process. It has two key-components, the processing LSI and the network LSI. The processing LSI has a MPY (multiplyer,16b), an ALU (arithmetic logic circuits 16b), two AU (addressing circuits, 22b), a DMI (data memory interface, up to 16MW) and IO (two input-ports and an output-port, 16b). It has a sophisticated control system which is executed by a microprogrammable sequencer. The network LSI is a programmable crossbar switch (32-input, 48-output, 2b wod length). By making microprograms of those LSIs, we can implement various real-time image processing applications such as pipeline and parallel processing.

PITCH DETECTION SUB SYSTEM

A. Block diagram

Fig.1 is a system block diagram. Three cars that follow runners send the image and distance data through a helicopter and modem. In the broadcast station one image and distance data is selected and processed. In the Picot system, a pitch is detected from the image and velocity is calculated from the differential calculus of the distance data. These results are transmitted to another personal computer which stores these data and makes the superimpose image.

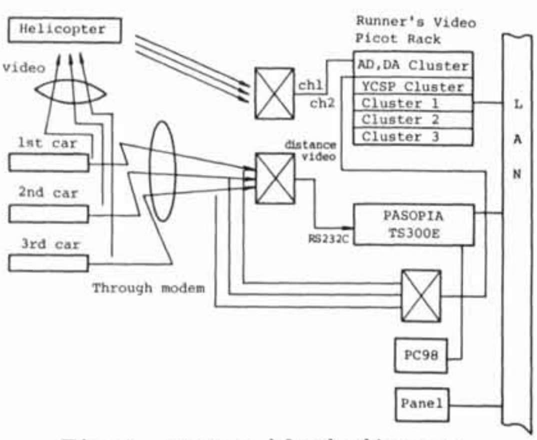


Fig.1 system block diagram

B. Pitch detection - method 1

The area of pixels of runner's image which are in the window and have some luminance level is detected by counting the number of bi-leveled pixels. And by FFT of the values of the area obtained at each video field, pitch is detected.

Fig.2 is the image example of method 1. The measuring window is on the central runner. An operater must track this window manually. Three bar-graphs below the image express the value of area and by watching them he can know how the system is working.

Fig.2 method1 image example

C. Pitch detection method - 2

The motion vector of runner's face is detected automatically by the block matching method. And by FFT of the vertical components of the vector obtained at each video field, pitch is calculated.

Fig.3 is the image example of the seconnd method. The matching template is on the central runner's face. At first an operater must point the runner's face by a joystick, after that the template will track the runner's face automatically.

Fig.3 method2 image example

Fig.4 shows the matching template and Table 1 shows the detect area. In the matching template, 30 points are used for pattern matching. In case of a tele-photo camera shot, both the detect area and the increment value are increased in order to correspond the large motion vector, on the other hand in case of a wide-angle shot, they are decreased. In this way, the same amount of calculation are needed in both cases. In the Picot system, 6 processing LSIs are working in parallel process, and the controller (microprocessor, 68k) which controls 16 processing LSIs arbitrates these 6 indepndent data and avoids that these data scatters.

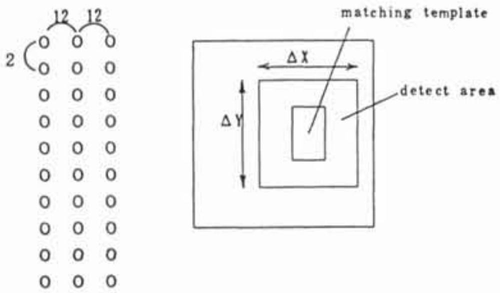


Fig.4 matching template

	X detect area	Y detect area	X increment	Y increment
1	±20	±20	1	1
2	±40	±20	2	1
3	±40	±40	2	2
4	±80	±40	4	2

Table.1 detect area

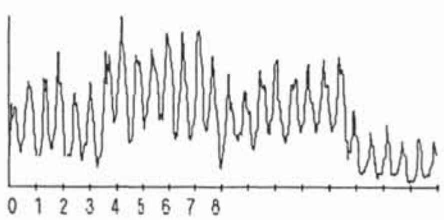


Fig.5 time domain data display

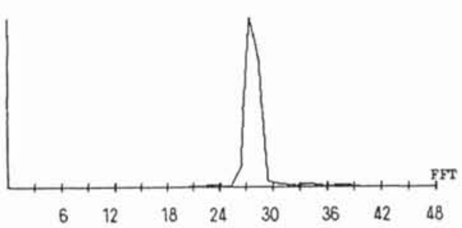


Fig.6 FFT data

D. Result

In both methods, 512 data (during 8.5 sec) are obtained, and by FFT pitch is calculated. Fig.5 shows the time domain display of these data and Fig.6 shows the result of FFT of these 512 data. If 512 data are not complete because of mismatching, proper 256 data in the middle are exploited.

The resolution of frequency depends on the number of data. As 512 data are not enough to get a good resolution, we must interpolate the discrete frequency data.

Generally the method 1 is suitable for a tele-photo camera shot and the method 2 is available for a wide-angle shot in which several runners run together. In fact we mainly used the method 2.

CG subsystem

A. Block diagram

Fig.7 is a system diagram. The runner's video is processed by the chromakeyer ,the noise reducer and the bi-level quantizer. Thus the runner's legs are detected and these bileveled legs data are stored for 30 video fields. This process is constructed by 16 processing LSIs of the Picot system which works at real-time rate.

Then the skelton lines are detected from those 30 V data, and the joints of the legs are obtained from the turning points of the skelton lines. This skelton-process is processed by 30 processing LSIs of the Picot system which work in parallel process and at non-real-time rate.

At last, the motion curves of the leg's joints are calculated by matching the sine curves to the joint points obtained above and CG controller displays the animation of the runner's body by the sine curve parameters. This is the CG-process and the microprocessor is used for matching, a personal computer and the graphic processor are used for the creation of CG animation.

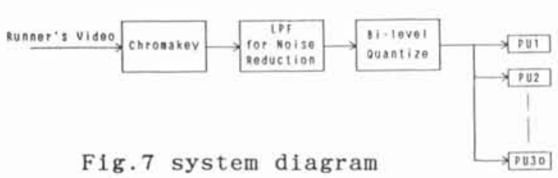
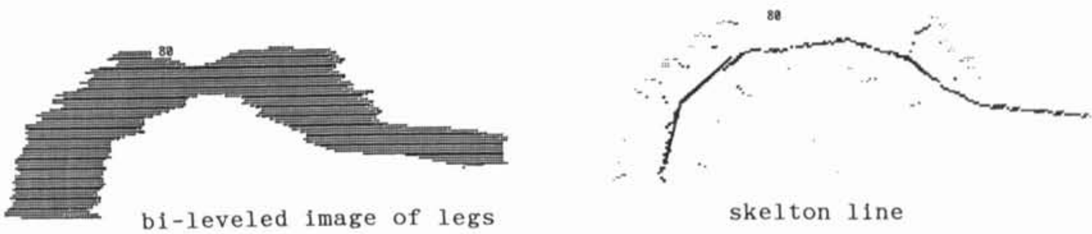


Fig.7 system diagram

B. Skelton-process

The skelton lines are detected by an ordinary image processing



bi-leveled image of legs   skelton line

Fig.8 detecting process

method. From the start point, the turning point is searched by calculating the curvature from each proup of points. Thus the joint of a knee is specified. The lines of an upper and lower leg are specified by making the line of constant length from the knee point up or down. Fig.8 shows the detecting process.

C. CG-process

Fig.9 shows the time domain display of X,Y components which are obtained above as the positions of joints. The dotted line of the curve is a part in which runner's both legs intersect. So by matching the sine curve of which frequency is already known as a pitch, the motion of each joint is specified and the hidden parts are interpolated very naturally.

As for CG, it has two parts, calculating the vertexs of the polygons and shading process. The former is calculated by a personal computer and the latter is processed by the HSP[2]. The HSP is the fast graphic processor which can do z-buffer sort and Gouraud shading very rapidly (10M pixel/sec). About 600 polygons are used to express the human body and legs.

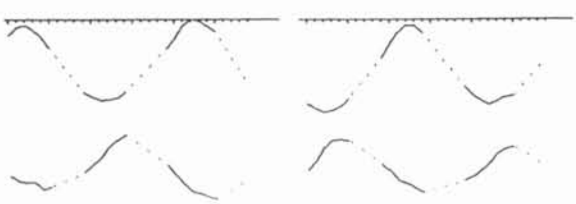


Fig.9 time domain data of joints position

D. Result

Actually the automatic detecting process of the joints position is rather diffcult, especially when the leg is almost straight. The speed of a personal computer is too slow to produce the real-time rate CG (3field/sec).

Because of those difficultys, CG subsystem is not completed yet. But we are now trying to overcome these problems and some of them are already resolved by various methods.

CONCLUSION

The pitch detection and CG display of runner's legs system using the real-time image processor and the fast graphic pocessor has been well developed. As this system is totally programmable image processing system, it was very easy to develop in so short term and it has great possibility in future,for example the pitch detction technology will expand to the camera tracking system.

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