어안렌즈 카메라의 영상왜곡보정처리 시스템 구현

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Image Distortion Correction Processing System Realization for Fisheye Lens Camera

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요 약

본 논문은 어안 렌즈 카메라의 영상 왜곡 보정 처리 시스템 구현에 관한 것이다. 영상 보정 처리 알고리즘은 역맵핑기법을 적용하고 실시간 처리를 위해 DSP 프로세서를 사용하여 시스템을 구현하였다. 알고리즘 적용시 카메라의 왜곡 계수는 실시간 처리를 위해 룩업 테이블화하여 처리한다. 실험 결과, 원영상과 각도변화에 대한 PSNR 변화는 8.3%정도로 안정적 자연스러우며, 화질보다는 실시간 처리에 중점을 두어 한 프레임 720x480 왜곡영상 처리 시간이 약 31.3ms 소요되었다.

ABSTRACT

A realization for image distortion correction processing system with DSP processor is presented in this paper. The image distortion correcting algorithm is realized by DSP processor for focusing on more real time processing than image quality. The lens and camera distortion coefficients are processed by the Lookup Tables and the correcting algorithm is applied to reverse mapping method for geometrical transform. The system experimentation results in the processing time about 31.3 msec on 720x480 wide range image, and the image is stable and spontaneous to be about 8.3% average PSNR variation with changing a wide angle.

키워드

Fisheye lens, correction algorithm, reverse mapping, lookup table and real time processing

Ⅰ. Introduction

A development of DIP (digital image processing) leads a most industry to be applied to testing equipment, security solution and so on. A CMOS and CCD image sensing cameras are very important component of DIP for image data acquisition. A sort of lens enables a camera to acquire the wide visual range and various video image. The first types of fisheye lenses to be developed were circular fisheye lenses which took in a 180 degree hemisphere and projected this as a circle within the film frame. Fisheye lens is a wide angle lens that takes in an extremely wide hemispherical image. Originally developed for use in astronomy and meteorology. It featured a 220 degree field of view, designed to capture the entire sky and surrounding ground.. All the ultrawide angle lenses suffer from some amount of distortion. while this can easily be corrected for moderately wide angles of view, rectilinear ultrwide angle lenses with

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angles of view greater 90 degrees are difficult to design. Fisheye lenses achieve extremely wide angles of view by foregoing a rectilinear image, opting instead for a special mapping, which gives images a characteristic convex appearance. Fisheye lenses has barrel distortion that is image magnification decreases with increasing distance from the optical axis. The apparent effect is that of an image which has been mapped around a sphere. Fisheye lenses, which take hemispherical views, produce this type of distortion as a result of a hemispherical scene being projected onto a flat surface. Thus, a image of the wide angle range lens camera is required to correct the distorted image geometrically. There are two correction algorithm, the forward mapping and reverse mapping. The input image correction techniques of geometric transformation have been studying and developing between camera and lens in compensation for image distortion. The dependance on software for distortion correction entirely is given rise to be delayed processing time of DIP system.[1-8] This paper is presented the system focusing on more real time processing and realized the hardware with DSP processor than image quality with fisheye lens of camera. The correction algorithm is applied to reverse mapping and lookup table.

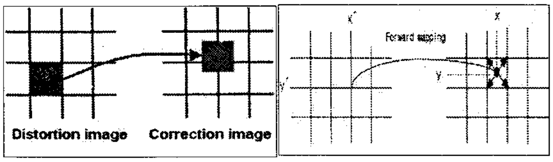
II. CORRECTING ALGORITHM AND SYSTEM REALIZATION

2.1. Correcting algorithm

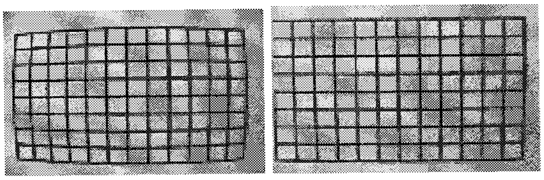
The geometrical transform between interframes is composed of space transform to reconstruct pixels on the space and RGB interpolation to allocate a pixels moving into space. The transforming coefficients makes image to correct a distortion. That is presented the forward mapping and reverse mapping methods. There are two problems with forward mapping: holes and overlaps. holes are pixels that are undefined, and the destination pixel has no corresponding source pixel. Overlaps occur when two input pixels get mapped to the same output pixel. The reverse mapping traverses the destination image and calculates via some inverse transformation which pixels in the source image will be used to produce the destination pixel. computing destination images in this manner eliminates the problems of holes and overlaps.

1) Forward mapping

The forward mapping is that a correcting position is searched by applying the correcting coefficients to distorted image pixles such as shown Fig. 1 (a). That is, transformed coefficients is found out on the distorted image to attain the correcting image and that applies to the distorted image for mapping directly. As shown Fig.1 (a) the image coordinate g(x,y) for correction is calculated by applying the correcting coefficients to distorted image f(x,y), and then this coordinate g(x,y) is allocated the distorted image pixels.



(a) Forward mapping



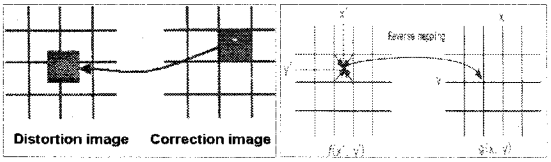
(b) experimental crosshatch image

Fig. 1 Forward mapping and images

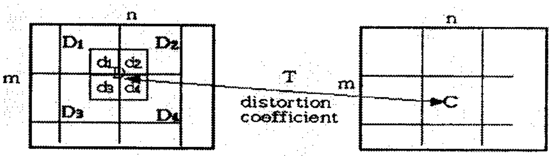
However the corrected image is generated the holes points because of digital data. They needs plus interpolation processing to fill out. The experimental result at 120 degrees is shown in Fig. 1 (b).

2) Reverse mapping

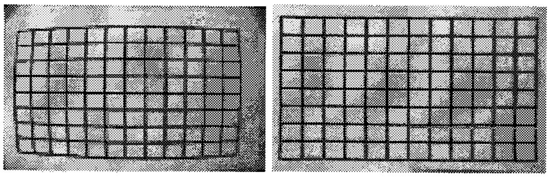
The forward mapping weakness get solved by the reverse mapping method. The reverse mapping is expanded that the distorted image position f(x,y) is searched by applying distortion coefficients to the image pixels g(x,y) to be corrected as shown Fig. 2 (a). This method is postulated the corrected image and search for any matching point on the distorted image. The distorted image is equal to applying the extracted distortion coefficients to undistorted image. As shown in Fig. 2 (b) in order to find out the corrected image coordinate $C(x_i, y_i)$ from the distorted image coordinate, the distortion coefficients apply to undistorted image coordinate $D(x_i, y_i)$, and takes the pixel value of coordinate that a pixel value of distorted image coordinate is mapped as the corrected image.



(a) Reverse mapping



(b) Distorted pixel and correcting pixel



(c) Experimental crosshatch image

Fig. 2 Reverse mapping and images

Accordingly in order to decide a pixel value in the corrected image, inquire into 4 subpixel area by an adjacent pixel value of the distorted image. Fig. 2 (b) left shows the relation between the distorted image and the corrected image for MxN image, mapping into the distorted image by applying the distortion coefficients to the spatial coordinate that is the corrected image is shown in Fig. 2 (b) right, and Fig. 2 (c) shows the experimental result of the corrected image in (c) right for the distorted input image (c) left.

2.2. System realization

The system consists of fisheye lens camera module and video signal processing module executed the algorithm with DSP processor shown in Fig. 3. The fisheye lens camera module converts CMOS sensor image signal to 8 bits ITU-R BT.656 format digital image data. The visual range of lens has 180 degrees over.

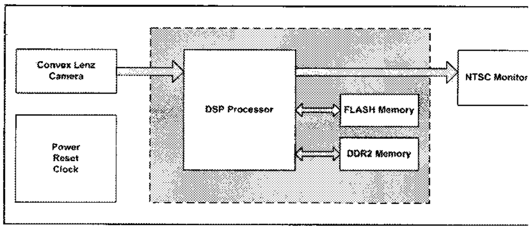


Fig. 3 System realization blocks

The parallel interface for YCbCr(4:2:2) signals of ITU-R 656 are multiplexed in the following way: Y, Cb, Cr are producing the Parallel Digital Signal, that has 27MHz frequency. The signal is driven to a bus of 11 pairs (10 for the data and 1 for the clock). Lines must be balanced ECL with characteristic impedance 100 ohms. Cables enables to be 50 m long without equalization. Connectors are type D 25 pins. The serial interface has 270 MHz frequency. The conversion includes a scrambling process, in order to reduce the DC components and makes easier the clock reconstruction, and a Non Return to Zero Inverted coding, that make the signal insensible to polarity. The cable is coaxial 75 ohms, the connectors are BNC. The video signal processing module is driven by DSP processor and stores image data in external memory in a frame. The memory access is used DMA(Direct Memory Access) to be reduced the accessing time in the Processor. The processor is constructed the program architecture to operate the distortion correction algorithm with QDMA (Quick DMA). QDMA get executed the data access to reduce the delay time between the processor and external memory. Program architecture is reconstructed to make the optimized coding to lots of operation routines, and realized the soft pipeline and is coded by micro-assembler to be fast. The distortion coefficients of fisheye lens has regularly fixed values. That enables to reduce operation time to make lookup table for YCbCr distortion coefficients respectively.

2.3. Lookup Table

The scanning is applied to interlace that a frame size 720x480 has odd and even fields such as 720x240 respectively. The distortion coefficients of 1/2 image size enables to be known the coefficients of the other half size. The Lookup Table is composed of odd and even fields that has the array 360x240 to be the half size for a field 720x240 as shown in Table 1.

Table 1. Lookup table arrays

Odd field	Even field
LUT1[360]	LUT3[360]
LUT2[240]	LUT4[240]

Ⅲ. EXPERIMENTATION

The realized system is shown in Fig. 4 (a), that is main board based on DSP processor with the correcting algorithm for distorted image 720x480 given by fisheye lens camera.

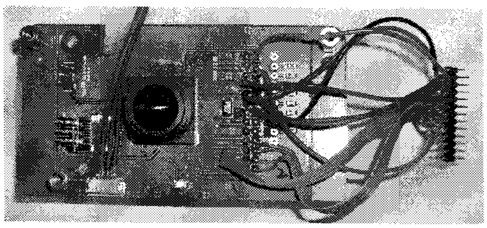
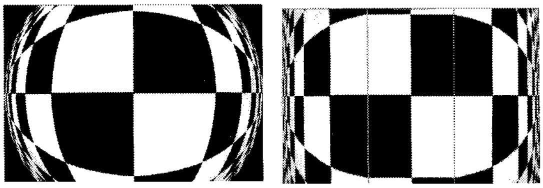
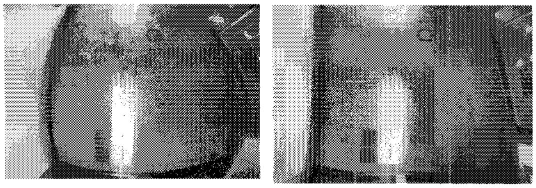


Fig. 4 Realized system board with camera

And shows the experimental image on NTSC monitor display applied a sample image to the correcting algorithm using the reverse mapping method. As shown in Fig. 5 (a) the original distorted image given by fisheye lens camera for checkerboard image. That is curved toward inside at 120 degree visual range. Fig. 5 (a) left shows the corrected image using reverse mapping method of geometrical transform and YCbCr lookup tables. And Fig. 5 (b) is shown the wide range angle 150 degree. A wide range angles are increased has only average PSNR difference 8.3% based on the original as shown in Table 2.



(a) Checkerboard image



(b) Inside room image

Fig. 5 Experimental images

Table 2. Lens angles and PSNR

Lens angles	PSNR
Original	31.1
100	30.1
120	29.5
150	27.9
170	26.6

The experimentation is not given the picture quality because of focusing on real time system realization. As shown in Table 3 the realized system is measured for processing time in a frame. That takes about 28.4 msec to operate the correcting algorithm that is composed of reverse mapping method of geometrical transform and lookup tables, and pre and post processing 2.9 msec, and the amount 31.3 msec totally. That makes a stable and spontaneous flat image.

Table 3. System processing required time

Measured items	Required times(msec)
Preprocessing	1.5
Correcting algorithm	28.4
Post processing	1.4
Amount per frame	31.3

V. CONCLUSIONS

The system realization based on DSP processor and the correcting image algorithm to the curved distortion image on fisheye lens camera is presented. The algorithm is used the reverse mapping method of geometrical transform and the distortion coefficients of fisheye lens are substituted into lookup tables. The processing time of the system is totally taken about 31.3 msec on 720x480 curved image at 170 degree visual range, and the image is stable and spontaneous to be about 8.3% average PSNR variation with changing a wide angle. Accordingly this system is satisfied with real time operation. However this time is required to optimized the system for reducing to about 2 msec to be faster in future.

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