Realization for Image Distortion Correction Processing System with Fisheye Lens Camera

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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 YCbCr Lookup Tables and the correcting algorithm is applied to reverse mapping method for geometrical transform. The system experimentation results in the processing time about 34.6 msec on 720x480 curved image at 150 degree visual range.

KEYWORDS

Fisheye lens, DSP, correction algorithm, reverse mapping, look-up 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 to 180 degree and various video image. A Convex lens is good and common to take them. However that is required to correct far image distortion geometrically. Thus input image correction techniques 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.[1-7] 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.

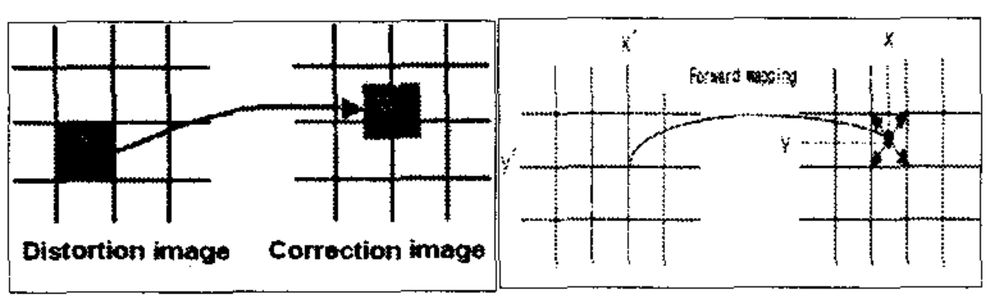
II. CORRECTING ALGORITHM AND SYSTEM REALIZATION

2-1. Correcting algorithm

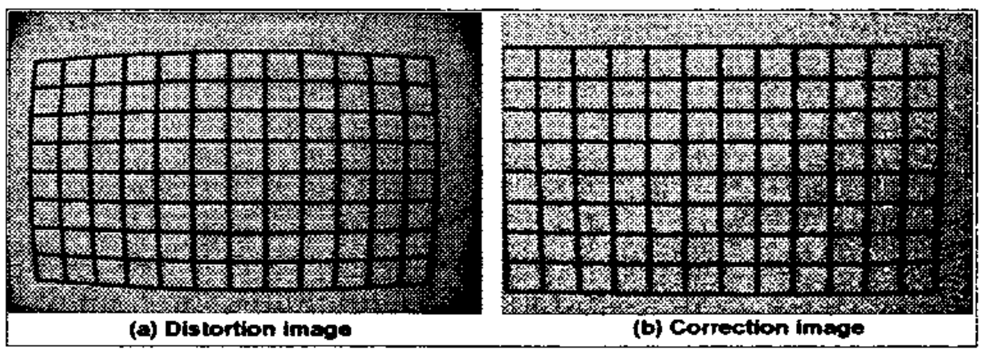
The geometrical transform between interframes is composed of space transform to reconstruct pixels on the space and RGB interpolation to allocate a pixels moving into space. The transforming coefficients makes image to correct a distortion. That is presented the forward mapping and reverse mapping methods.

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

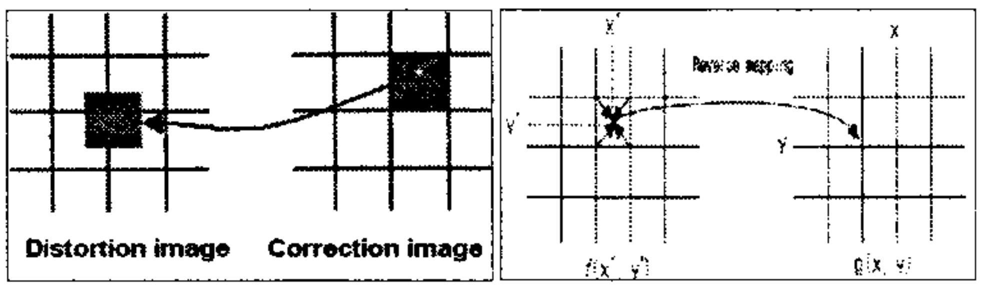


(b) experimental images
Fig. 1 Forward mapping and images

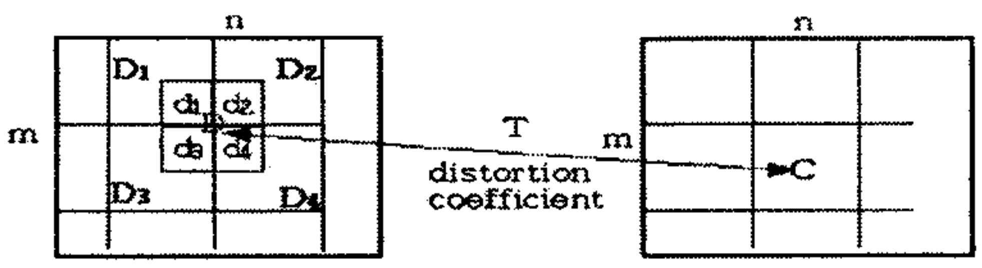
However the corrected image is generated the rest points because of digital data. They needs plus interpolation processing to fill out. The experimental result at 150 degrees is shown in Fig. 1 (b).

2) Reverse mapping

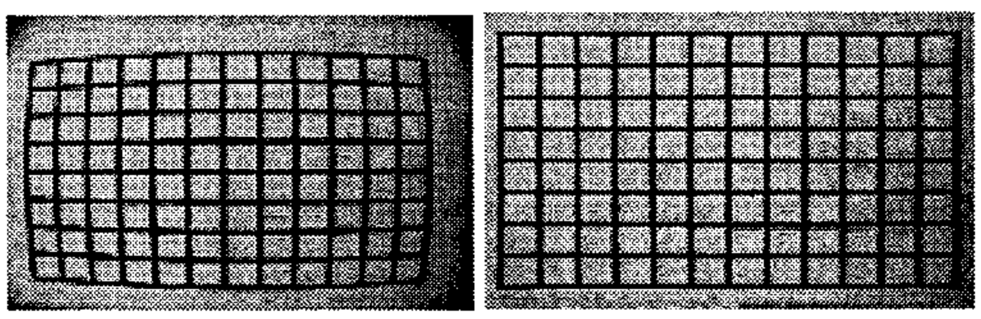
The forward mapping weakness get solved by the reverse mapping method. The reverse mapping is expanded that the distorted image position f(x,y) is searched by applying distortion coefficients to the image pixels g(x,y) to be corrected as shown Fig. 2 (a). This method is postulated the corrected image and search for any matching point on the distorted image. The distorted image is equal to applying the extracted distortion coefficients to undistorted image.



(a) Reverse mapping



(b) Distorted pixel and correcting pixel



(c) Experimental images
Fig. 2 Reverse mapping and images

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. 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 Fig. 3.

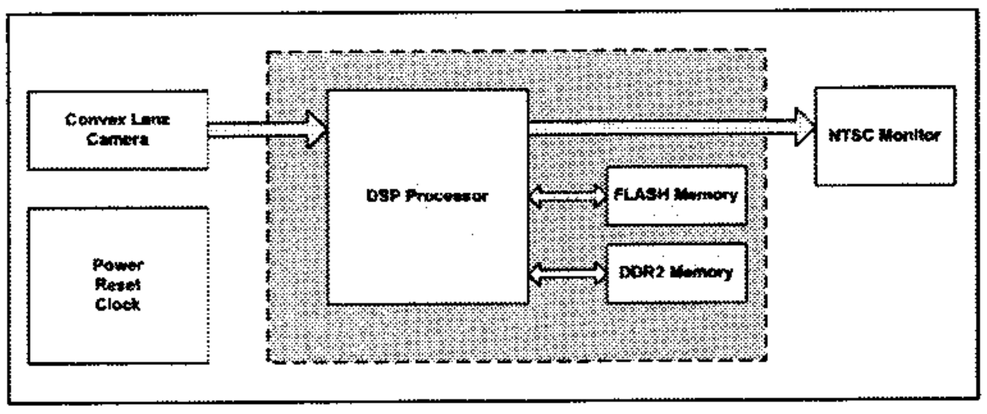
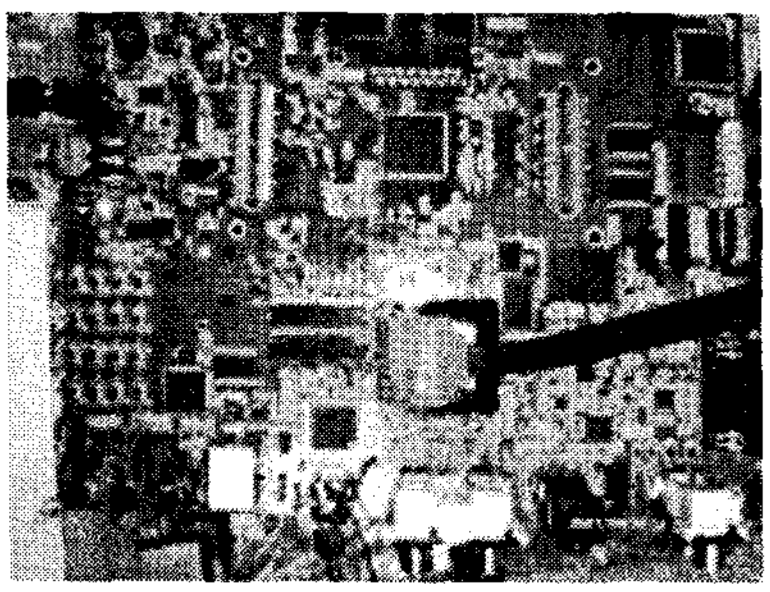


Fig. 3 System realization blocks

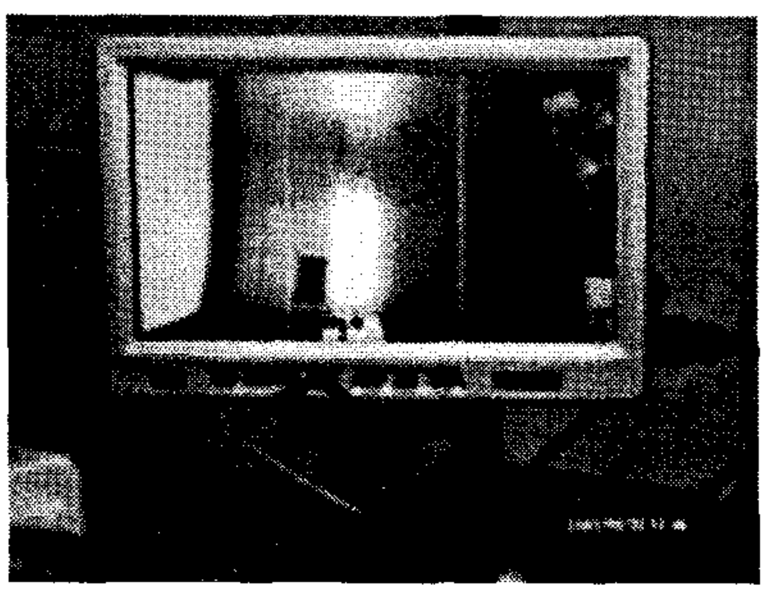
The fisheye lens camera module converts CMOS sensor image signal to 8 bits ITU-R BT.656 format digital image data. The visual range of lens has 180 degrees over. The parallel interface for **Y, Cb, Cr(4:2:2)** signals of ITU-R 656 are multiplexed in the following way: Y, Cb, Cr are producing the Parallel 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 make 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.

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.



(a) Realized system board

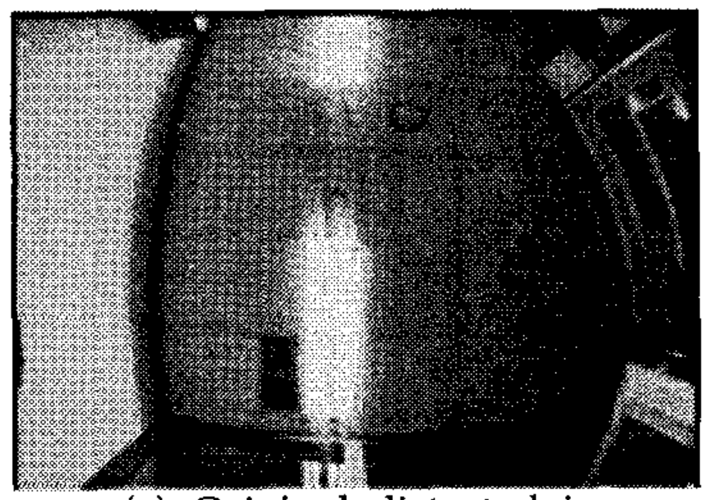


(b) NTSC monitoring

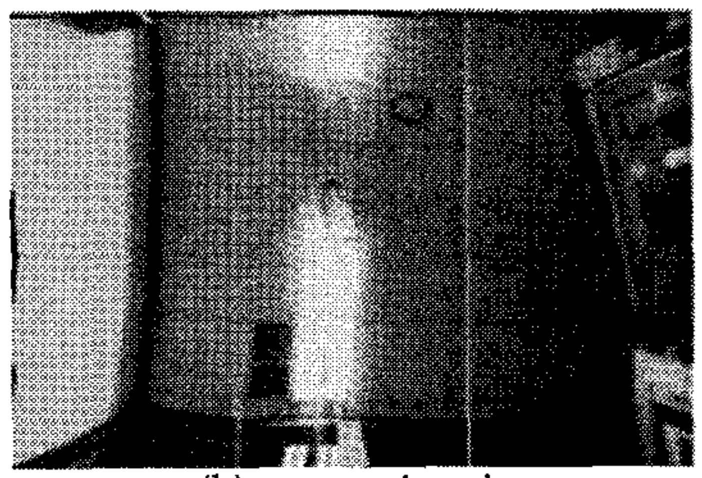
Fig. 4 System board and monitoring

Fig. 4 (b) 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. That is curved toward inside at 150 degree visual range. Fig. 5 (b) shows the corrected image using reverse mapping method of geometrical transform and YCbCr lookup tables.



(a) Original distorted image



(b) correcting image

Fig. 5 Experimental images

The experimentation is not given the picture quality because of focusing on real time system realization. As shown in Table 1 the realized system is measured for processing time in a frame. That takes about 31.7 msec to operate the correcting algorithm that is composed of reverse mapping method of geometrical transform and lookup tables, and 2.9 msec pre and post processing, and 34.6 msec totally.

Table 1 System processing times

Measured items	Required times(msec)
Preprocessing	1.5
Correcting algorithm	31.7
Post processing	1.4
Amount per frame	34.6

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 34.6 msec on 720x480 curved image at 150 degree visual range. Accordingly this system is almost satisfied with real time operation. However this time is required to optimized the system for reducing to 2 msec to be faster in future.

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