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SPECIAL ISSUE PAPER

Low-power DSP system for real-time correction of fish-eye cameras in automotive driver assistance applications

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Abstract The development of an embedded system for real-time correction of fish-eye effect is presented. The fish-eye lens is applied to driver assistance video systems because of its wide-angled view. A large field of view can reduce the number of cameras needed for video system and their cost, installation, maintenance and wiring issues. On the other hand, this lens causes inherent radial distortion to image that has to be corrected in real-time with a low-cost and low-power processing platform. This paper proposes a solution that can be easily adapted to different types of lens and camera, and meets real-time constraints with a power budget within 100 mW and a board size of few cm^2. Starting from mathematical equations, given by the geometrical optics, a state-of-the-art correction method is presented, then optimizations are introduced at different levels: algorithmic level, where a real-time correction parameter calculation avoids extra non-volatile off-chip memory cards; data transfer level, where a new pixel pair management reduces memory access and storage burden; HW-SW implementation level, where a low-power board has been developed and tested in real automotive scenarios. Other applications of the developed system, such as multi-camera and multi-dimensional video systems, are finally presented.

Keywords Fish-eye · Video correction · Automotive · Driver assistance · Real-time video processing

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1 Introduction

In last years, the use of cameras for automotive driver assistance has increased a lot [1–22]. Nowadays most of the car manufacturers offer video systems on their vehicles to give to the driver a better view of the so-called "blind spots", areas that are normally impossible to look easily in the driving position. Therefore, it is important to use an array of cameras mounted towards every directions or, as alternative, cameras equipped with wide-angled lens (referred in this paper as "fish-eye cameras").

Fish-eye lenses have been commonly used for surveillance applications [15, 17] due to their large field of view (FoV), but nowadays they find new useful applications in automotive driver assistance video systems [7–17]. In fact a single camera with a fish-eye lens can substitute, in some cases, up to four cameras with traditional lenses.

On the other hand, the fish-eye lens suffers of distortion problems, mainly radial [11, 15]. Since it is very important to give a correct view to the driver, with exact proportions and without any distortions, the correction of images captured by a fish-eye camera is required. Correction of the fish-eye effects has been treated in literature mainly for photography applications. For example, there are several software tools that led the photographer correct this distortion for a picture (e.g., PanoTools [23], Fisheye-Hemi Plug-In [24] for Photoshop and others). However, these solutions, like some other works for surveillance applications [16], refer to a software running on a personal computer. On the contrary, automotive applications call for the real-time correction of fish-eye cameras with hardware platforms compliant with use on-board a car. To this aim limited cost, size and power consumption are required; therefore, the platforms are constrained in terms of computational and memory capabilities.

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