Title	Wide field of view (WFoV) imaging for consumer devices
Author(s)	Corcoran, Peter
Publication Date	2014
Publication Information	Corcoran, P. M., Bigioi, P., & Stec, P. (2014, 10-13 Jan. 2014). Wide field of view (WFoV) imaging for consumer devices. Paper presented at the 2014 IEEE International Conference on Consumer Electronics (ICCE).
Link to publisher's version	http://ieeexplore.ieee.org/xpl/articleDetails.jsp?arnumber=6775955
Item record	http://hdl.handle.net/10379/5573
DOI	http://dx.doi.org/10.1109/ICCE.2014.6775955

Wide Field of View (WFoV) Imaging for Consumer Devices

Peter M. Corcoran[1], *Fellow, IEEE*, Petronel Bigioi[1,2], *Senior Member, IEEE*, Piotr Stec[2].
[1]National University of Ireland Galway; [2]DigitalOptics Corp., Galway
peter.corcoran@nuigalway.ie, pbigioi@doc.com, pstec@doc.com

***Abstract*--The concepts of wide field of view (WFoV) imaging for consumer devices are explained. Some current examples and enabling technologies are provided. The need for real-time distortion correction is outlined. Several new fields of application for consumer WFoV technology are briefly described. Practical use cases will be demonstrated at the conference presentation.**

I. Introduction

Recent developments in imaging sensor technology have made 40 Megapixel sensors available in commercial devices such as the Nokia 808 PureView smartphone [1] and the Pentax 645D camera [2]. These large sensors allow wider fields of view to be imaged by consumer devices. Current devices mainly employ these very large sensors to provide basic electronic zoom functionality. Zoom is typically along the main optical axis and thus somewhat limited. When the zoom function is not used then the extra pixels provided by the 40 Mp sensor provide improved image quality through advanced image processing techniques.

It is noted that some lens configurations can be modified to enhance the resolution of peripheral regions as described in U.S. Pat. No. 5,508,734 to Baker el al. [3] Coupled with new miniature focusing technologies for handheld devices we are on the cusp of next generation of imaging modules that will be able to provide immersive wide-field imaging experiences.

In this paper we review and survey a number of key technologies that are essential to enable WFoV imaging on consumer devices. In addition we consider what new applications a WFoV handheld imaging device might enable. Smartphones and tablets have already shown their general applicability and established themselves as 'must-have' devices. However we feel their current uses are only the beginning of a whole new set of helpful and empowering applications for handheld consumer technologies..

II. Foundation Technologies

A. Keyhole Imaging

Modern imaging & display systems have evolved significantly, in particular driven by recent developments in mobile devices and smartphones. One challenge is to access a large display area on smart-phone sized screens. Even with HD screen resolutions these devices cannot provide detailed access to large 2D images, for example a large map view.

One approach to this problem is known as 'keyhole' imaging and involves displaying only a portion of the 'map' or image on the device screen; however as the device is moved backwards/forwards or to the left/right over a larger 'virtual' map the portion shown on the device screen is updated. This approach is also used in many augmented reality applications, notably in Web mapping systems [4], [5].

B. Virtual Scenes and Augmented Reality

US utility patent application 2011/0216060 [6] describes a method for maintaining multiple views on a shared stable virtual space. This describes methods, apparatus, and computer programs for controlling a view of a virtual scene with a portable device. In one method, a signal is received and the portable device is synchronized to make the location of the portable device a reference point in a three-dimensional (3D) space. A virtual scene, which includes virtual reality elements, is generated in the 3D space around the reference point. The created view is displayed in the portable device, and the view of the virtual scene is changed as the user moves the portable device within the 3D space. This represents the current state-of-art for augmented reality.

The UI techniques for handheld display described in this patent specification are closely related to how we propose to navigate a WFoV image. Clearly the WFoV scene is not a 3D representation of an acquired image scene, but reasonable enhancements over conventional consumer imaging may still be realized. Future challenges are to provide a detailed pseudo-3D by creating an accurate depth map and using paired stereoscopic wide-field.

III. WFoV Imaging on Consumer Devices

The Kogeto Dot [7] is an attachment that snaps onto the back of an iPhone 4, fitting snugly over the phone's camera. The device contains a cylindrical mirror that directs light from every direction down into the lens. Thus the conventional smartphone sensor is used to capture the full 360 degree WFoV image. Free software will allow the user to de-warp this donut-shaped footage and share it online in an interactive player. A similar device and overall concept is also offered by GoPano [8].

One of the challenges for users of these devices is that the recorded image and video have to be de-warped by specialized software. While these provide outputs in various image & video formats and provide some flexibility in aspect ratio, they require post processing on the users computer. In the case of the Kogeto Dot the standard output is a very elongated MPEG video. Typically users find it difficult to assimilate this extended format as it can involve multiple persons having different interactions/conversations at different points on the 'image strip'. Many users of the Dot have commented that they find little use for the unusual native format it generates. This is due to the human visual system having a significantly narrower field of view, and thus viewers are more comfortable with conventional 4:3 and 16:9 aspect ratios. GoPano offers more sophisticated extraction of portions of the main image, but also performs this post-processing on a desktop computer.

A. The Need for Real-Time Distortion Correction

WFoV systems tend to introduce heavy and non-uniform distortion patterns across the field of view so that acquired images do not conform uniformly to ideal mappings. In addition to optical distortions there are additional distortion effects from lens structure and materials. To properly enable WFoV imaging for consumer devices it is desirable to correct for these distortions in addition to normal optical distortions. In addition, as a handheld imaging devices is in constant motion and continually changing its perspective on a scene it is necessary to apply corrections in real-time.

In a high definition image acquisition device, enormous quantities of imaging data are received and transmitted across the system bus at high frame acquisition speeds. This places pressure on many processing modules, especially system memory, that may be connected to the system bus to ensure their demands on the system bus are within an allocated budget and so do not interfere with other processing [9]. This imaging bandwidth problem represents a key challenge for WFoV imaging.

IV. New Applications & WFoV Devices

WFoV imaging devices offer some interesting advantages over current technology that requires an individual 'videographer'; specifically the details of an event, meeting or other social gathering can be captured in detail by placing a number of recording devices at strategic locations. These devices can capture very rich details of the surrounding activities. The Kogeto Dot and GoPano are good examples of such a prototypical *rich imaging device* (RID).

A. Rich Imaging Devices

If we consider that today's HD video requires approximately 3-4 megapixels to generate a full HD image, then a 40 Mp sensor can potentially capture the equivalent of 10x HD video content. In reality, however, the potential is even greater because with sufficient resolution it would be possible to track individuals, or groups of people through different sequences of activities so the potential number of HD videos that might be generated from a single RID increases geometrically with the size of image sensor. At the same time many potential video sequences are not of interest to most users of the system.

To take an example, at a school concert/play each group of parents is primarily interested in their child (or children) and would wish to have a video that included some of the overall group activity, but that mostly focused on their child and their contribution to the school concert/play. The advantage of an RID is that after the main video is captured each parent can access the same raw video data and re-generate one or more customized video sequences of the concert/play that can zoom and pan to focus on the activities of their child, but revert to a broader view of the stage when group activities are the focus.

B. The Personal Videophone

Consider a smart-phone enabled with such a WFoV imager. You can simply place the smart-phone in the middle of the table and activate a 'videophone' mode. This searches the full WFoV image for faces and after detecting them it zooms/pans to generate a similar sized face representation for each local participant. Each face is aligned to appear upright and corrected for lens distortions. Such a device facilitates inexpensive multi-user videoconferencing for consumers.

C. Home-Watch for the Elderly

There is a large body of research on monitoring the stay-at-home elderly to ensure their safety and well-being. The most promising techniques feature the use of non-invasive monitoring by video or passive sensors. Many researchers have proposed to detect falls and track daily *activities of living* from video analysis. However practical deployment of such technologies requires deployment of multiple video cameras. Consider, however, a WFoV unit that can electronically track and zoom to follow people as they move through the rooms of their house. A suitably configured imaging unit per room could provide suitable video output, thus liberating many of today's research algorithms from the laboratory into the field.

D. Other Applications

We did not yet touch on a range of other potential applications. Low cost, smart 360° security micro-cameras can substitute for expensive *pan-tilt* cameras. WFoV can also contribute to new automotive technologies. And it is already creating a new market for wearable personal action-cams.

V. Concluding Remarks

At ICCE 2014 a hardware-based, real-time distortion correction engine will be demonstrated. Example videos and playback concepts will also be shown demonstrating the potential of WFoV as a new consumer imaging technology.

References

[1] T. Vuori, J. Alakarhu, E. Salmelin, and A. Partinen, "Nokia PureView oversampling technology," in *Proc. SPIE 8667, Multimedia Content and Mobile Devices*.

[2] S. Grotta and D. Grotta, "Not all pixels are created equal [Tools & Toys]," *IEEE Spectr.*, vol. 49, no. 5, pp. 22–24, May 2012.

[3] R. Baker, K. Kettler, and G. Suarez, "Method and apparatus for hemispheric imaging which emphasizes peripheral content," 5,508,7341996.

[4] A. Chen, J. Bailey, L. Postpischl, P. Danecek, A. Morelli, and S. Pondrelli, "Standardization of seismic tomographic models and earthquake focal mechanisms data sets based on web technologies, visualization with keyhole markup language," *Comput. Geosci.*, vol. 37, no. 1, pp. 47–56, 2011.

[5] "Keyhole Markup Language — Google Developer Page." [Online]. Available: https://developers.google.com/kml/.

[6] G. Weising and T. Miller, "Maintaining Multiple Views on a Shared Stable Virtual Space," US 2011021606008-Sep-2011.

[7] "Say hello to Dot!" [Online]. Available: http://www.kogeto.com/say-hello-to-dot.

[8] "GoPano EU — GoPano Plus." [Online]. Available: http://www.gopano.com/products/gopano-plus#page=technology.

[9] C. Zaharia, P. Bigioi, and P. Corcoran, "Hybrid video-frame pre-processing architecture for HD-video," in *IEEE International Conference on Consumer Electronics (ICCE),* 2011, pp. 89–90.