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RESEARCH REPORT

Simulating SVAVISCA Panoramic Images of Agam Fiducials

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Abstract

We simulate how Agam fiducials are imaged by a catadioptric panoramic camera with a log-polar arrangement of pixels. Experiments show that there are good prospects of using such a non-classical camera to localize an observer wrt to fiducials.

1 Introduction

In this report we study how Agam fiducials [3] are imaged by a catadioptric panoramic camera with a log-polar arrangement of pixels on its retina [1] based on SVAVISCA log-polar CMOS sensor [2]. Since there is no real SVAVISCA panoramic camera at the moment available, we had to resort to simulations [4].

The general aim is to determine the position and orientation of an observer from one panoramic image of one fiducial by knowing the distance to the fiducial from its apparent size in the image and the angle wrt the fiducial reference direction from the observed intensities [3]. Our aim in this work is to gain an intuition. We like to see how images of fiducials look like in SVAVISCA panoramic images and also if there are measurable changes of intensities inside fiducial squares related to the position of the camera. To that end, the following simulated experiment was carried out.

2 Simulated experiment

A set of 30 images was taken by a panoramic catadioptric camera. The catadioptric camera comprised a parabolic mirror and an ordinary CCD camera producing image of the size 576×768 pixels. Three images from the sequence are shown in Figure 1. In each image, there are two fiducials, each of them consisting of four panels. The fiducial closer to the camera will be called number 1, the one farther will be called number 2. Fiducials are at different heights. The camera moves along a line with the constant separation between the consecutive views that equals 12 cm. The image numbers were chosen so that they correspond to the order in which the images were taken. The fiducial number 1 is about 60 cm far from the line of camera motion. The panels of fiducials are labeled as it is shown in Figure 2.

Figure 3(a) shows a simulated image of the scene as if taken by the log-polar panoramic catadioptric camera obtained by replacing a CCD retina by a SVAVISCA retina. Figure 3(b) shows a detailed view of the fiducials. The images were obtained by warping and re-sampling the original images.

In each of the 30 original images, the panels of the fiducials were manually marked in images. The selected regions were shrink so that they did not contain any transitions between the panels and average intensities inside them were computed. The regions were also propagated to the SVAVISCA images.

Figures 4(O.*) show average intensities inside the fiducial squares as functions of image position computed from original images. Figures 4(S.*) show average intensities inside the fiducial squares as functions of image position computed from SVAVISCA images. Figures 4(*.1) show average intensities inside the fiducial squares 2 and 4 for both fiducials altogether. These squares have their plane segments oriented vertically and therefore their average intensities change as the position of the camera changes. Figures 4(*.2) show average intensities inside the fiducial squares 1 and 3 for both fiducials altogether. These squares have their segments oriented horizontally and therefore their average intensities remain approximately constant. In theory, the graphs on Figures 4(O.*) should be exactly same as the graphs on Figures 4(S.*) since the SVAVISCA images were obtained only by a transformation of the original images. We believe that the small differences that can be found are caused by resampling, interpolation, and rounding errors.

Figure 5(O) shows the ratios of average intensities inside squares computed from the original panoramic images. Figure 5(S) shows ratios of average intensities inside squares computed from simulated SVAVISCA panoramic images. Again, the differences between the graphs are believed to be caused by discrete nature of image representations.

3 Conclusions

Experiments show that fiducials can be observed even in SVAVISCA images. Though the resolution of SVAVISCA images is very low, we expect that the localization based on fiducials will still work until the apparent size of the fiducial is larger than the radius of optics point spread function.

The opened questions are:

1. What is the smallest size of a fiducial when the average intensity is still not too much influenced by the point spread distribution function of the optics?

2. How much the simulations correspond to the reality?

3. What are the theoretically correct courses of average intensities wrt to the position of the camera?

Acknowledgements

The original images of Agami fiducials were kindly provided by D. Livshitz and A. Bruckstein from Computer Science Department of the Technion in Haifa, Israel.

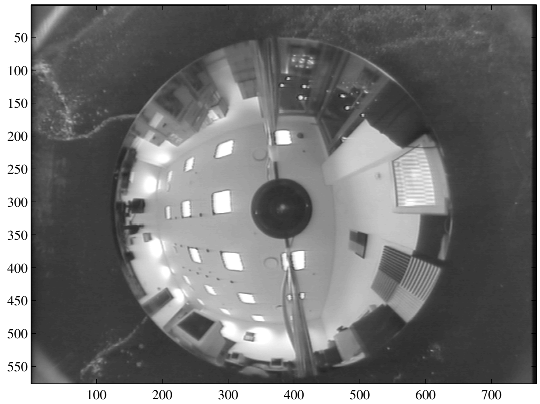
References

[1] Omniviews: Project description .
http://cmp.felk.cvut.cz/cmp/omniviews/proposal.part.B/, 1999.

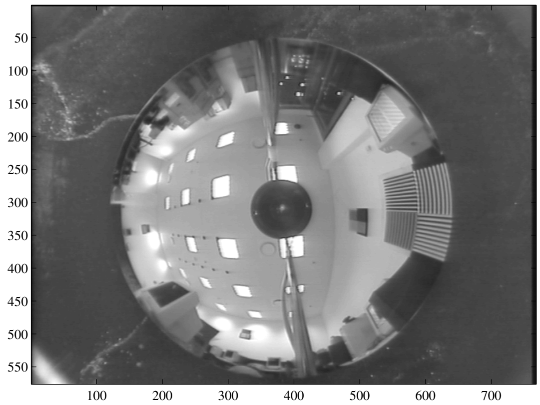
[2] SVAVISCA Retina - The Space-variant Color CMOS .
http://www.lira.dist.unige.it/svavisca.html, 1999.

[3] A.M. Bruckstein, R.J. Holt, Huang T.S., and Netravali A.N. New devices for 3D pose estimation: Mantis eyes, agam paintings, sundials, and other space fiducials. *IJCV*, 39(2), 2000.

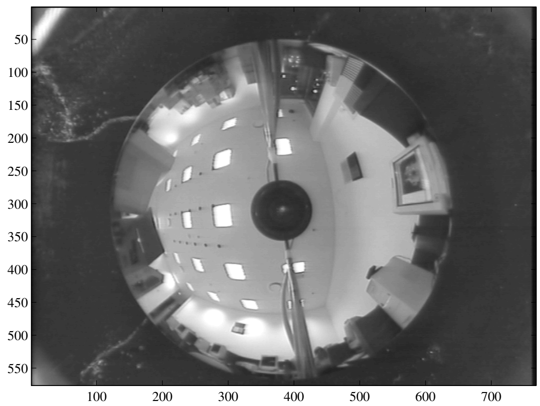
[4] T. Pajdla and H. Roth. Panoramic imaging with SVAVISCA camera - simulations. Technical Report CTU-CMP-2000-16, Center for Machine Perception, Czech Technical University in Prague, 2001.



(1)



(10)



(30)

Figure 1: The first (1), the 10-th (10), and the 30-th (30) image of the sequence of 30 images capturing two fiducials by a panoramic catadioptric camera consisting from a telecentric lens and a parabolic mirror (by Cyclovision Inc., www.cyclovision.com). The camera moved along the line in the scene that was about 60 cm far from the fiducial number 1. The distances between viewpoints on th line were about 12 cm, i.e. the camera traveled apx. 381 cm.

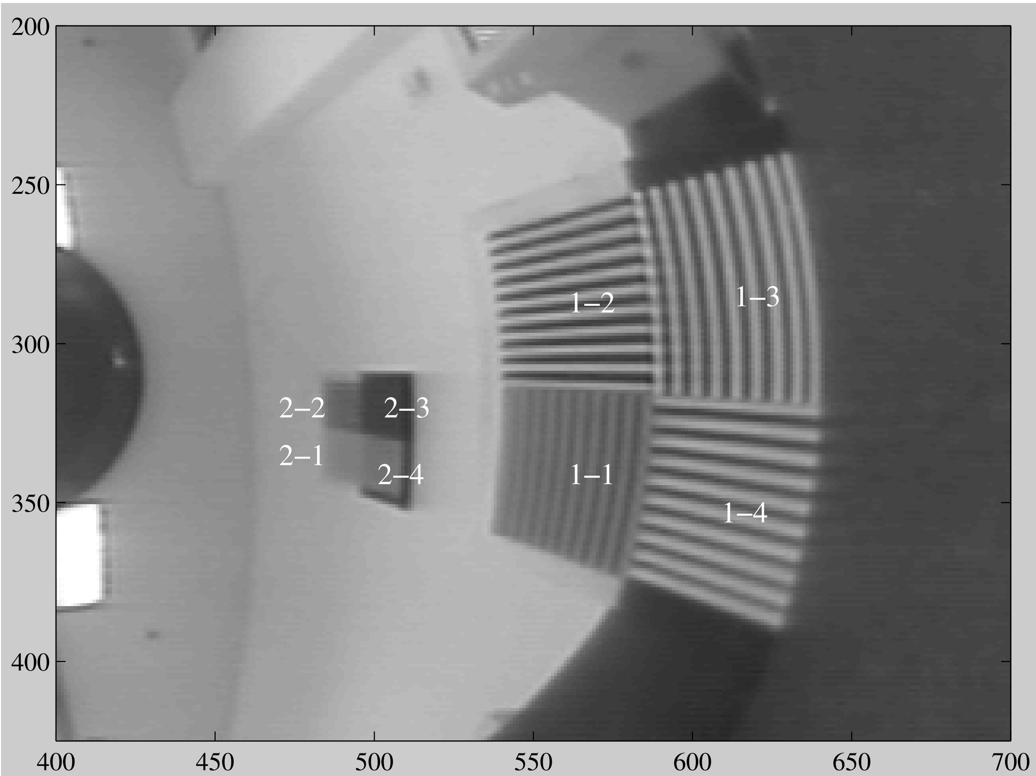
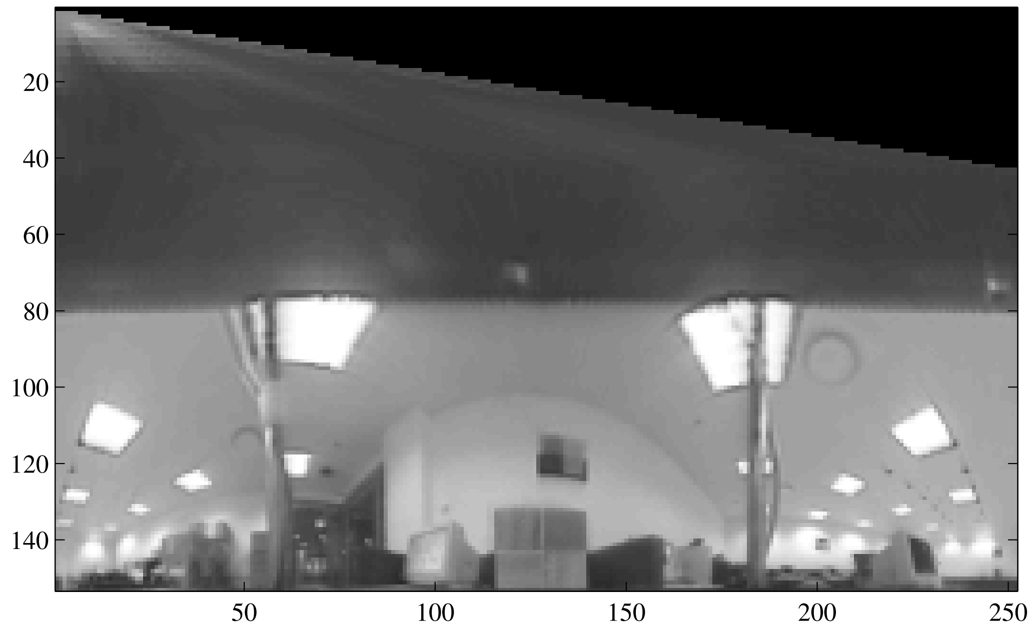
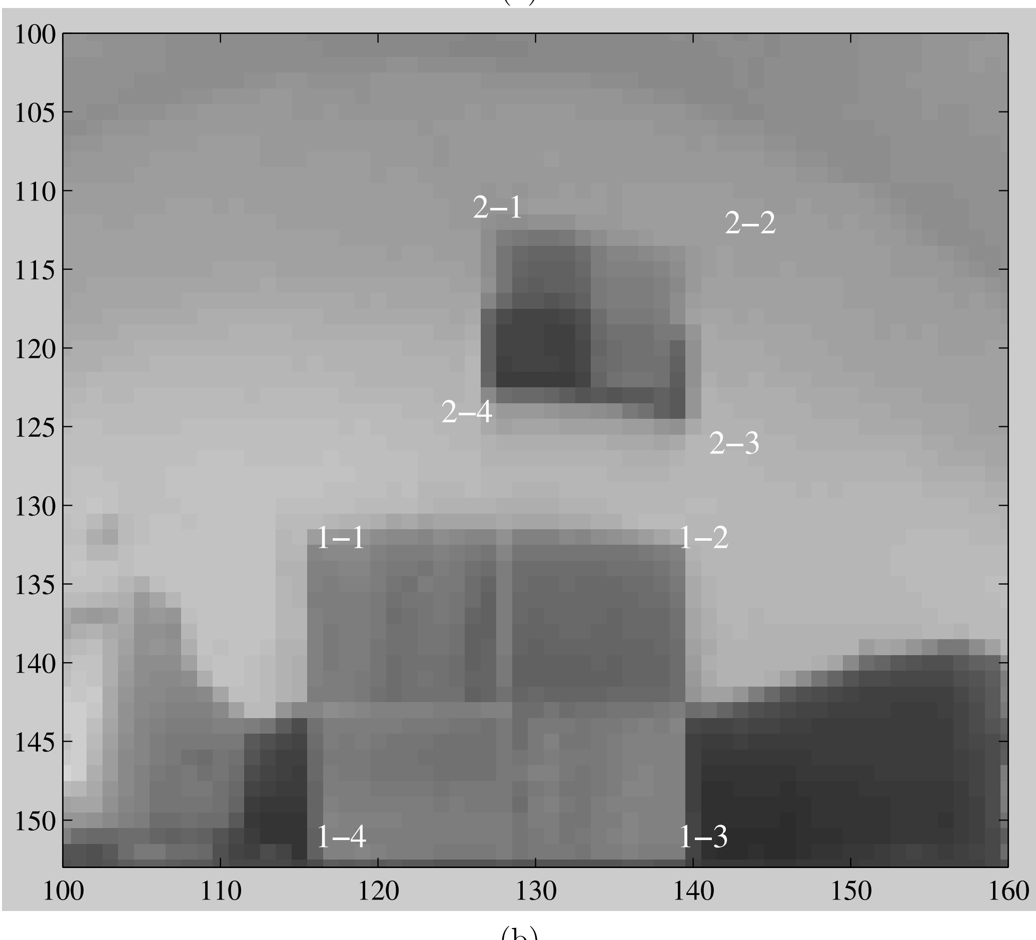


Figure 2: A detail view of the two fiducials. Each fiducial consists of four squares. The fiducials as well as the squares are numbered by $M-N$, where M stands for the number of the fiducial and N stands for the number of the square.

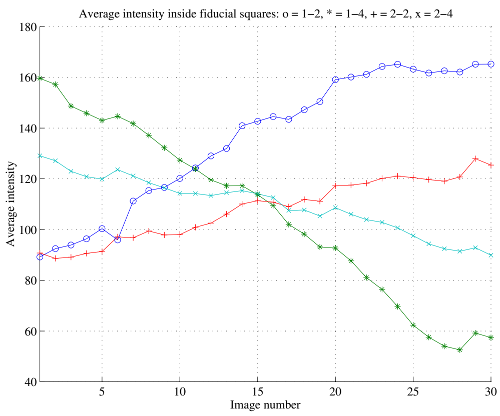


(a)

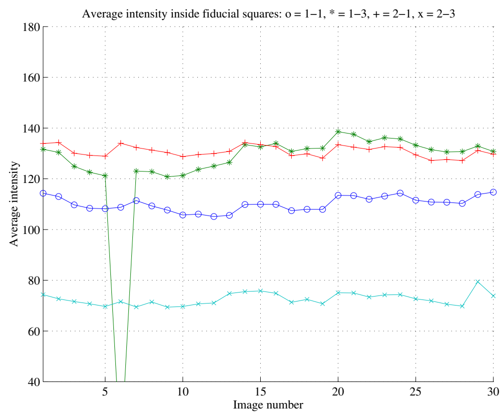


(b)

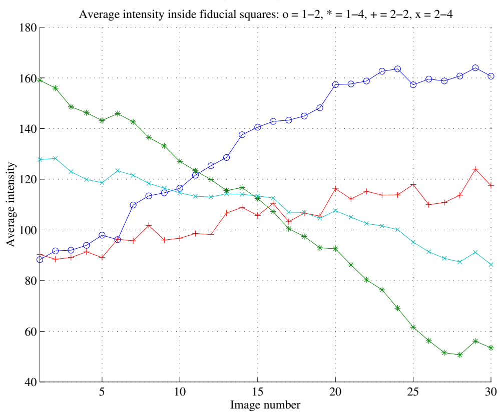
Figure 3: (a) Simulation of panoramic image taken by a SVAVISCA panoramic camera. The upper half of the image. (b) The detail of the image of the fiducials.



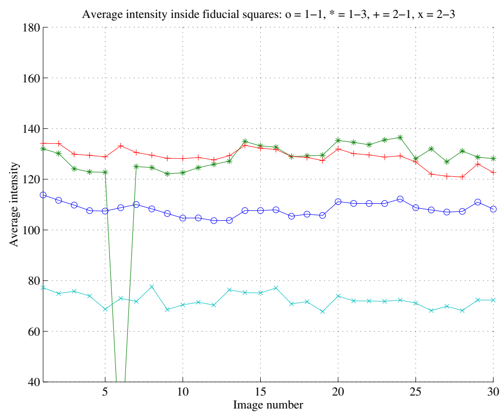
(O.1)



(O.2)

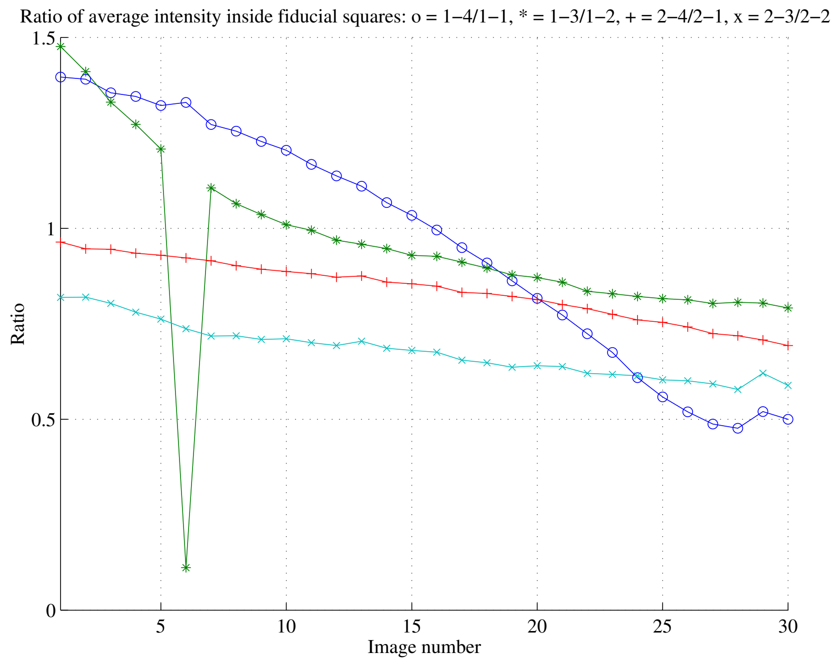


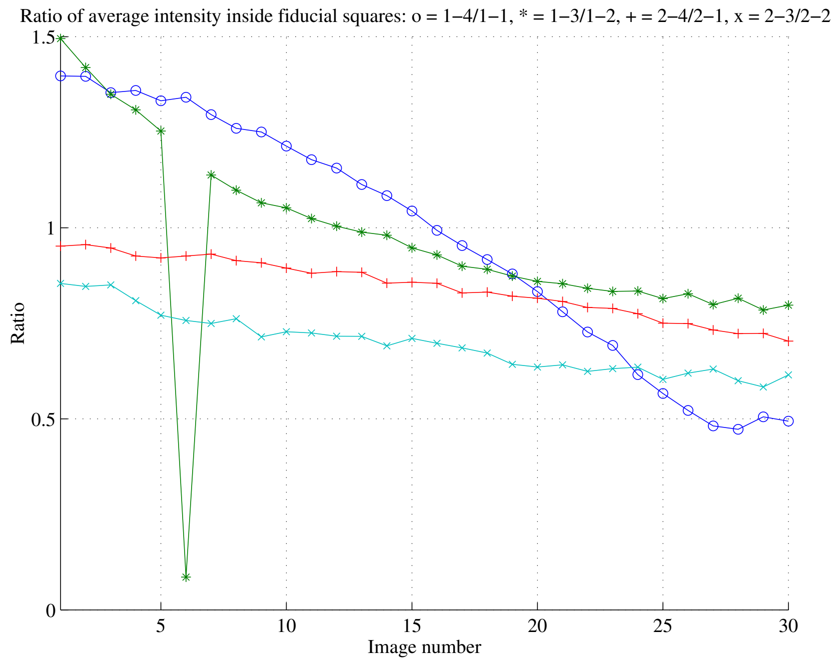
(S.1)



(S.2)

Figure 4: Average intensities inside of the fiducial squares as functions of the camera position. See text.





(O)

(S)

Figure 5: Ratios of average intensities inside of the fiducial squares as functions of the camera position. See text.