

Ultra-wide field of view face recognition

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Introduction

Face recognition in uncontrolled or weakly controlled environments requires sensors with a wide field of view. This project examined the use of omni-directional cameras for face-recognition. It then discusses results on evaluation of face-recognition using a zoomable omni-directional camera developed at Columbia University. The omni-directional cameras considered have a unique resolution profile that provide greater resolution within its effective field-of-view, and can be unwarped in any direction to provide a perspective correct image. The experimental results show commercial face-recognition systems applied to the resulting perspective image are comparable to regular cameras using similar pixels-on-face and that both the zoomnicam and omni-directional cameras are viable sensors.

Omni-directional face recognition

For flexible imaging we have undertaken 3 data collections (omni-directional, zoomnicam and long-distance) with the resulting data submitted as part of the DARPA HBASE, and also available directly from Dr. Boulton. We briefly review those sensors, the experiments and the results.

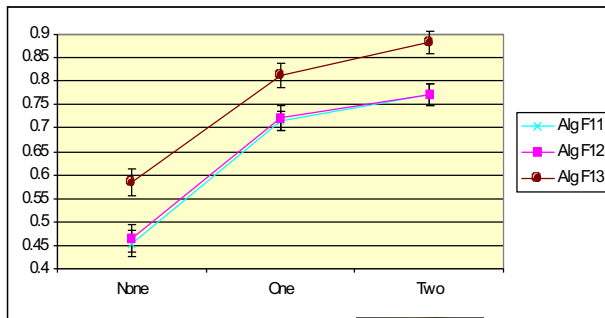
The first of our non-traditional sensor projects sought to address the question of how well a parabolic-catadioptric omni-directional camera [1] could be used for face recognition. To allow it to operate over a wider range of distance we chose a 3.1 Megapixel camera, the Nikon 990. The omni-directional images were obtained using Remote Reality's OneShot lens attached to the Nikon 990. This lens has a 360 horizontal field of view around and a 105 degree vertical FOV, (i.e. it sees above the top edge of the mirror). The vertical resolution has a non-linear compression and the highest resolution is near the horizon.



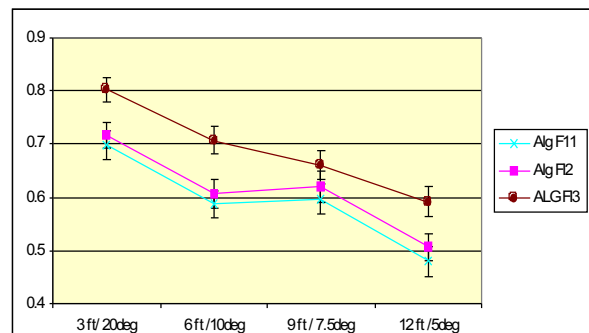
Dr. Boulton and students developed Linux software that controlled the Nikon 990 camera being used and combined video rate person tracking [2] using its analog TV output with high-resolution image capture to provide face images suitable for recognition. While the camera supported un-compressed TIFFs, the project always used the high-resolution jpeg format. This software simplified our data collection process and was used in four different data collections at NIST. In all but one collection, the subject stood at fixed distances to support repeatable measurements.

The subjects were also involved in other collections at NIST at the same time allowing comparison with traditional camera (and theoretically with thermal sensors though we did not pursue that comparison). In the collections there are multiple images of each subject at each setting with over 8000 images in total. Variations included view angle, lighting (artificial and natural), distance and time. Standard camera images of each subject were also available.

Lighting (7 ft, 10° view angle)



Distance/FOV (No extra lighting)

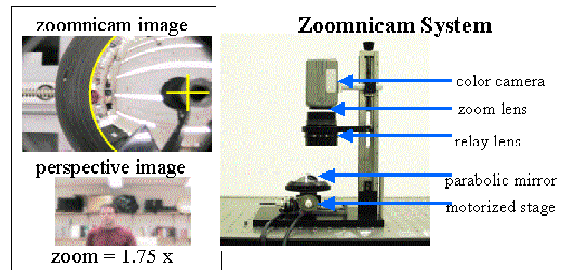


Two examples of the analysis are shown above, with the example subject's gallery image shown in the middle. The left show face recognition performances at off angle viewing of 10 degrees as the number of additional lights are

added. The images were taken with a fixed aperture and shutter speed so that the brightness variations are not masked by automatic gain controls. The three graphs are for variations of the matching algorithms in the FaceIt SDK, with the algorithm F13 using full template matching and the other two using smaller (faster) templates. The error bars show 95% confidence intervals computed using the BRR we presented in [3,4]. With two lights, consistent with what is used in the standard images and gallery, the recognition rate for the unwarped omni-directional images are approximately 90%, consistent with off axis regular images of comparable resolution. The second examples considered the impact of distance on recognition from omni-directional cameras in ambient lighting conditions. It is clear the images are quite dark, yet the recognition rates are reasonable. It is important to remember these are omni-directional images, with the face image cropped from that, so one might interpret the results as suggesting the system could recognize 60% of all the people within 12ft of the camera, and 70% of those within 6ft. Combining the results with the omni-directional imaging with lighting results, it is clear that in a well-lit area the system can increase to near 90% recognition. The results show that omni-directional sensors have potential for human identification at a distance.

The Zoomnicam, a Super wide field-of-view Sensors for HID

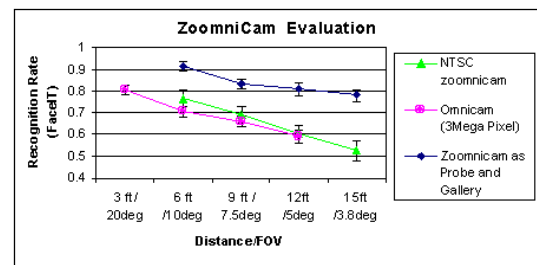
The second flexible imaging sensor explored was an omni-directional system capable of zooming, or a zoomnicam. Design and implementation of the zoomnicam prototype was done at Columbia. The unit uses a Sony DFW-V500 color zoom and a relay lens to make the imaging approximately telecentric and allows it to focus on the nearby parabolic mirror. The mirror was mounted on a xy-stage with 4" motion, though most motions were much smaller and hence much faster than a traditional Pan/Tilt system. Dr. Nayar and the team at Columbia developed a controller for the stage and calibration software that allowed unwarping the resulting image to a perspective correct image. Dr. Boulton and students extended the control software to support facial image collections and did the face recognition experiments using Identix FaceIT SDK (version 4).



The Zoomnicam data was collected on two different dates, imaging stationary subjects at 4 or 5 distances producing a total collection of over 2000 images from 85 subjects with 72 overlapping between the collections. In addition to the zoomnicam images, all subjects had same and different day traditional camera images taken as part of parallel collections at NIST and most also were imaged by the mega-pixel omni-directional system. This figure shows a standard mega-pixel camera image (upper left) from 3 feet and then a range of NTSC zoomnicams at distances from 6 to 15 feet. Note how the zoomnicam images also have strong directional lighting effects, effects that would impact the recognition rate of standard face recognition.



The results of these data collections were used for addressing the facial recognition quality of these sensors. The experimental analysis was to test the hypothesis that the zoomnicam, when it was zoomed to provide a similar resolution as the MegaPixel omni-camera, would have essentially the same recognition rate. Since the first experiments showed the omnica in a wide-range of settings, a smaller set of experiments were done with the zoomnicams. The next graph summarizes these results. The error bars show the results of our STRAT/BRR technique for performance analysis, allowing us to draw conclusions across different data sets. Clearly the two curves are not statistically different. The upper curve shows the results when the zoomnicam data was used as both probe and gallery images. Multiple images were taken so different images are in the probe/gallery, but they have similar lighting. This suggests that lighting is a much stronger factor than the difference in sensors.



References

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- [4] R.J. Micheals, "Biometric System Evaluation" Ph.D. Thesis, Lehigh University, Jan. 2003