Supplementary Material for Privacy Preserving Optics for Miniature Vision Sensors

Francesco Pittaluga and Sanjeev J. Koppal
University of Florida, Electrical and Computer Engineering Dept.
216 Larsen Hall Gainesville, FL 32611-6200
f.pittaluga@ufl.edu and sjkoppal@ece.ufl.edu

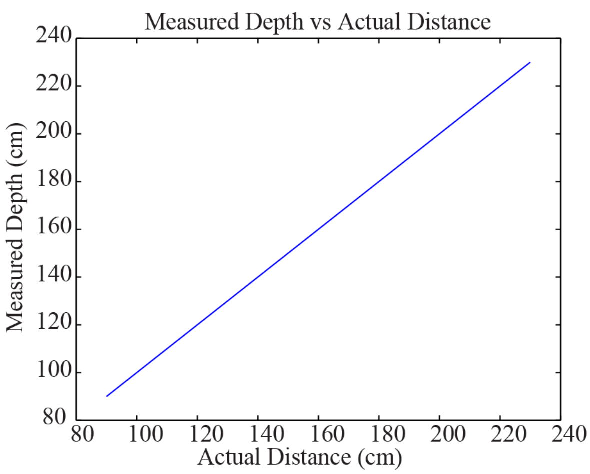

Figure 1. Measured Depth vs Actual Distance

1. Kinect with Privacy Sleeve Measured Depth vs Actual Distance

For relatively planar surfaces of large enough size, such as a human body, our defocusing optics leave the Kinect IR phase image (or depth information) mostly intact. Figure 1 shows the depth measurements of a Kinect with our defocusing optics vs the actual distance, between the Kinect and a 4 by 4 foot poster board.

2. Face Recognition Rate vs Blur Degree

Face images from the Feret database [3] were convolved with a Gaussian filter and inputed to the CSU Face Identification Evaluation System (FES) [1]. Both the gallery and probe images were convolved with the Gaussian filter before being inputed to the FES. The probe images were convolved with the Gaussian filter to simulate optical defocus. The gallery images were convolved with the Gaussian filter to improve recognition of the filtered probe images [2]. The fa and fb partitions were set as the gallery and probe images respectively. This experiment was repeated for Gaussian filters of standard deviations $\{2, 4, 8, 16, 32, 64, 128, 256\}$. Fig 2. shows the rank 1 recognition rate of three algorithms from the FES for the set of standard deviations. The three algorithms tested were Principle Components Analysis (PCA), Linear Discriminant Analysis (LDA), and Elastic Bunch Graph Matching (EBGM).

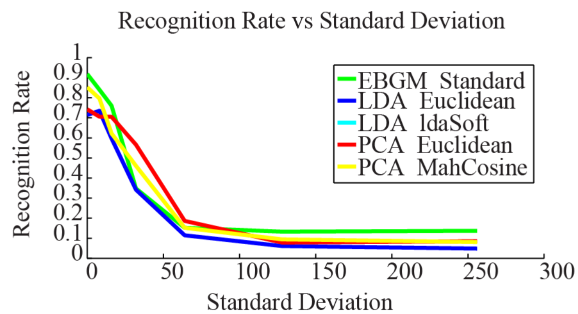

Figure 2. Recognition Rate vs Standard Deviation (Blur Degree)

3. Angular Support Derivation for FLIR One Thermal Sensor with fitted Optics

The angular support of FLIR One thermal sensor fitted with our optics was derived geometrically as follows.

$$\omega_o = 2tan^{-1}\left(\frac{d}{f}\right) = 0.9855^\circ$$

where d and f as well of a ray diagram of the system are shown in Fig 3.

4. Angular Support Derivation for Kinect Time-of-Flight Sensor with Privacy Sleeve

The angular support for the Kinect with our privacy sleeve was derived through two methods. **Method 1:** the angular

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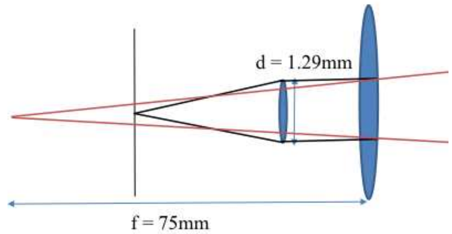

Figure 3. Ray Diagram of FLIR One with fitted Optics

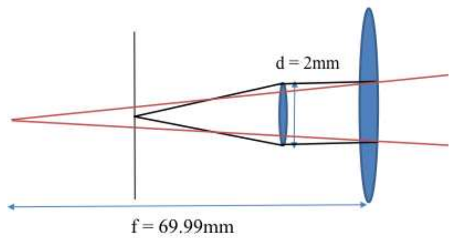

Figure 4. Ray Diagram of Kinect with Privacy Sleeve

support was derived geometrically as follows:

$$\omega_o = 2tan^{-1}\left(\frac{d}{f}\right) = 4.0967°$$

where d and f as well of a ray diagram of the system are shown in Fig 3. **Method 2:** using a Kinect fitted with our privacy sleeve, we captured an IR amplitude image of a point IR light source. We approximated 2σ to be the radius in pixels of the blob corresponding to the point light source in the IR amplitude image. The angular support was then computed as follows:

$$\omega_o = 2\sigma\left(\frac{\Theta}{R}\right) = 3°$$

Both methods resulted in the same angular support $\pm 0.6°$.

References

[1] D. S. Bolme, J. R. Beveridge, M. Teixeira, and B. A. Draper. The csu face identification evaluation system: Its purpose, features and structure. 2003. 1

[2] E. Newton, L. Sweeney, and B. Malin. Preserving privacy by de-identifying facial images. *CMU Technical Report CMU-CS-03-119*, 2003. 1

[3] P. J. Phillips, H. Moon, S. A. Rizvi, and P. J. Rauss. The feret evaluation methodology for face-recognition algorithms. 2000. 1