Summary of NIST Iris and Face Recognition Testing (ICE and FRGC)

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Please find below test results of our iris and face recognition system conducted on standard databases with procedures provided by the National Institute of Standards and Technology. To our knowledge, **KaloVision was the only company** to participate in both face and iris NIST testing prior to the Multiple Biometric Grand Challenge (MBGC).

Iris Testing

We participated in the Iris Challenge Evaluation (ICE), the very first iris recognition testing organized by the National Institute of Standards and Technology. The testing consisted of two experiments with over a million iris comparisons in each for a total of ≈ 2.2 million comparisons. The provided iris image database was far from perfect and included images with various shortcomings (see Figures 1-4 below) to allow testing of potential difficulties with iris image acquisition.

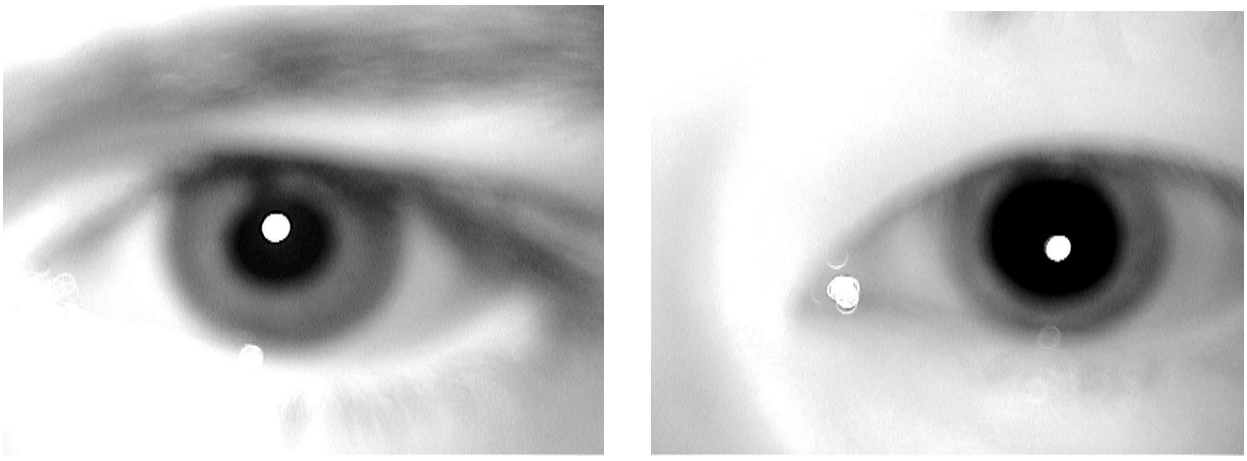

Figure 1. Lens is out of focus

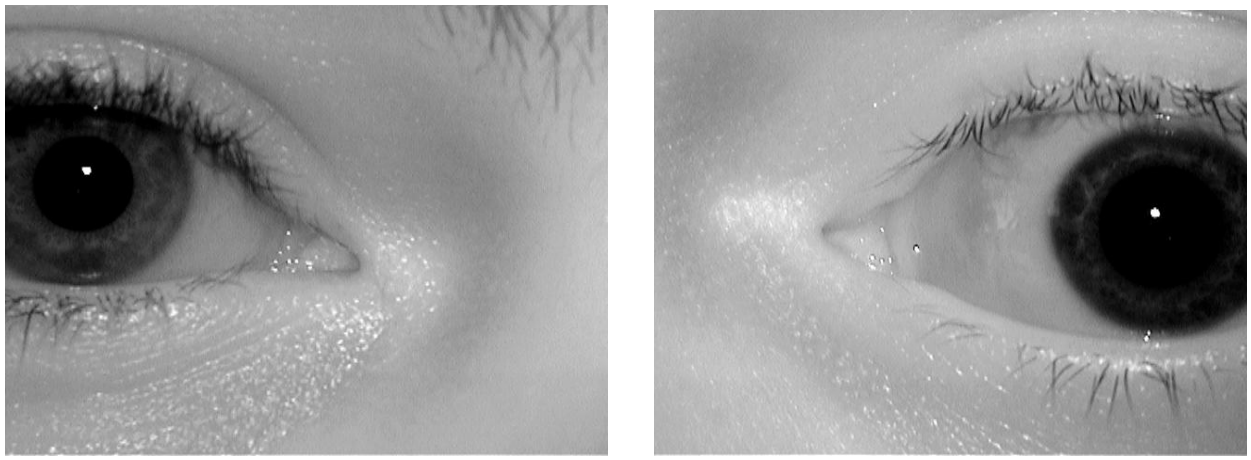

Figure 2. Camera is not centered on the iris

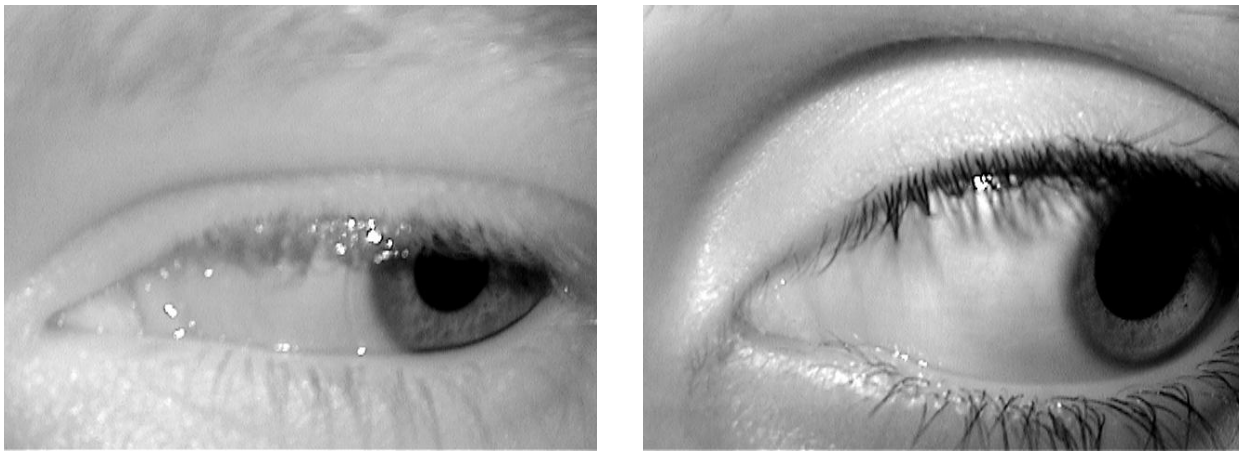

Figure 3. The subject is not looking at the camera

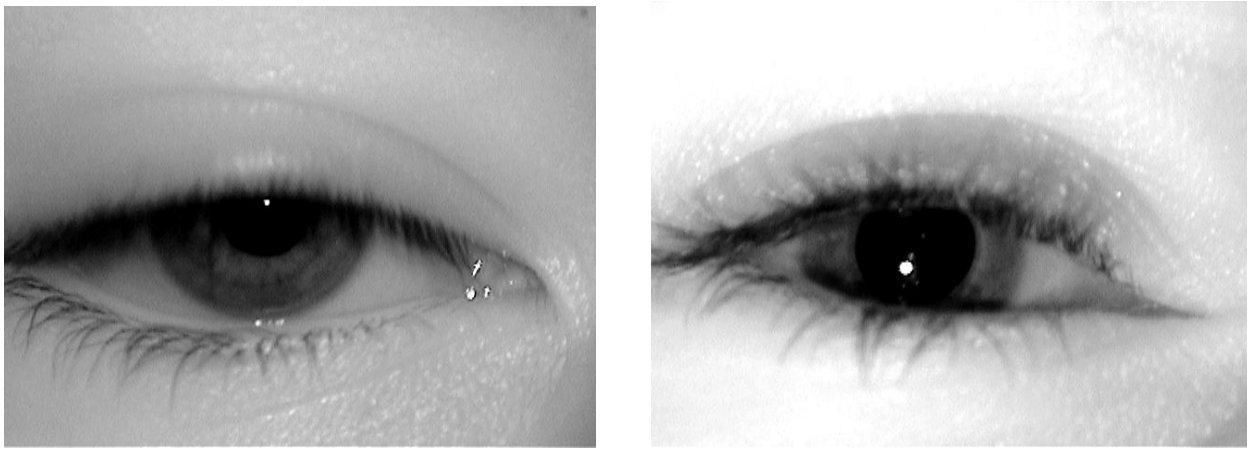

Figure 4. The subject's eye is partially closed

Results

Please find below the results of the two iris experiments. For comparison our results are shown together with the baseline one provided by NIST. Note that he original NIST experiments only considered about 2/3 of the available iris similarity data however, for completeness here we present results on the full provided data set.

Experiment 1 (right eye):

	Equal Error Rate (EER)	False Reject Rate (FRR) @ FAR = 0.001
KaloVision	**0.0082**	**0.0295**
NIST	0.0833	0.1445

Table 1. Equal Error Rates and False Reject Rates for Experiment 1.

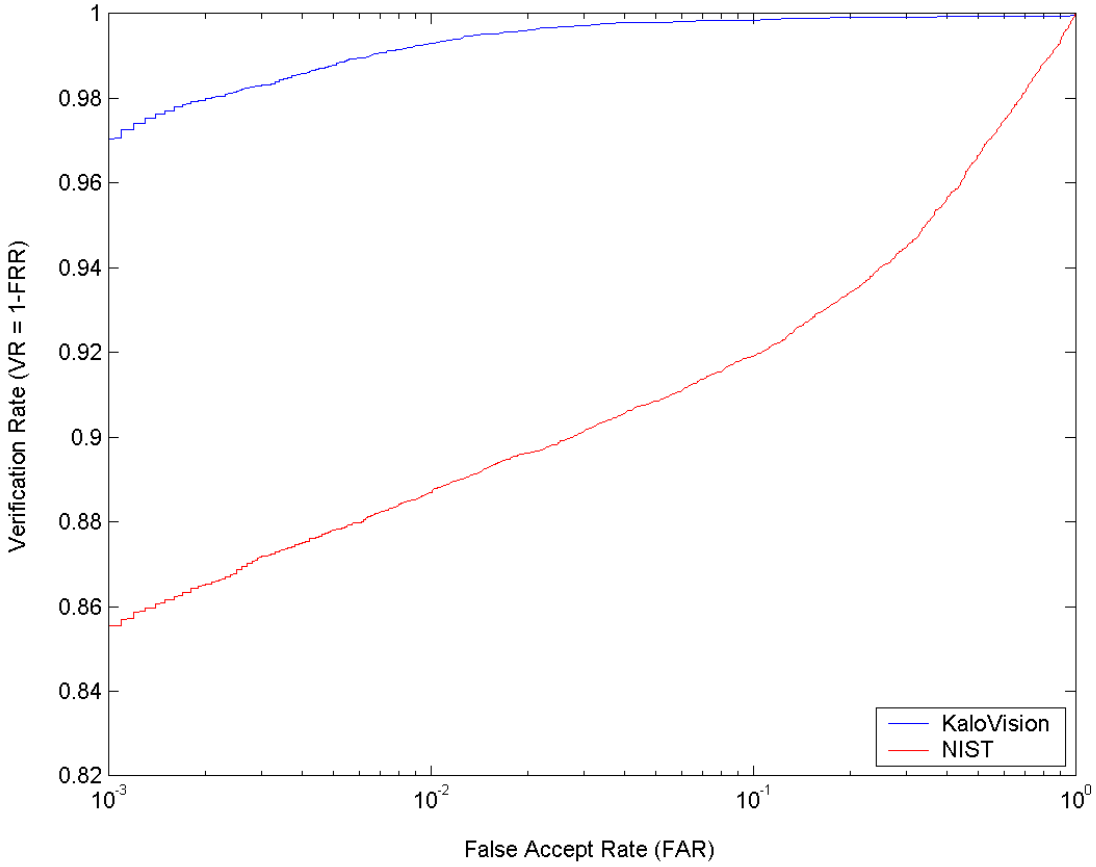

Figure 5. Receiver Operating Characteristic (ROC) curves for Experiment 1.

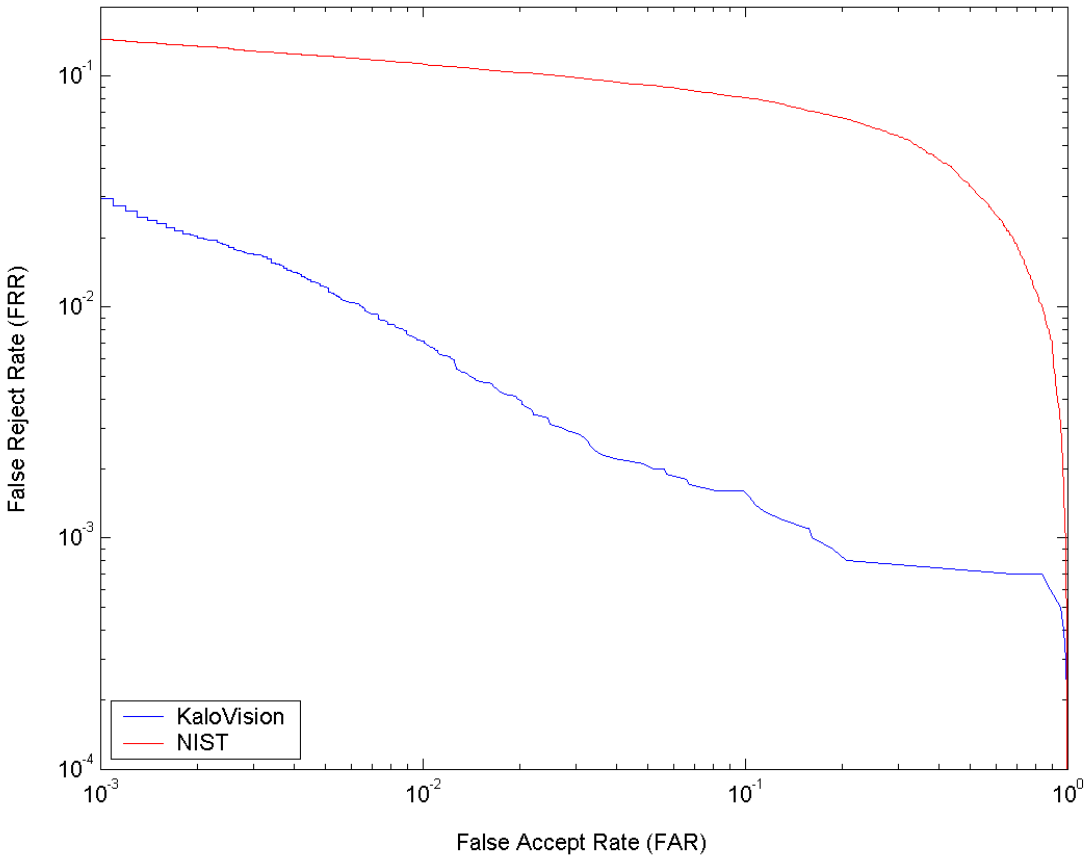

Figure 6. Detection Error Trade-off (DET) curves for Experiment 1.

Experiment 2 (left eye):

	Equal Error Rate (EER)	False Reject Rate (FRR) @ FAR = 0.001
KaloVision	**0.0087**	**0.0307**
NIST	0.0779	0.1450

Table 2. Equal Error Rates and False Reject Rates for Experiment 2.

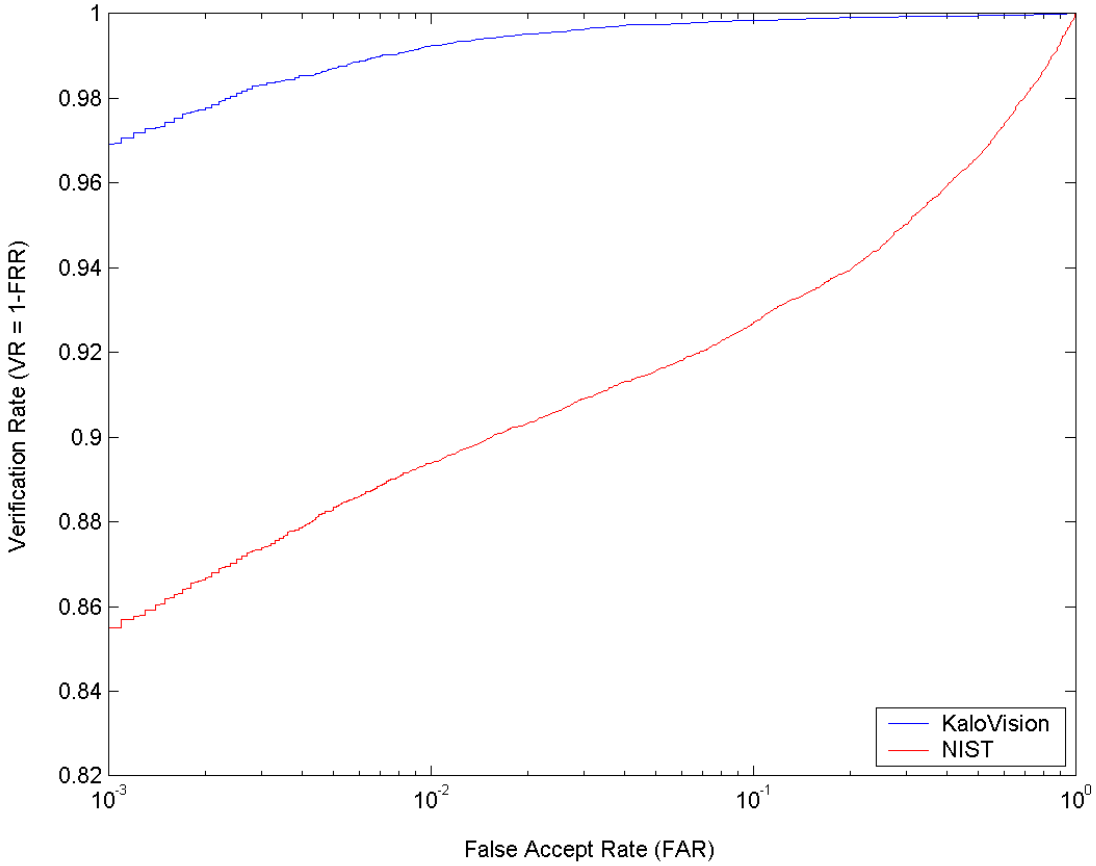

Figure 7. Receiver Operating Characteristic (ROC) curves for Experiment 2.

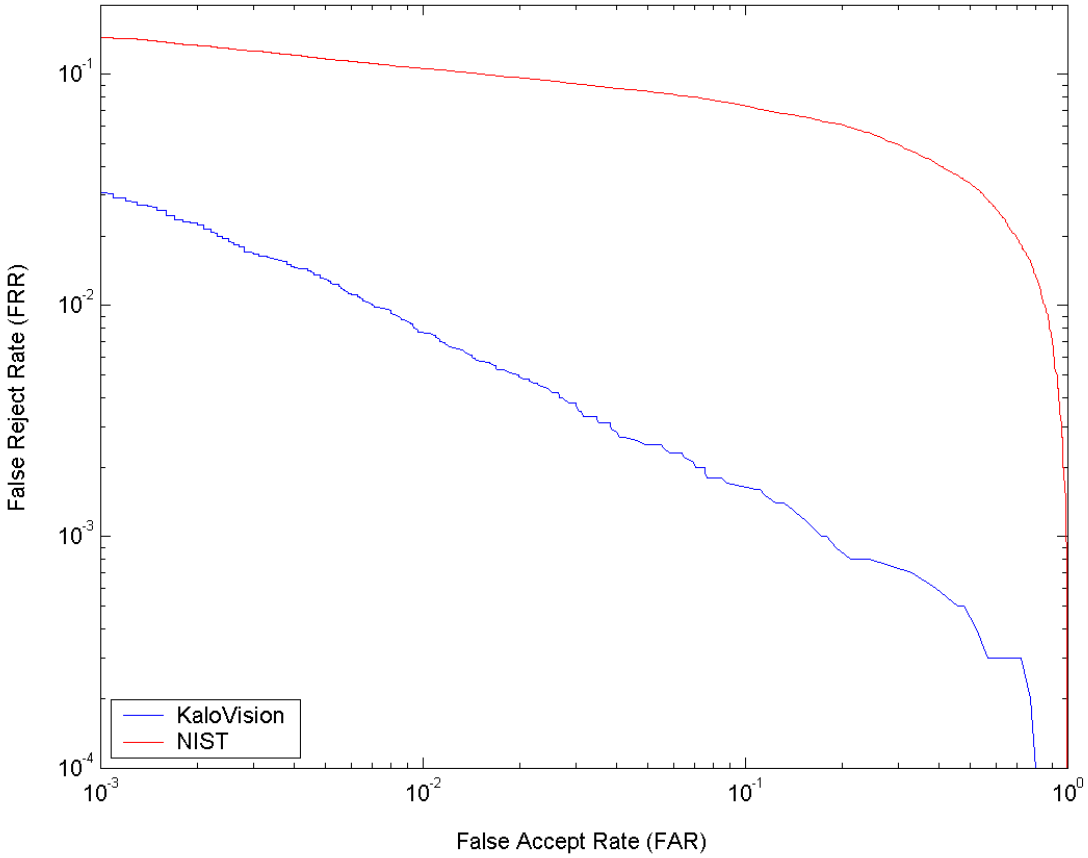

Figure 8. Detection Error Trade-off (DET) curves for Experiment 2.

These results indicate that our current Equal Error Rate measures are about a **magnitude better** than the NIST provided baseline. Our False Accept and Reject Rates are also several times better than that of the baseline. Please also note that if iris measurements were taken simultaneously from both eyes (data fusion), that would further reduce all error rates significantly.

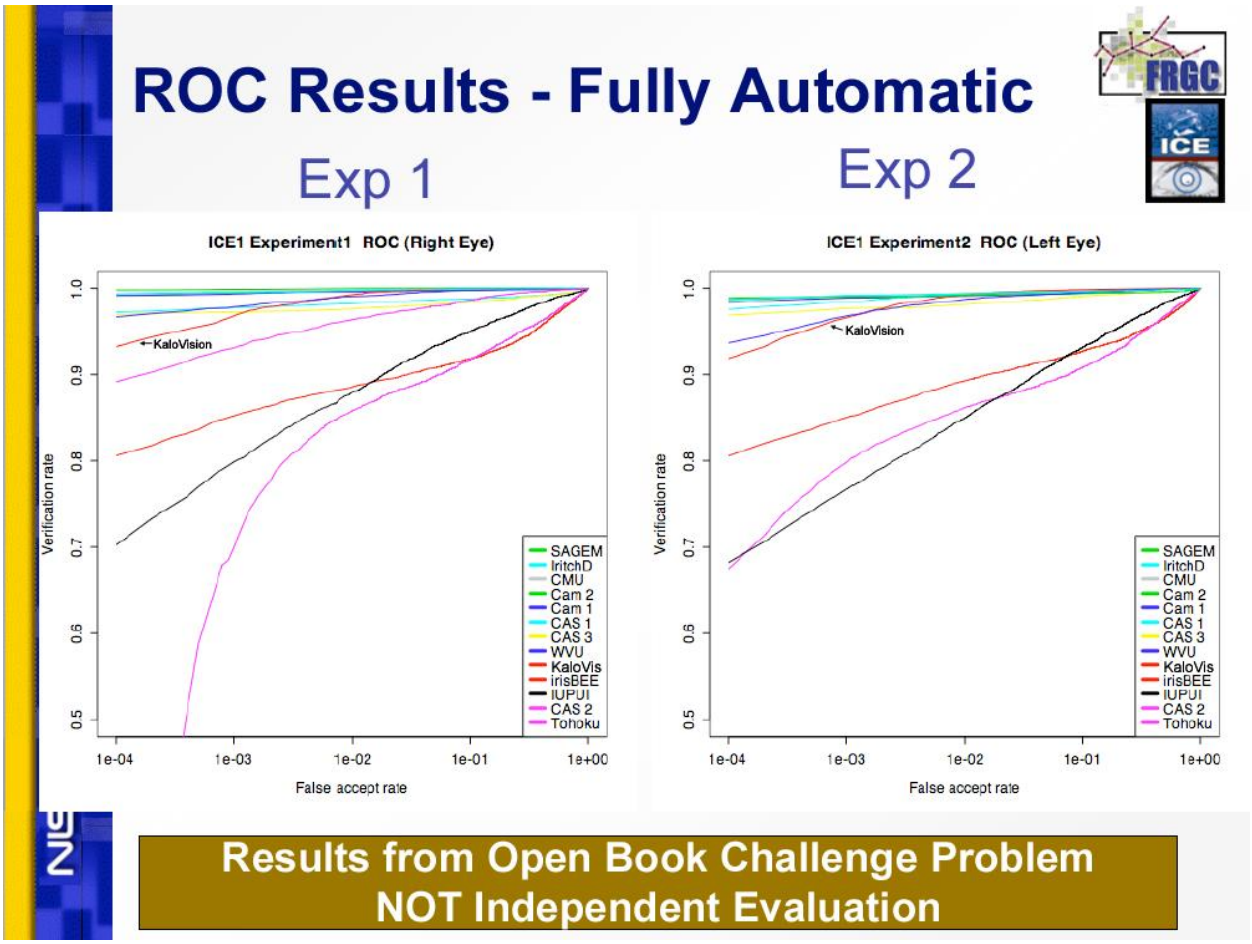

Figure 9. The graph above displays our performance compared with that of other participants of the Iris Challenge Evaluation.

Figure 9 is a slide produced by NIST that summarizes the results of all participants on the Iris Challenge Evaluation. For easier viewing our company name is superimposed on the slide. The two graphs show the ROC curves of all participants on both eyes. The flatter the curve, that is, the closer it is to the top left corner of the graphs the higher the performance. KaloVision's recognition result can be found in the upper area of the graphs together with the industry leaders.

Face Testing

We had also participated in the Face Recognition Grand Challenge (FRGC). The face images and testing procedure were, again, provided by the National Institute of Standards and Technology. Our result for Experiment 1 of this test is based on over 92,000 face comparisons. Just as for iris the provided face image database was far from perfect and included images with various shortcomings (see Figures 1-4 below) to allow testing of potential difficulties with face image acquisition.

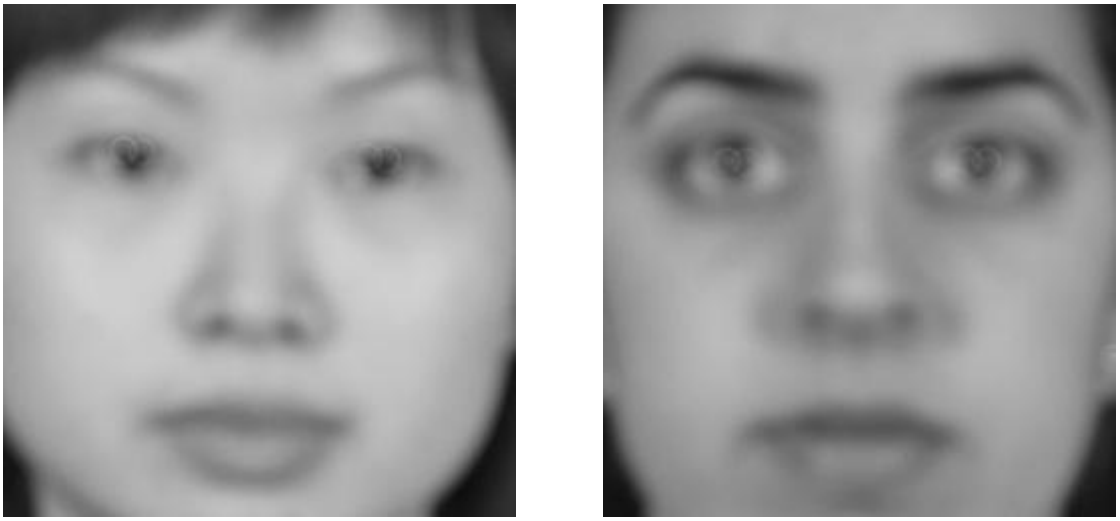

Figure 10. Lens is out of focus

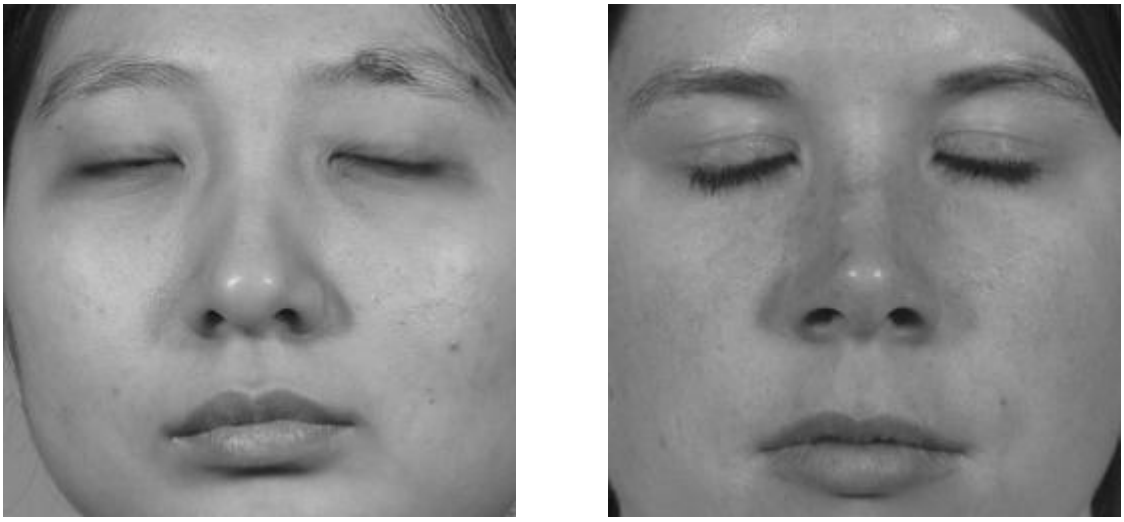

Figure 11. Closed eyes (sleeping beauties)

Figure 12. Emotional expression

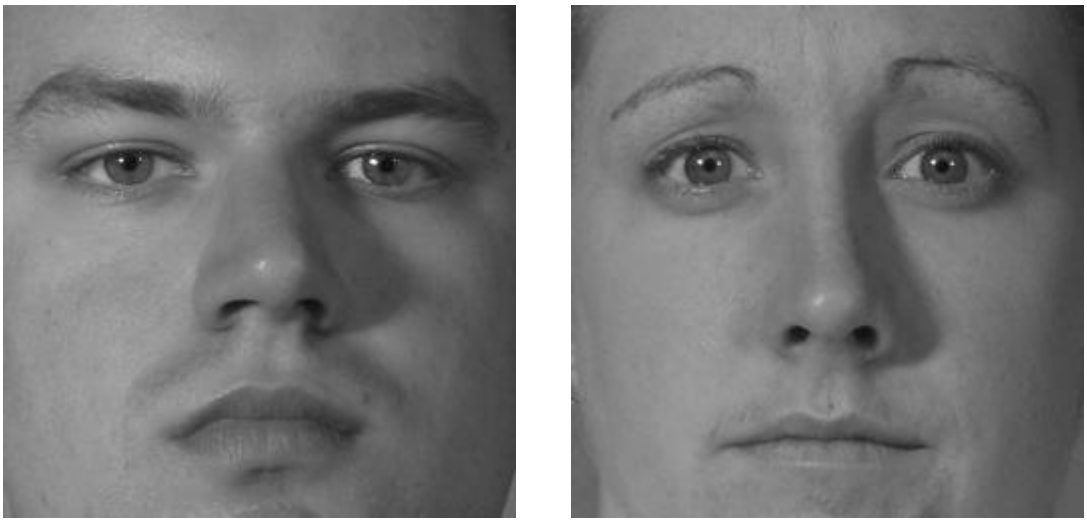

Figure 13. Uneven lighting

Please find below our test result (Figure 14) along with the baseline performance provided by NIST (Figure 15) on this standard government face database. Figure 16 is a summary slide provided by NIST that displays the recognition performance of all FRGC participants. KaloVision's own result is superimposed on this slide.

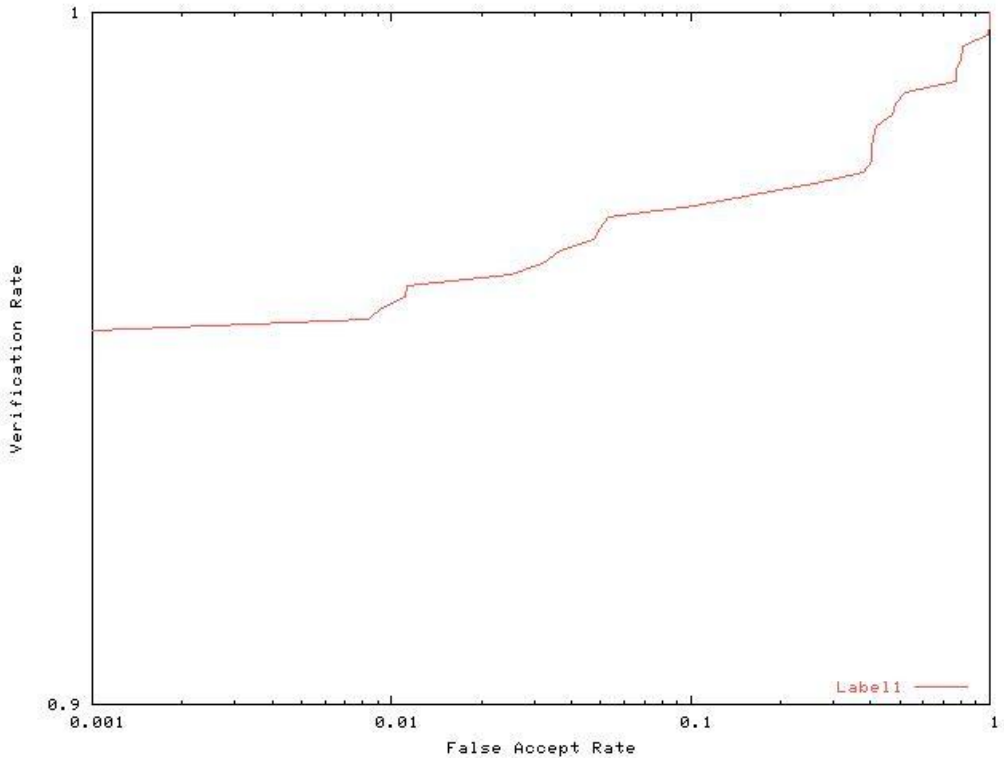

Figure 14. KaloVision's ROC curve on the face database provided by NIST

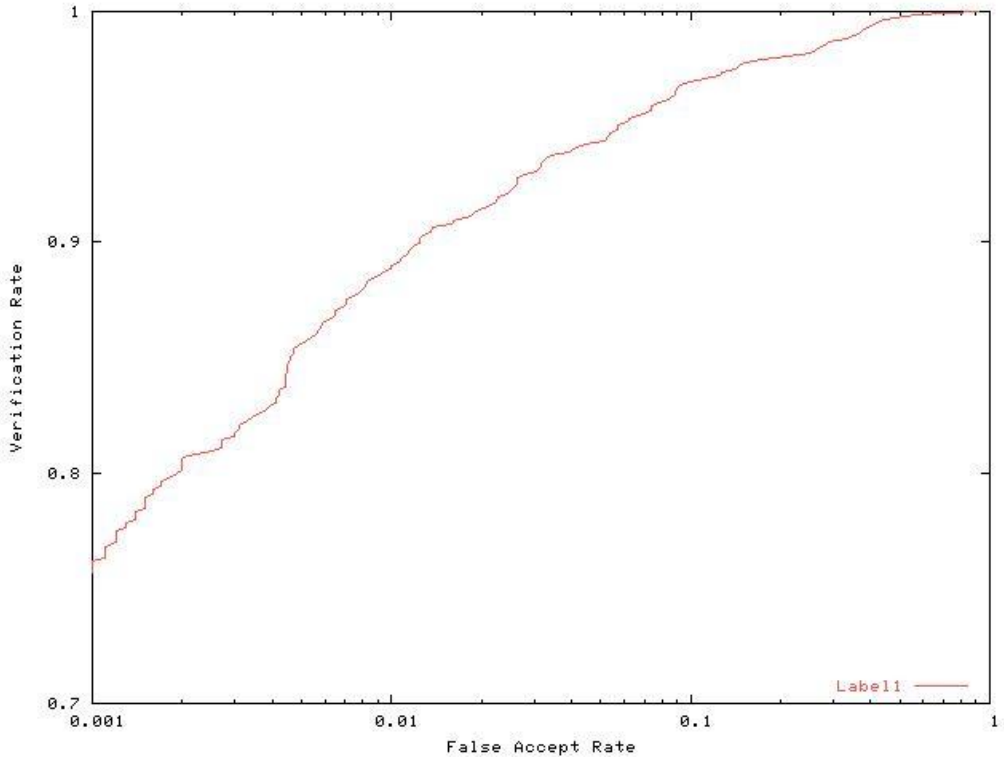

Figure 15. Baseline ROC curve provided by NIST on the same database

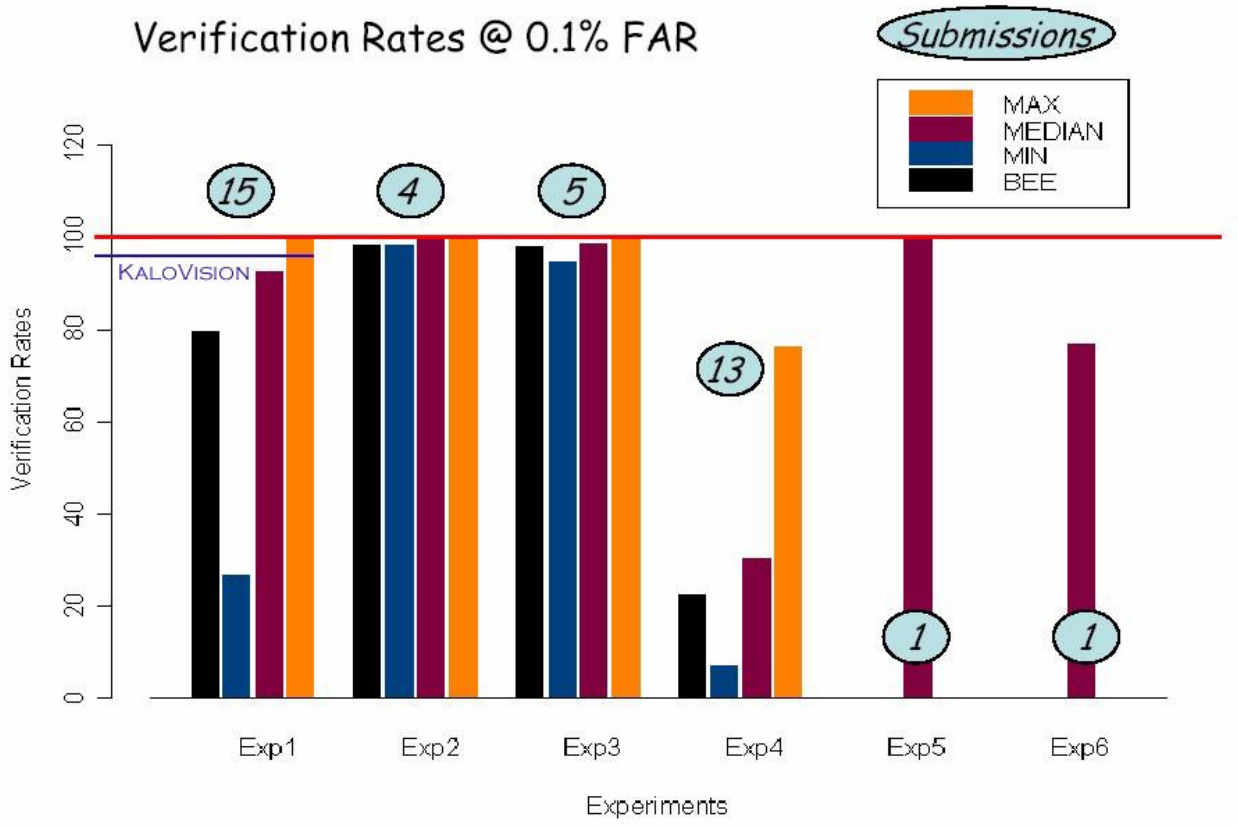

Figure 16. The graph above displays our performance compared with that of other participants of the Face Recognition Grand Challenge. It shows that KaloVision is very close to the best performers of the FRGC.

Face recognition that's par with iris

As shown above (Figures 1-4 and 9-13), both the NIST iris and face database contained certain amount of rather **low quality image data**. Due to those images the performance of all participants was markedly lower than it would have been otherwise. In a real life deployment the recognition system itself could filter out bad quality images and would only allow images which met a certain quality criteria to enter the matching phase of the system. With this type of rigorous quality control the overall performance of the system can significantly be improved.

Due to the above mentioned quality checks our face recognition system working with live data now displays properties more typical of a high performance iris systems. Please observe Figures 17 and 18 displaying the probability distribution of same and different comparisons for a typical iris system and that of our face system. Since no errors had been made by our system on this limited amount of data the error rates can not even be plotted at this point.

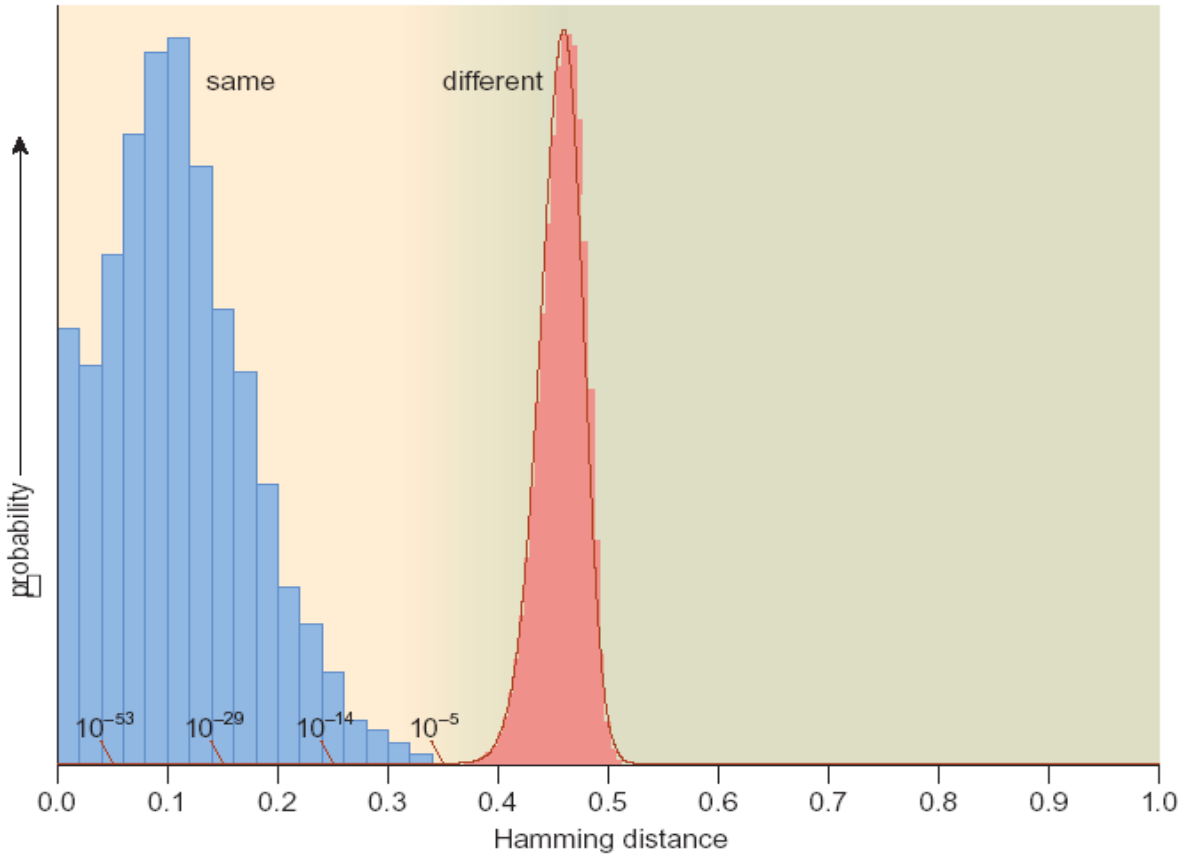

Figure 17. Typical probability distribution of an iris recognition system. The Hamming distance distribution of same and different irises is plotted.

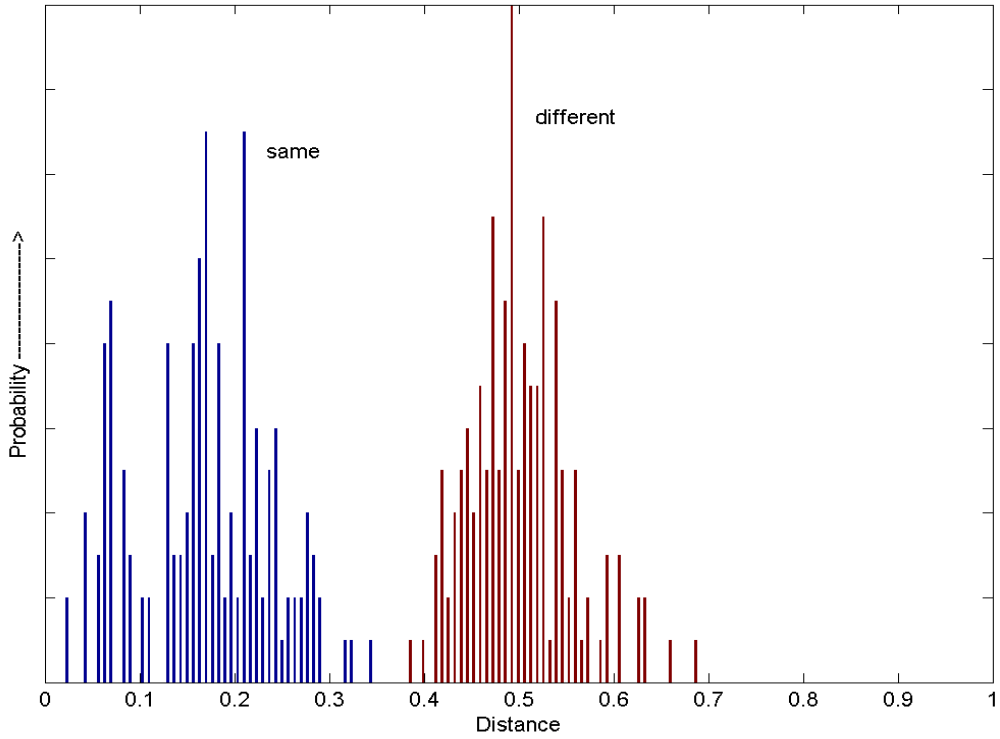

Figure 18. The probability distribution of KaloVision's Face Recognition System based on 320 live trials. Again, the distance distribution of same and different faces is plotted.

Comparing Figures 17 and 18 reveals that our face recognition system displays probability distribution properties more typical of iris recognition systems.

Summary

The purpose of this white paper was to show that KaloVision Inc. has its own, in-house developed, iris and face recognition algorithms. As the above data demonstrates, these algorithms **performed among the best in the industry** on standard, government sponsored accuracy tests conducted by the National Institute of Standards and Technology. It is important to note that KaloVision was the only company in the world to participate in both iris and face recognition tests.

The only other company that has both its own face and iris recognition algorithms is L1 Identity Solutions. However, as opposed to KaloVision, this company acquired these combined capabilities by the acquisition of face and iris recognition companies (Iridian, Identix and Viisage).

We believe that our unique combination of multimodal biometric capabilities at the algorithm level accompanied with our advanced and inexpensive hardware allow us bring previously unseen, attractive solutions to the security and identity management market.