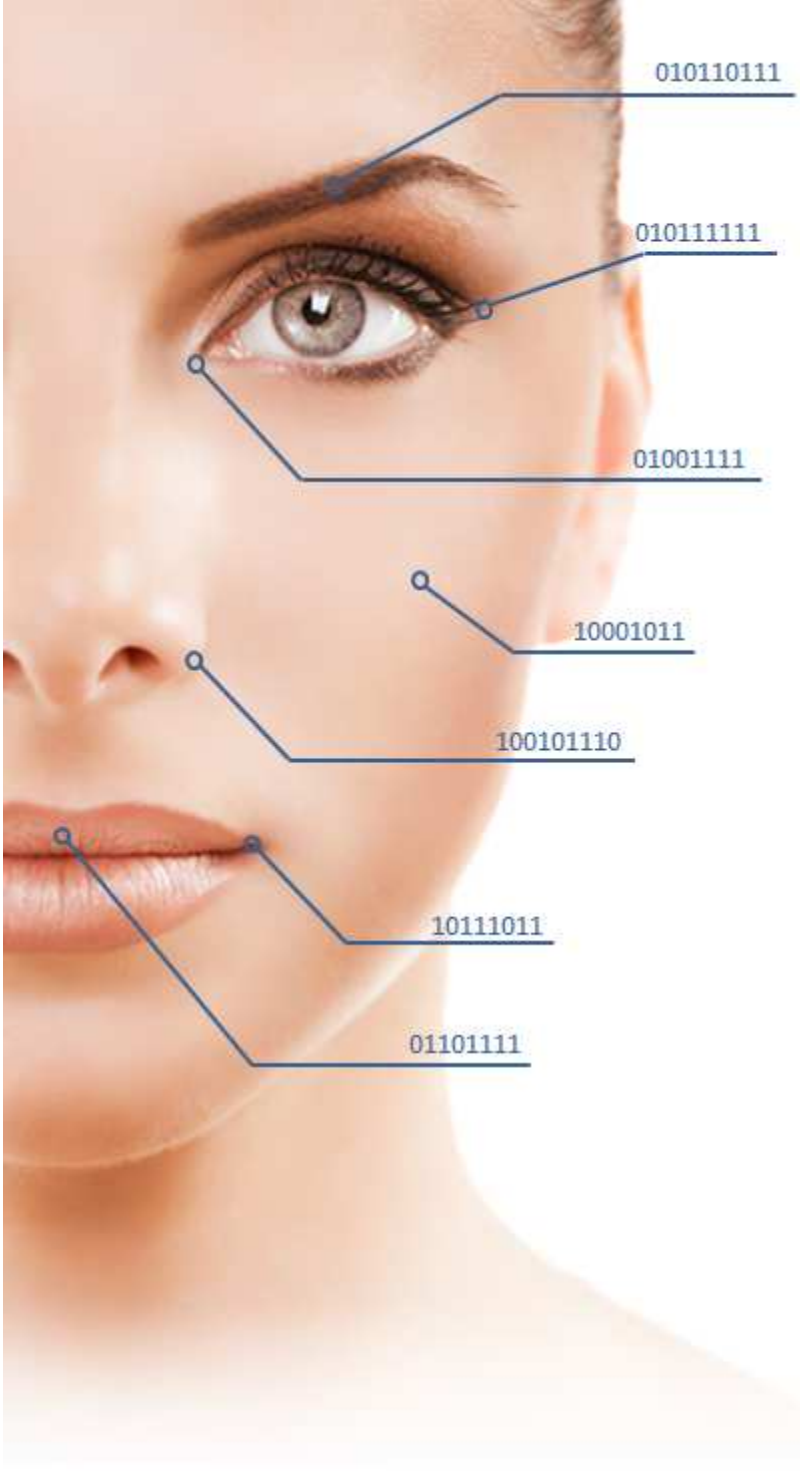


AURORA

THE FACE OF BIOMETRICS

MARKET COMPARISON

SUMMARY

This document provides a comparison of Aurora's face recognition accuracy against other biometrics companies and academic institutions. Comparisons against three major benchmarks are provided:

- Face Recognition Vendor Test
  - We compare the identification accuracy of our infrared Deep Learning engine against the figures published in the latest FRVT report.
- FERET
  - We compare the verification accuracy of our infrared Deep Learning engine against published figures from other biometric suppliers.
- Labelled Faces in the Wild
  - We present the world-leading results that we achieved in February 2014 using "wild" full colour images.

Aurora's current focus is the application of Deep Learning to our infrared face recognition technology and this has shown remarkable improvements in accuracy. Work has already begun on the application of Deep Learning to colour (visible spectrum) face recognition, for which results will be published at a later date.

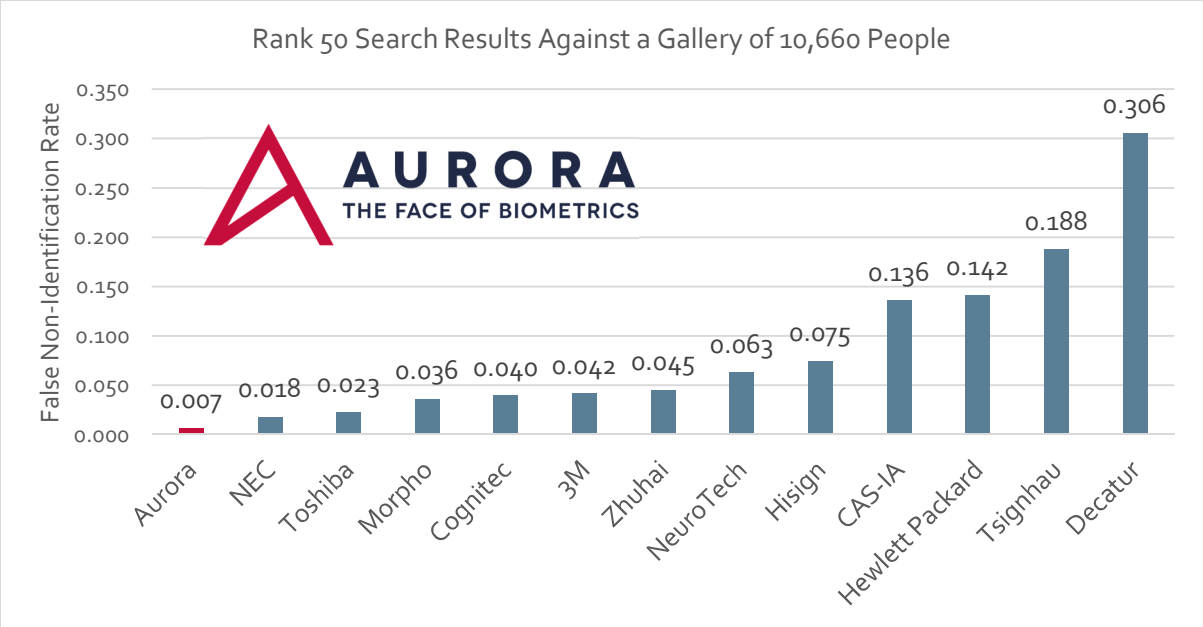
FRVT COMPARISON

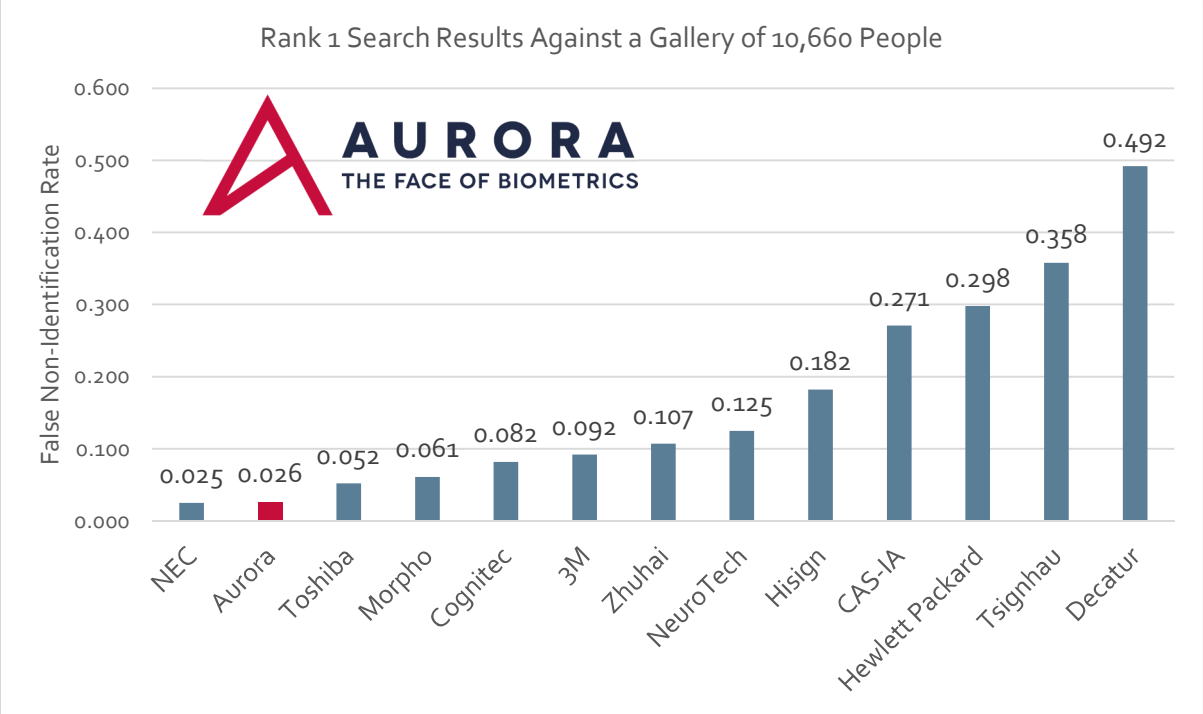
The most recent Face Recognition Vendor Test is the NIST Interagency Report 8009 "Face Recognition Vendor Test (FRVT): Performance of Face Identification Algorithms." Below is Table 9 from page 26 of the NIST Report.

	RANK 1			RANK 50		
ENROL	MUGSHOT	MUGSHOT	WEBCAM	MUGSHOT	MUGSHOT	WEBCAM
SEARCH	MUGSHOT	WEBCAM	WEBCAM	MUGSHOT	WEBCAM	WEBCAM
A31C	[5]0.092	[3]0.467	[4]0.264	[5]0.042	[4]0.187	[4]0.107
B32C	[4]0.082	[6]0.591	[8]0.476	[4]0.040	[7]0.344	[8]0.240
C31C	[7]0.125	[9]0.782	[10]0.617	[7]0.063	[9]0.472	[11]0.428
D31C	[3]0.061	[4]0.489	[3]0.230	[3]0.036	[3]0.184	[3]0.105
E30C	[1]0.025	[1]0.104	[1]0.066	[1]0.018	[1]0.031	[1]0.026
G31C	[8]0.182	[12]	[5]0.343	[8]0.075	[12]	[5]0.153
H30C	[9]0.271	[8]0.762	[7]0.428	[9]0.136	[8]0.389	[7]0.223
J32C	[2]0.052	[2]0.236	[2]0.153	[2]0.023	[2]0.067	[2]0.051
L31C	[11]0.358	[10]0.913	[11]0.629	[11]0.188	[10]0.714	[10]0.389
M30C	[10]0.298	[7]0.670	[9]0.521	[10]0.142	[6]0.341	[9]0.280
P30C	[6]0.107	[5]0.530	[6]0.344	[6]0.045	[5]0.242	[6]0.161
S20C	[12]0.492	[11]0.968	[12]0.789	[12]0.306	[11]0.890	[12]0.604

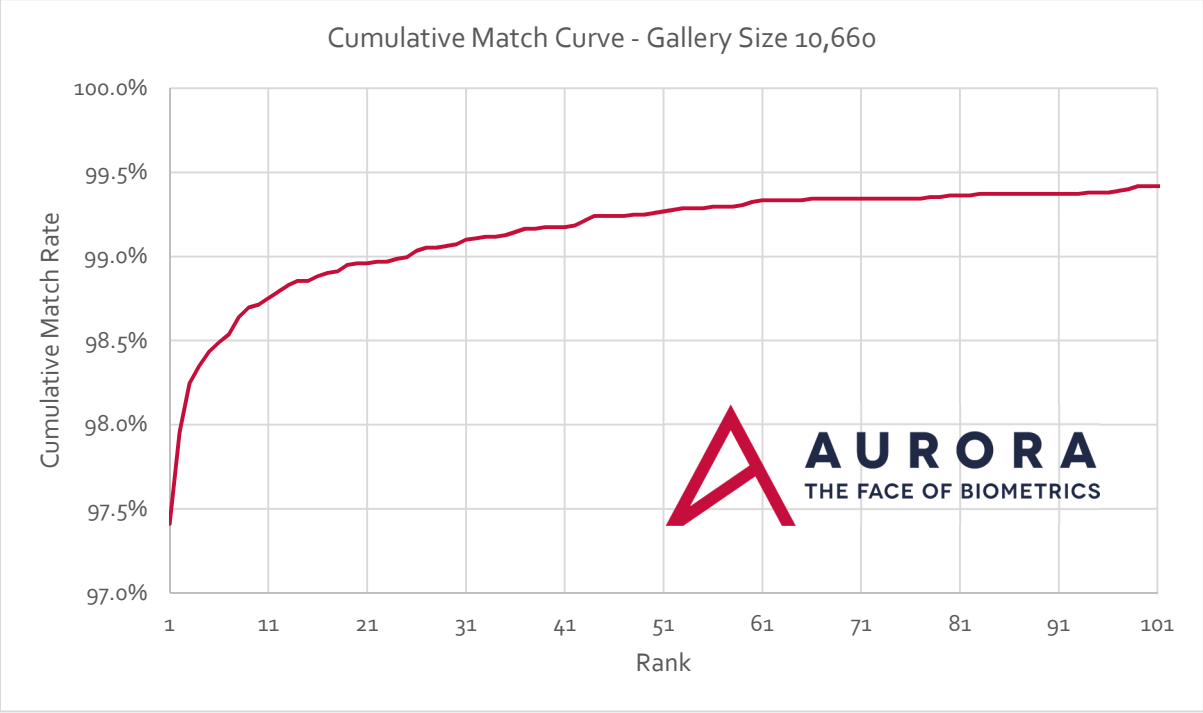
Table 9: **Mugshots, webcams, and interoperable recognition**: The figures are miss rates, FNIR(N, R, T, L) with N = 10,660, R = {1, 50}, L = 50, T = 0, for enrolment using the image type given on row 2 and search image type given on row 3. The blue superscripts indicate algorithm rankings, by column. Missing values are due to software crashes.

Aurora have carried out exactly the same identification test protocol, using our infrared Deep Learning engine, with an identical number of images, same number of people and same quantity of searches. The bar charts below show Aurora's resultant error rates alongside other figures taken from the NIST report.



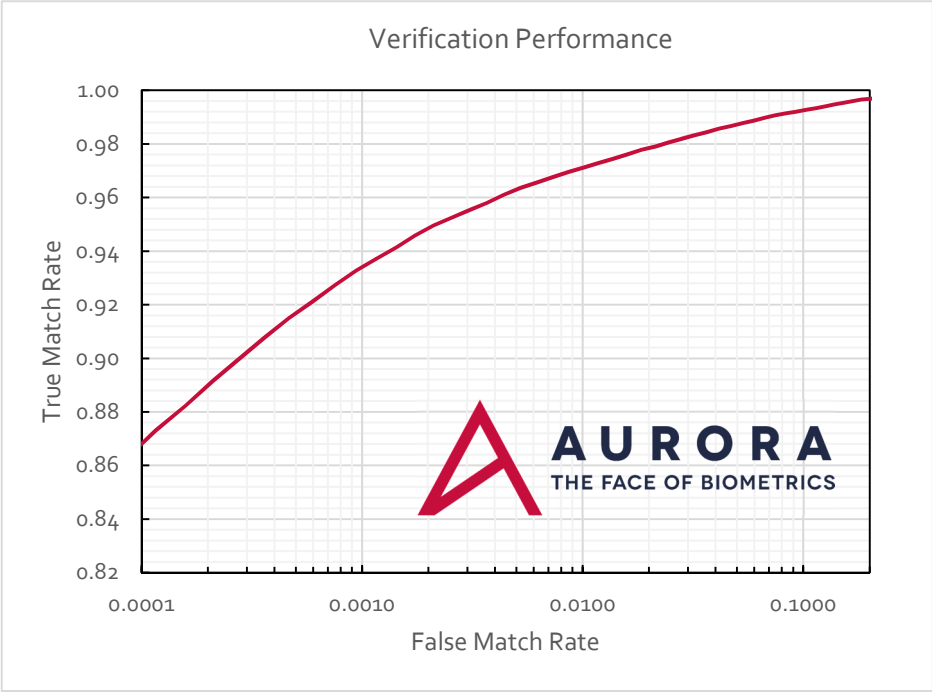


Below is the full Cumulative Match Curve (CMC) generated by performing 10,660 single image searches against a gallery of 10,660 different people.



FERET COMPARISON

Below is an ROC graph generated from 5,599 infrared face images. Likeness scores were produced from 15,643,606 different-person comparisons and 27,995 same-person comparisons. We display the True Match Rate on the y-axis and a logarithmic scale of False Match Rate on the x-axis.



The test procedure and format of results are directly comparable to the results generated from the FERET database.

LFW COMPARISON

In February 2014, Aurora took part in the "Labelled Faces in the Wild" benchmark, run by the University of Massachusetts. We achieved the top ranking position, with the highest level of accuracy. The top six entries are shown in the table below.

Organisation	Algorithm	Mean Accuracy ± (Standard Dev.)
Aurora	**Aurora-c-2014-1**	**0.9324 ± (0.0044)**
UST China, MS Research Asia	High-dim LBP	0.9318 ± (0.0107)
Oxford University	Fisher vector faces	0.9303 ± (0.0105)
Vision Labs	VisionLabs ver.1.0,aligned	0.9290 ± (0.0031)
NEC	CMD+SLBP, aligned	0.9258 ± (0.0136)
Face.com	Face.com r2011b	0.9130 ± (0.0030)

The graph below shows the ROC curve generated from the benchmark tests.

Since 2014, new entrants to the LFW benchmark have surpassed these figures, mostly by academic organisations using Deep Learning approaches and significantly greater quantities of training data. Since Aurora has developed its own Deep Learning capability, we have concentrated on infrared and not yet revisited the LFW challenge. However, once we have applied Deep Learning to colour images and created a new recognition engine, we will apply the new technology to this benchmark once again.