# Facial Recognition

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## INTRODUCTION

Over the past decade Facial Recognition has become more cohesive and reliable than ever before. We begin with an analysis explaining why certain facial recognition methodologies examined under FERET, FRVT 2000, FRVT 2002, and FRVT 2006 have become stronger and why other approaches to facial recognition are losing traction. Second, we cluster the stronger approaches in terms of what approaches are mutually inclusive or exclusive to surrounding methodologies. Third, we discuss and compare emerging facial recognition technology in light of the aforementioned clusters. In conclusion, we suggest a road map that takes into consideration the final goals of each cluster, that given each clusters weakness, will make it easier to combine methodologies with surrounding clusters.

## BACKGROUND

The National Institute of Standards and Technology (NIST) sponsored 2006 Face Recognition Vendor Test (FRVT) which is the most recent large scale independent synopsis of the state-of-the-art for face recognition systems. The previous tests in the series were the FERET, FRVT 2000, and FRVT 2002. The following organizations participated in the FRVT 2006 evaluation: Animetrics, Inc., Carnegie Mellon University, Cognitec Systems GmbH, Diamond Information Systems (DIS), Geometrix, Inc., Guardia, Identix, Inc., Neven Vision, New Jersey Institute of Technology (NJIT), Nivis, LLC, Old Dominion University, Panvista Limited, Peking University, Center for Information Science, PeopleSpot Inc., Rafael Armament Development Authority Ltd., SAGEM SA, Samsung Advanced Institute of Technology (SAIT), Tsinghua University, Tili Technology Limited, Toshiba Corporation, University of Houston, and Viisage. It should be noted that while the FRVT

2006 was conducted by the National Institute of Standards and Technology (NIST), it was jointly sponsored by five other U.S. Government agencies which share NIST's interest in measuring the improvements in face recognition technologies: Federal Bureau of Investigation, National Institute of Justice, National Institute of Standards and Technology, U.S. Department of Homeland Security, and the Transportation Security Administration.

The FRVT 2006 measured the progress of facial recognition systems including commercial systems that used Windows or Linux based algorithms. The sequestered data comprised a large standard dataset of "full frontal" pictures provided to NIST by the U.S. State Department using non-conforming pixel resolutions and lighting angles of 36,000 pictures of persons applying for non-immigrant visas at U.S. consulates in Mexico. The tests evaluated 4 dimensions of facial recognition: high resolution still imagery, 3D facial scans, multi-sample still facial imagery, and pre-processing algorithms that compensate for pose and illumination. The results of the best of the 13 groups that entered have improved remarkably; the best algorithms in the FRVT 2002 computed 20% false rejections compared to only 1% false rejections in the FRVT 2006 tests. However, some of the groups that entered FRVT 2006 had results no better than that of 2002. In the tests, the rejection was less palatable: 12% for the best algorithms which still it is better than the 29% rejection rate of the 2002 tests.

FRVT tests digress from the traditional facial recognition tests of the 1990's in two ways: First, speed was not the issue in the tests, some of the algorithms took hundreds of hours to find matches in the database. The correct identification (precision) is the issue. Secondly, rather than the traditional ID searches of comparing a face in the camera with every face in the database for a match, the FRVT tests comprised security verification: is the face of the person standing in front of the

*Figure 1. The reduction in error rates of facial recognition algorithms*
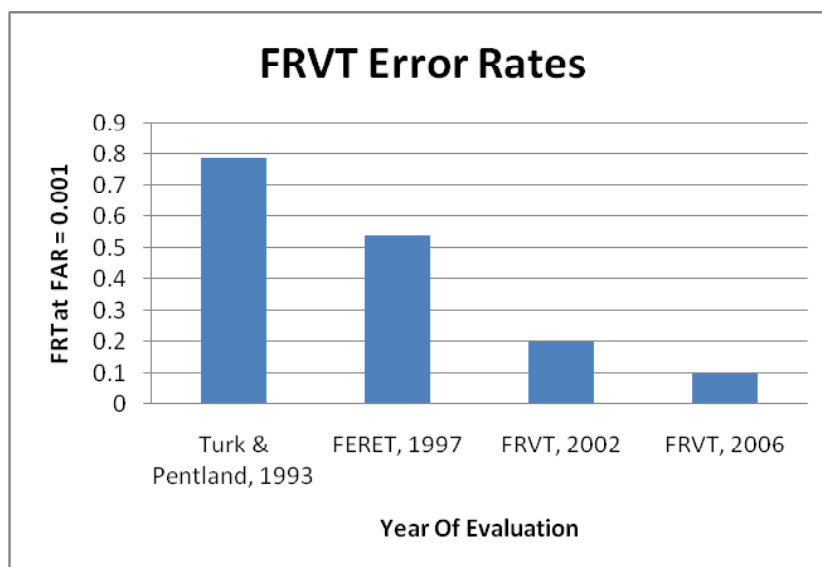


camera claiming to be Mr. Whomever indeed the Mr. Whomever whose picture is in the database?

## THE STATE-OF-THE-ART OF THE 13 GROUPS IN FRVT 2006

The three well known facial recognition corporations, Google owned Neven Vision, Viisage Technology (owned by L-1 Identity Solutions), and Cognitec Systems of Germany performed the best. The two universities that excelled were the University of Houston and Tsinghua University in China. The four methodology clusters are (i) Support Vector Machines, (ii) Manifold/Eigenface, (iii) Principal Component Analysis with Modified Sum Square Error (PCA/SSE), and Pure Eigenface technology:

1.  *Cognitec Systems* - Cognitec Systems FaceVACS-incorporates Support Vector Machines (SVM) to capture facial features. In the event of a positive match, the authorized person is granted access to a PC (Thalheim, 2002).

2.  *Neven Vision* - In 2002, Neven's Eyematic team achieved high scores in the Face Recognition Vendor Test (Neven, 2004). Neven Vision incorporates Eigenface Technology. The Neven methodology trains an RBF network which constructs a full manifold representation in a universal Eigenspace from a single view of an arbitrary pose.

3.  *L-1 Identity Solutions Inc* – L-1's performance ranked it near or at the top of every NIST test. This validated the functionality of the algorithms that drive L-1's facial and iris biometric solutions. L-1 was formed in 2006 when Viisage Technology Inc. bought Indentix Inc. The NIST evaluations of facial and iris technology covered algorithms submitted by Viisage and Indentix, both of which utilize variations of Eigenvalues, one called the principal component analysis (PCA)-based face recognition method and the other, the modified sum square error (SSE)-based distance technique.

4.  *M A. Turk and A P. Pentland* – they wrote a paper that changed the facial recognition world - "*Face*

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