

# Creative Inquiry: Robust Facial Recognition with Reconfigurable Platforms

Authors: Andrew Kruzner, Jack Merwin, Ananth Nallamuthu, Derek Rollend, Scott Gibson, Prof. Melissa Smith  
(Future Computing Technologies Creative Inquiry Team)



## Biometrics

Biometrics is the use of physical features to identify a person. Immigration departments, gate entry control, ATMs etc. are beginning to use biometrics for authenticating identity. With advancement in technology to allow real-time, consistent, and robust identification, biometrics will find many new applications.

### Common Biometric features

The table below is a comparison of the most commonly used features for identification: fingerprint, iris and face

Biometric	Universality	Uniqueness	Permanence	Collectability	Performance	Acceptability	Circumvention
Face	High	Low	Medium	High	Low	High	Low
Fingerprint	Medium	High	High	Medium	High	Medium	High
Iris	High	High	High	Medium	High	Low	High

- Universality** - Universal availability
- Uniqueness** - how well the biometric separates individuals from one another
- Permanence** - how well a biometric resists aging
- Collectability** - ease of acquisition for measurement
- Performance** - accuracy, speed, and robustness of technology used
- Acceptability** - degree of approval of a technology
- Circumvention** - ease of use of a substitute

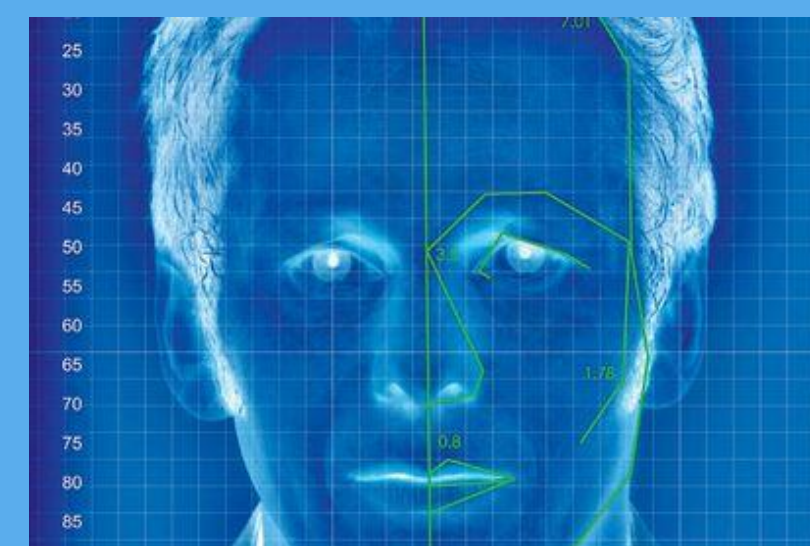


Image courtesy: www.autoexpress.co.uk

### Facial Recognition Technique

Facial recognition techniques use the facial features of a person to establish identity. The image of the person is compared with an existing database of known identities. The image needs to be preprocessed into mathematical representation for algorithms to make the comparison. As shown in the table above, though the facial recognition technique is better than fingerprint and iris based recognition techniques in terms of collectability and acceptability, facial recognition techniques are not commonly used yet due to the low performance of the algorithms and lower uniqueness.

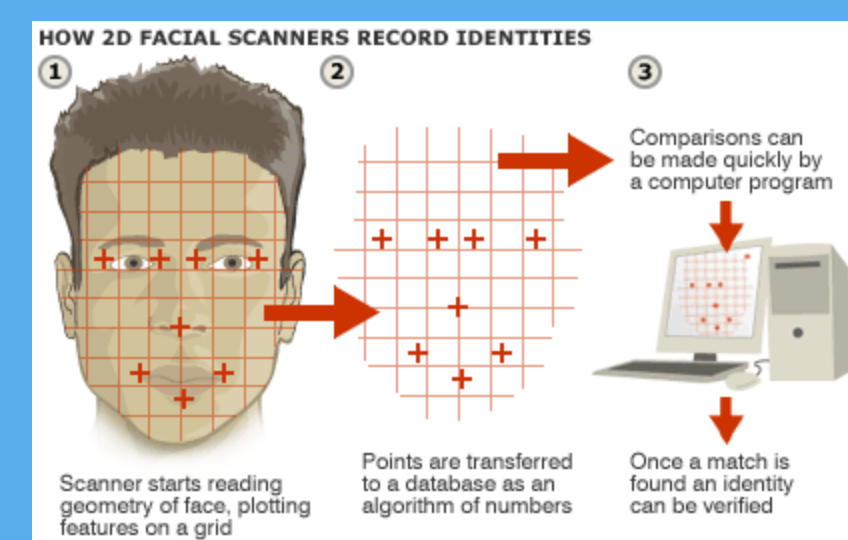


Image courtesy: www.bbc.co.uk

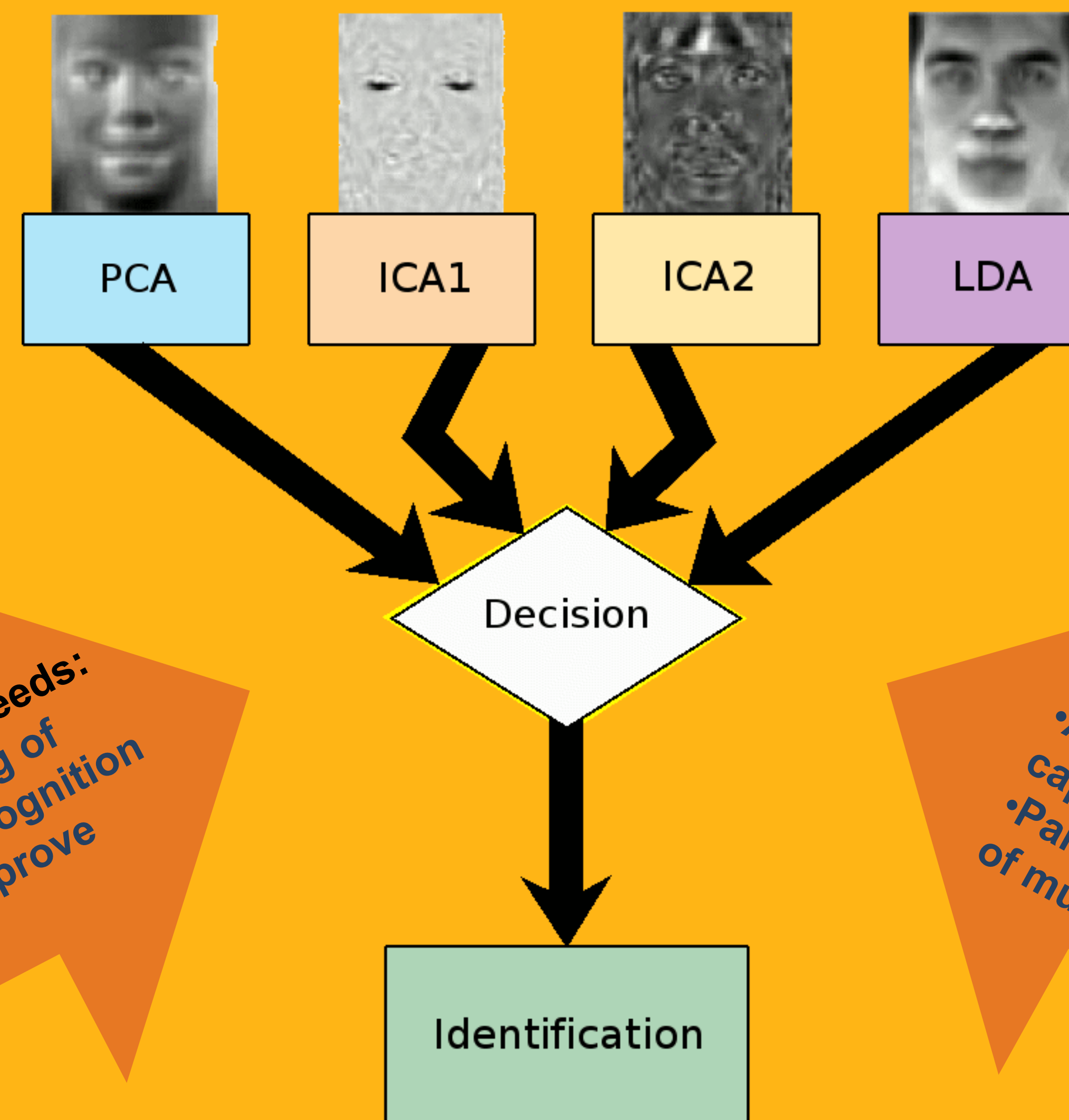
### Low performance of facial recognition algorithms

Different facial images of the same person may differ by illumination conditions, facial expressions, temporal changes in the face etc. The facial recognition algorithm used should be able to identify matches even when the compared images differ in such attributes. Though a number of facial recognition algorithms are available none of them could be used for all types of input data. A consensus made by comparing the results of multiple algorithms could improve the reliability of the facial recognition system. But processing data with multiple algorithms will be very slow. Hence there is a need for a hardware technology that would enable parallel processing of multiple algorithms in a small footprint, low-power (for embedded applications) and in real-time (or psuedo) performance.

**Goal:** Execute multiple facial recognition algorithms in parallel on FPGA-based platform and obtain a reliable identification decision

- The following analysis will be performed on the facial image to be identified
- Principal Component Analysis (PCA)
  - Independent Component Analysis (ICA1 and ICA2)
  - Linear Discriminant Analysis (LDA)

The MISC capability of FPGAs will be exploited to process the same input data with a heterogeneous set of algorithms simultaneously. This capability will enable real-time comparison of algorithm results and when coupled with a final decision algorithm, a more robust identification.



Facial images courtesy: "Independent Comparative Study of PCA, ICA, and LDA on the FERET Data Set" by Kresimir Delac et al

**Facial recognition Needs:**  
•Parallel processing of multiple facial recognition algorithms to improve accuracy

**FPGAs offer:**  
•Algorithm-specific capable hardware  
•Parallel processing of multiple algorithms

### Benefits

- Space/Power efficient (small footprint), eliminating need for supercomputers
- Algorithm-specific optimization on the reconfigurable logic and parallel processing capability improves processing speed

### Challenges

- Modify current algorithms to exploit FPGA features
- Develop decision process and algorithm(s)

## FPGA-based Reconfigurable Computing

The future is Reconfigurable !

FPGA-based systems are emerging as an alternative to traditional microprocessors for several classes of applications. Their lower clock speeds minimize power consumption and performance is maintained through application specific hardware implementation. The graph on the right compares the performance of Pentium family processors with Xilinx virtex-4 FPGAs.

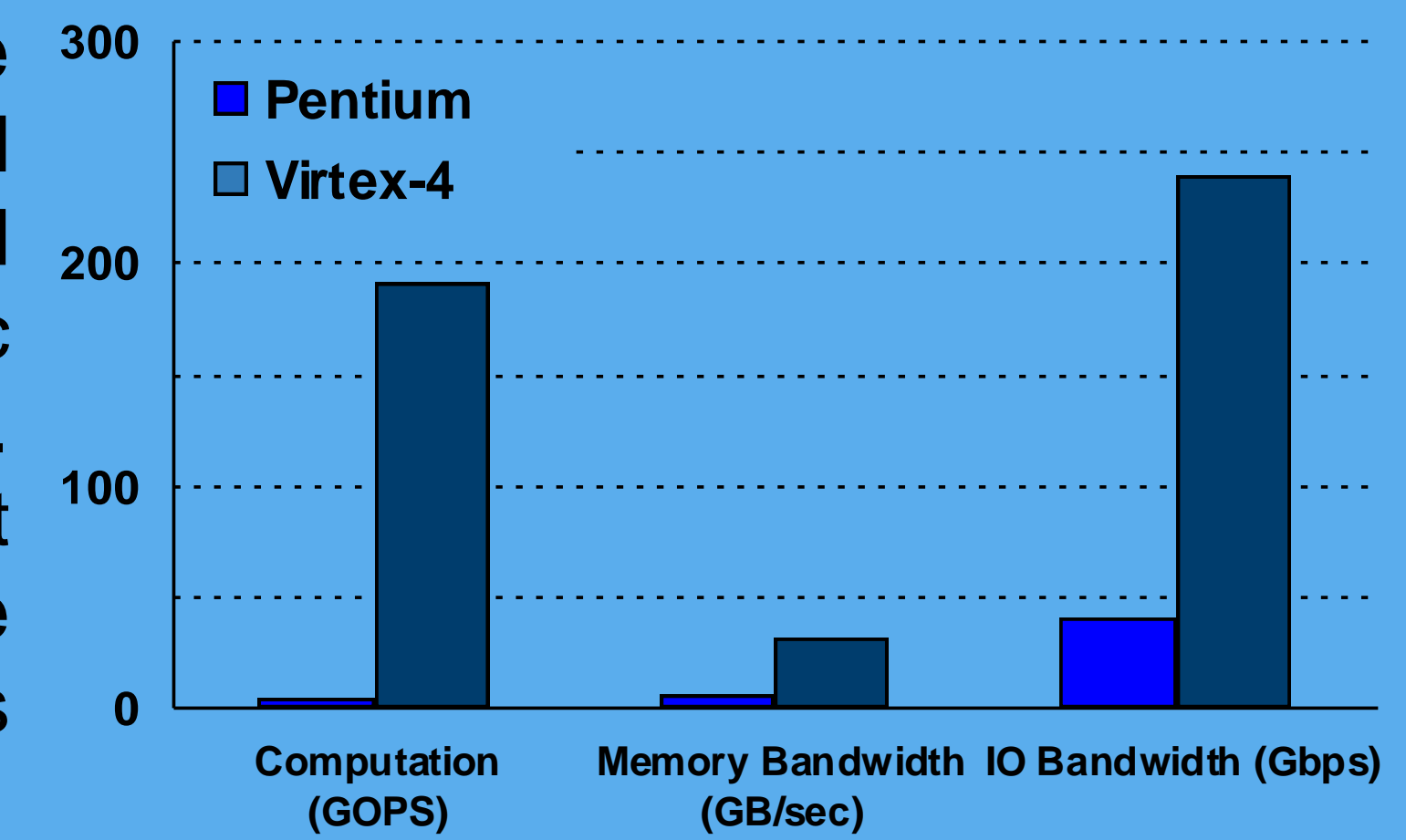


Image courtesy: K. Underwood

Via runtime reconfiguration, multiple algorithms can be implemented in FPGAs during different segments of the runtime to support the overall application. Alternatively, several algorithms, either homogeneous copies of a single algorithm working on different data or heterogeneous algorithms working on the same data, can be implemented to run in parallel as demonstrated by several large-scale data manipulation applications like encryption and string pattern matching.



Image courtesy: www.xtremedatainc.com

The Future Computing Technologies Creative Inquiry Team uses an XtremeData XD1000 (left), SRC-6 MAPstation (right) a Xilinx XUP VirtexII-Pro Development system, and two other FPGA-based computing clusters.



Image courtesy: www.srccomp.com

### FPGA Implementation Challenges

Application development (specifically formulation and design) are two areas of open research in FPGA-based computing that are prime for major improvements. Due to the lack of mature compilers and integrate, full design cycle tool support for these systems, algorithm development, partitioning, and runtime scheduling for FPGA-based platforms is a challenging process. Additionally, overheads in setup, configuration, and data transfer must also be considered in performance-demanding applications.

