

Advanced Biometrics

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Four General Class of Biometrics Applications

- Access (Cooperative, known subject)
 - Logical Access (Access to computer networks, systems, or files)
 - Physical Access (access to physical places or resources)
- Transaction Logging
- Surveillance (Non-cooperative, known subject)
- Forensics (Non-cooperative or unknown subject)

Verification and Identification

- Biometric system can be deployed in two scenarios
 - Verification/Authentication
 - To verify the claim "I am Mayank."
 - 1:1 matching
 - Identification
 - To answer the questions "Who am I?"
 - 1:N matching

Enrollment

- What to match with?
 - We need a “database” and enroll subjects in the database - recall Aadhaar project?
 - The process of collecting a biometric sample from an end user; converting it into a biometric reference, and storing it in the biometric system’s database for future comparison
 - Failure to enroll: Failure of a biometric system to form a proper enrollment reference for an end user. Common failures include users who are not trained to provide their biometrics

Gallery and Probe

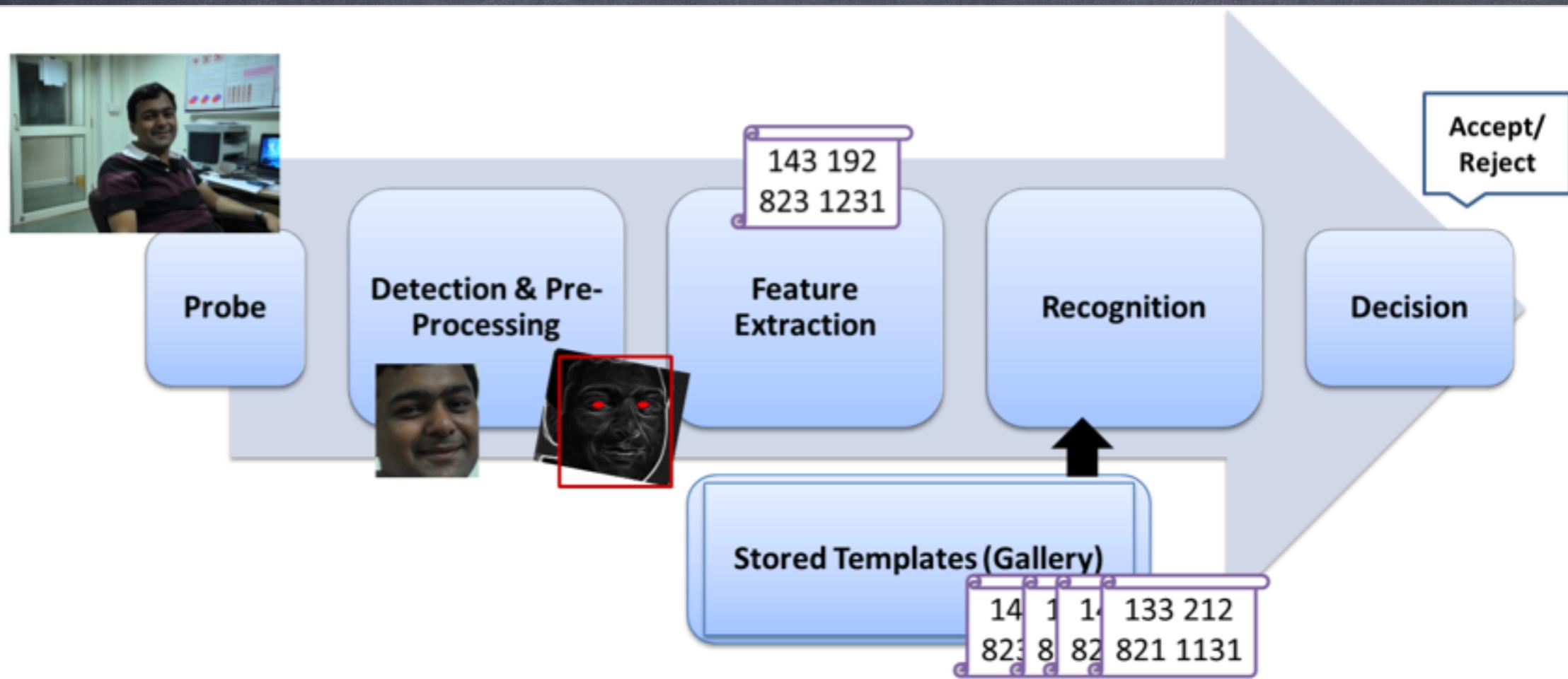
- **Gallery:** The biometric system's database or set of known individuals for a specific implementation or experiment
- **Probe:** The biometric sample that is submitted to the biometric system to compare against one or more reference in the gallery

Failure to Acquire

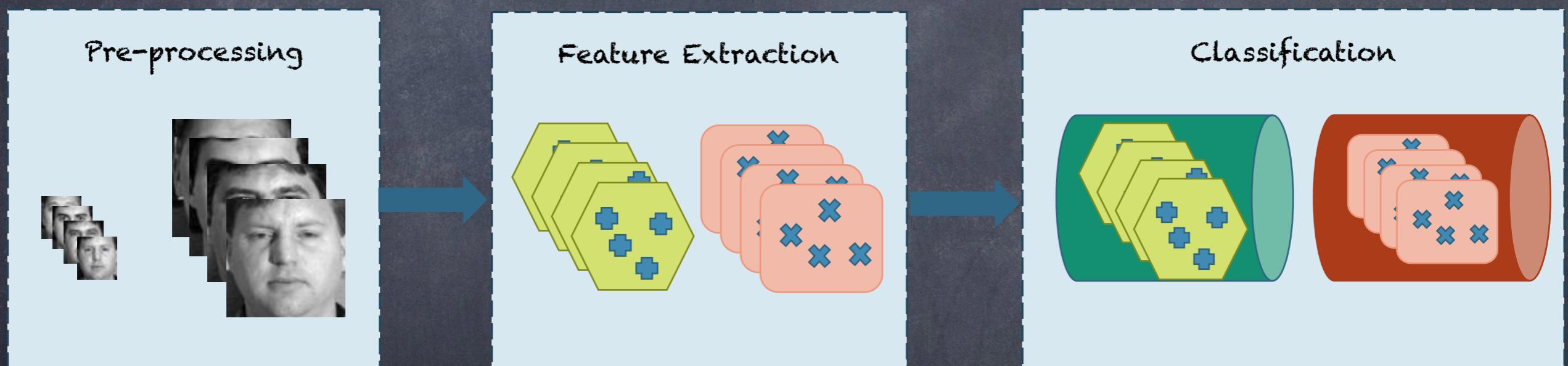
- Failure to acquire: failure of a biometric system to capture and/or extract usable information from a biometric sample



Biometrics Pipeline



From Pattern Recognition or Machine Learning Perspective



How to Design a Biometric System?

- Know your population set
- What is your application?
- Population: students from IITJ or India?
- Do you have sample set that represents your population?

How to Design a Biometric System?

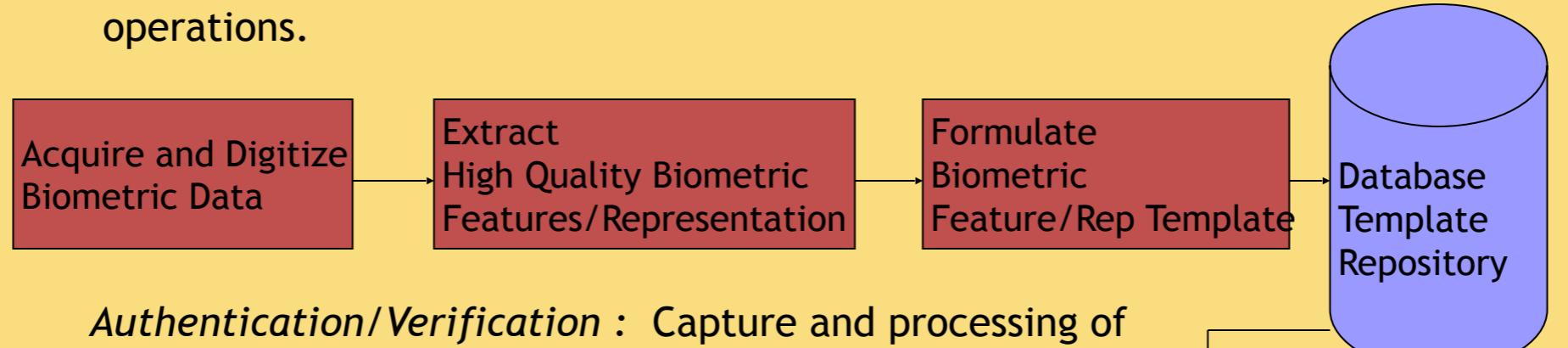
- If your population is IITJ students, how much representative data (minimum number) you require to show that your system works?

How to Design a Biometric System?

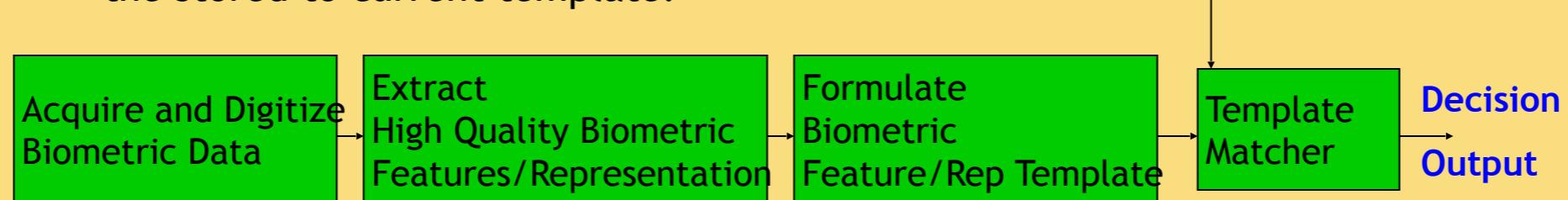
- Design your algorithm
- What are the preprocessing steps?
- How will you extract features?
- How will you verify/identify (classification)?
- Train your system on a representative sample set

System Architecture View

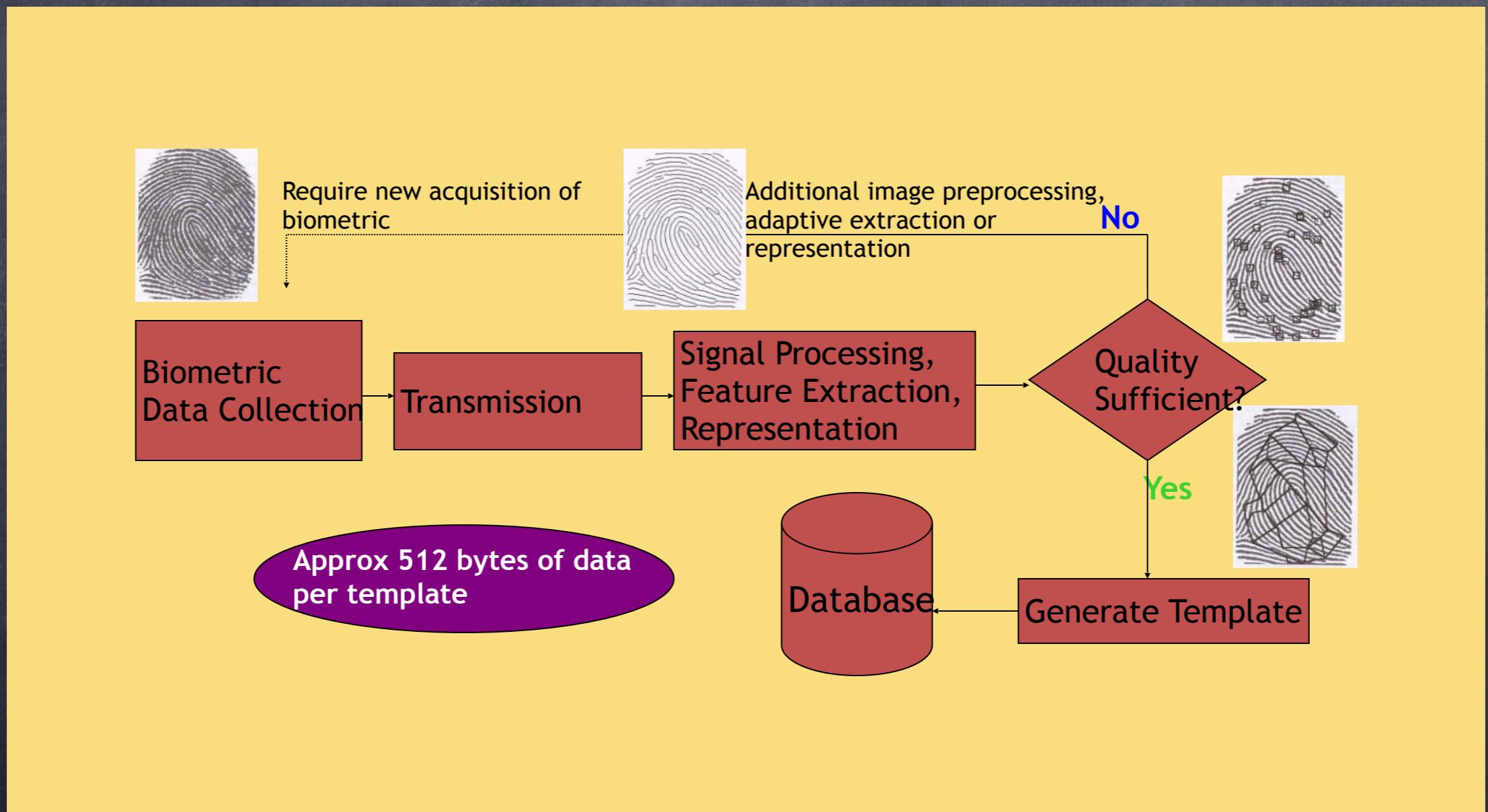
Enrollment : Capture and processing of user biometric data for use by system in subsequent authentication operations.



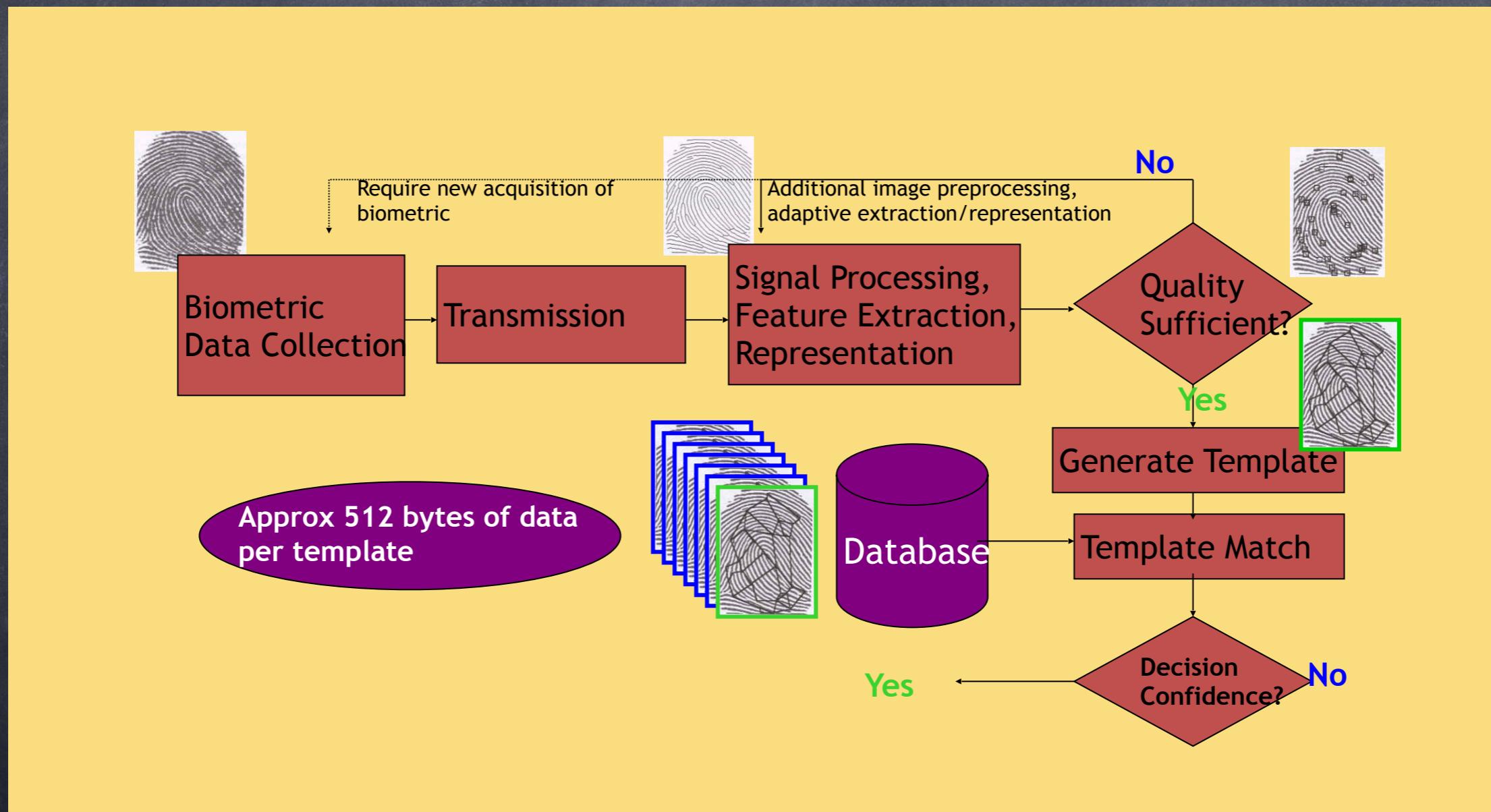
Authentication/Verification : Capture and processing of user biometric data in order to render an authentication decision based on the outcome of a matching process of the stored to current template.



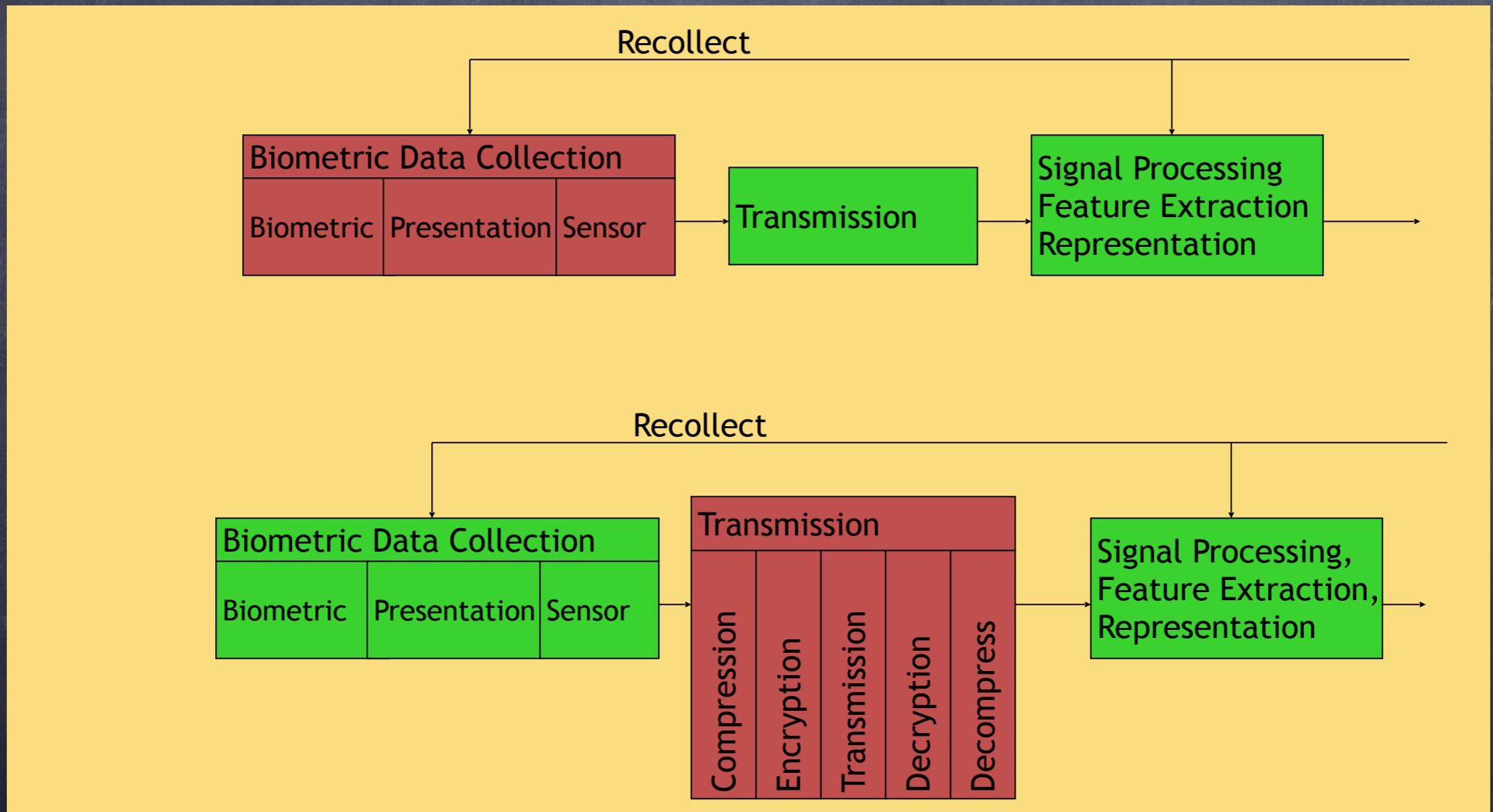
System Architecture View



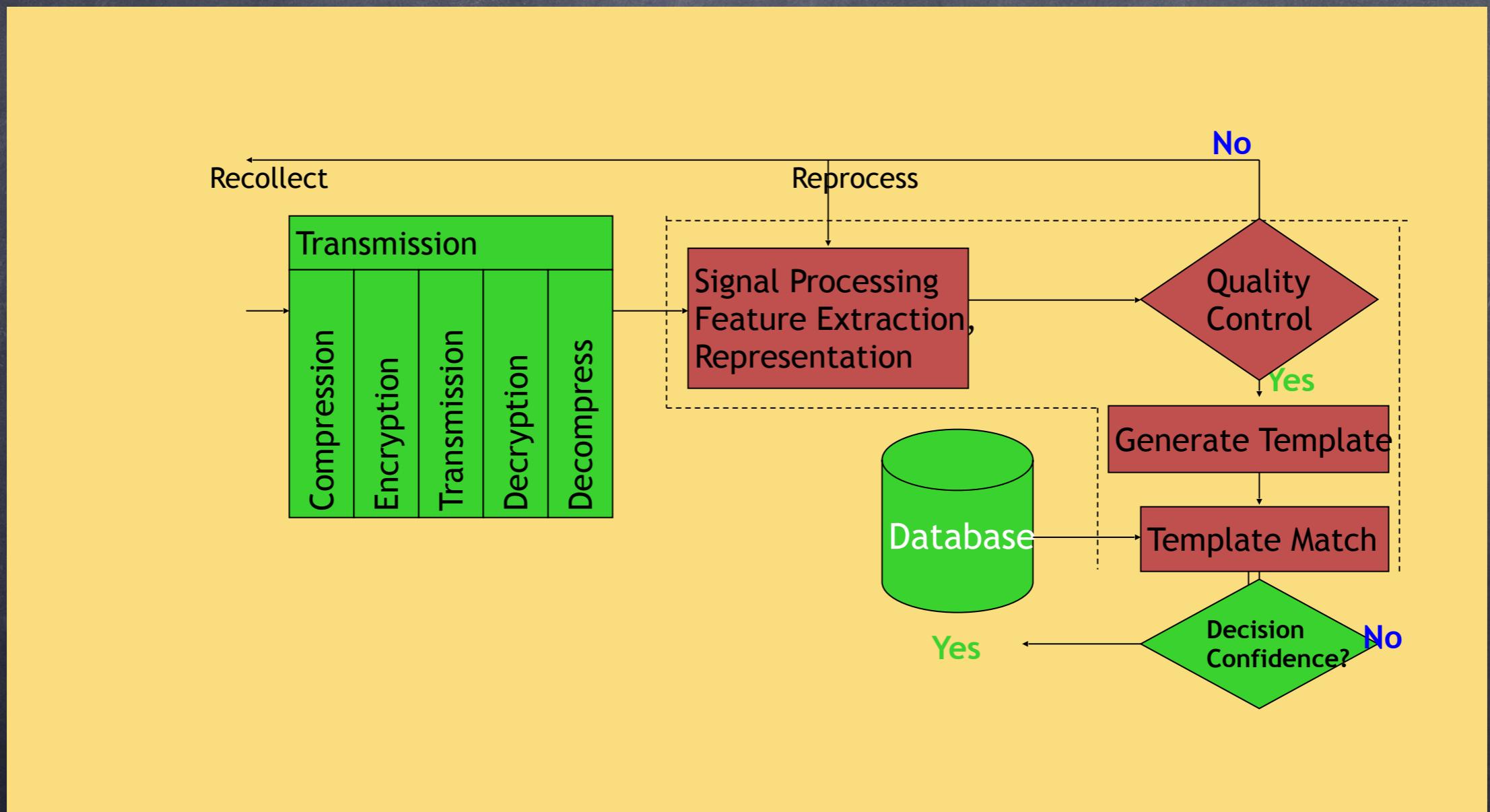
System Architecture View



System Architecture View



System Architecture View



How to Showcase That Your System Works?

- ④ Test your system on a representative sample set
- ④ Performance evaluation
 - ④ Given a sample set, how should we best utilize all the samples to showcase effective but correct results?
- ④ Define your training-testing protocol

Training-Testing Protocol

- Generally algorithms require “learning” some parameters
- Therefore, you require a training set (from your sample set) to learn parameters
- Given a sample set (database that you are using for performance evaluation)
 - Split it into train-test partitions
 - Create at least five such partitions (why?)

Training-Testing Protocol

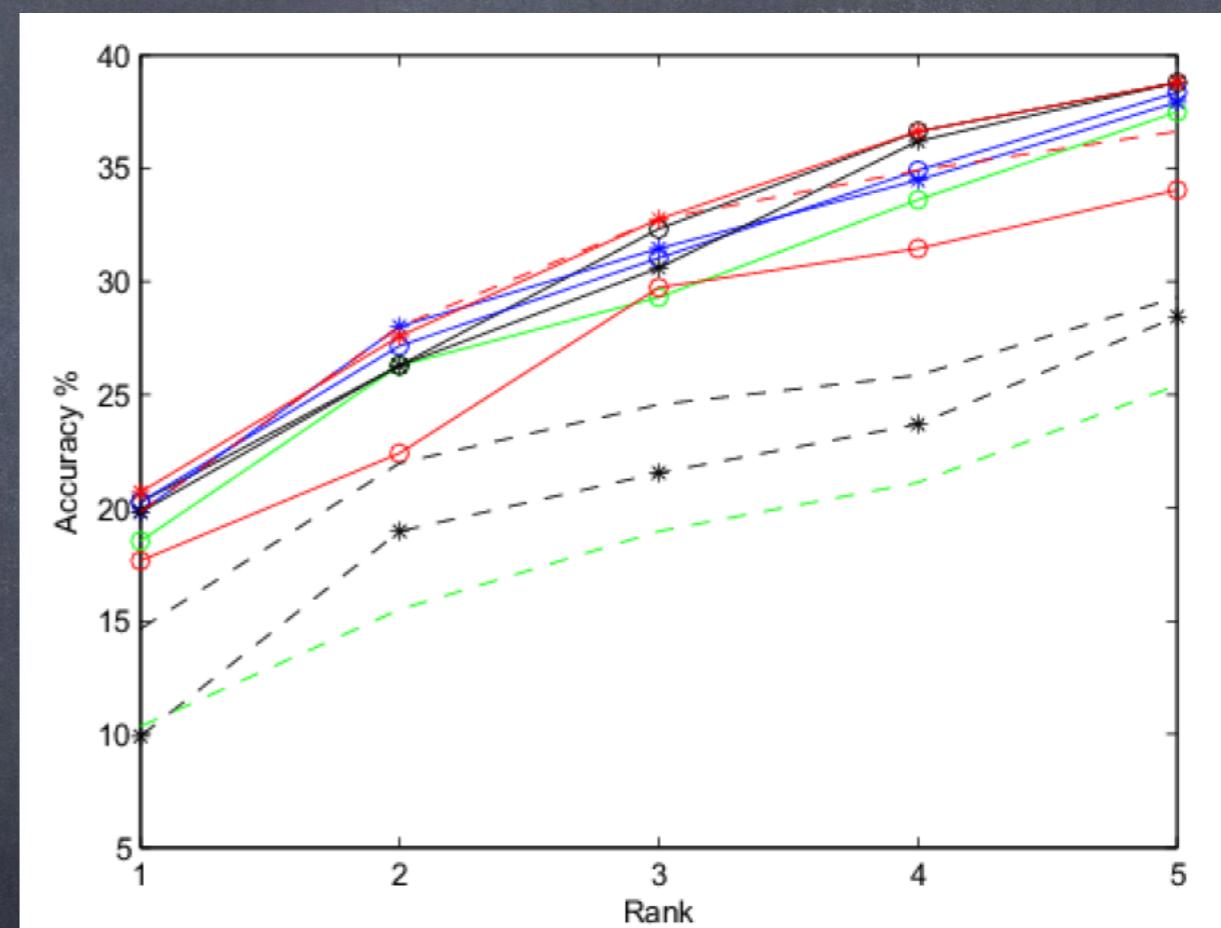
- Cross Validation
 - It is required to showcase that your algorithm is not biased towards a particular training-testing split
- Two ways:
 - K-fold
 - Random subsampling

Training-Testing Protocol

- For each fold
 - Train your algorithm (Learn the parameters)
 - Using the trained algorithm, perform testing on the "test set"
 - Repeat this process for each fold and then compute average accuracy and standard deviation

Performance Evaluation Metrics

- Identification:
 - Cumulative Match Characteristics Curve
 - Rank- k Identification accuracy



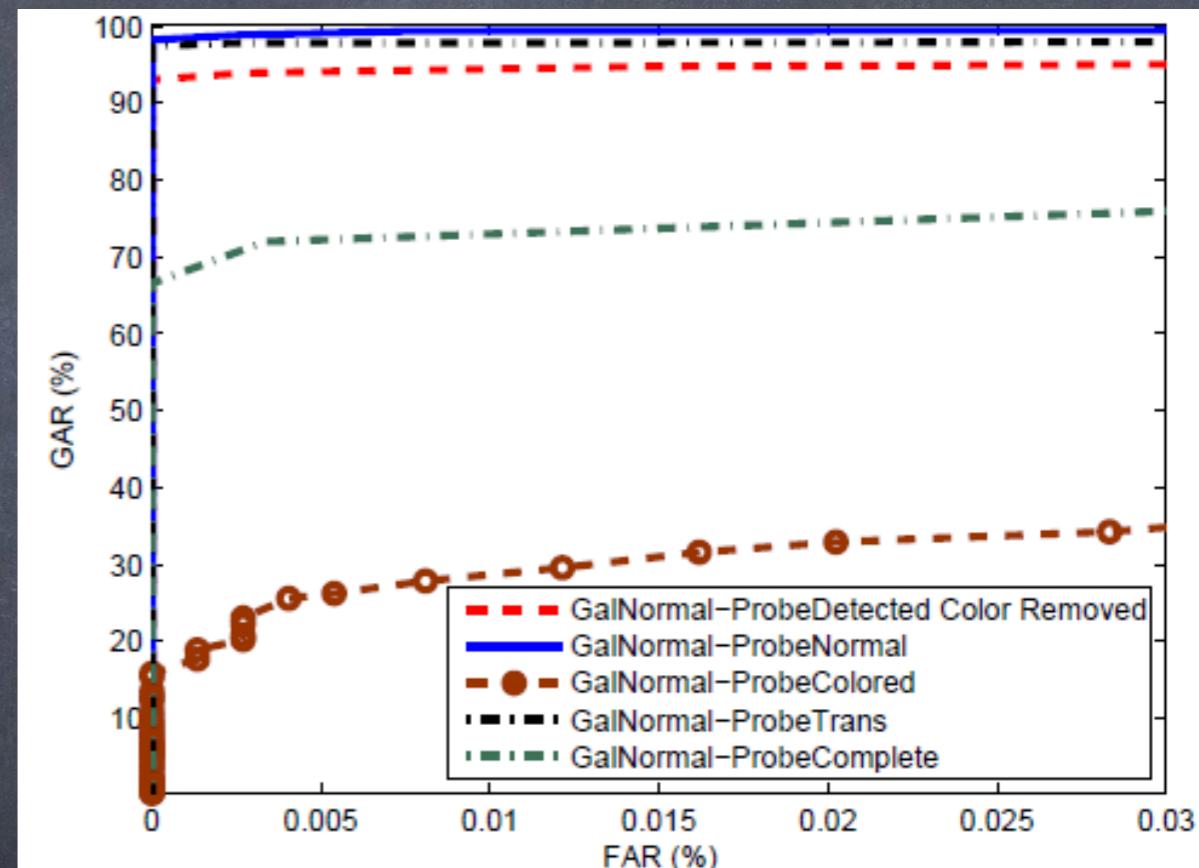
How to Draw CMC Curve

- Each probe biometric sample is compared against all gallery samples
- The resulting scores are sorted and ranked
- Determine the rank at which a true match occurs
- True Positive Identification Rate (**TPIR**): Probability of observing the correct identity within the top K ranks
- CMC Curve: Rank-based metric

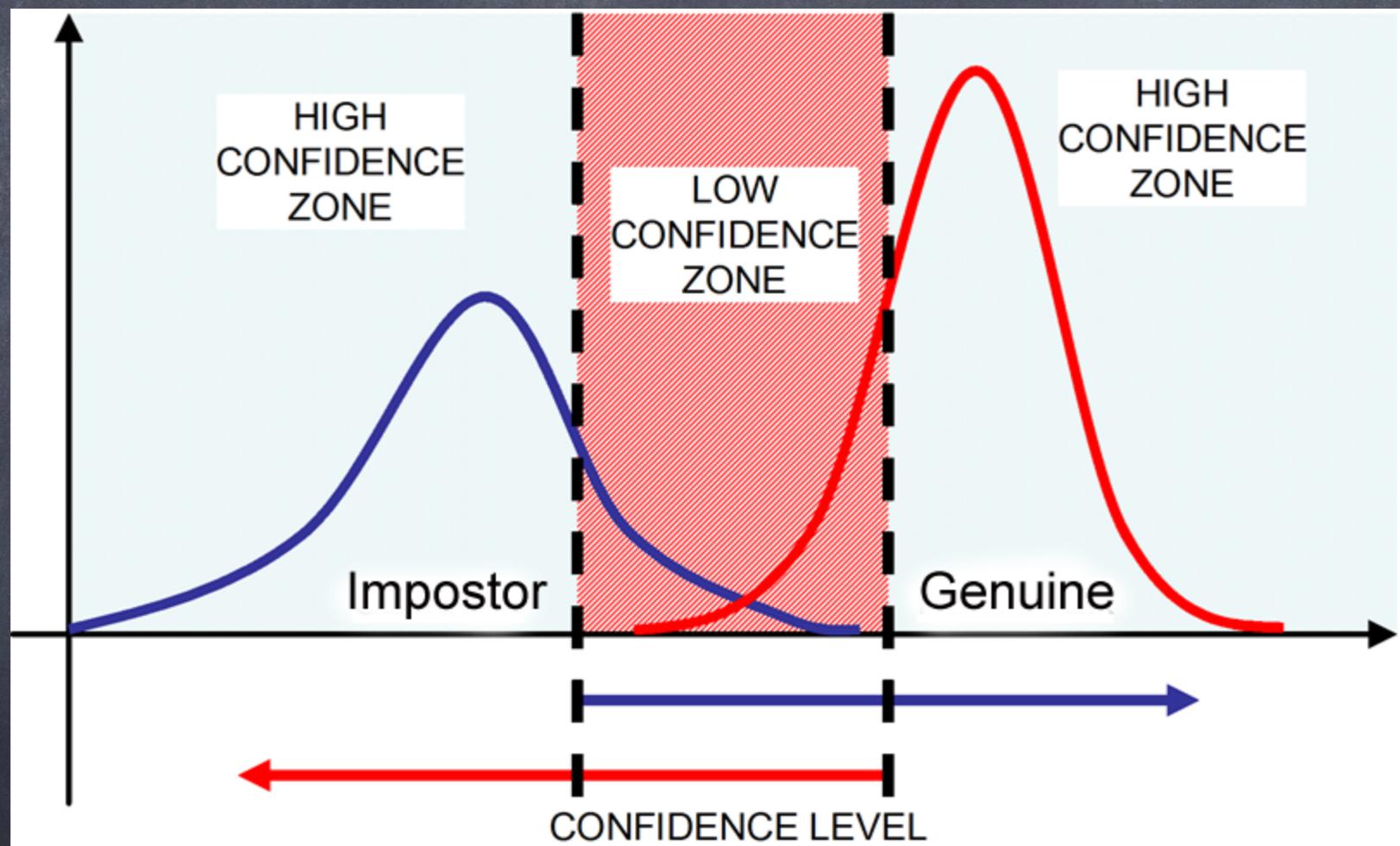
Performance Evaluation Metrics

- Verification:

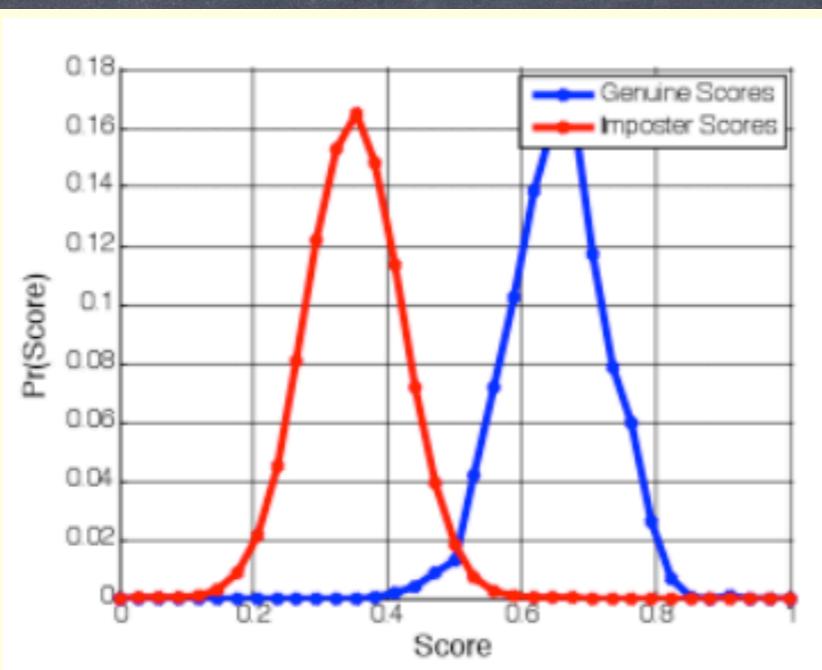
- Genuine/True accept rate
- False accept rate
- Verification accuracy
- Equal error rate
- Receiver operating characteristics curve



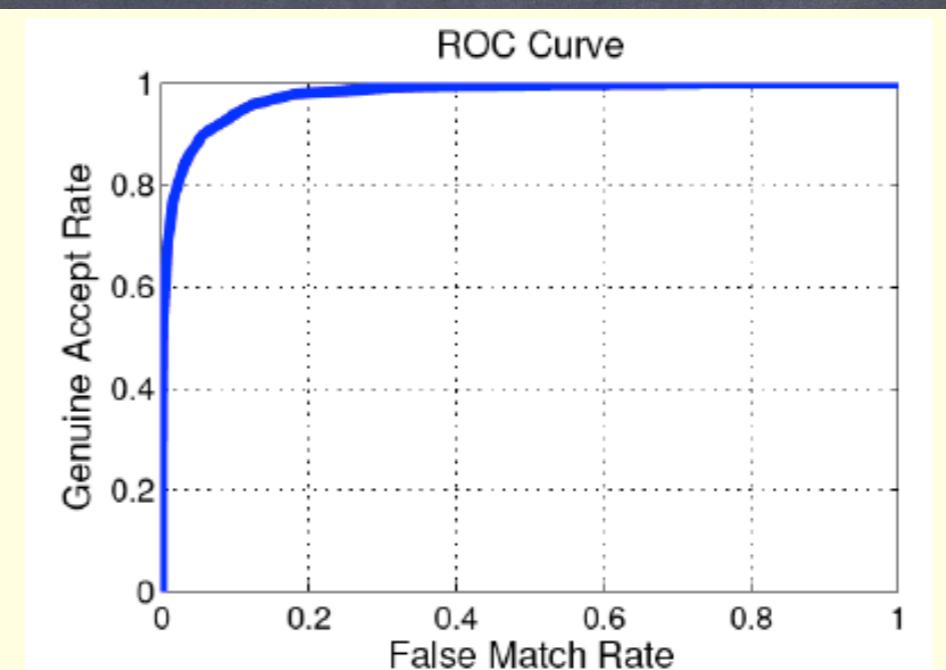
How to draw ROC Curve



How to draw ROC Curve



Match Score Distributions



ROC Curve

Two Scenarios

- Closed Set Matching

- Refers to a biometric task in which an unidentified individual is known to be in the database of biometric characteristics and the system attempts to determine his/her identity
 - Time and attendance system
 - Access system
 - Aadhaar
 - US Visit

Two Scenarios

- Open set identification: A task in biometrics that more closely follows operational biometric system conditions
 - to determine if someone is in a database and find the record of the individual in the database
 - De-duplication
 - Aadhaar
 - US Visit

Research Directions

- Biometrics research has seen several advancements but several “hard” tasks are yet to be addressed
- Few research ideas:
 - How to recognize uncooperative users who are actively deceiving biometric systems?
 - Biometrics for “at-a-distance” samples
 - Designing resource effective systems (for mobile applications)
 - Solving small sample size problem in biometrics
 - Application of biometric methodologies in other domains – healthcare, entertainment
 - Animal biometrics

More Next Week

- We will start face recognition