A Framework for Human-Algorithm Teaming in Biometric Identity Workflows

Identity and Data Sciences Laboratories

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Disclaimer

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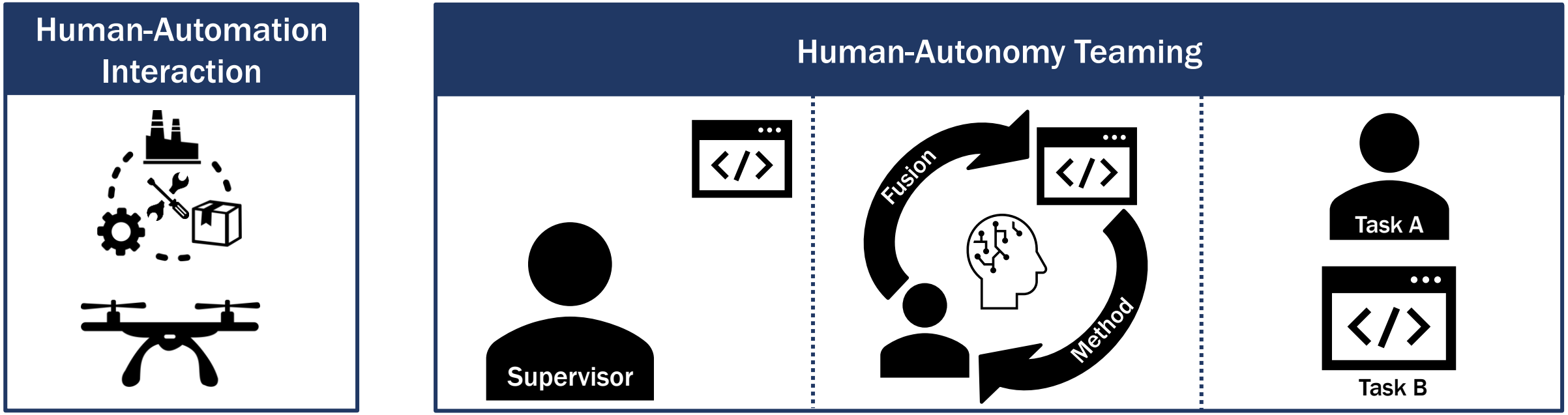
- The views presented here are those of the authors and do not represent those of the Department of Homeland Security, the U.S. Government, or their employers

Overview

- Human-Algorithm Teaming
- Biometrics
- Human Processing and System Functions
- Proposed Framework
- Automation Determination Flowchart
- Use Case Examples

Human-Algorithm Teaming

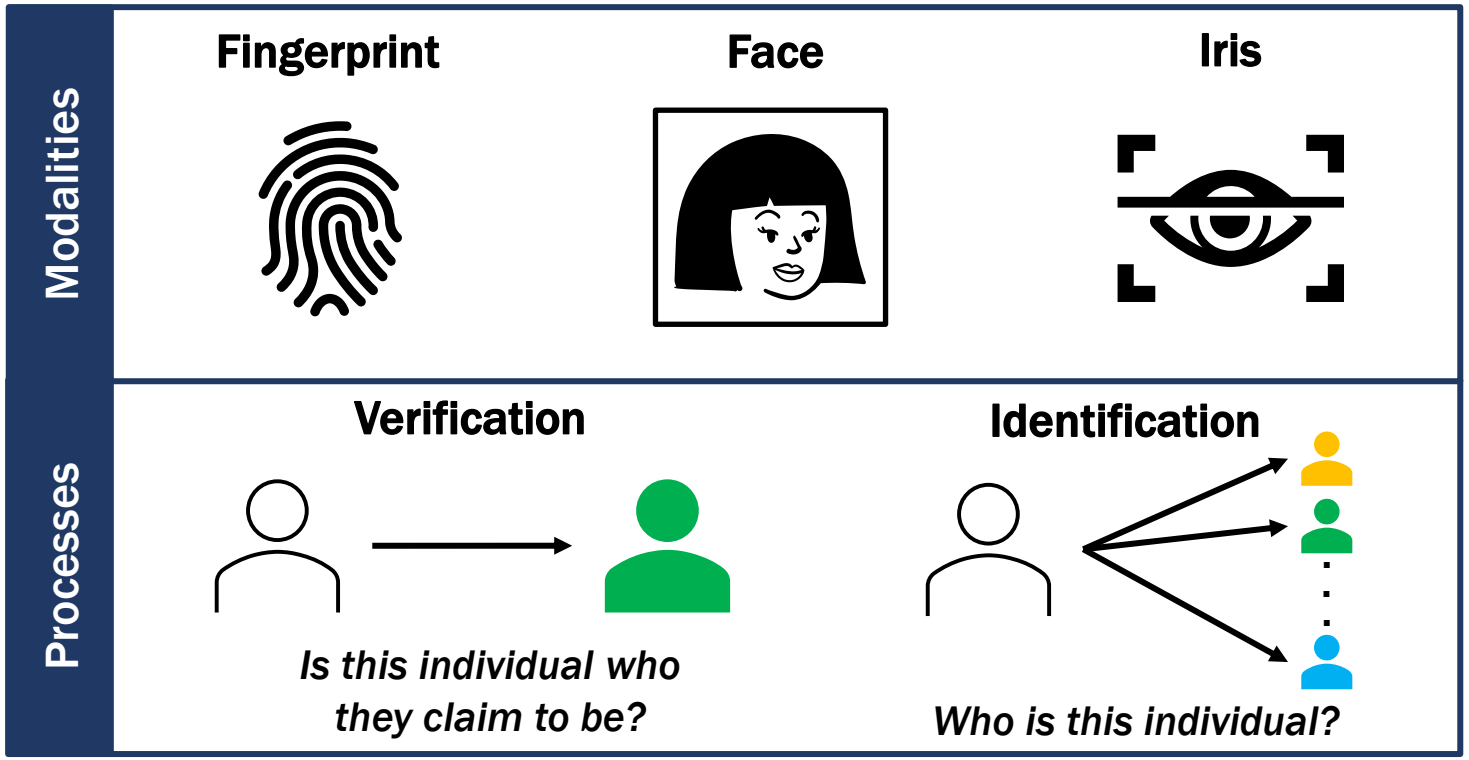
- **Human-automation interaction is not the same as human-autonomy teaming**
- **Teaming dynamics can vary based on task requirements and the current state of technology**
  - Proposed framework focuses on employing a human-algorithm team for the entire general biometric system by allocating tasks based on each entity's strengths and weaknesses



Lyons et al., 2021

Biometrics

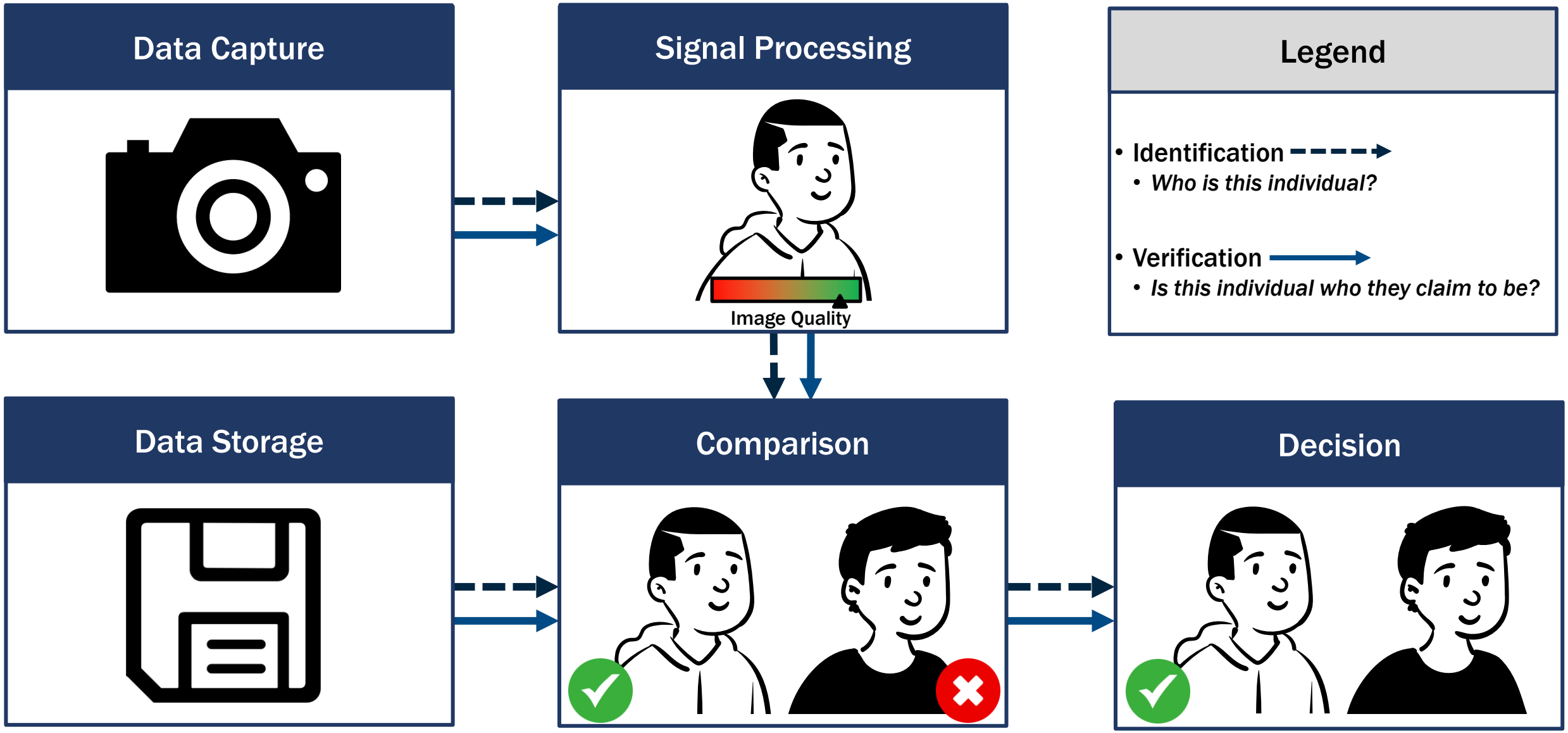
- Biometrics refers to automated recognition of individuals based on their behavioral and biological characteristics (ISO/IEC 2382-37)
- Two different processes are used within biometrics to confirm someone's identity
- Use of biometric systems continues to become integrated in our day-to-day experiences



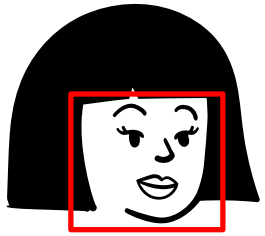
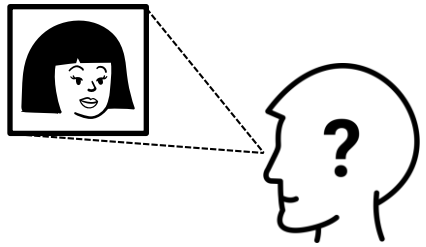
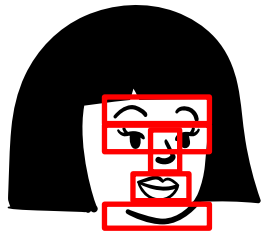
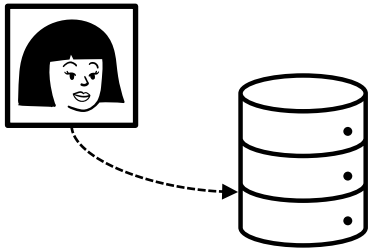
Human-Algorithm Teaming in Biometrics

- Biometrics are being used to confirm people's identities with unintended negative outcomes

General Biometric System Defined by ISO/IEC 19795-1

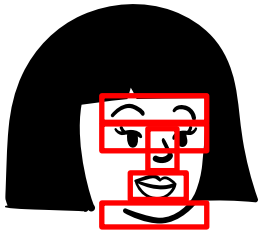
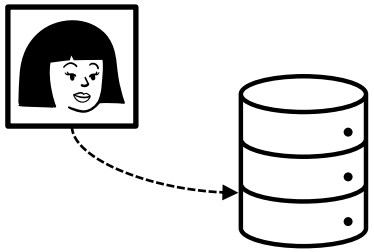


Human Processing and System Functions

Human Processing			
Sensory Processing	*Perception and Memory*	*Decision Making*	*Response Selection*
		Different Person	NA
System Function			
Information Acquisition	*Information Analysis*	*Decision and Action Selection*	*Action Implementation*
		Same Person	NA

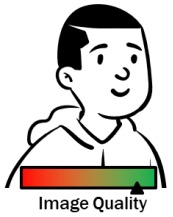
Parasuraman et al., 2000

Mapping System Functions to the General Biometric System

System Function	Information Acquisition	Information Analysis	Decision and Action Selection	Action Implementation
			Same Person	NA

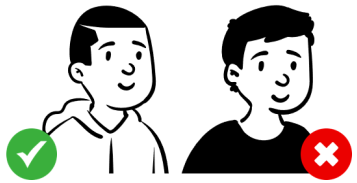
Data Capture

Signal Processing

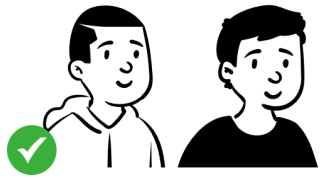


Data Storage

Comparison



Decision



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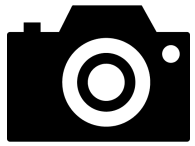
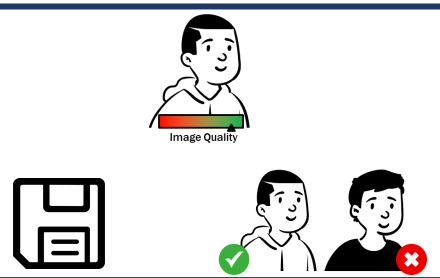
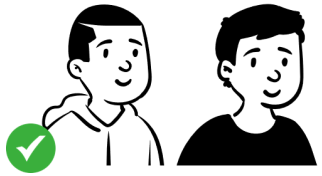
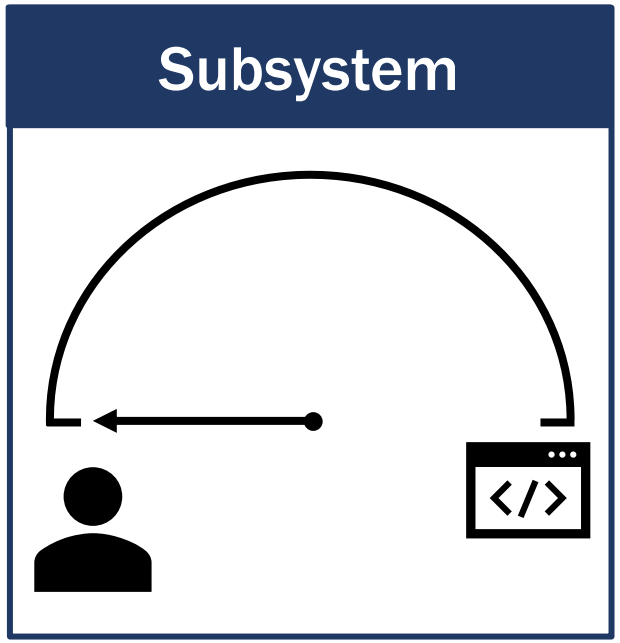
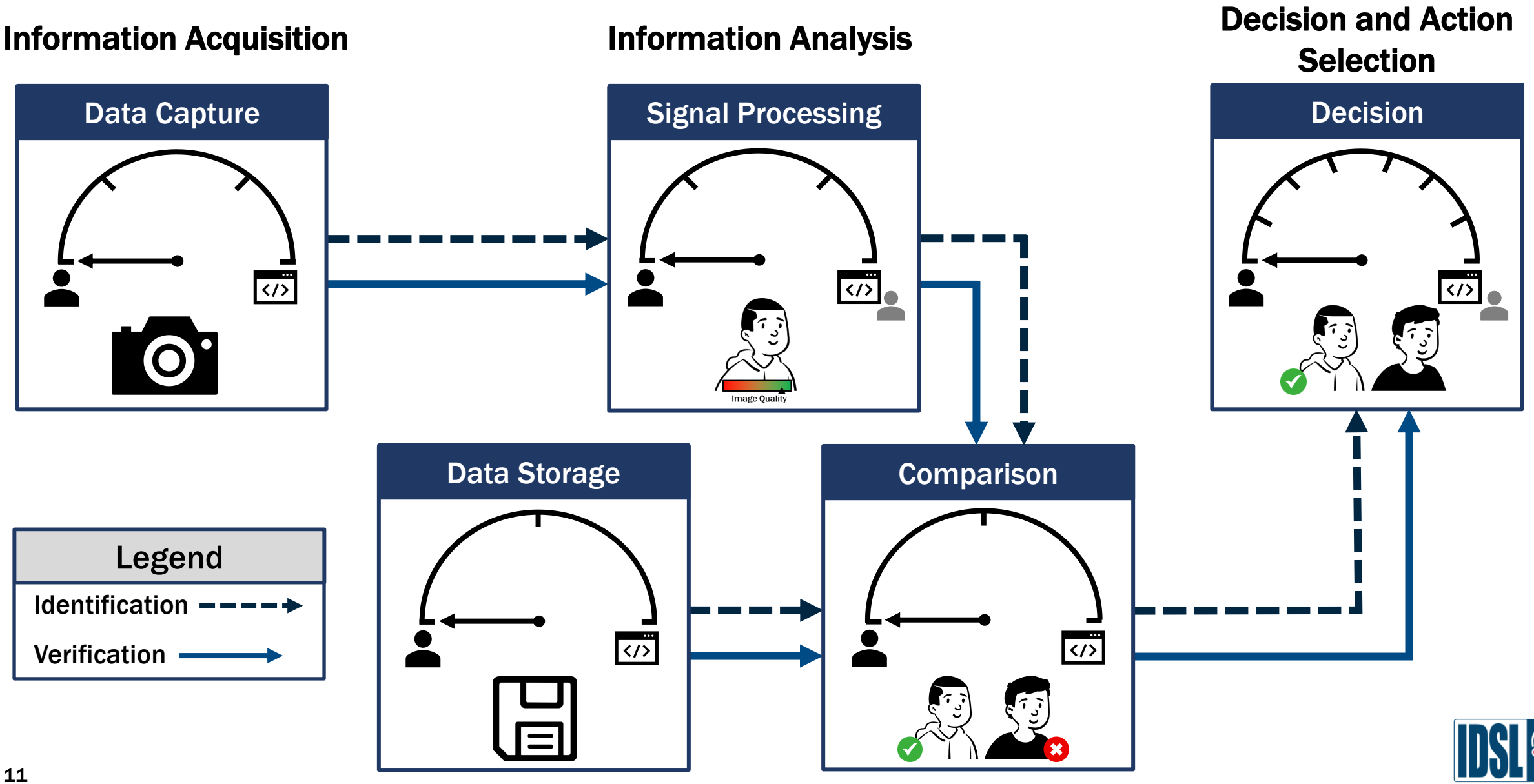
				NA

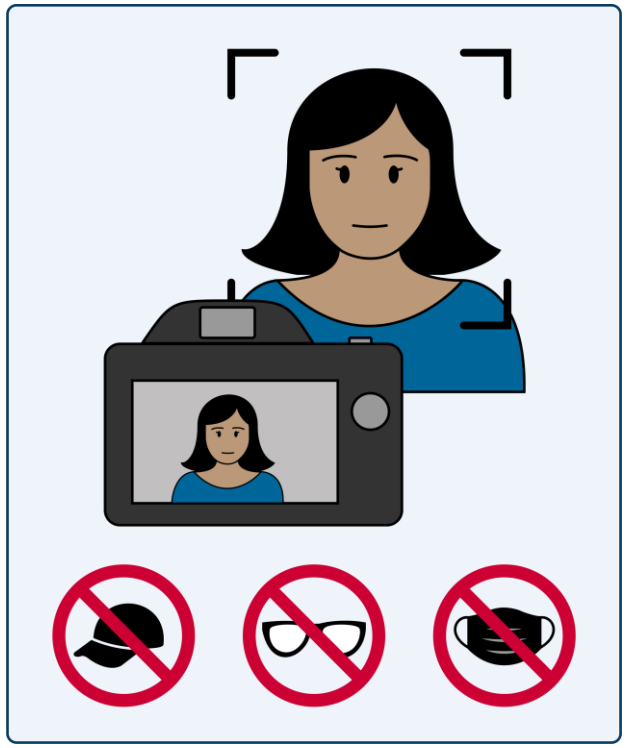


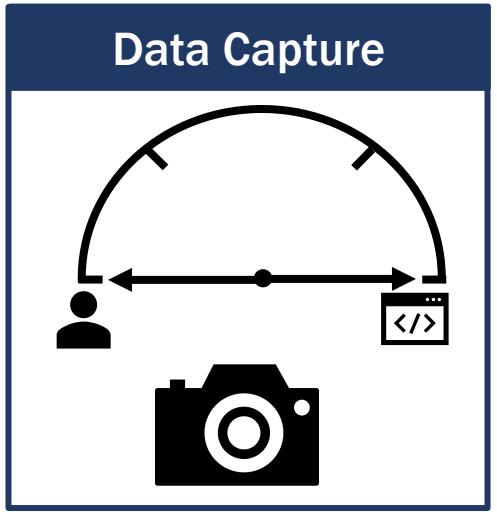
- We determined that each subsystem has different levels of automation (LOAs)
- LOAs range from the human performing all tasks to the algorithm performing all tasks
- For two of the subsystems the highest LOA may require adjudication from the human

Proposed Framework



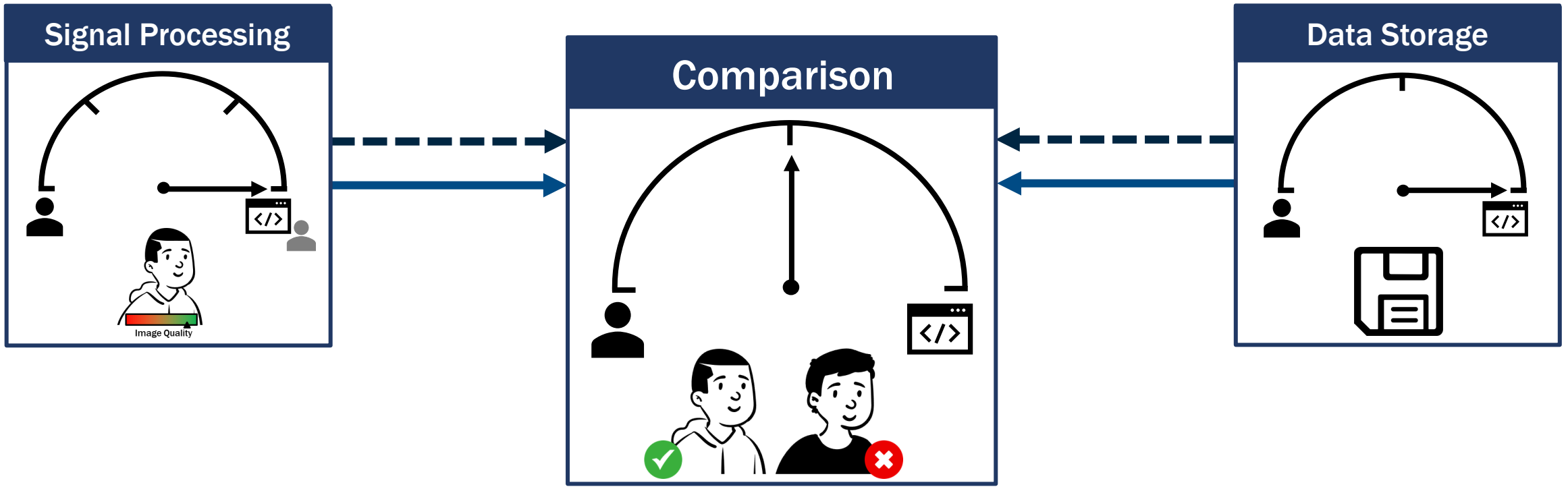
Information Acquisition





- **Data capture could be set to the lowest LOA**
  - Factors like light correction and focus of the image will be dependent on the operator
- **Data capture could be set to the highest LOA**
  - Algorithms can't instruct the user to remove occlusions from their face or maintain a neutral expression and pose
- **Regardless of the LOA, low quality images can impact the remaining subsystems**
  - False negatives
  - Failure to capture
  - Equitability

Information Analysis

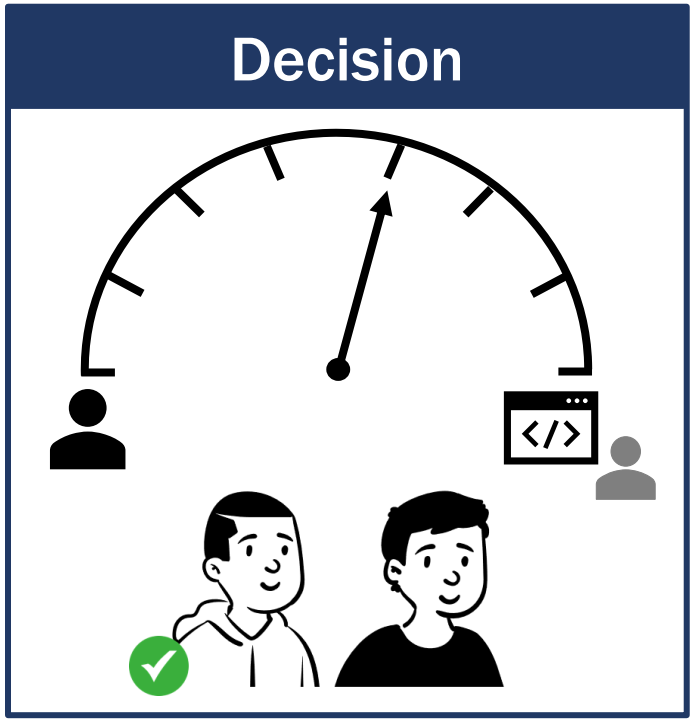


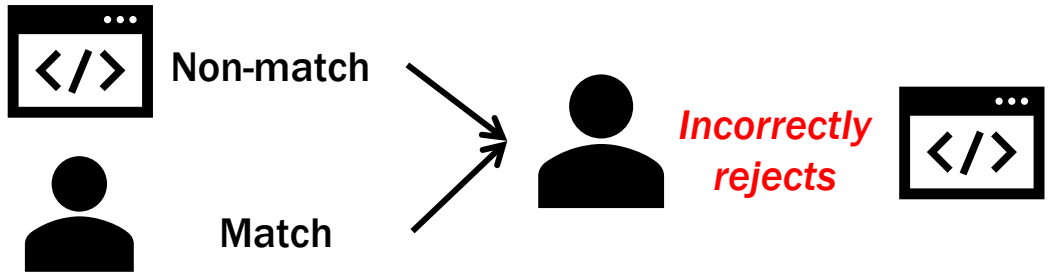
- **Both humans and algorithms can independently complete a comparison of unfamiliar faces**
  - Humans can very quickly process faces but perform poorly with unfamiliar faces
  - The LOA selected is highly dependent on the use case

Decision and Action Selection

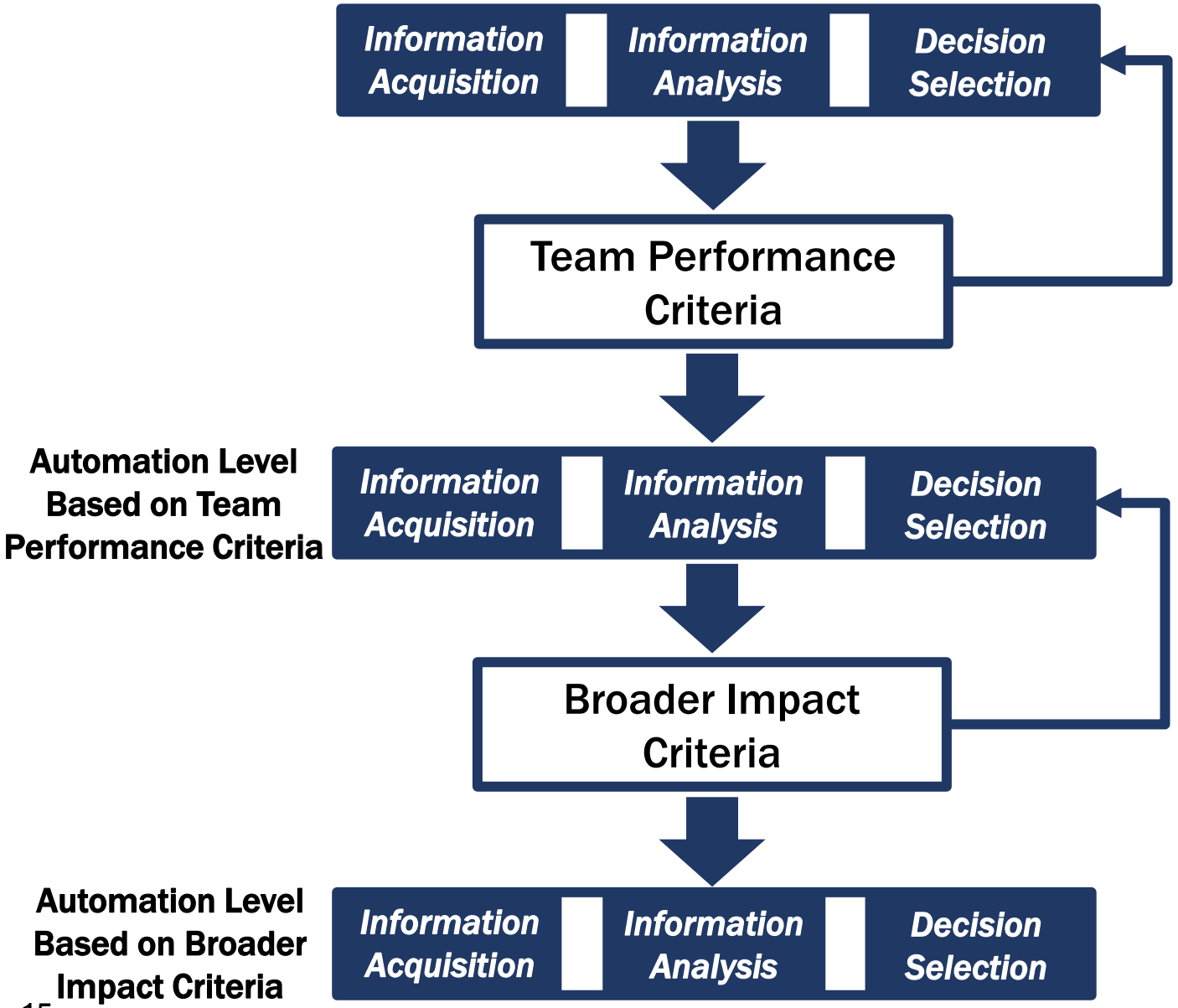
Images from Joshi et al., 2022

Not the same person

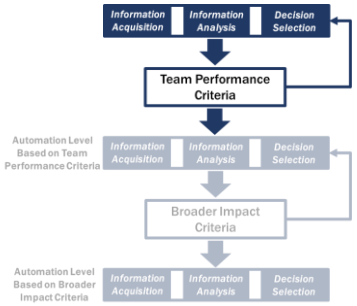




Automation Determination Flowchart



- **We developed criteria specific to the general biometric system based on Parasuraman and colleagues (2000)**
- **Two sets of criteria**
  - Team performance: measurable metrics
  - Broader impact: ethical concerns
- **Iterative process**
  - Team performance criteria is optimized before broader impact criteria to minimize errors experienced by a larger population



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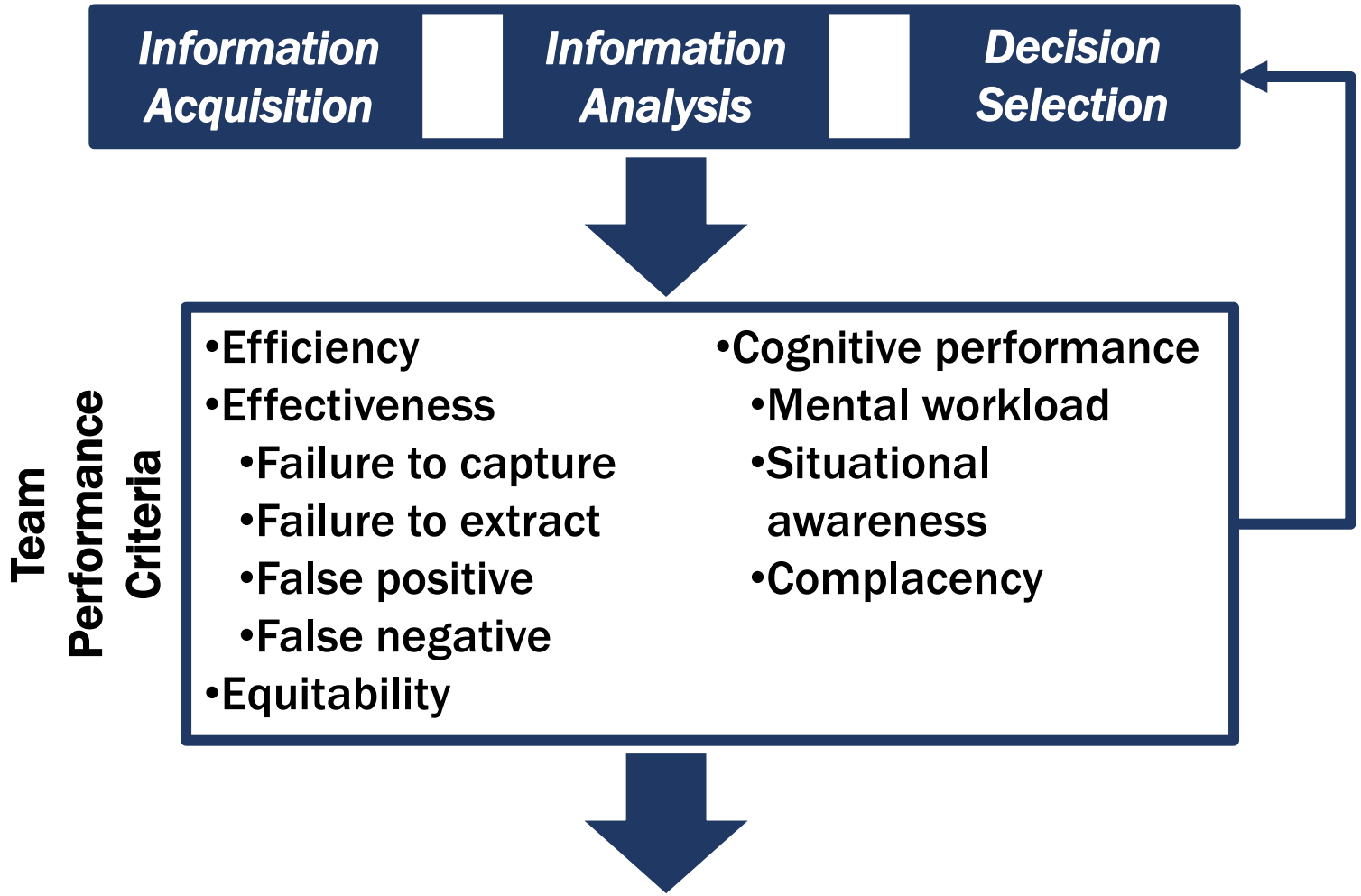
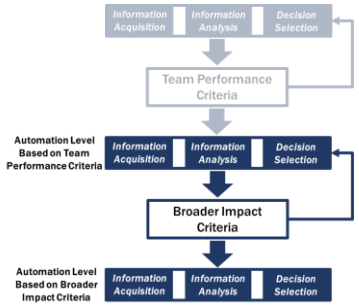




Automation Determination Flowchart

Automation Level Based on Team Performance Criteria

Information Acquisition | ***Information Analysis*** | ***Decision Selection***

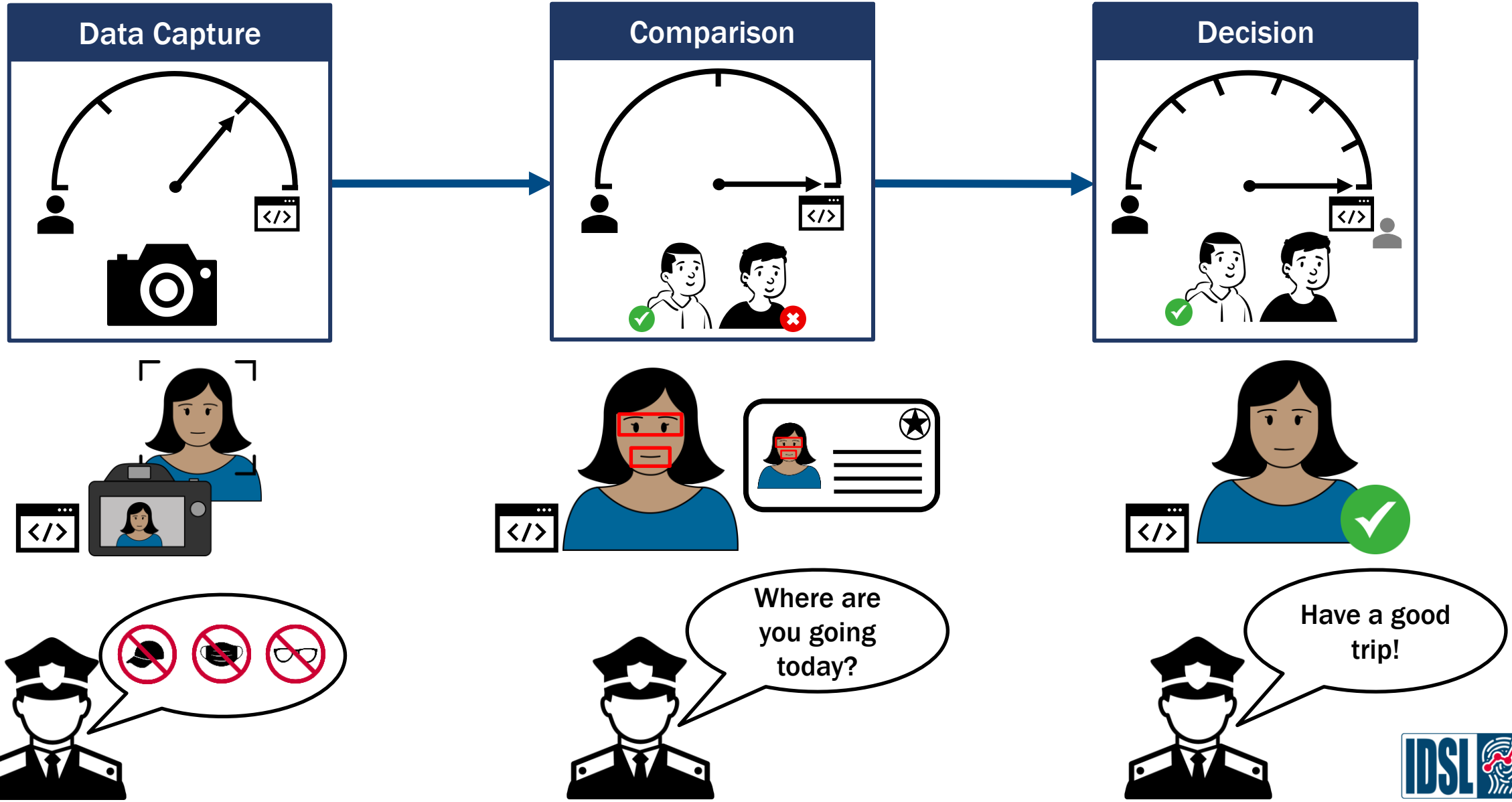
Broader Impact Criteria

- •Organizational impacts
  - •Long-term skill degradation
  - •Safety
- •Societal impacts
  - •Costs of errors
  - •Privacy
  - •Equitability

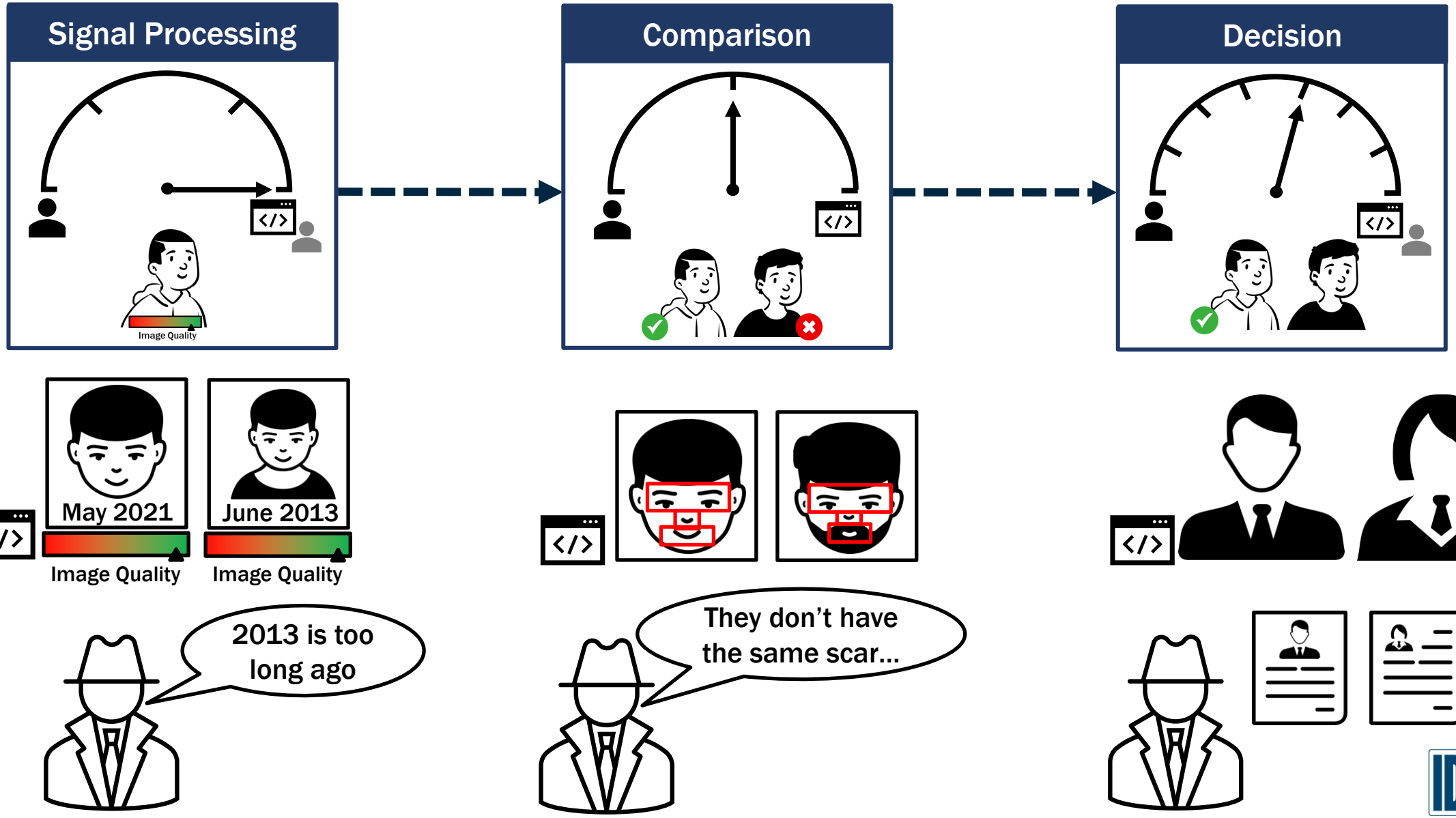
Automation Level Based on Broader Impact Criteria

Information Acquisition | ***Information Analysis*** | ***Decision Selection***

Airport Security: Verification



Forensic Examiner: Identification

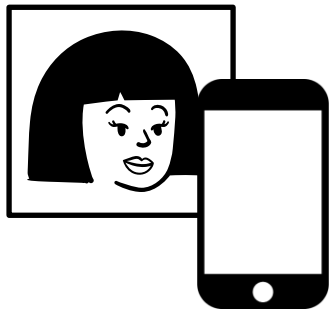


Conclusions

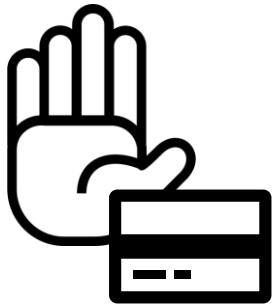
- Use of biometric systems has continued to become more common

Biometric Borders
2003

Investigations
2006



Face ID
2017



Palm Payment
2020

- Implementation of algorithms can be extremely helpful, but can also be misused leading to negative outcomes
  - The negative outcomes can be minimized by applying the proposed framework

Application of Proposed Framework

HAT CARD

System Name _____

Image Acquisition

1☐	2☐	3☐	4☐	☐
Not automated Human completes image acquisition	**Semi automated** Algorithm identifies features to acquire, human completes image acquisition	**Mostly automated** Algorithm completes acquisition and human reviews	**Fully automated** Algorithm completes image acquisition	*NA*

Quality Assessment

1☐	2☐	3☐	4☐	☐
Not automated Human assesses quality and directs recapture	**Semi automated** Human reviews algorithm's quality assessment and directs recapture	**Mostly automated** Algorithm completes quality assessment, human directs recapture	**Fully automated** Algorithm completes quality assessment and directs recapture	*NA*

Biometric Comparison

1☐	2☐	3☐	☐
Not automated Human performs comparison alone	**Collaborative** Human and algorithm perform comparisons independently	**Fully automated** Algorithm performs comparison alone	*NA*

Biometric Decision

1☐	2☐	3☐	4☐	
Not automated Human makes all decisions	**Full Candidate List** Algorithms presents a complete set of candidates, human decides	**Partial Candidate List** Algorithm selects set of best candidates, human decides	**Automated Alternatives** Algorithm suggests one alternative decision	
5☐	**6**☐	**7**☐	**8**☐	☐
Full Human Review Algorithm decides, human approves each algorithmic decision	**Partial Human Review** Algorithm decides, human controls information communicated by algorithm	**Human Consults** Algorithm decides and controls information communicated to human	**Fully Automated** Algorithm makes all decisions; human adjudicates when needed	*NA*

System Impacts

Organizational

Impact 1	Mitigation 1
Impact 2	Mitigation 2
Impact 3	Mitigation 3

Societal

Impact 1	Mitigation 1
Impact 2	Mitigation 2
Impact 3	Mitigation 3

Team Performance

Biometric	
Efficiency	
Effectiveness	%
Equitability	%
Cognitive	
Workload	
Situational Awareness	
Complacency	

- Contact information: ishuggi@idslabs.org
- Other biometrics related work and publications are available at https://mdtf.org