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# A NOVEL MULTI-MODAL BIOMETRIC SYSTEM FOR HUMAN COMPUTER INTERACTION

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## ABSTRACT
*Human-Computer Interaction studies the relationship between humans and computer systems, specifically examining the user interface and the underlying processes that drive their interactions. Human-Computer Interaction is the field that focuses on creating, assessing, and executing interactive computer systems for human users, as well as studying the significant aspects associated to them. It will have a significant impact on developing future user interface software and technology by backing a wide range of essential research. This research will reshape the human-computer interaction experience, making the computer less of a distraction and more of an invisible tool that enhances the user's capabilities and enables seamless human collaboration. This study aims to research Automatic Recognition Algorithms in Human Computer Interface. The study introduced an innovative multi-modal biometric system that combines features at a neural network level, incorporating Fingerprint and Iris biometric qualities. The system demonstrates an accuracy rate of 95.20% with a False Acceptance Rate (FAR) of 0.5% and a False Rejection Rate (FRR) of 0.3%. The results suggest that the Haar wavelet coefficient demonstrates great precision and effectiveness. The multimodal biometric identification algorithm combines fingerprint and iris data using feature level fusion and neural network approach, achieving a recognition rate of 96.41% in the HCI technique.*

*Keywords: HCI; Multimodal Biometric Systems; HCI Technologies; Automatic Recognition; Fingerprint; Iris.*

## INTRODUCTION
Human-Computer Interaction (HCI) is a field that intersects computer vision, psychology, artificial intelligence, and other academic disciplines. With the integration of computers into daily objects (ubiquitous and pervasive computing), it is crucial to have good natural human-computer interaction (Gupta et al., 2023). Users often require the ability to communicate with computers in a fashion that mimics face-to-face human-human contact. Users can also communicate verbally and using body language such as posture, look, and hand motions to convey emotions, moods, attitudes, and focus (Karpov & Yusupov, 2018). The seven pillars of Human-Computer Interaction are depicted in the figure below.

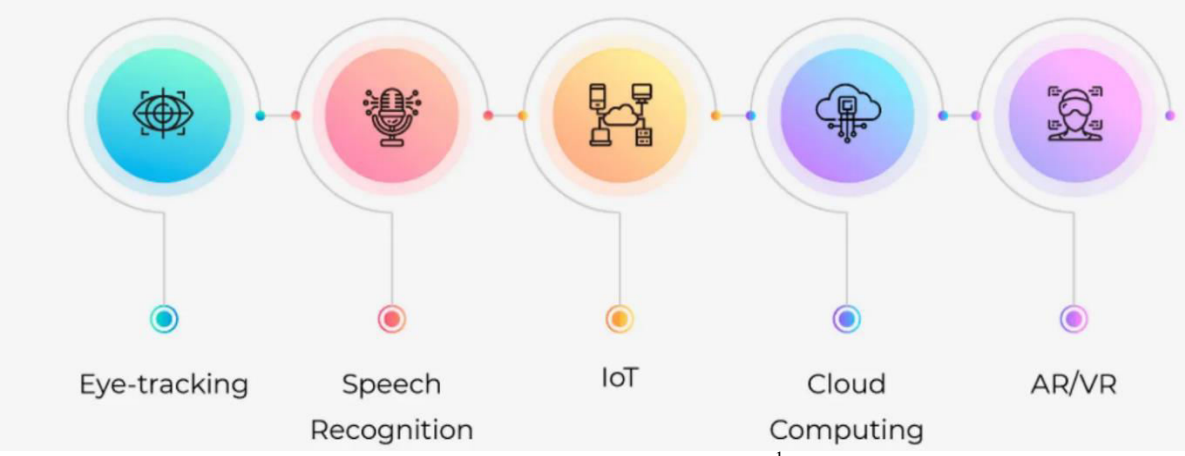


**Figure 1:** Seven Pillars of HCI [1]

[1] https://botpenguin.com/glossary/human-computer-interaction

This research presents an innovative multimodal biometric recognition system utilizing HCI that is very beneficial and well-structured. Human-Computer Interaction examines the relationships between humans and computer systems, focusing on the user interface and the processes that drive these interactions. It is a distinct science that focuses on designing, evaluating, and implementing interactive computing systems for human use, as well as studying the significant phenomena related to them. This research involves two characteristics, Fingerprint and Iris, which combine at the feature level utilizing three models. They utilize HCI technology with Fingerprint Recognition System, Iris Recognition System, and Multimodal Biometric Recognition System. A discussion of the previous literatures that are relevant to this investigation is presented in the following section.

## LITERATURE REVIEW

An overview of the previous research that has been conducted on the topic of Automatic Recognition Algorithms in Human Computer Interfaces is presented in the table that follows.

**Table 1:** Related Works

| AUTHORS AND YEAR | METHODOLOGY | FINDINGS |
|---|---|---|
| **Qi et al., (2019)** | Hand gesture recognition system uses linear discriminant analysis (LDA) and extreme learning machine (ELM) to eliminate redundant information in sEMG signals and increase recognition efficiency and accuracy. | The feature re-extraction method extracts the typical map slope (CMS) to improve cross-time recognition by strengthening feature relationships. Experimental results reduce sEMG gesture recognition time disparities. |
| **Jalal, Khalid & Kim (2020)** | The proposed methodology proposed a hybrid of four novel features—spatio-temporal, energy-based, shape-based angular and geometric, and a motion-orthogonal histogram of oriented gradient (MO-HOG); encodes hybrid feature descriptors using a codebook, a Gaussian mixture model (GMM), and fisher encoding; optimizes the encoded feature using a cross entropy optimization function; and applies a MEMM classifier. | The features extraction approach with cross entropy optimization has averaged 91.25% accuracy with SBU, 90.4% with UoL, and 87.4% with UT-Interaction datasets. |
| **Lin et al., (2022)** | The authors created a cryptographic bio-human–machine interface (CB-HMI) that seamlessly converts touch-based entries into encrypted biochemical, biophysical, and biometric indices like circulating biomarkers, heart rate, oxygen saturation, and fingerprint pattern. The CB-HMI uses thin hydrogel-coated chemical sensors and a signal interpretation framework to access/interpret biochemical indices, overcoming circulating analyse accessibility and pressing force variability. | This study showcased a vehicle-activation and medication-dispensing system with integrated CB-HMI, enabling user bio-authentication based on biological state and identity before providing services. This study utilizes the bio-perception levels of CB-HMI and other intelligent HMIs to provide a thorough understanding of persons' psychophysiological state and requirements. |

| | | |
|---|---|---|
| **Alnuaim et al., (2022)** | AI was used to recognize human speech emotions in this investigation. Data is crucial to artificial intelligence. The study employed the open-source Ryerson Audio-Visual Database of Emotional Speech and Song (RAVDESS). | Compare the suggested model's performance to similar research and evaluate the results. The suggested model classified eight emotions with 81% accuracy on the RAVDESS dataset. |
| **Ramezani et al., (2023)** | This study used coarse thickness classifications in reflected-light optical micrographs to categorize hBN crystallites with a new deep learning pipeline. This study trained DetectoRS as an object detector on 177 pictures of hexagonal boron nitride (hBN) flakes of various thicknesses. | The trained algorithm detected unusual thin flakes atomic layers thick with great accuracy. The workflow may be applied to different microscope settings and is robust to color and substrate backdrop changes, according to further investigation. |
| **Sadeghi Milani et al., (2024)** | This study systematically reviewed studies on Human–Computer Interaction strategies for medical, healthcare, and engineering teaching and learning. The focus is on HCI strategies using Extended Reality (XR) technology—Virtual, Augmented, and Mixed Reality. | Through answers to three exploratory study questions, this study validated XR-HCI as a novel paradigm that improves skills, safety, prices, and learning time. |

## RESEARCH GAP

Based on this literature study, it is evident that an ideal Automatic Recognition Algorithm for Human-Computer Interface does not already exist.

The study introduced an innovative multi-modal biometric system that combines features at a neural network level, incorporating two biometric traits: fingerprint and iris. The project focuses on examining various feature extraction and classification algorithms using multiple databases for Fingerprint and Iris modalities. The suggested fusion perspective clearly achieves enhanced strategies that rely on a single modality. This study evaluates the fusion methodology for combining iris and fingerprint biometrics without various pre-processing procedures.

## METHODOLOGY

Multimodal biometrics involves combining many sources at different levels to enhance accuracy, security, and dependability. Unimodal biometric systems sometimes struggle to accurately authenticate an individual. However, multimodality refers to the presence of many characteristics and is used to address many of the problems related to single-mode systems. The term multimodal refers to combining at least two different biometrics, such as iris and fingerprint, using separate sensors to enhance the accuracy of a biometric system by gathering data from multiple input modalities. The process of feature level fusion involves two stages: normalizing an extracted feature and selecting a feature. The feature sets are initially translated into a generic domain, and their diversity is altered using the normalization procedure. Thus, the individual's identity cannot be verified using iris patterns, causing the biometric system to halt. The system processes noisy fingerprints inaccurately, resulting in the incorrect extraction of minutiae points and hence causing false recognition of individuals. A new combination is suggested for the recognition system to address issues related to individual qualities of iris and fingerprint. The integrated systems prevent spoofing by making it challenging for a violator to spoof many biometric features simultaneously. Scores from each individual trait are aggregated accordingly.

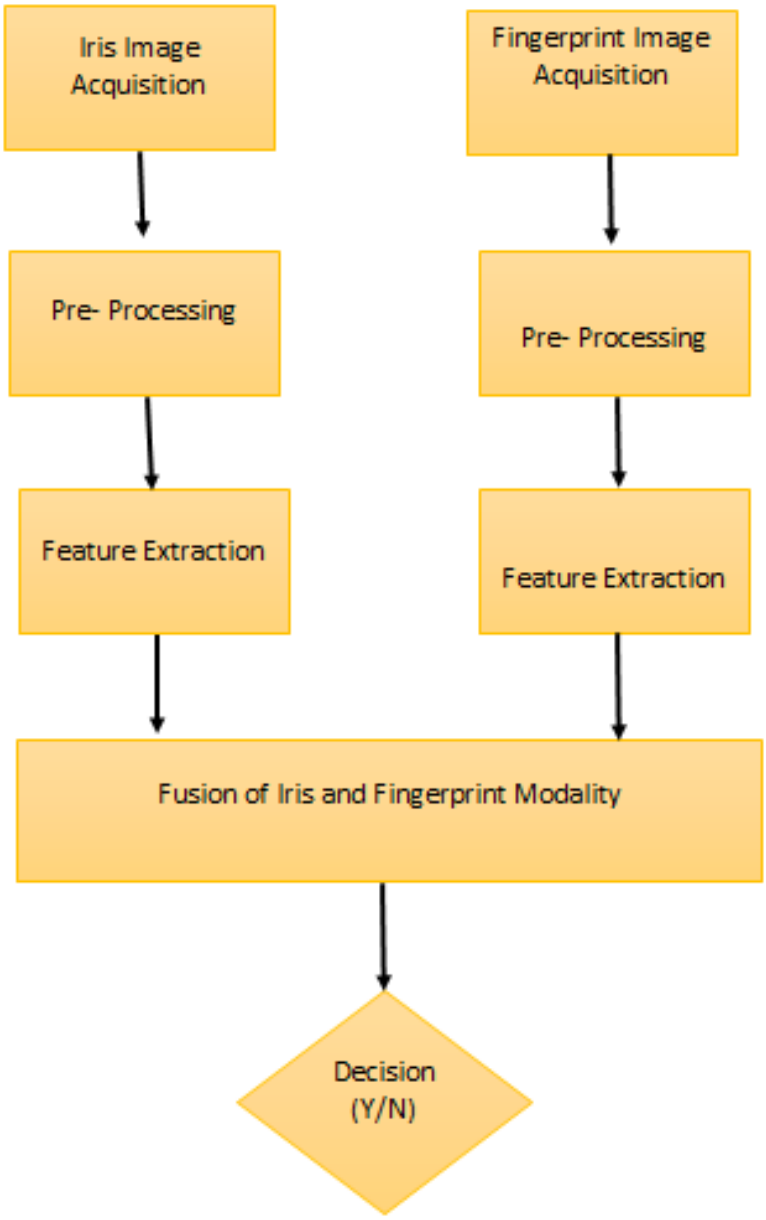


**Figure 2:** Proposed Architecture of Fingerprint and Iris modalities fusion

**RESULTS AND DISCUSSIONS**

Multimodal biometrics uses several sources at different levels to improve accuracy, security, and dependability. This is done by fusion. Unimodal biometric systems may fail to authenticate a precision-seeking user. Multimodality refers to several characteristics and is used to solve many unimodal system difficulties. A biometric system's accuracy can be developed by sequencing multiple input modalities, which is why "multimodal" refers to the combination of at least two biometrics, such as a person's iris and fingerprint, sensed by different sensors. After normalizing a retrieved feature, feature level fusion involves selecting and normalizing the feature. After translating feature sets into a generic domain, their diversity is changed. This can be done by normalizing. Because of this, iris patterns cannot be used to identify people, and the biometric system stops working. Similarly, noisy fingerprints inhibit the algorithm from retrieving minute features, resulting in inaccurate

identification. Due to fingerprint and iris differences, a new recognition system combination has been presented to address these concerns. The integrated systems prevent spoofing by preventing many biometric traits from being fooled. This enhances evaluation. All trait scores are combined for matching.

**Table 2:** Experiments are performance of comparing with existing methods on fusion level accuracy

| Trait | Algorithm | FAR (%) | FRR (%) | Accuracy |
|---|---|---|---|---|
| Fingerprint | Minutiae extraction | 1.11 | **5.01** | 94.11 |
| Iris | Haar Wavelet | 1.11 | 5.04 | 95.55 |
| Fingerprint + IRIS | Haar wavelet based Method,Block Sum Method, Mahalanobis Distance Technique | **0** | **8** | **92.01** |
| Proposed Fusion Fingerprint + IRIS | Minutiae Extraction + Haar Wavelet | 0.3 | 0.5 | 96.41 |

Graphic representation in depth is a method that can be utilized to illustrate this point.

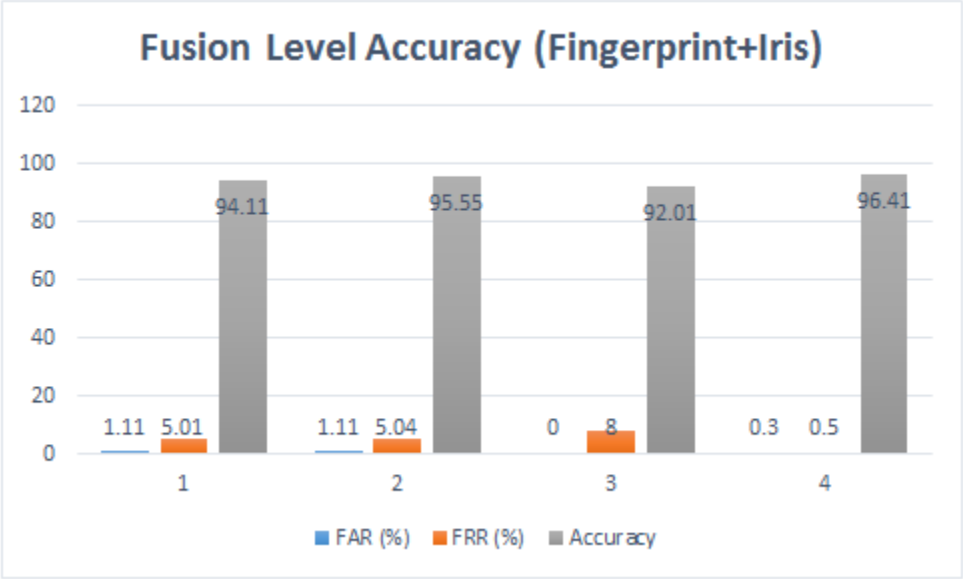


**Figure 3:** Comparison of existing methods on fusion level accuracy

## CONCLUSION

Individuals can be identified via fingerprints, which are an excellent source of information. Among the several types of biometric identification, fingerprint recognition is one of the more traditional methods. Getting a fingerprint image that is of a good quality is not always an easy task. Consequently, the fingerprint picture must be pre-processed before the matching process can begin. The intention behind the development of the system that has been offered is to provide a fingerprint picture that is improved and improved. The process of automatically matching fingerprints involves gradually extracting minute details from the binary fingerprint images that have been collected. When it comes to extracting the fingerprint details, there is a large variety of methods that can be utilized. Through the utilization of a neural network, the proposed system was able to attain a performance level of 94.10% for the fingerprint recognition system rate. In the discipline of biometrics for the purpose of human identification, iris recognition is becoming an increasingly important technique. An accuracy of 95.5 percent is achieved by the system, which also has a FAR and FRR of 1.11% and 5.04% respectively. It can be deduced from the findings that the Haar Wavelet coefficient is capable of producing high levels of precision and competency.

The identification rate of the fingerprint and iris-based multimodal biometric technique that was developed through groundwork on feature level fusion and neural network approach is 96.41%.

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