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| **Title:** | **A Biometric Voting Solution: Integrating Face Recognition with Embedded Systems for Secure Offline Elections** | | |
| **Author(s) Name:** | **Tamim Hasan Apurbo, Mahdi Hassan Noor Asif, Farhana Jarin Alam, Fahima Tajmoon Tafree, Efrath Hossion Shihab, Fatima and Sadman Shahriar Alam** | | |
| **Contact Email(s):** | sadman.alam@aiub.edu | | |
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| **Abstract:** |  |
| This research presents the development of a secure, cost-effective, and offline-capable electronic voting system, specifically designed for rural and connectivity-limited areas, integrating face recognition with embedded hardware to ensure transparency, voter authenticity, and protection against electoral fraud. The system is designed for small-scale institutional elections and serves as a scalable prototype for larger democratic processes. Built using Python and OpenCV, the face recognition module employs the Local Binary Pattern Histogram (LBPH) method for efficient and accurate voter identification. During registration, facial images are captured via a standard webcam and preprocessed using grayscale conversion, histogram equalization, and Gaussian blurring to improve robustness under varied lighting conditions. These processed images are stored locally with unique voter IDs. During the voting phase, a live facial scan is matched against the stored dataset, and upon successful authentication, the voter is granted access to vote via an embedded system powered by Arduino Uno R3. The microcontroller communicates with peripheral components such as an LCD display, buzzers, and LEDs to provide intuitive real-time feedback to users. A clear block diagram and compact hardware layout ensure the system’s portability and ease of setup, making it suitable for practical deployment and demonstration purposes. Performance evaluations yielded a face detection rate of 98.1%, recognition accuracy of 94.6%, a false acceptance rate (FAR) of 2.1%, and a false rejection rate (FRR) of 3.3%, with an average prediction time of approximately 0.3 seconds—demonstrating its reliability and real-time feasibility. The methodology merges basic image processing techniques with embedded control to deliver a simple yet powerful solution for one-person-one-vote integrity. With no dependence on continuous internet connectivity, the system is particularly effective in rural or low-resource environments. Overall, this work establishes a practical and scalable foundation for future electronic voting systems that are transparent, secure, and trusted by voters. | |