**Capstone Project Concept Note and Implementation Plan**

**Project Title: Voter Registration System: Face Recognition implementation**

**Team Members**

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**Concept Note**

**1. Project Overview**

* The proposed project centers on implementing a part of technology used in biometric voter registration system which is Facial Recognition. The project has a relationship with SDG10: Reduced Inequalities. In many countries, including Madagascar, marginalized communities often face barriers to political participation, leading to unequal representation and decision-making processes. This is due to the population not trusting the electoral system. By introducing a biometric voter registration system, the electoral process could become more transparent and secure, thereby increasing public trust.

**2. Objectives**

The main objectives of the project include:

* Reduce instances of voter fraud and duplication by implementing a secure biometric system.
* Increase voting participation rate by getting voters’ trust.

This project aims to train a model able to make facial recognition which will be part of the Voter Registration System. The model should be very efficient with high accuracy because errors in the recognition of a voter may lead to very unfortunate results such as the loss of right of a voter.

**3. Background**

* Everyone has the opportunity to choose the leaders by practicing their democratic right to vote. Therefore, the voting process is fundamental in determining everyone's destiny. The demand for online voting is growing because of the simplicity it brings, less paperwork, less time and energy, but also more secure, i.e. less prone to fraud.
* Current voter registration systems are using biometrics such as face recognition and fingerprint. In this project we aim to train a model for face recognition using Convolutional Neural Networks (CNNs) due to their high accuracy, ability to automatically learn and extract relevant features from images, robustness to variations in lighting and facial expressions, and efficiency in processing large datasets, making them ideal for ensuring reliable and scalable voter identification.

**4. Methodology**

To implement the Face recognition system, Neural Networks, specifically Convolutional Neural Networks (CNN) are widely used. CNNs are a specialized type of deep learning neural network primarily used for image classification. They can be divided into two types of layers, which are the image feature extraction layer and the classification layer.

**5.** **Architecture Design Diagram**

A diagram of a process

Description automatically generated

* Enrollment Module:

The system should register and save the picture of each voter in the database. Pictures pass by preprocessing step where all images would have the same format (dimension, scaling, …)

* Verification Module:

This is where the facial recognition phase occurs. The voter enters his voter id, and the system should take real time picture of the voter. The model then does the verification by comparing the real time picture with the picture saved in the corresponding id in the database. The model returns either the voter is recognized or not.

**6. Data Sources**

The used dataset is called DigiFace-1M dataset which is a collection of over one million diverse synthetic face images for face recognition. It was introduced in the paper DigiFace-1M: 1 million Digital Face Images for Face Recognition and can be used to train deep learning models for facial recognition. The dataset contains 720K images with 10K identities (72 images per identity).

As preprocessing, we copied to our working directory only 500 identities to reduce processing time.

**7. Literature Review**

Existing literature on biometric voter registration systems since 2018 reveals a variety of approaches and outcomes across different contexts. Najam et al. (2018) propose a hybrid biometric electronic voting system integrating fingerprint and facial recognition to enhance accuracy in countries like Pakistan, Nepal, and Sri Lanka, emphasizing future security enhancements. Agarwal et al. (2020) focus on a fingerprint-based system in India, demonstrating effectiveness in preventing fraud and ensuring fair elections. Komatineni and Lingala (2020) advocate for a secure electronic voting system combining facial recognition and biometric authentication to address historical challenges of malpractice. Afolabi (2020) discusses the benefits and limitations of biometric technology in Nigeria and Zimbabwe, noting improvements in voter registers despite technical challenges.

**Implementation Plan**

1. **Technology Stack**

* List the technologies and tools you plan to use for the implementation of your project.
  + Including programming languages
  + Libraries
  + Frameworks
  + Any other software or hardware components.

**2. Timeline**

* Provide a detailed timeline for the different stages of your project,
  + Data collection and preprocessing
  + Model development
  + Training, and evaluation
  + Deployment
* Break down the timeline into manageable tasks with corresponding deadlines. You can use Gantt chart.
* If you have pair you should add **task distribution matrix** to clarify each members responsibility.

**3. Milestones**

Key milestones specifically for the machine learning (facial recognition) part of our project include:

* **Dataset Collection**: Acquiring a diverse and representative dataset of facial images suitable for voter identification.
* **Data Preprocessing**: Cleaning, annotating, and preprocessing the facial images to enhance quality and standardization for machine learning model training.
* **Algorithm Selection**: Choosing and implementing suitable facial recognition algorithms, considering factors like accuracy, speed, and scalability.
* **Model Training**: Training the facial recognition model on the prepared dataset to achieve high accuracy in identifying voters.
* **Performance Benchmarking**: Evaluating the trained model's performance metrics such as accuracy, precision, recall, and F1-score.
* **Integration with System**: Integrating the facial recognition module into the broader biometric voter registration system architecture.
* **Testing and Validation**: Conducting rigorous testing and validation of the facial recognition module in simulated and real-world electoral environments.
* **Optimization**: Iteratively optimizing the facial recognition model based on testing results and user feedback to improve accuracy and efficiency.

**4. Challenges and Mitigations**

Anticipating challenges in our project, we will focus on:

* **Data Quality**: Implementing rigorous data collection protocols, calibration, and validation processes.
* **Model Performance**: Using advanced algorithms, continuous training, and real-world testing to optimize accuracy.
* **Technical Constraints**: Conducting feasibility assessments, ensuring compatibility, and maintaining contingency plans for smooth deployment.

These strategies aim to enhance the reliability and effectiveness of our biometric voter registration system, ensuring fair and transparent electoral processes.

**5. Ethical Considerations**

Our project on implementing biometric voter registration systems must carefully navigate several ethical considerations. Data privacy is paramount, requiring stringent measures to protect voter information from unauthorized access or misuse. Bias in biometric systems, such as facial recognition, poses risks of disenfranchisement if not properly mitigated, particularly affecting marginalized communities. Additionally, the potential impact on the target community should be considered, ensuring that the implementation respects cultural sensitivities and local norms. Transparency in how data is collected, stored, and used is crucial to maintaining trust and safeguarding democratic principles, thereby promoting fair and equitable electoral processes.

**6. References**

Mohd, F., Satar, S., Mohamed, M., & Hamid, N. (2023). A Secure Online Voting System Using Face Recognition Technology. *Malaysian Journal ofComputing and Applied Mathematics*, 1-19.

Gwangbin, B., Martin, d., & Tadas, B. (2022). *DigiFace-1M: 1Million Digital FAce Images for Face Recognition.* Microsoft.