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A web application for reporting and identification of missing persons in Kenya

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Submitted in partial fulfilment of the requirements of the Degree of Master of Science in Information Technology at Strathmore University

Faculty of Information Technology

Strathmore University

Nairobi, Kenya

March 2024

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Approval

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Date: 30/03/2034

Abstract

In Kenya, the escalating number of missing individuals, including both children and adults, has become a pressing issue. The existing methods for reporting missing persons are often inefficient, relying heavily on manual processes that consume significant time and resources. This research endeavours to tackle this challenge by developing a web-based system designed to manage cases of missing individuals. Central to this system is the integration of a facial recognition module, allowing for the comparison of facial features against a centralized database of missing persons. This integration aims to enhance the efficiency and accuracy of the search process. Authorized personnel are granted access to update and maintain the missing persons database within the system, further streamlining the search process. Additionally, the system incorporates Google Maps functionality, enabling users to pinpoint the precise location of a disappearance or where an individual was found. To ensure unbiasedness and effectiveness, the system underwent rigorous testing and evaluation using a diverse range of facial images. This evaluation aimed to verify its performance across various facial types while guarding against biases or discriminatory outcomes. By offering an efficient and precise mechanism for reporting and searching for missing persons, this research strives to enhance the efficacy of reuniting individuals with their families, thereby addressing the critical need for improved missing persons management in Kenya.

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List of Abbreviations/Acronyms

ANN - Artificial Neural Network

CCTV – Closed Circuit Television

CID – Criminal Investigation Department

CNN - Convolutional Neural Network

CPIMS - Child Protection Information Management System

CWSK - Child Welfare Society of Kenya

DNA - Deoxyribonucleic acid

ERD - Entity Relationship Diagram

ICMEC - International Centre for Missing and Exploited Children

MCK – Missing Child Kenya

MySQL – My Structured Query Language

NamUS - National Missing and Unidentified Persons System

NCIC - National Crime Information Centre

NCMEC - National Center for Missing & Exploited Children

KNN - K-Nearest Neighbour

OB - Occurrence Book

ORM - Object-Relational Mapping

SVM - Support Vector Machine

Definition of Terms

Facial Recognition: A biometric technology that identifies and matches human faces from images or videos to a database of faces (Kortli et. al , 2020).

Missing Persons: Individuals whose whereabouts cannot be established, often due to various reasons such as abduction, dementia, accidents, human trafficking, or intentional disappearance (ICMP,n.d).

Chapter 1: Introduction

1.1 Background

Numerous countries worldwide grapple with incidents of missing persons daily, stemming from various causes such as kidnapping, human trafficking, dementia, homicide, and enforced disappearance (CPIMS, 2022). Some individuals may vanish willingly for their own safety, further complicating the issue. Statistics from the Child Protection Information Management System (CPIMS) indicate that between January 1, 2022, and May 1, 2022, Kenya reported 6,374 cases of missing children (CPIMS, 2022). Over the period from July 2016 to November 2021, Missing Child Kenya documented significant efforts, including reuniting 794 children with their families, placing 109 children in government homes for safekeeping, recording 25 child fatalities, and noting 258 children still missing (MCK, 2020). While data on adult disappearances are often lacking, cases related to enforced disappearances are better documented. Missing Voices (2022) reported 152 cases of enforced disappearances, with monthly distribution illustrated in Figure 1.1.

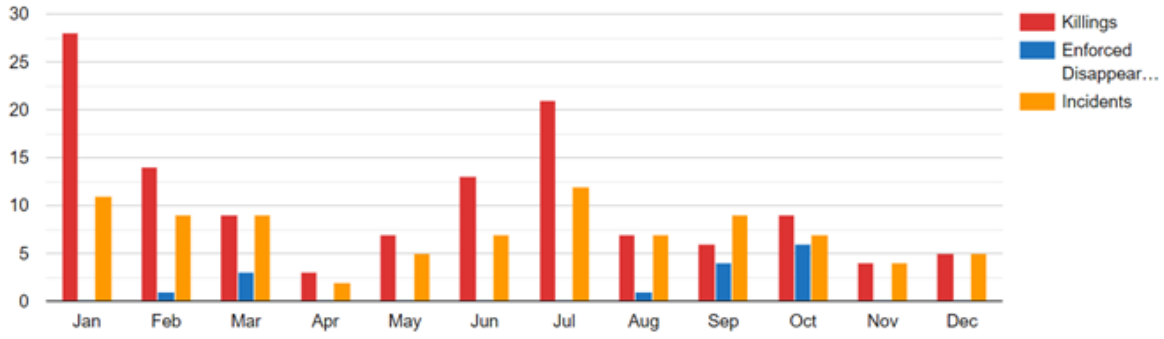

Figure 1. 1: Enforced Disappearances in Kenya in 2022 (from Nation, 2022)

As of now, Kenya has yet to implement a centralized system for managing missing person cases. Various private entities and government agencies, such as the Child Welfare Society of Kenya (CWSK) and the National Emergency Response, Welfare, and Rescue Organization for Children (PSCU, 2014), have established their own systems. For instance, CWSK serves as both a National Adoption Society for Kenya and a resource for missing children, maintaining a database on their website for

missing and found children. This platform allows for the upload of photos and additional details of missing children. Additionally, organizations like Missing Child Kenya play a significant role in addressing missing children cases by utilizing social media platforms to disseminate information and facilitate the reunification of missing children with their families.

1.2 Problem Statement

The critical initial hours following a person's disappearance are crucial for locating the individual. However, in Kenya, the filing of a missing person case with the police is only permissible after a 24-hour period has elapsed (Nation, 2020). Once a person is reported missing, a formal report is lodged at the local police station, where comprehensive details are documented and recorded in the Occurrence Book (OB), assigning it a unique OB number for reference. Subsequently, the case is transferred to a police station equipped with investigators from the Crime Investigation Department (CID). The individual who filed the report is advised to await the outcome of the investigation and may need to make periodic visits to the investigating office for updates. The search process may extend over days or even months before the missing person is located, with unfortunate instances where the individual remains untraceable.

Despite the evident necessity, Kenya lacks a centralized national database for missing persons, as highlighted by the International Centre for Missing and Exploited Children (ICMEC) (ICME, 2018). The annual crime report released by the National Police Service includes statistical data on abduction cases but does not specifically address missing persons. Instead, individual police stations maintain registers of reports filed with them (Nation, 2020). This fragmentation of data complicates collaboration among different agencies or police departments and hinders the provision of comprehensive updates to the families of missing persons (Omweri, 2015). This situation underscores the urgent need for an integrated system that can be utilized by Kenyan law enforcement and relevant government agencies to efficiently record and update reports of missing persons.

1.3 Research Objectives

The main objective of this research is to develop an integrated system for reporting missing person cases in Kenya. The following are the specific objectives:

i. To review the challenges of the existing systems used for reporting missing persons in Kenya.
ii. To review the existing studies relating to missing persons reporting systems.
iii. To review the different facial recognition algorithms and models.
iv. To develop a web application for reporting missing persons.
v. To test the developed system

1.4 Research Questions

i. What are the challenges of the existing systems used for reporting missing persons in Kenya?
ii. What are the existing studies around missing person reporting systems?
iii. What are the facial recognition algorithms and models that can be incorporated in developing a facial recognition module in a system for reporting missing persons in Kenya?
iv. How can the system for reporting missing persons in Kenya be developed while integrating a facial recognition module?
v. How can the developed system be tested?

1.5 Assumptions

The following assumptions will be made by the researcher:

i. The respondents will fully understand the questions they will be asked.
ii. The respondents will provide honest expressions of their knowledge.

1.6 Scope and Limitations

The research centres around the development of a web system for reporting and identifying missing and found persons. The system will allow entry of information of the missing persons for reporting purposes. The database of found persons allows to be searched to find a match of a missing person. Facial recognition has been integrated

to matching the missing person's face against the database of found people's faces. This research employs the use of web solutions as well as image processing based on the image inputs versus existing image database.

1.7 Justification

There have been numerous cases of reports of missing persons in Kenya (CPIMS,2022). The Kenya Police department is yet to put in place a central system for reporting and identification of missing persons. This has led to long lead times in processing of data and finding the missing persons. Information sharing by different police departments is a challenge due to isolation of databases. Having a centralized system will provide visibility of information across the country and faster handling of cases.

Therefore, this research will gear towards providing the solution through a web-based application integrated with image processing module to identify missing persons based on image inputs of found persons.

VT OMNES VNVM SINT

Chapter 2: Literature Review

2.1 Introduction

People going missing is a worldwide issue that affects communities and families at large. The phenomenon of individuals disappearing without a trace is not limited to any specific region or country and occurs in both developed and developing nations. A missing person can be described as anyone whose whereabouts cannot be established. Adult's and children's disappearances are due to several reasons including abduction, dementia, accidents, human-trafficking, intentional disappearance from one's abode for safety among other reasons (NCIC, 2021). This chapter will present the literature review around existing systems that are used to handle missing cases reports in Kenya and around the world. It will also discuss various facial recognition algorithms and models. Finally, it will present the conceptual framework of the proposed system.

2.2 Empirical Literature

A Missing person can be defined as an individual who has disappeared and his/her whereabouts is unknown. The problem of missing persons affects families, communities, and society, and it is a source of concern for many people.

Empirical literature on missing persons has revealed that the reasons why people go missing are complex and multifaceted. According to a study by the National Institute of Justice (NIJ), most missing persons in the United States are children, and the most common reason for their disappearance is a run-away or a parental abduction (NIJ, 2022). However, other factors such as mental illness, substance abuse, and criminal activity also play a role in missing persons cases. The literature also suggests that the impact of a missing person on their family and community can be profound and long-lasting.

A study by the European Council found that the disappearance of a child can have a traumatic effect on their family and can result in long-term psychological and social problems (Citroni, 2016). Moreover, the absence of a missing person can also have a

significant impact on their community, as it can lead to a loss of trust and a decline in social cohesion.

To address the problem of missing persons, law enforcement agencies and civil society organizations have developed various programs and initiatives. In Kenya, various private entities and government agencies have established systems, such as the Child Welfare Society of Kenya (CWSK), serving as the country's National Adoption Society, and the National Emergency Response, Welfare, and Rescue Organization for Children (PSCU, 2014). The organization maintains a database for missing and found children on its website. The website includes features allowing users to upload photos of missing children along with additional details. The Missing Child Kenya (MCK) is a private organization dedicated to locating and reuniting missing children with their families. MCK's objective is to enhance search efforts by swiftly sharing photo posters and alerts with a wide audience. The organization operates a website featuring a comprehensive database of missing children nationwide, along with modules for reporting missing children and cases of lost and found children.

Internationally, various systems are in place for reporting and updating information on missing individuals. The International Commission on Missing Persons (ICMP) is an autonomous global entity focused on facilitating government cooperation and locating missing persons resulting from conflict, human rights violations, disasters, organized crime, irregular migration, and other circumstances. The ICMP also aids in establishing institutional and legal frameworks to address missing persons issues, offering technical assistance and supporting related organizations. Its key activities include DNA-based identification, database development, outreach and support, and policy formulation.

The National Center for Missing & Exploited Children (NCMEC) provides an online reporting system called the CyberTipline, enabling individuals to report cases of missing children or suspected child sexual exploitation. This system, available on the NCMEC website, serves as a reporting mechanism for child sexual exploitation crimes, including child pornography, online enticement, and child sex trafficking. The CyberTipline operates 24/7, allowing anonymous reporting by the public and

electronic service providers. Reports submitted through the CyberTipline are reviewed by NCMEC and forwarded to the appropriate law enforcement agencies for investigation.

The National Missing and Unidentified Persons System (NamUS) is a program administered by the United States Department of Justice's Office of Justice Programs. NamUS serves as a centralized repository and resource center for records of missing persons and unidentified decedents nationwide. It assists law enforcement, medical examiners, coroners, and families in identifying deceased individuals whose identities are unknown.

2.3 Theoretical Literature

Facial recognition is a technology utilized for identifying and matching human faces against a database of faces (Kortli et al., 2020). Over the years, various models and frameworks for facial recognition have been developed, with ongoing research in this field as technology advances. This section explores some of these models and frameworks.

Numerous studies have explored the use of facial detection for identifying missing persons. Vinavatani et al. (2022) proposed a system leveraging CCTV cameras, face photos, and other capturing devices to locate missing individuals. When a person is potentially sighted, their information is input into the system, enabling quick comparison with images in the database. Monyambo (2018) utilized an algorithm to create a prototype system for finding missing persons using facial recognition, aiming to assess the system's accuracy and recognition rate.

Several worldwide solutions have been proposed and implemented for reporting and tracking missing individuals. Kumar et al. (2020) introduced a methodology employing a KNN classifier to identify missing persons from their photos. When an individual goes missing, a report is generated with photos and pertinent information such as name, age, and complexion. The KNN Classifier is then trained using registered cases, and the prediction algorithm is applied to each photo. If a match is found, it is reported.

Furthermore, Kumar et al. (2020) developed a deep learning CNN prediction model utilizing the FGNET public dataset for missing children. After training the model, the uploaded child's image is compared to determine its presence in the database. The SVM Multiclass classifier is employed to extract images based on age and other attributes, and the identified face is then input into the CNN model for verification.

2.4 Models and Frameworks for Facial Recognition

2.4.1 Eigenface

Eigenface is a foundational and straightforward method for facial recognition introduced in the 1990s. It relies on principal component analysis (PCA) to extract the most significant features of a facial image and condense them into a concise mathematical model (Turk & Pentland, 1991). The process involves transforming a facial image into numerical values and constructing a mathematical representation. Subsequently, the algorithm compares the new facial image with this mathematical model and generates a match score. While Eigenface boasts a simple implementation and computational efficiency, it lacks robustness against changes in lighting, facial expressions, and pose variations. The algorithm comprises five steps: face pre-processing, feature extraction, face representation, and face recognition.

In the face pre-processing stage, the facial image is normalized and aligned to ensure uniform positioning of the eyes, nose, and mouth across all images. This alignment eliminates variations in scale, orientation, and lighting. During feature extraction, the normalized facial image undergoes transformation into numerical values representing facial features. PCA is employed for this transformation, identifying eigenvectors that capture significant variations in facial images. These eigenvectors, termed eigenfaces, lend the algorithm its name.

In the face representation phase, the eigenfaces are utilized to depict the facial image as a linear combination of these eigenvectors. The coefficients from this linear combination constitute a feature vector, serving as a compact representation of the facial image. Lastly, in the face recognition step, the feature vector of a new facial image is compared against those stored in the database to identify the best match. This

comparison utilizes a distance metric, such as the Euclidean distance, to gauge the similarity between feature vectors. The algorithm then identifies the closest match in the database as the recognized face.

2.4.2 Fisherface

Fisherface represents an advancement over Eigenface, aiming to overcome its shortcomings. Developed by Belhumeur, Hespanha, and Kriegman (1997), Fisherface employs linear discriminant analysis (LDA) to construct a mathematical model that accounts for both spatial and intensity alterations in facial images. Compared to Eigenface, Fisherface exhibits greater resilience to changes in lighting and pose, although it still encounters challenges with variations in facial expressions.

The Fisherface algorithm emphasizes the ratio between the variability of one individual and that of another. It strives to maximize the determinant of the between-class scatter matrix while simultaneously minimizing the determinant of the within-class scatter matrix. This approach enhances the algorithm's ability to discriminate between different individuals and improves its performance in facial recognition tasks.

2.4.3 Local Binary Pattern (LBP)

Ojala, Pietikainen, and Maenpaa (2002) introduced Local Binary Patterns (LBP) as a texture-based technique for facial recognition. This method involves partitioning an image into small regions and extracting local features from each region. These features are subsequently compared with a database of templates to identify the closest match. LBP exhibits robustness against variations in lighting conditions and demonstrates computational efficiency. However, it may struggle to effectively recognize faces with diverse expressions or poses, limiting its overall effectiveness in certain scenarios.

2.4.4 DeepFace

DeepFace, introduced by Facebook in 2014, represents a deep learning-powered facial recognition system. Developed by Taigman et al. (2014), it leverages a multi-layer neural network trained on an extensive dataset of human faces. The primary goal of DeepFace is to accurately identify and verify individuals based on their facial

characteristics. Notably, the system demonstrates the capability to recognize faces across varying lighting conditions, poses, and facial expressions.

The architecture of DeepFace relies on convolutional neural networks (ConvNets) and was meticulously trained using a large, annotated dataset of faces. This comprehensive training regimen enables DeepFace to achieve state-of-the-art performance in facial recognition tasks, marking a significant advancement in the field of computer vision. Since its introduction, DeepFace has served as a cornerstone for further research and development in deep learning-based facial recognition technologies.

2.4.5 Facenet

Facenet, developed by Google researchers in 2015 as outlined by Schroff, Kalenichenko, and Philbin (2015), is a deep learning-driven facial recognition system. It employs a Siamese neural network architecture to acquire a condensed representation of facial images and execute facial recognition tasks. Facenet utilizes a triplet loss function to train the network, aiming to minimize the distance between similar faces within the learned feature space. This approach facilitates the system in effectively distinguishing between different individuals based on their facial characteristics.

2.4.6 VGGFace

VGGFace is a convolutional neural network architecture tailored for face recognition tasks. Developed by researchers at the Visual Geometry Group, University of Oxford, it was introduced in a paper published in 2014. VGGFace derives its structure from the VGG (Visual Geometry Group) architecture, originally designed for the ImageNet Large Scale Visual Recognition Challenge (ILSVRC). The initial VGG network comprised 16 layers of convolutional neural networks trained on a vast dataset of over 1.2 million images from the ImageNet dataset.

The VGGFace architecture modifies the original VGG network to be specifically optimized for face recognition, as detailed by Parkhi, Vedaldi, and Zisserman (2015). It consists of a sequence of convolutional and max-pooling layers followed by three

fully connected layers. The final layer of the network outputs the identity of the detected face. This specialized architecture enables VGGFace to effectively recognize faces with high accuracy and reliability.

2.4.7 Haars Cascade

Haar Cascade is a machine learning technique utilized for object detection in images or videos, introduced by Viola and Jones in 2001. This method involves training a classifier on a dataset comprising positive and negative images to recognize a specific object within an image or video frame. The classifier relies on Haar-like features, which are essentially simple rectangular filters applied to the input image. A boosting algorithm is employed to prioritize the most significant features for classification.

The distinctive characteristic of the Haar Cascade classifier lies in its cascade structure, which facilitates efficient processing by swiftly discarding image regions unlikely to contain the target object. This sequential rejection process enhances computational efficiency, making Haar Cascade suitable for real-time applications. Overall, Haar Cascade offers a rapid and effective solution for object detection tasks.

2.5 Facial Recognition Algorithms

This section explores machine learning algorithms employed in facial recognition. Machine learning, a subset of artificial intelligence, focuses on creating and refining algorithms. It entails teaching computers to learn from data by developing algorithms capable of identifying patterns within data and subsequently making predictions based on those patterns.

2.5.1 Convolutional Neural Network (CNN) algorithm

A Convolutional Neural Network (CNN), also referred to as ConvNet, represents a type of Artificial Neural Network (ANN) characterized by a deep feed-forward structure. CNNs are renowned for their superior generalization capabilities compared to networks with fully connected layers (O'Shea & Nash, 2015). They excel in learning highly abstract features from spatial data, particularly in tasks like image recognition. A deep CNN model comprises multiple layers of processing, each capable of learning different features of the input data, such as an image, at varying levels of abstraction.

In this architecture, the initial layers specialize in extracting high-level features with low abstraction, whereas deeper layers focus on learning low-level features with higher abstraction. Figure 3 illustrates the fundamental conceptual model of a CNN along with different types of layers.

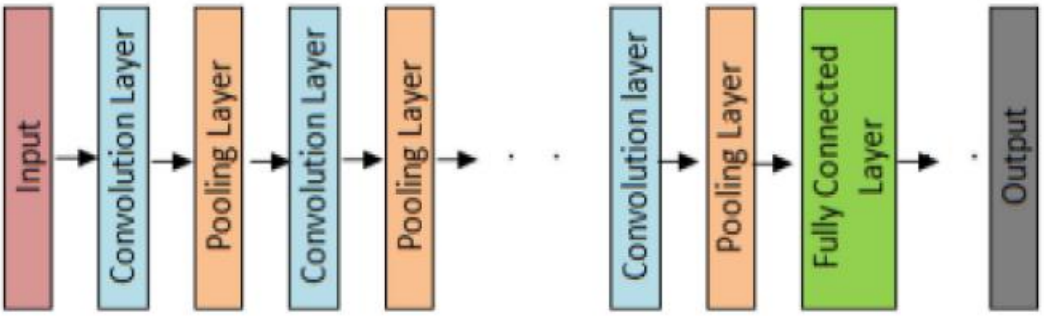

Figure 2. 1: Conceptual Model of CNN (from Sultana, Sufian & Dutta (2018)

2.5.2 Models of CNN for Image Classification

2.5.2.1 Convolution Layer

The convolutional layer serves as a pivotal element in Convolutional Neural Networks (CNNs), playing a crucial role in processing input data such as images. It operates by applying filters to different sections of an input image and aggregating them into a consolidated output known as a feature map through convolutional operations (Wu, 2017). During the training phase, these filters are learned iteratively using backpropagation, enabling the network to extract significant features from the input image. Convolutional layers play a vital role in enabling the network to efficiently process large images and comprehend spatial hierarchies of features, thereby proving indispensable for tasks like image classification and object detection. By incorporating multiple convolutional and pooling layers, deeper networks can extract progressively higher-level and more abstract features from the input image. This capability is particularly advantageous for tasks requiring complex representations. Convolutional layers have demonstrated remarkable success across various computer vision tasks, serving as a primary driving force behind the advancements in deep learning for image analysis.

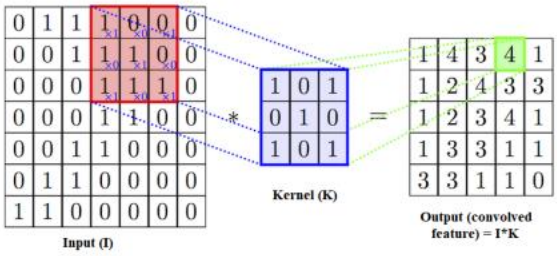

Figure 2. 2: Convolution Layer (from Wu, 2017)

Pooling involves down sampling an image by dividing it into smaller regions within the convolutional output, followed by sub-sampling to generate a single output. Various pooling techniques exist, including max pooling, mean pooling, and average pooling. Max pooling selects the largest pixel value within a region, while mean pooling computes the average pixel value, and average pooling calculates the mean of all pixel values.

Pooling serves to reduce the number of parameters required for computation while also imparting translation invariance to the network regarding shape, size, and scale. This process aids in simplifying the network's representation of the input data while retaining essential features, thereby enhancing efficiency and robustness in tasks such as image classification and object detection.

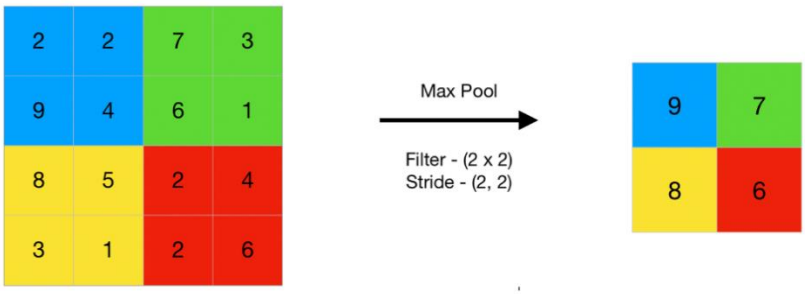

Figure 2. 3: Max Pooling (from Murray & Perronnin,2014)

2.5.2.2 Fully Connected Layer

The fully connected layer, also known as the dense layer, constitutes the final layer of a Convolutional Neural Network (CNN). In this layer, each neuron receives input from every neuron in the preceding layer and performs operations with each

individual neuron in the current layer to produce an output. This operation typically involves a weighted sum of the inputs, followed by the application of an activation function, which determines the output of the neuron. The fully connected layer is responsible for learning complex patterns and relationships in the input data, making it crucial for tasks such as classification and regression.

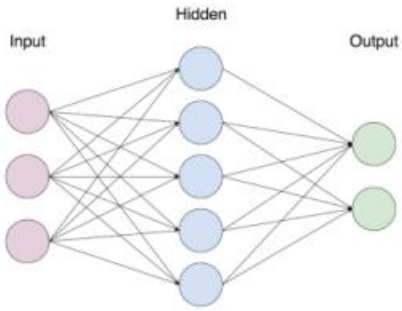

Figure 2. 4: Fully Connected Layer (from Sultana, Sufian & Dutta, (2018)

2.5.3 K-Nearest Neighbour (KNN) Algorithm

K-Nearest Neighbours (KNN) is a supervised learning algorithm utilized for classification or regression tasks. It operates by identifying the k nearest data points to a given sample and making predictions based on either the majority class (for classification) or the average value (for regression) of these neighbours. KNN is categorized as an instance-based algorithm, as it does not construct a model during training but instead utilizes the training data directly as the model itself. When presented with a new sample, KNN searches the training data for the k nearest neighbours using a distance metric such as Euclidean or Manhattan distance. It then classifies the sample based on the majority class of these neighbours or computes the average of their values for regression tasks. KNN is applicable for both binary and multi-class classification tasks, as well as regression tasks. According to the Euclidean distance formula, the distance between two points in the plane with coordinates (x, y) and (a, b) is given by:

$$Dist((x, y), (a, b)) = \sqrt{(x - a)^2 + (y - b)^2}$$

…… Equation 1

2.5.4 Support Vector Machine (SVM) Algorithm

Support Vector Machine (SVM) is a supervised machine learning algorithm utilized for classification and regression tasks. It's adept at binary classification but can handle multi-class problems too. SVM finds the optimal hyperplane to separate classes with the maximum margin, minimizing misclassifications using slack variables. It's efficient for high-dimensional data and performs well with small datasets. SVM is widely used in text classification, image classification, and bioinformatics due to its versatility and effectiveness.

2.6 Applications and Solutions for facial recognition

2.6.1 Security Law Enforcement

Facial recognition is used for enforcing security through identification suspected or wanted criminals. This in turn helps to fight and combat crime. It is also used during issuance of government identity cards whereby other biometrics like fingerprints are also captured. This technology has been employed at the borders to identity people crossing different borders. Border control facial recognition systems can be transformed into crime investigation tools, administrative and corporate identity assurance mechanisms, customer service enhancements, and the backstop to a comprehensive digital identity management capability (Israel, 2020). Even at the border itself, where the state is generally granted significant latitude to achieve its objectives, the harms of facial recognition systems are frequently underestimated while their effectiveness is inflated. Carlos-Roca, Torres & Tena (2018) presents the Face Matching Tool (FMT), a system defined to assist border guards in the process of validating the identity of a travel document holder during the crossing border process.

2.6.2 Attendance Registration

Facial recognition has been employed in the work sectors and buildings as a biometric technique to capture attendance. The technology can be integrated with an attendance system to automate the process of recording attendance in real-time (Essien& Ansa (2023). The system typically requires the person to stand in front of a camera, where their face is scanned, and then compared to the database to determine their identity. If the system recognizes the person, it can automatically mark them as present. This can save time compared to traditional methods of attendance taking and reduce the chance of errors.

2.6.3 Controlling access to restricted areas

Facial recognition can be used to grant or deny access to a restricted area based on permissions. This system can also be used to track and monitor who enters and exits restricted areas, providing a record of activity for security purposes. To ensure effective access control, organizations should regularly evaluate their systems, update permissions, and train employees on proper procedures.

2.6.4 Health Care

Facial recognition technology is being increasingly explored for its potential use in healthcare, particularly in the areas of patient identification, disease diagnosis, and treatment monitoring. In healthcare, accurate patient identification is critical to ensuring that patients receive the right care at the right time. Facial recognition technology can be used to identify patients quickly and accurately, reducing the risk of medical errors. Facial recognition technology can assist healthcare professionals in diagnosing certain conditions by analysing facial features, such as asymmetry or skin colour, that may be indicative of a particular disease. Facial recognition technology can be used to track changes in a patient's appearance over time, allowing healthcare professionals to monitor the effectiveness of treatment and adjust as needed. Verma, Kansal & Bhatnagar (2020) proposes a system for patient identification through facial recognition. They use Haar Cascades for image processing.

2.6.5 Identification of missing persons

Face recognition CCTV systems can significantly accelerate operators' efforts to search a missing person by enabling them to add a reference photo provided by the reporter and match it with past appearances of that face captured on video. Police can use face recognition to search video sequences (video analytics) of the estimated location and time the person was declared missing. A real-time alert can trigger an alarm whenever there's a match. Police can then confirm its accuracy and do what's necessary to recover the missing person. The same process can be applied for disoriented missing adults (e.g., with dementia, amnesia, epilepsy, or Alzheimer's disease).

2.7 Geotagging

Geotagging involves affixing geographical metadata to media, thereby indicating its specific geographical location.

2.8 Conceptual Model

The current process for reporting missing persons in Kenya, is largely based on manual processes and relies heavily on the local police station. This can lead to delays in the reporting process and make it difficult for families to locate missing loved ones. The researcher found out that there is no centralized system in place to report and find missing persons in Kenya. The police stations maintain their own records of missing persons which can lead to duplication and inconsistent data (The Star,2022). The lack of a centralized database makes it difficult to search for missing persons and makes it difficult to track the progress of cases.

The existing online systems in Kenya ran by private entities solely focus on children. This results in people to use social media to circulate posts of their loved ones. The existing systems do not have proper separation of databases of the children who are reported missing and the ones who have been found. This results in inaccuracy of information. The researcher aims to develop a web-based system for reporting and searching missing persons. The system will accept user inputs of the details about the missing person. This will include data such as name, age, height, skin colour, hair colour, eye colour, where they were last seen, next of kin and most importantly their

most recent photo. The system will also generate unique case numbers. There will be a module for image processing that will compare photos of the missing persons and found persons. If a match is found, then the families are notified, and case is closed.

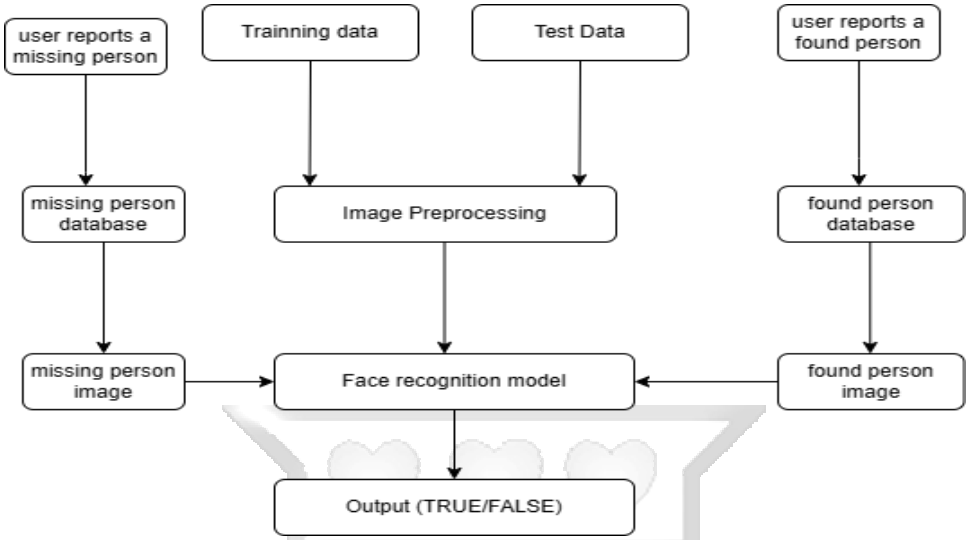

Figure 2. 5: Conceptual Model

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Chapter 3: Research Methodology

3.1 Introduction

This chapter outlines the research methodology employed to achieve the research objectives presented in Chapter 1. It takes a systematic approach to identify, collect, and analyse data related to the research topic. Additionally, it describes the rationale behind selecting the chosen methodology.

3.2 Research Design

This research aims to develop a web-based application that can be used for reporting missing person cases in Kenya. The application uses image-based data input that will be used to compare faces with a database of faces. The design adopted for this study is of experimental approach because several test will be carried out to ascertain the accuracy of the system.

3.2.1 Design, development, and testing of the system.

The research objective 3 and 4 is met through the design and development of a system for reporting and searching missing persons following the waterfall methodology. The Waterfall methodology is a linear sequential model that follows a rigid set of steps to complete a project. It is a popular choice for software development projects, as it is well-structured and easy to understand. The Waterfall methodology is composed of several phases, including the requirement analysis, design, implementation, testing, and maintenance phase.

3.2.1.1 Requirement analysis

The requirement analysis phase is the first step in the Waterfall methodology, and it involves gathering and analysing the requirements of the project. This phase is crucial for the success of the project, as it sets the foundation for the rest of the project. The researcher gathered system requirements from the potential end users to ensure usability of the system. This was done through questionnaires.

3.2.1.2 Design phase

The design phase involves designing the architecture of the web application and the facial recognition system. This phase is crucial for ensuring that the web application is easy to use, and that the facial recognition system is accurate and efficient. Data Flow Diagrams were used to explain the flow of information from one component of a system to another component.

Flowcharts were used to show the flow of the system and how the different components of the web application and facial recognition system interact with each other. They are used to visualize the logic and functionality of the system and to identify potential issues and bottlenecks.

Entity Relationship Diagram (ERD) were also be used to model the data and the relationships between the data in the designed system. This helps to ensure that the data is properly organized and that the relationships between the data are clear. It will ensure understanding of the requirements, visualizing the data structure and to identify the relationships between data entities before the actual implementation of the system.

3.2.1.3 Implementation phase

The implementation phase is the third step in the Waterfall methodology, and it involves coding and testing the web application and the facial recognition system. This phase is crucial for ensuring that the web application is functional, and that the facial recognition system is accurate and efficient. This involved coding and testing the web application and the facial recognition system. During this phase, the web application was built using python and frameworks and the facial recognition system will be integrated using OpenCV and Dlib Python libraries. The database was implemented using SQLite will be connected to the web application using Object-Relational Mapping (ORM) libraries.

3.2.1.4 Testing phase

The testing phase involves testing the web application and the facial recognition system to ensure that they meet the requirements set out in the requirement analysis

phase. This phase is crucial for ensuring that the web application is reliable, and that the facial recognition system is accurate and efficient. The web application was thoroughly tested to ensure its functionality, reliability, and usability. This involved a combination of manual and automated testing to validate the application's performance and security.

3.2.1.5 Maintenance phase

The maintenance phase is the final step in the Waterfall methodology, and it involves maintaining and updating the web application and the facial recognition system. This phase is crucial for ensuring that the web application is always up-to-date, and that the facial recognition system is accurate and efficient. The developed system will go through maintenance to ensure it works properly.

3.3 Data collection methods

The study used literature reviews and questionnaires to collect relevant data. Review of relevant literature was conducted to gather information about the existing systems used for reporting missing persons in Kenya and the challenges faced by these systems.

3.4 Population

The population represents the entire group of individuals or objects that you want to study and make inferences about. The researcher targeted the Criminal Investigation Department (CID) and police officers to collect data relating to filing of missing person reports. As of 31st December 2021, the total number of Police officers stood at 101,421 (The National Police Service, 2022). The researcher targeted a population of 50 CID and police officers from one CID office and one police station. These people were targeted as they deal with issues relating to missing people reports. Research population also comprised of facial image data collected for the training and testing of the system.

3.5 Sampling

Sampling is the process of selecting a portion of the population to represent the entire population in the study (Maxfield & Barbie, 2017). Simple random sampling was done to identify the sample of officers that would fill out the questionnaires. The following formulae was used:

$$n=N/(1+N(e^2)) \text{ ……. Equation 2}$$

Where N is the population size (50), and e (0.05) is the margin of error or desired level of precision.

$$\text{Sample} = n=50/(1+50(0.05^2))$$

$$= 50/1.125$$

$$= 45$$

Therefore, a sample of 45 officers took take part in this study.

In terms of handling image datasets, the sampling technique that will be used is experimental sampling, where controlled experiments are conducted to create, train, and validate the facial recognition model. The dataset was divided into training and testing subsets, ensuring that the model's performance is assessed with real-world-like facial images.

3.6 Model Development and Training

3.6.1 Sourcing Data

The process begins with data acquisition, where facial image datasets are sourced. These datasets contain a wide array of facial images, including diverse individuals and variations in facial expressions. The richness and diversity of the data are essential for training a robust facial recognition model. The researcher will source dataset of randomly from consenting individuals.

3.6.2 Data Pre-processing

Data preprocessing involves preparing the facial image data for training. This includes tasks such as resizing, cropping, and normalization to ensure consistency in image

dimensions and quality. Noise reduction techniques may also be applied to enhance the model's performance. OpenCV was used for image processing. OpenCV Library is written in C++ and supports multiple programming languages, including Python, Java making it the preferred option.

3.7 Facial Recognition Module

The core of this research involves developing a web application that will intergrate a facial recognition module. The researcher used an existing python library for facial recognition and therefore there was no need of building a model from scratch.

3.8 Data Analysis

The gathered data was subjected to a thorough analysis employing a thematic approach. This method encompasses the systematic coding of data into distinct themes and subthemes, followed by the synthesis of information to uncover prevailing patterns and emerging trends. These identified themes will play a pivotal role in shaping and informing the design and development of the web application intended for reporting missing persons.

3.9 Research quality.

Research quality relates to the extent to which research can accurately and effectively address the research question it is studying. Three key components of research quality are validity, reliability, and objectivity.

3.9.1 Validity

Validity pertains to the degree to which a study accurately assesses its intended subject matter. For the research to be deemed valid, it necessitates a well-defined research inquiry, and the methodologies employed for data collection and analysis must align effectively with addressing that inquiry. Utilizing questionnaires and interviews, appropriate techniques for data collection and modelling will be implemented to ensure accuracy in the research process.

3.9.2 Reliability

Reliability refers to the consistency of results obtained from a study. If a study is reliable, it should produce the same results if it were repeated multiple times with the same participants and under the same conditions. The researcher will ensure that system will be reliable during several tests until the desired outcomes are achieved.

3.9.3 Objectivity

Objectivity denotes the absence of partiality or prejudice in research endeavours. It holds significance in ensuring that research outcomes remain uninfluenced by the subjective beliefs or inclinations of the researcher. A research undertaking is deemed objective when its methodologies exhibit impartiality, and the conclusions drawn are unaffected by the researcher's personal convictions or predilections. This objective stance will be fostered through the utilization of extensive and diverse datasets, devoid of bias, and by subjecting the system to a varied array of inputs during testing phases.

3.10 Utilization of Results

The research findings obtained through literature reviews and interviews will play a pivotal role in shaping the system requirements for the missing persons reporting web application. Specifically, the results will be analysed to ensure that user needs are accurately captured and incorporated into the system's design and functionality. This process will involve translating the insights gained from the research into concrete software requirements and features, with a focus on enhancing the usability and effectiveness of the application.

3.11 Dissemination of Results

The research findings are presented using visual aids such as tables, graphs, and pie charts to facilitate a better understanding of the information. This visual representation enables stakeholders to grasp the key insights quickly and effectively. As Few (2012) notes, graphs and charts are powerful tools for conveying complex data in a comprehensible manner. Additionally, the completed system will be made available to different audiences for evaluation and feedback. This process involves the

release of the application to selected users, including law enforcement personnel, relevant government agencies, and potential end-users. Their feedback and recommendations will be invaluable in refining the system, ensuring that it meets their specific needs and functions optimally.

3.12 Ethical Considerations

Ethical considerations constitute a fundamental element of research methodology, necessitating meticulous attention to ensure the responsible and ethical conduct of the study. Prior to participation, the researcher diligently informed all participants about the study's nature, research objectives, and their rights as participants. Participants were afforded the autonomy to withdraw from the study at any juncture without facing repercussions. Moreover, stringent measures were enacted to fully safeguard the confidentiality and anonymity of participants' personal and sensitive information feasible. Upholding privacy standards, the researcher implemented appropriate safeguards to prevent any misuse of participant data. Additionally, any potential conflicts of interest were transparently disclosed, and the researcher abstained from engaging in practices that could jeopardize the integrity of the research endeavour.

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Chapter 4: System Analysis and Design

System analysis is the process of studying, analysing, and understanding a system or proposed system to identify its goals, processes, and requirements. The goal of system analysis is to identify problems or inefficiencies in the system and develop solutions to address them. This involves identifying the requirements for the system by interviewing stakeholders, analysing documents, and observing the existing systems. System design involves designing the system to meet the identified requirements. This may include creating diagrams and models of the system, such as use cases, data flow diagrams, and entity relationship diagrams.

4.1 System Requirements

The main objective of this research is to develop a web application that can be used to handle missing person cases in Kenya by the law enforcement units. The following are the functional and non-functional requirements.

4.1.1 Functional requirements

i. The system needs to allow a user to register an account.

ii. The system should have a database for system user's details.

iii. The system should have a database of reported missing person's details.

iv. The system should have a database of found person's details.

v. The system should allow users to upload images.

vi. The system should have a module for facial recognition.

vii. The system should allow users to query system to view report status.

viii. The system will allow users to select location from a map.

4.2 Non-functional requirements

4.2.1.1 Scalability

The web application should be able to handle a growing number of reports and users without significant performance degradation.

4.2.1.2 Maintainability

The web application should be designed with maintainability in mind to ensure that it can be updated and modified as needed.

4.2.1.3 Compatibility

The web application should be compatible with a range of web browsers and operating systems to ensure that it can be accessed by the widest possible audience.

4.2.1.4 Performance

The web application should be able to handle many users and submissions without slowing down or crashing.

4.2.1.5 Usability

The web application should be easy to use and navigate, with clear instructions and intuitive user interface elements.

4.3 System Architecture

The system architecture provides a comprehensive overview of the facial recognition system for locating missing persons, as depicted in Figure 4.1. This architecture outlines the primary components essential for the effective functioning of the system. The process begins with facial images sourced from authenticated users who either report a missing person or a found person. These images are stored in respective databases. Upon performing a search operation to locate a missing person the images from the databases undergo a thorough analysis using the facial recognition algorithm designed to identify and match key facial features which outputs true if it matches any image from the found person's database and false if there is no match.

At the core of the system lies a dynamic database containing records of both missing, found persons and users. The results of the facial matching process contribute to the identification mechanism, revealing matches between missing individuals and the stored records of found persons.

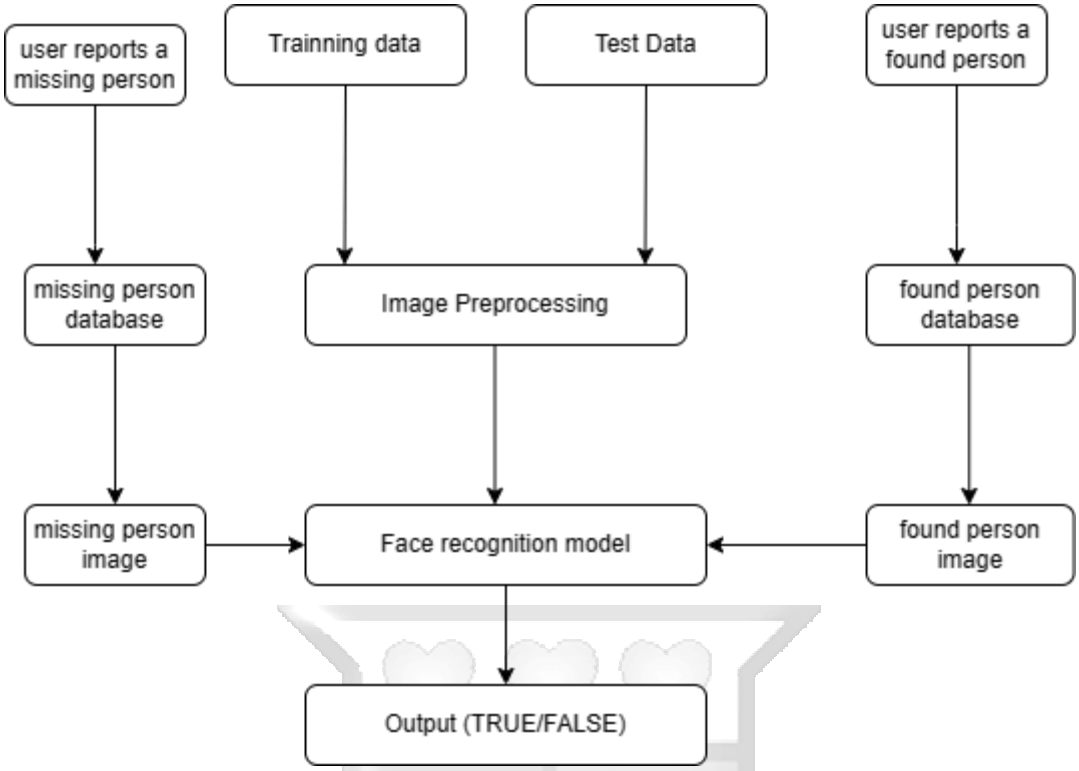


Figure 4.1: System Architecture

4.3.1 Use case diagram.

A use case identifies the actors involved in an interaction with the system and the name of the interaction. This is then supplemented by additional information describing the interaction with the system and can be implemented using UML sequence. The proposed facial recognition system revolves around three key roles. The developer is tasked with model training, testing, troubleshooting and ongoing maintenance, with the added ability to enhance the system through updates. The system administrator oversees user management and database updates, ensuring the system's smooth operation. Lastly, the observer, serving as the end-user, receives notifications and reports on potential matches and identified individuals. This structured framework, as depicted in Figure 4.2, delineates the collaborative efforts of the Developer, System Administrator, and Observer in the functionality of the Facial Recognition System for missing person.

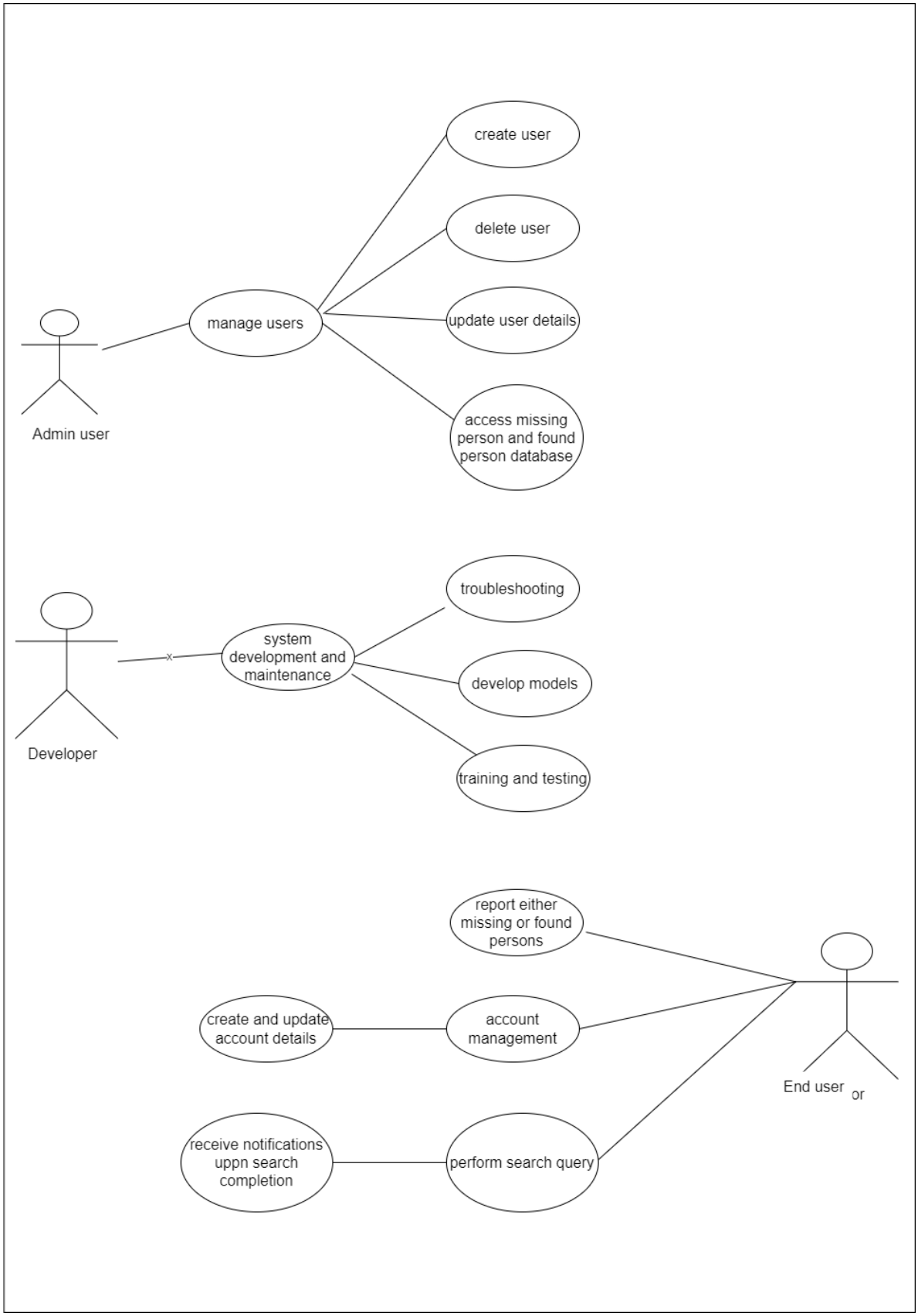


Figure 4.2 Use Case Diagram

4.3.2 Data Flow Diagram

Data flow is an illustration of representing the flow of data in a system. The Data Flow Diagram (DFD) provides information in terms of inputs and outputs of each entity in the system. The diagram of Figure 4.3 will outline how data flows in and out of the entities involved in the facial recognition system.

4.3.2.1 Context Diagram

The context diagram provides a high-level overview of how external entities interact with an internal facial recognition system. Figure 4.3 depicts the context diagram of the proposed system.

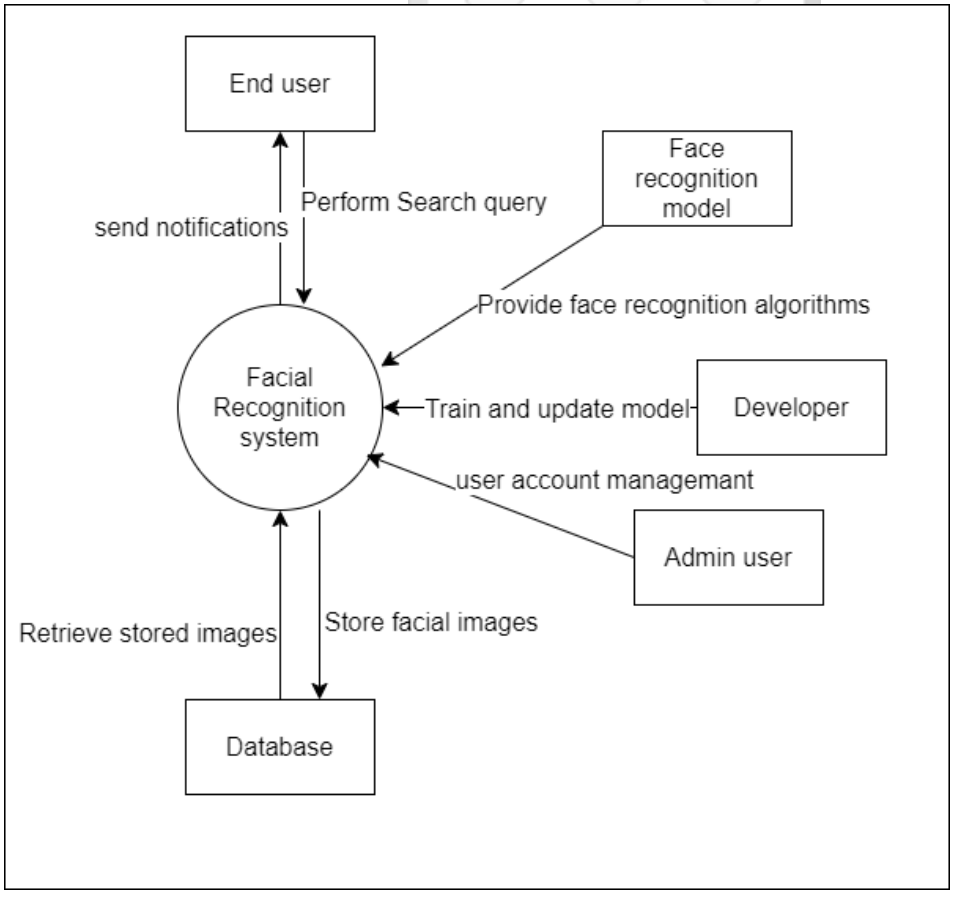


Figure 4.3: Context Diagram

4.3.3 Level 1 Diagram

Level 1 DFD breaks down the main processes into sub processes that can then be seen on a deeper level. Additionally, it includes data stores, denoted as D1, D2, and D3, which are utilized by the main process to store and retrieve data. The diagram illustrates the flow of information between these processes and data stores, offering a comprehensive understanding of the system's functional components at a higher level of detail.

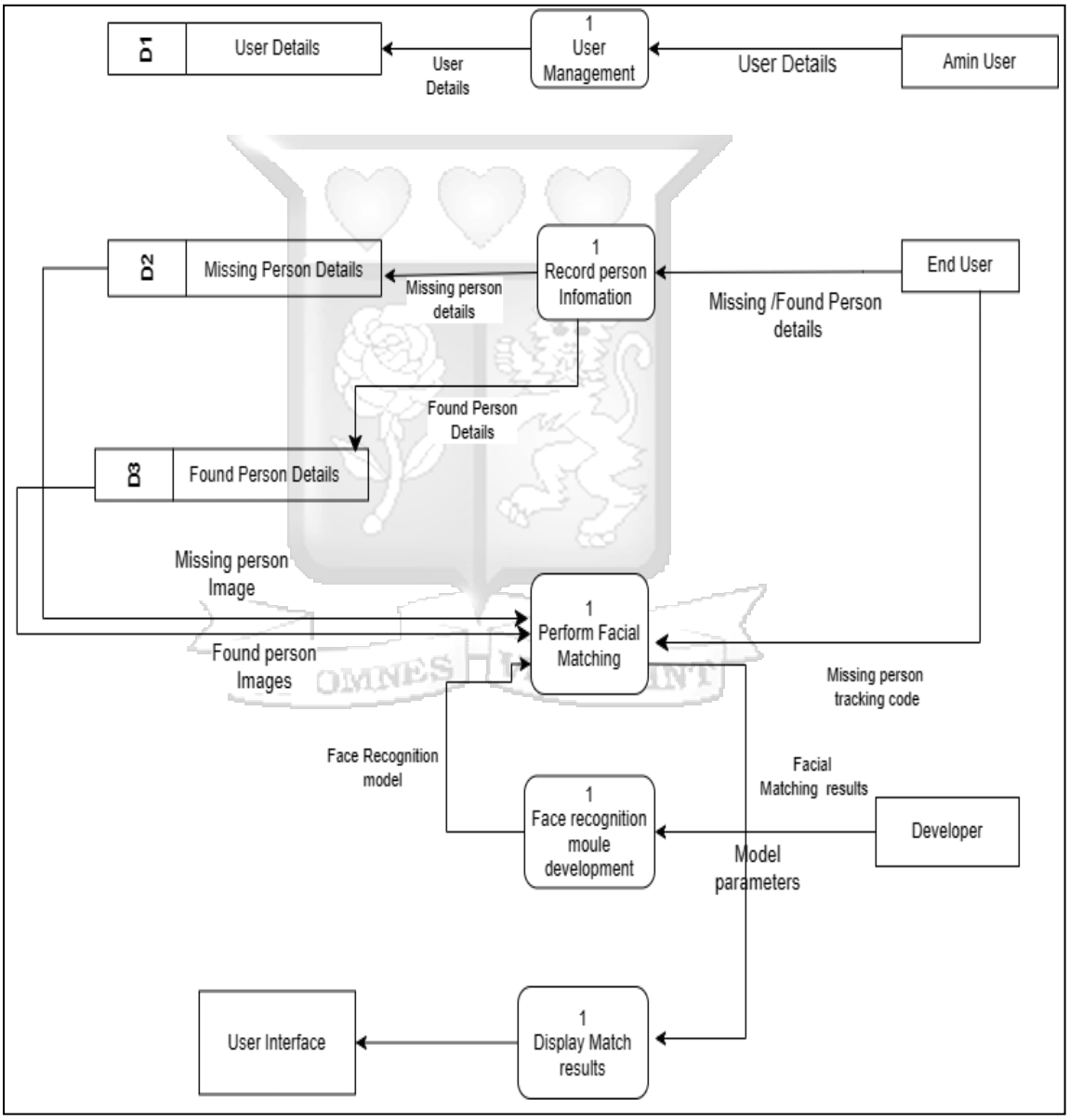


Fig 4.4: Level 1 Diagram

4.3.4 Sequence Diagram

Sequence diagrams are mostly used to model the interactions that take place within the system between actors and objects as well as between the objects themselves. It displays the flow of interactions that occur during a specific use case or use case instance. Figure below showcases the steps taken by the face recognition system to perform facial matching between a missing person and a found persons. The user is authenticated to access the system. Missing person details and found person details are obtained when a user uploads them to the system. The images are then pre-processed to conform to required specifications, after which features are extracted from the image in a process known as feature extraction. The model calculates the Euclidean distance between the images and if it is greater than the threshold it classifies them as similar. The results are then used to show retrieve the details from the database and match results shown on the web user interface.

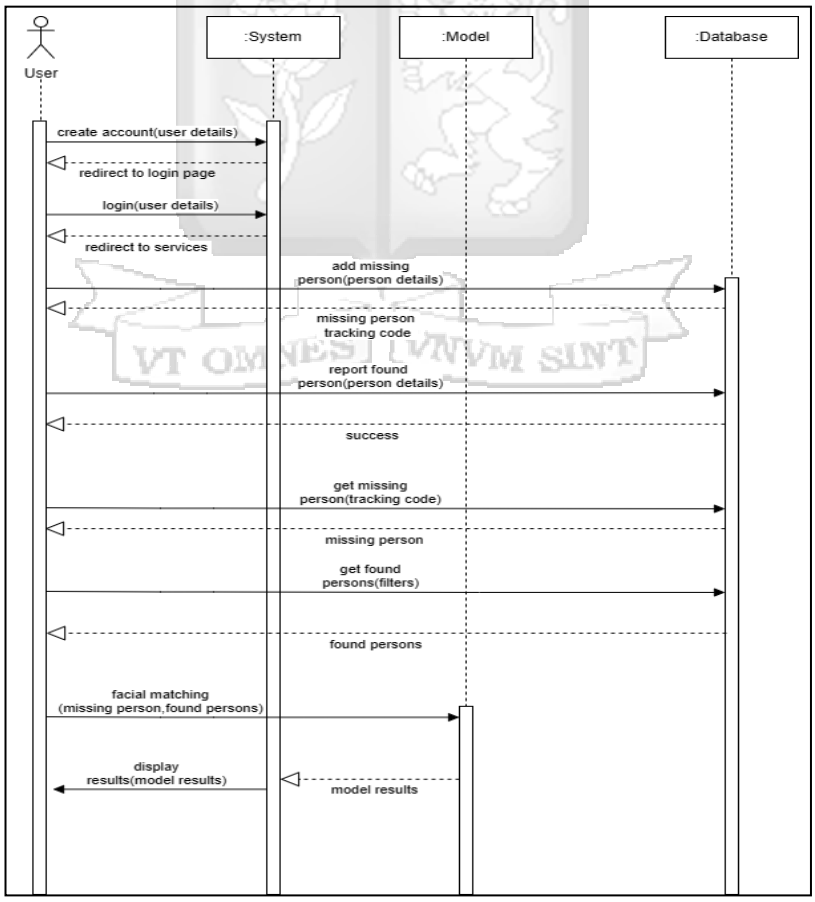


Fig 4.5 Sequence Diagram

4.3.5 Class diagram

Class diagrams are used when developing an object-oriented system model to show the classes in a system and the associations between these classes. Loosely, an object class can be thought of as a general definition of one kind of system object. An association is a link between classes that indicates that there is a relationship between these classes. Consequently, each class may have to have some knowledge of its associated class and it represents the types of objects, attributes and methods residing in the system and the relationships between them.
Figure below shows the major classes their attributes and the main methods alongside their relationships.

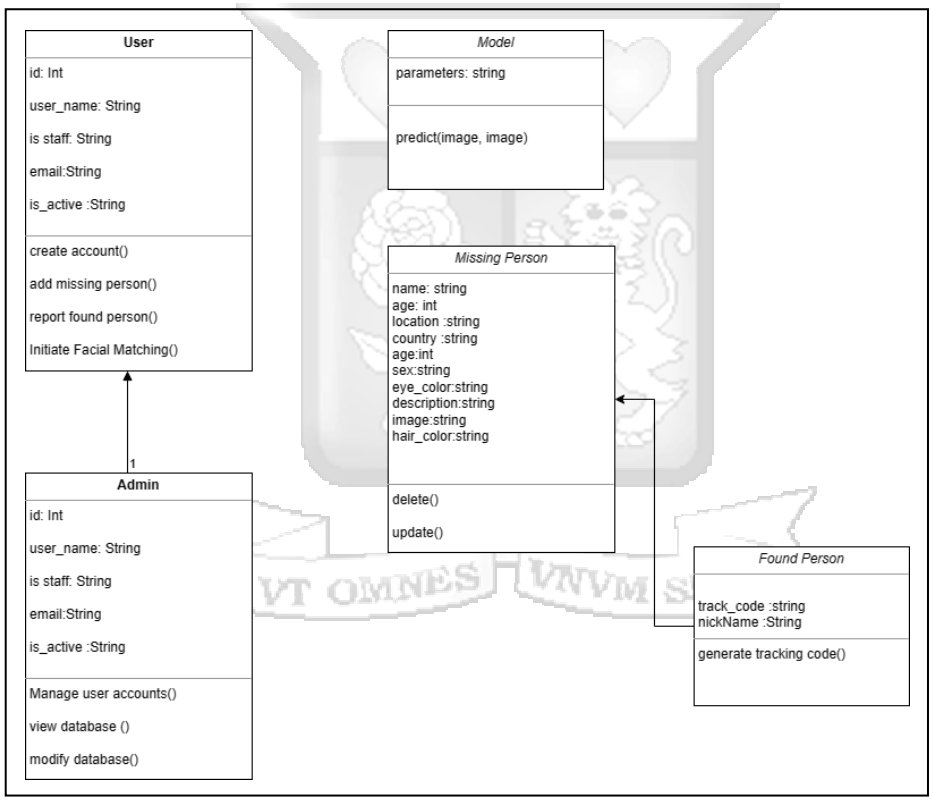


Fig 4.6: Class Diagram

4.3.6 Database Schema

A database schema serves as the logical representation of a database, illustrating the logical storage of data throughout the entire database. It comprises a list of attributes and instructions that guide the database engine

on how to organize data and establish relationships between elements. The figure below shows the database schema for the face recognition system. The user table stores user data and is utilized for authorization and authentication. The missing person table contains details about missing individuals, while the found persons table stores information about reported seen persons. From the user table to the other two tables, it demonstrates a one-to-many relationship, signifying that one user can create multiple instances of either a found person or a missing person. These relationships are established and linked by the "created by" column, serving as the foreign key.

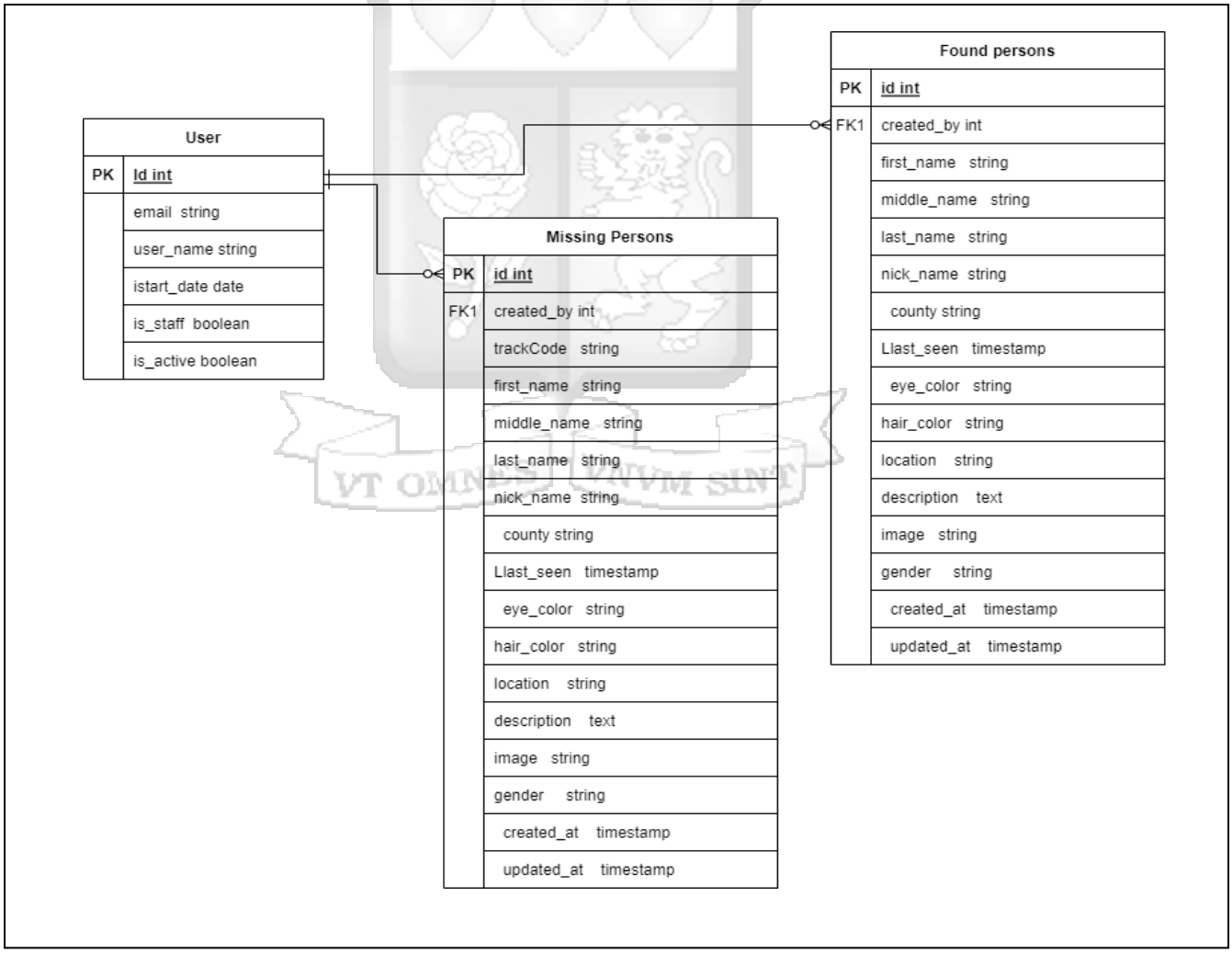


Fig 4.7: Database Schema

Chapter 5: Implementation and Testing

5.1 Introduction

This chapter aims at discussing the implementation and testing of the proposed system. This chapter extensively explores the implementation and testing phases of the model. The implementation section delves into data preparation, encompassing pre-processing activities, as well as the detailed development of various model sections and systems. This includes a thorough examination of their implementation, functionality, and the tools employed throughout the process. On the other hand, the testing phase concentrates on validating the model's capability to meet both functional and usability requirements.

5.2 System Implementation

5.2.1 Development Environment

The development environment setup is a critical face of the implementation process, encompassing various elements to establish a solid foundation for the coding and integration phases. The following components constitute the environment setup for the development of the web application:

5.2.1.1 Software

The selection of proficient software tools is pivotal in optimizing the development workflow. For this implementation, the following software tools are chosen:

Table 5.1: Software

Name	Tool
Operating system	Windows 11
Version control	Git and github
Text editor	Visual Studio Code
Database	Sqlite

5.2.1.2 Project Dependencies

The project relies on specific dependencies and their respective versions to ensure compatibility and stability throughout the development process. The following dependencies are included.

Table 5.2 Dependencies

Name	Version
dlib	19.24.2
numpy	1.26.1
face-recognition	1.3.0
face-recognition-models	0.3.0
Pillow	10.1.0
djangorestframework-simplejwt	5.3.0
djangorestframework	3.14.0
django-cors-headers	4.3.0
Django	4.2.6
Node js	21.1.0
Python	3.12.0

5.2.1.3 Virtual Environment

To ensure an isolated and reproducible development environment, a virtual environment is employed. This prevents conflicts with system-wide installations and ensures consistency.

5.2.1.4 Backend Implementation

The backend development phase constitutes a greater percentage of the overall system implementation. This section expounds on the key aspects of implementing the

Django backend, integration of the face recognition module, database configuration, and API development.

5.2.1.5 Face Recognition Module Integration

Once the library is installed within the virtual environment it installs additional libraries it ships with. The image below is a code snippet for the face distance function.

```
def face_distance(face_encodings, face_to_compare):
    """
    Given a list of face encodings, compare them to a known face encoding and get a euclidean distance
    for each comparison face. The distance tells you how similar the faces are.

    :param face_encodings: List of face encodings to compare
    :param face_to_compare: A face encoding to compare against
    :return: A numpy ndarray with the distance for each face in the same order as the 'faces' array
    """
    if len(face_encodings) == 0:
        return np.empty((0))

    return np.linalg.norm(face_encodings - face_to_compare, axis=1)
```

Figure 5.1: Face Distance Function Code

Using the above function the known person image was passed as an argument to the function as well as filtered images from the found person's databases then a numpy array is returned containing the results as either true or false.

5.2.1.6 Database Configuration

Django ships with SQLite database which is a relational database ideal for the project so the configurations majorly involved defining the schemas for the missing person, users, found person tables this was made possible by the Django ORM that allowed for the schemas to be defined in classes then on make migrations the ORM triggers the SQL queries to create the tables and populate default values.

5.2.1.7 API Development

The final part was to develop the API endpoints that was to be consumed by the react frontend. The response data was in JSON format that was easily converted to JavaScript datatypes and displayed in the user interface.

5.2.2 Frontend implementation

The frontend development is designed to provide a user-friendly interface for interacting with the Django backend. Key elements and security measures have been implemented, focusing on usability, API integration, and token management for user authentication.

5.2.2.1 React Project Setup

The React application is initiated using Create React App command from the terminal to generate project boilerplate.

5.2.2.2 API Integration

Axios package as well as JavaScript's fetch API is employed for making asynchronous HTTP requests to the Django backend. This facilitates efficient communication and data retrieval.

5.2.2.3 Security Measures

Security is enhanced through token-based authentication. User credentials are stored securely in the local storage after successful login. Subsequent requests include the token for authentication.

5.3 Testing

The testing phase is critical to ensuring the system's functionality, performance, and reliability. As part of development the system was tested using artificial data to check for anomalies within the system and to discover if the program meets the functional and non-functional requirements of the proposed system. The testing process includes Unit Testing, Component Testing, System Testing, Performance Testing, Requirement-based Testing, and specifically, API Endpoint Testing using Postman.

5.3.1 Unit Testing

Unit testing focuses on individual components of the system, ensuring that each function performs as expected. In the context of the facial recognition module, unit tests were conducted to verify the correctness of functions responsible for capturing, storing, and processing facial images. This includes confirming that image preprocessing and facial feature extraction algorithms function accurately on a per-unit basis.

5.3.2 Component Testing

Component testing involves validating the interactions and collaborations between various components within the application. For this system, component testing majorly assessed the integration of the Django backend with the React frontend and the seamless communication between the frontend and the facial recognition module. It ensured that different components work harmoniously to achieve the intended functionalities.

5.3.3 System Testing

System testing evaluates the application to ensure that all integrated components function cohesively. In the case of the missing and found person's database with facial recognition, system tests aimed to test the end-to-end functionality of the system. This includes testing the entire process, from user input in the search bar to the display of identified persons, ensuring that the entire system meets the specified requirements.

5.3.4 Performance Testing

Performance testing is essential to assess the responsiveness, scalability, and resource utilization of the system under different conditions. Specifically, for the facial recognition module, performance tests evaluated the efficiency of the recognition algorithm when handling a varying number of images. This ensured that the system remains responsive and stable even with increased workload.

5.3.5 API Endpoint Testing with Postman

While the previous testing stages focused on the internal functionality of the system, API Endpoint Testing is crucial to assess the external communication and integration of the web application. Postman was the main tool employed for this purpose, enabling comprehensive validation of the API endpoints.

Chapter 6 Discussions

6.1 Introduction

The main goal of this study was to develop a web application as an information system for handling missing person reports. The application was developed in relation to the research objective of developing a web application to efficiently process missing person reports.

6.2 Web application

The web application was developed using Visual Studio which is a comprehensive integrated development environment (IDE) developed by Microsoft, widely used by developers for building a variety of applications, including web, mobile, desktop and cloud. It supports multiple programming languages, facilitates cross-platform development, and integrates seamlessly with Git for version control and cloud development. This aided in using python and other development tools. The components of the system are discussed in the following sections.

6.2.1 The New User Page

The home page gives the user an option to create an account to be used in accessing the system. The user will be required to supply email address, username and password while creating the user account. Thereafter, the user will be allowed to login with the created credentials.

6.2.2 Creating a Missing Person Record

To create a missing person record, there are several bio data that must be provided. The data include the names, hair color, skin color, eye color, recent photo, place last seen, race, and date last seen. Diagram 6.1 shows how missing person form appears.

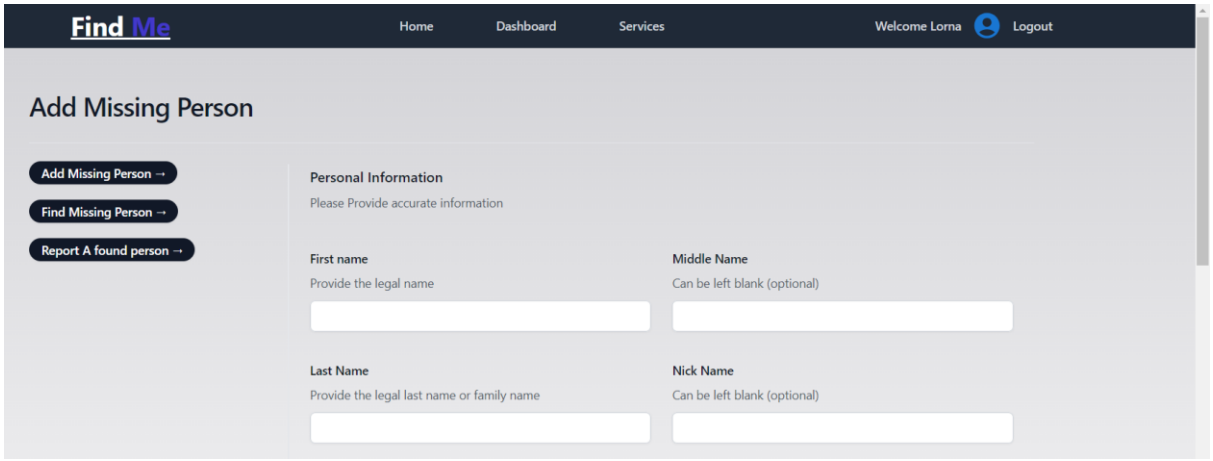


Figure 6.1: Creating Missing Person Record.

The place last seen is selected from a map as shown in figure 6.2.

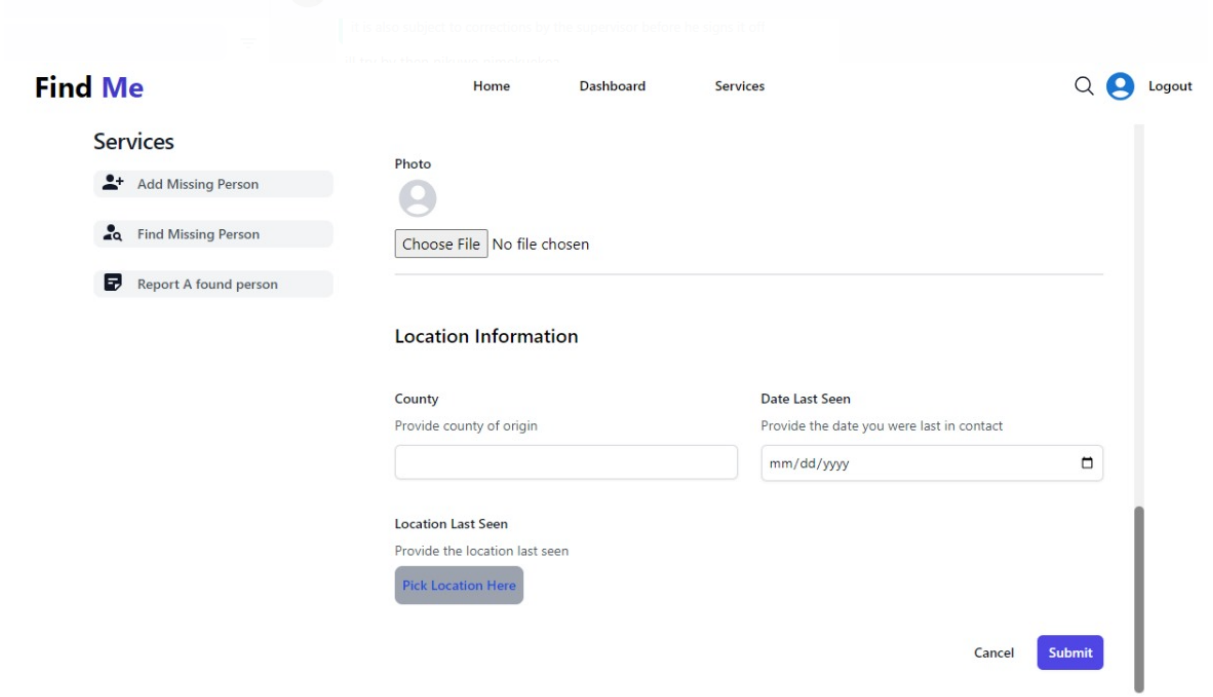


Figure 6.2: Adding Location

The person's image must be added in the system so that facial recognition can process the same. A clear photo is added while filling the missing person form. The photo is uploaded from the device used to make the entry. Once the missing person is added, the user gets a unique code. This code is used later check for updates on the missing person Upon successful completion of adding a missing person record, one can check the list on the missing person's tab as indicated in diagram 6.3.

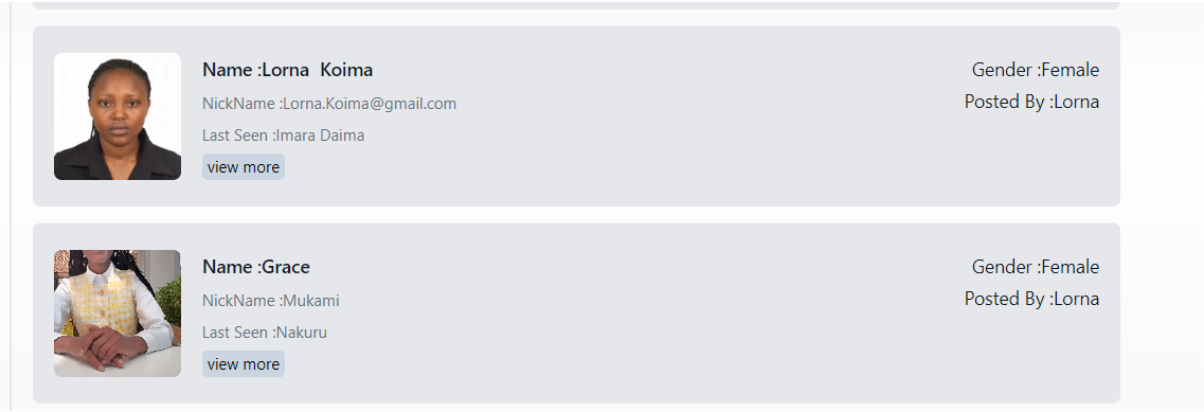
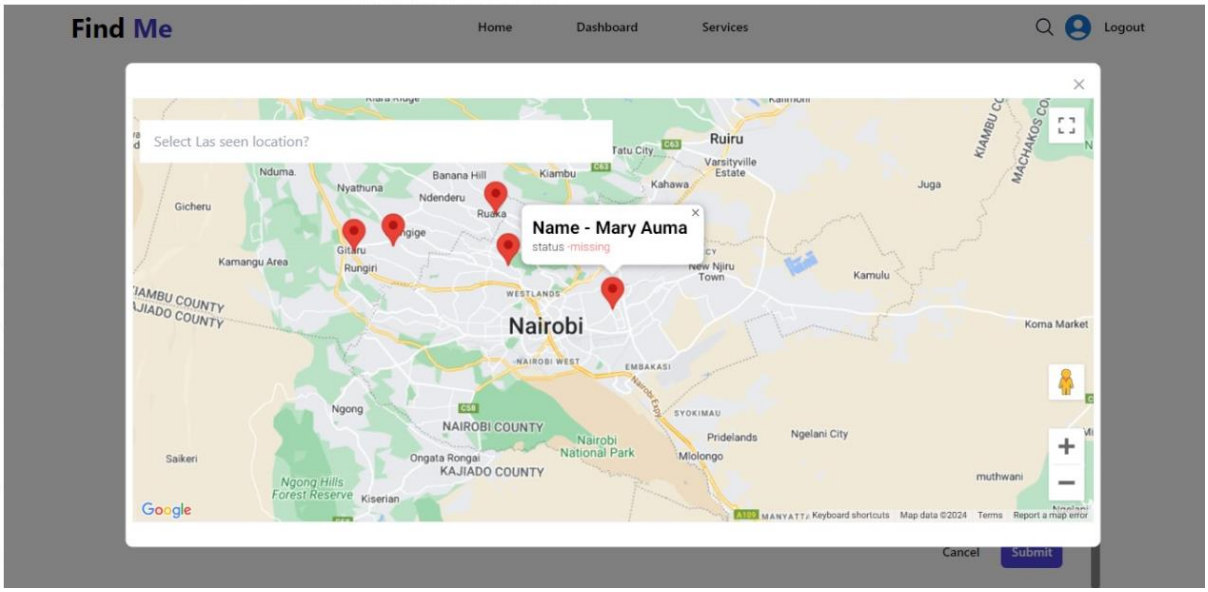


Figure 6.3.: Missing Person List

The map will display distribution of missing persons as per figure 6.4:



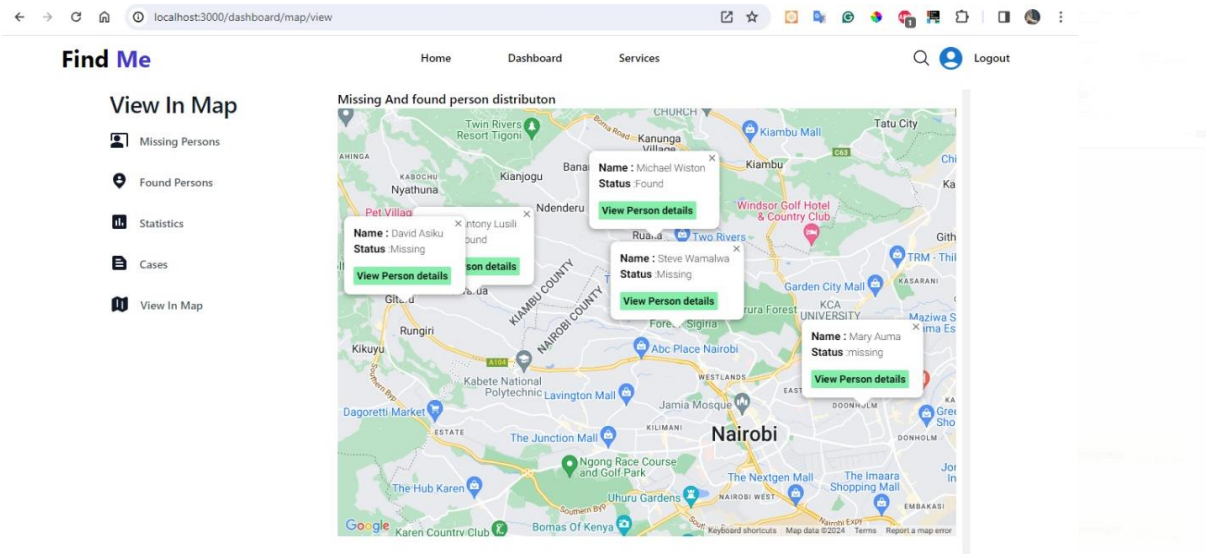


Figure 6.4: Missing Persons Location on Map

6.2.3 Creating a Found Person Record

If a person deemed to be lost is found, they are added in the found person database. The information that is entered in the system is the same as for the missing person. Location where the person was found is selected on a map. Below is the snip of this section presented in diagram 6.5.

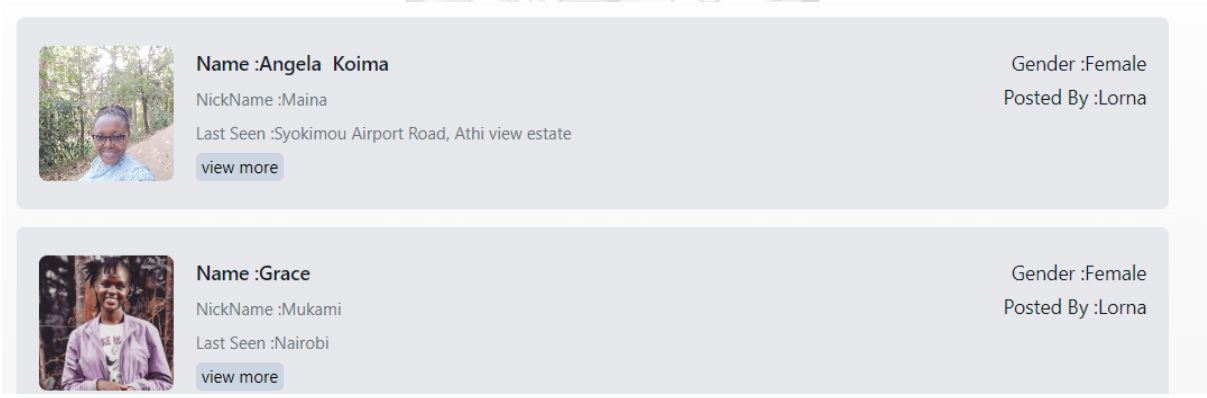


Figure 6.5 Found Persons Report.

6.2.4 Web application backend

The web application backend gives access to the admin to manage the application as well as the databases. The landing page of the backend is as shown below:

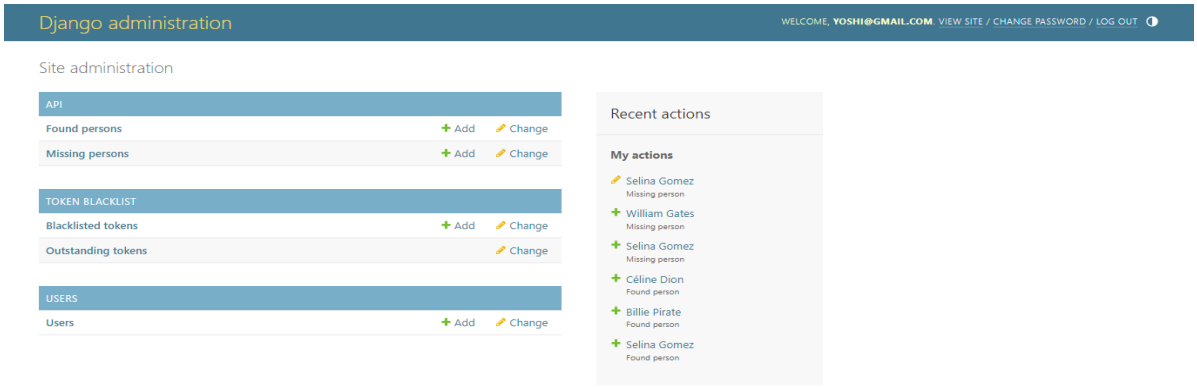


Figure: 6.6: Web Application Back End

The databases of missing persons found persons and system users can be viewed by administrator in the backend. The following diagrams illustrates the same.

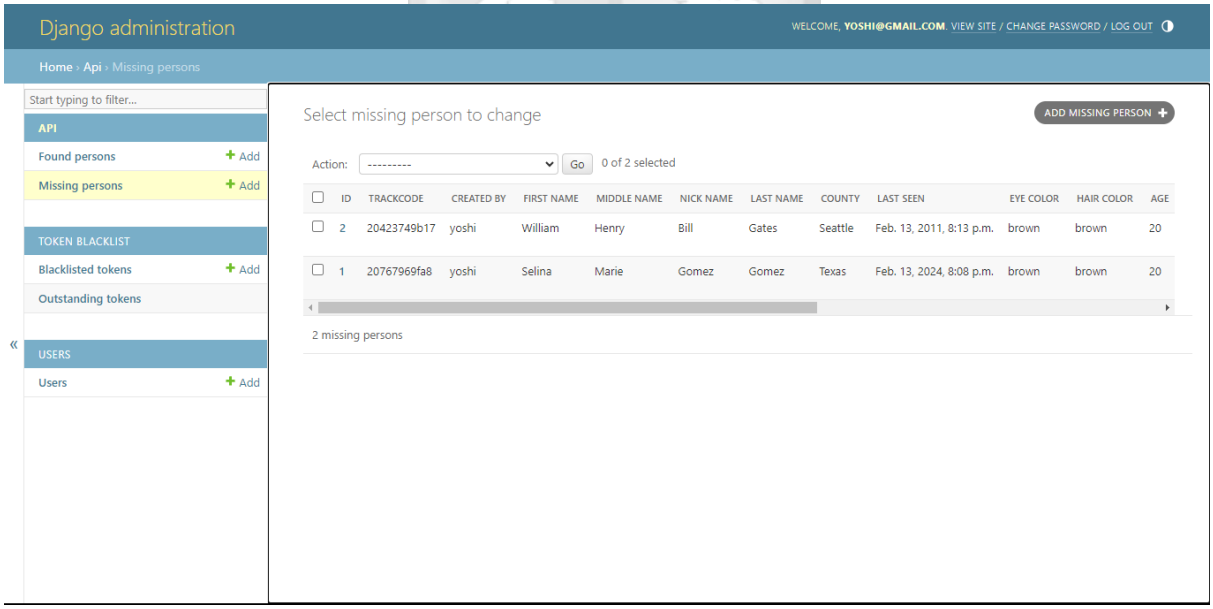


Figure 6.6: Missing Person Database on Backend View

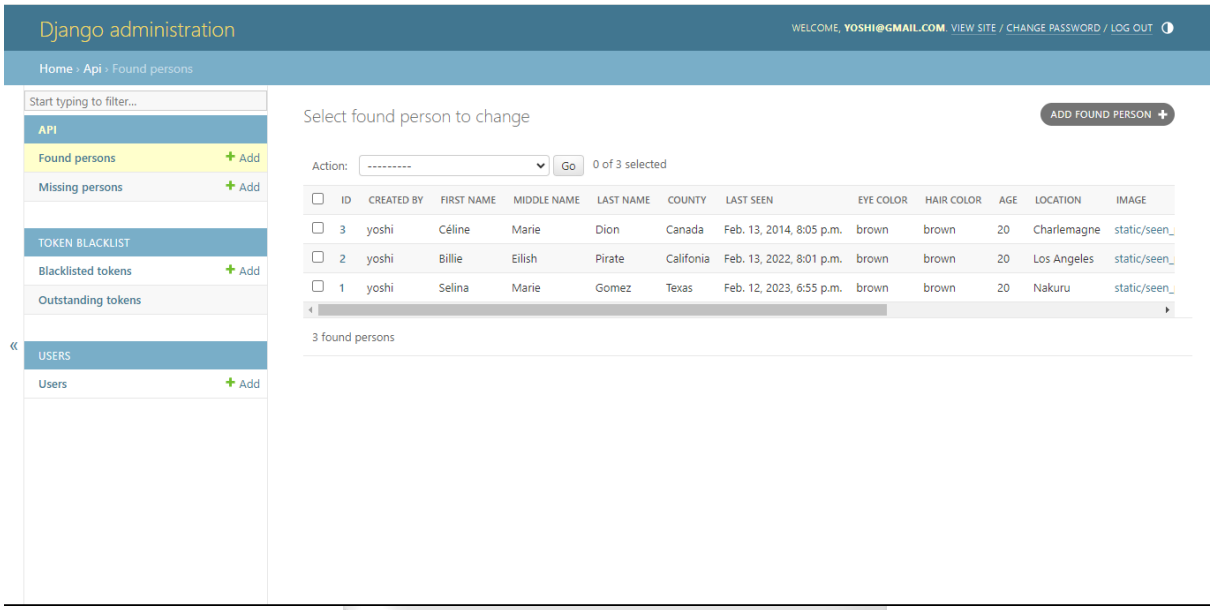


Figure 6.7: Found Person Database on Backend View.

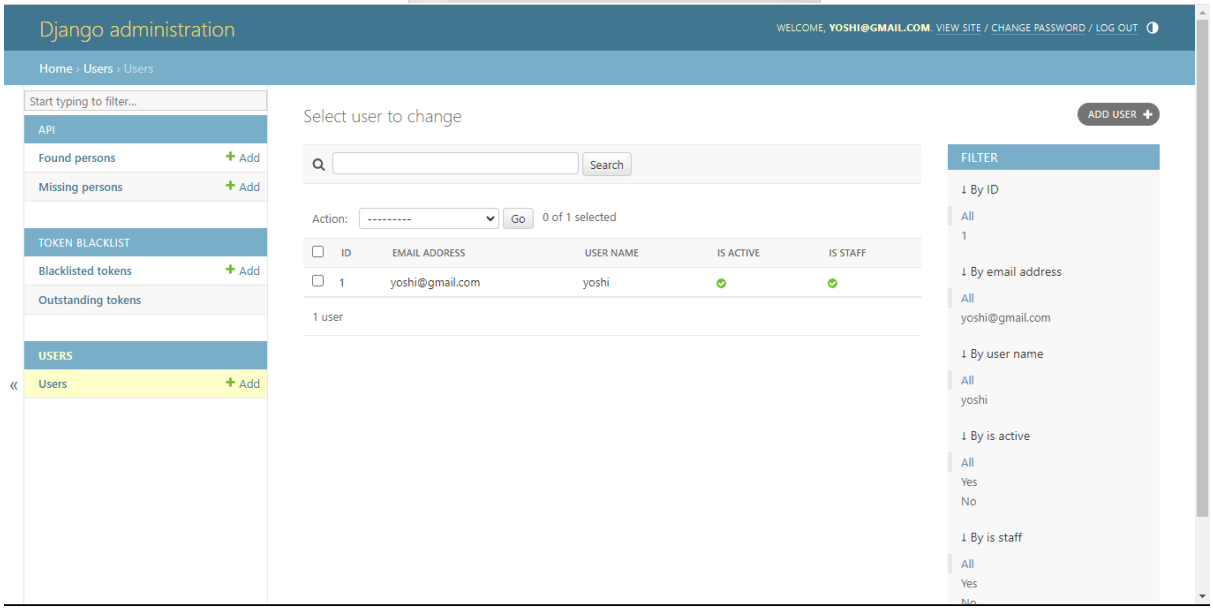


Figure 6.8: List Of System Users

The missing person can also be seen on the map as follows:

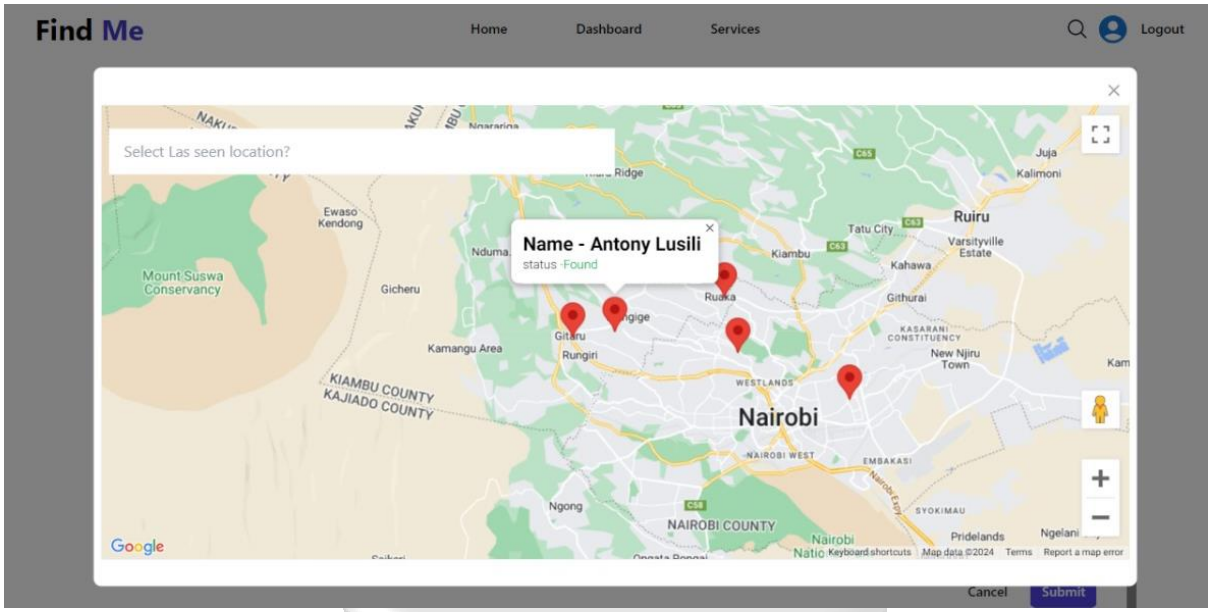


Figure 6.9: Found person on the map

6.2.5 System Testing

To show that the system works, the researcher did a few use cases of missing person records and corresponding found person records. In this use case different photos of the same people are used.

6.2.5.1 Web Application Testing Results

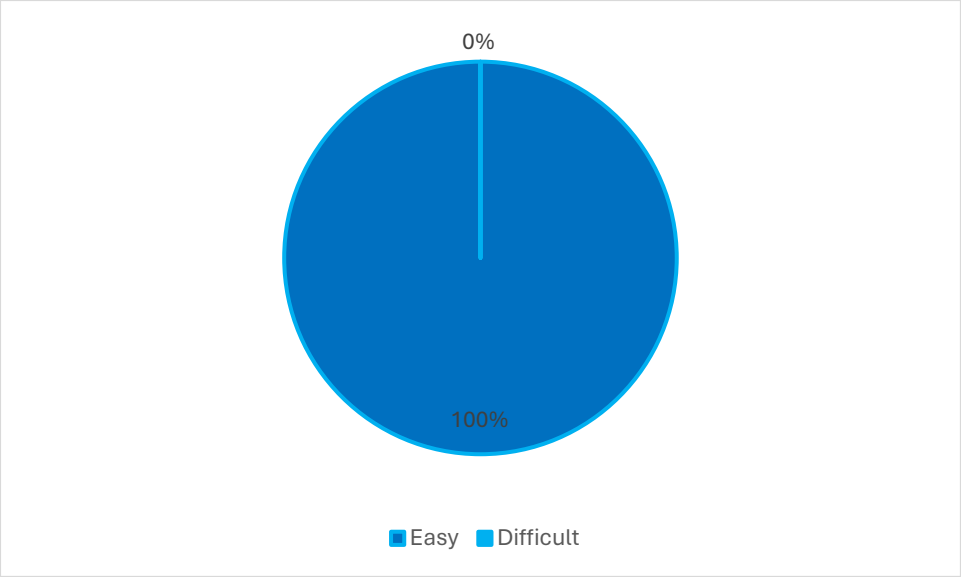
Test ID	Case	Expected result	Actual result
Test 1	Verify if the web application can be easily accessible	A user should be able to access the web application with no challenges	100 % of the testers agreed that the web application was easily accessible
Test 2	Verify if a new user can successfully create an account	A user should be able create an account without challenges	100 % of the testers were able to create accounts with no challenges
Test 3	Verify if a new missing person record could easily be created	A user should be able to create a new missing person record with no challenges	100 % of the testers were able to create a missing person record accounts with no challenges
Test 4	Verify if a new-found person record can easily be created	A user should be able to create a new-found person record with no challenges	100 % of the testers were able to create a missing person record accounts with no challenges
Test 5	Verify if a created user is properly authenticated	A user with an existing account should only be authenticated with correct credentials	100 % of all created accounts were authenticated only with correct username and password
Test 5	Verify if the supplied images for the missing persons and found persons were properly matched using the matching algorithm	The facial recognition algorithm should be able to match an image added during creation of missing person report with the database of faces of the found persons.	The system was able to match 100% of the faces and give the correct result of the person's information

Table 6.9: Web Application Testing Results

6.2.6 System Validation

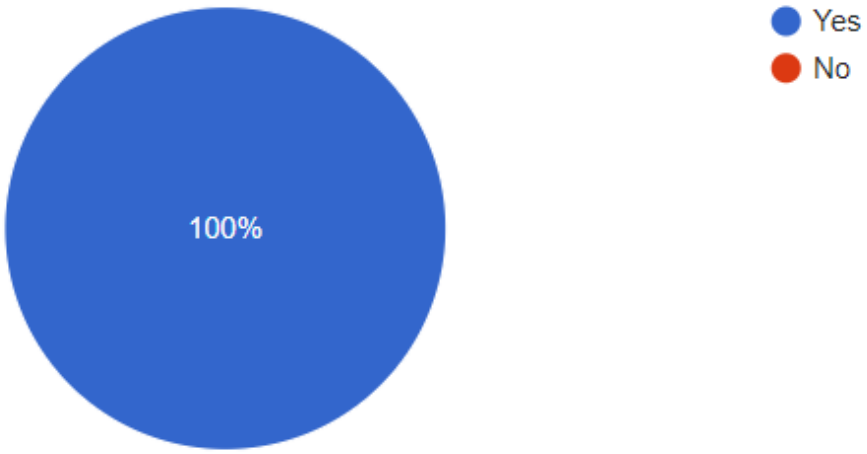
This section aims at validating that the developed system is efficient in handling missing person cases in Kenya. The responses were analysed and presented in graphs to illustrate the effectiveness of the developed system. A user survey was shared with the test users of the application and the results were documented as in the following section.

How easy is it to create a new user account?



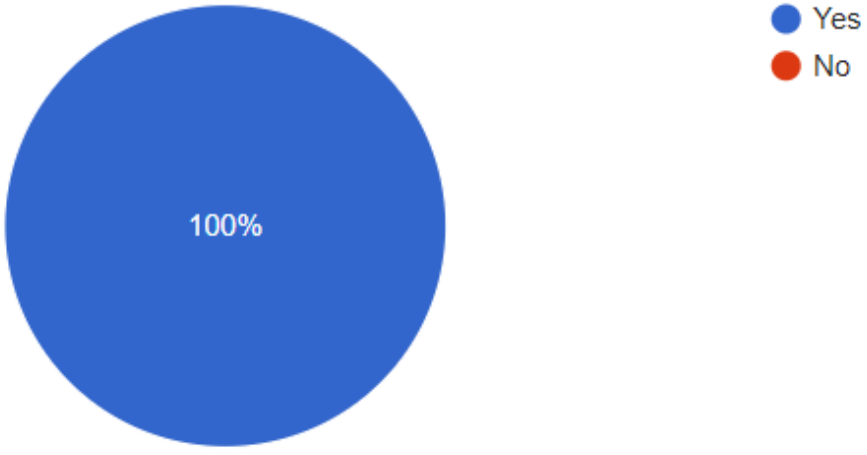
The results indicate that 100 percent of the testers found it easy to interact with the system while creating a new user account.

Was process of adding a new missing person record easy?



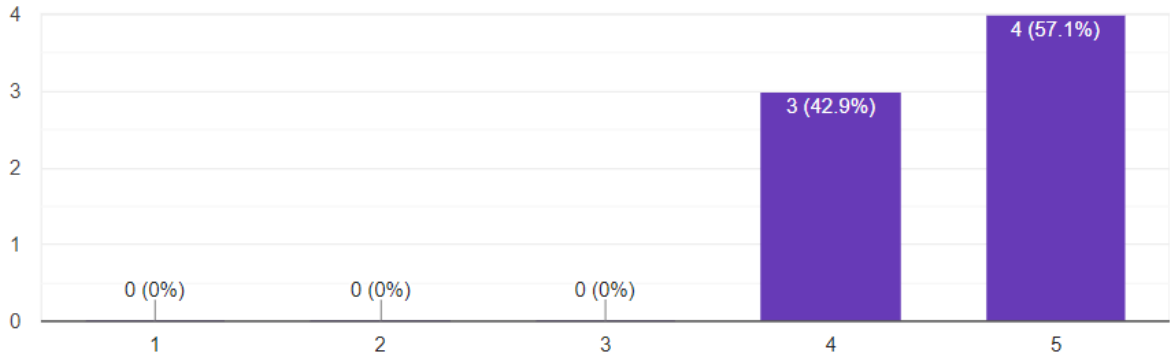
The results indicate that 100 percent of the testers found it easy to add a new missing person record.

Was process of adding a new-found person record easy?



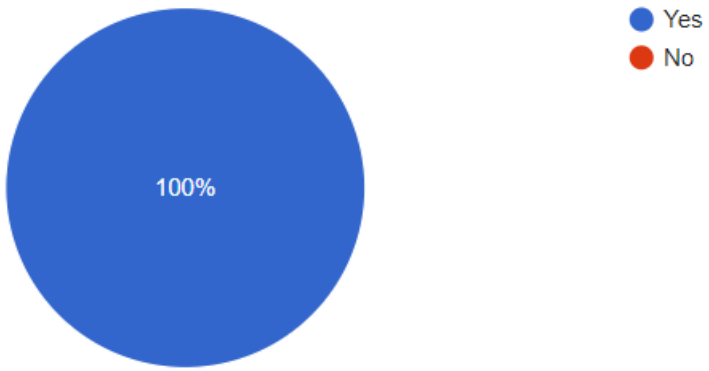
The results indicate that 100 percent of the testers found it easy to add a new found person record.

On a scale of 1 to 5 (1- lowest, 5- highest), rate the user-friendliness of the web application?



42 % of the tests found the system to be moderately friendly, while 57 % found the system to be very friendly.

Do you think the system is usable in managing missing person cases in Kenya?



The results indicate that 100 percent of the testers agree that the system is usable in managing missing person cases.

6.3 Comparison with other studies in Kenya

There have been two research papers towards the same objective of developing an application for managing missing persons in Kenya. Mutisya (2017), developed a mobile phone application for reporting and tracking missing persons in Kenya which presents a notable alternative approach to addressing the issue of missing persons cases. The mobile phone application focuses on leveraging the widespread use of mobile devices in Kenya to enable reporting and tracking of missing persons directly from users' smartphones. In contrast, the developed web application provides a centralized platform accessible through web browsers, catering to users who may have access to computers or prefer desktop-based solutions. The mobile phone application was integrated with GPS module for location-based services, to enable to add a specific location on a map.

Omweri and Kahonge (2015), on the other hand, developed a mobile application that can also be accessed on the web to help report and find missing persons. The application has the functionality to file and missing and found person. The person who reported a missing person case receives an email notification once a match is found. This application does not encompass geotagging or facial recognition as compared to the research project being undertaken by this research.

In conclusion, the developed web application has additional features which make it more effective in addressing the research objective. The geotagging feature enables ease of locating the exact location of disappearance which can aid in the search efforts. Facial recognition on the other hand helps in identifying a missing person from a pool of found person database which can result on fast resolution of the case. The system data visualization on the map gives insightful information on trends and patterns regarding missing person cases and can help in mitigating such issues.

Chapter 7: Conclusions and Recommendations

7.1 Conclusion

This research delved into finding a solution for reporting missing person cases in Kenya. Interviews conducted by the researcher revealed that the current method of recording missing person cases is through manual methods rather than the digital method. Records are only kept per the police administration region, hence there is no centralized database for viewing and managing the missing persons' records. This leads to difficulty in collaboration among the different regions in terms of updating the records of missing people. The researcher aimed at developing a missing person web application with a centralized database with a case study of Kenya. Therefore, the researcher developed a more efficient system that would be centralized and incorporate facial recognition to speed up the process of searching for a missing person. The developed system allows for a new missing person record to be created. Upon creation, a unique code is given to the person who created the record. The code is used to query the database in case to ascertain of a missing person has been found. This works by comparing the photo that was added during the creation of new missing person record, against the database of faces of found people's faces.

The literature review provided a comprehensive understanding of global initiatives and technologies addressing missing persons cases, serving as a foundational resource for this web application development project. By synthesizing findings from various studies and projects, it highlighted the significance of geotagging technologies and facial recognition systems in missing persons databases and search operations, informing the integration of these features into the application. Furthermore, the review identified best practices and potential strategies adaptable to the Kenyan context, guiding decision-making processes regarding technology selection, user interface design, and system architecture. The researcher did thorough investigation of different literature to understand the ecosystem of missing person systems. The wealth of research presented in the literature review provided invaluable insights into missing persons cases and the technologies employed in their resolution. The review of facial recognition technology, as elucidated by Smith and Johnson (2019),

underscores its potential as a powerful tool for expediting identification processes. Similarly, the exploration of geospatial analysis techniques by Brown and Garcia (2020) highlights the importance of location-based data in understanding missing persons cases. Chen and Wang's (2018) comparative study offer a broader perspective on technological solutions, emphasizing the need for adaptable approaches tailored to specific contexts. Moreover, the practical insights provided by Garcia and Martinez (2021) and Kim and Lee (2019) through their respective case studies offer valuable lessons for the implementation of facial recognition and geotagging technologies in law enforcement and database management. These studies underscore the importance of leveraging advanced technologies and interdisciplinary approaches in addressing the complex challenges of missing persons cases, laying a solid foundation for the development and implementation of the web application discussed in this thesis.

This study contributes largely to provide a better platform for the Kenyan police administration to handle missing person cases. It provides them with a centralized platform for recording and managing missing person cases and found persons. By digitizing and organizing this information, the administration can access and update case details more efficiently, leading to improved response times and coordination in search and rescue operations.

The integration of facial recognition technology significantly enhances the administration's search capabilities. It allows the system to automatically compare images of missing persons with databases of found individuals or known missing persons. This feature can expedite the identification process and increase the likelihood of locating missing individuals, thereby reducing the workload on police officers and resources required for manual searches.

With geotagging functionalities, such as integration with Google Maps, the administration gains access to precise location data associated with missing person cases. This enables police officers to prioritize search efforts based on the last known locations of missing individuals, optimizing the allocation of resources, and increasing the efficiency of search operations. The web application facilitates collaboration between the law enforcement administration and other relevant agencies, such as non-

profit organizations and search and rescue teams. By providing a centralized platform accessible to multiple stakeholders, the application fosters greater coordination and information sharing, ultimately enhancing the effectiveness of search and rescue efforts.

The accessibility of the web application to the public can also contribute to increased public engagement and awareness regarding missing persons issues. Citizens can report missing persons or provide information on found individuals through the platform, fostering a sense of community involvement in search and rescue operations.

The validation of the web application was conducted through a multi-faceted approach aimed at ensuring its functionality, usability, and effectiveness in addressing missing persons cases within the Kenyan context. First, extensive testing was carried out to verify the accuracy and reliability of the facial recognition technology integrated into the system. This involved using a diverse dataset of facial images to assess the system's ability to correctly match missing persons with found individuals. Additionally, user acceptance testing was conducted to evaluate the usability and accessibility of the application interface, soliciting feedback from both the users who interacted with the platform.

In conclusion, the development of a web application for recording missing person cases and found persons, incorporating facial recognition technology and integration with Google Maps, represents a significant step towards addressing the challenges associated with missing persons in Kenya. Its potential to aid in search and rescue efforts, reunite families, and contribute to the broader societal goal of ensuring safety and security cannot be overstated.

7.2 Recommendations

The research was able to illustrate the power of integrating facial recognition and location-based services. The researcher recommends the following:

i. Adoption by Kenyan agencies handling missing person cases: The system demonstrates efficacy in aiding missing person investigations, thus it is recommended for adoption by relevant Kenyan agencies tasked with handling such cases.

ii. Customization for different departments: The system's flexibility allows for customization to meet the specific needs of various departments, including but not limited to the Criminal Investigation Departments and Police departments throughout the country.

iii. Implementation in children's homes or shelters: Given its potential to facilitate the reunification of lost children with their families, the system is deemed suitable for implementation in children's homes or shelters, where such reunifications are paramount.

iv. iv. Utilization of data from maps: Valuable data accessible through the system's mapping features can be leveraged for various purposes, such as enhancing decision-making processes and resource allocation within relevant organizations.

7.4 Future Work

Based on the research findings, the following recommendations are proposed for further enhancement and development of the system:

i. Development of an Android Version: To broaden accessibility, an Android version of the application should be developed, allowing users on Android devices to access the system's functionalities conveniently.

ii. Integration of Camera Option: Implementing a camera option within the application will enable users to upload live pictures of individuals they have found or wish to report as missing. This feature enhances the immediacy and accuracy of reporting, facilitating faster response times.

iii. Inclusion of Map Functionality: Future iterations of the system could incorporate map functionality, enabling users to pinpoint the exact location where a person was last seen or found. This feature enhances precision in reporting and search efforts, streamlining the process of reunification.

These recommendations aim to improve the accessibility, usability, and effectiveness of the system in aiding missing person cases, thereby furthering its potential impact and utility for users.



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Appendices

Appendix A: Ethical Clearance Confirmation

Strathmore UNIVERSITY

31st October 2023

Ms Koima Lorna Jematia,
Lorna.Koima@strathmore.edu

Dear Ms Koima,

RE: Towards a centralized system for Reporting and Identification of Missing Persons in Kenya

This is to inform you that SU-ISERC has reviewed and **approved** your above SU-masters research proposal. Your application reference number is **SU-ISERC1882/23.** The approval period is from **31st October 2023 to 30th October 2024.**

This approval is subject to compliance with the following requirements:

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by SU-ISERC.
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to SU-ISERC within 72 hours of notification.
iv. Any changes anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to SU-ISERC within 72 hours.
v. Clearance for the export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to the expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days of completion of the study to SU-ISERC.

Before commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology, and Innovation (NACOSTI) https://research-portal.nacosti.go.ke/ and obtain other clearances needed.

Yours sincerely,

Mr Ambrose Rachier,
Chairperson; SU-ISERC

STRATHMORE UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICAL REVIEW COMMITTEE
(SU-ISERC)
31-Oct-2023
Email:ethicsreview@strathmore.edu
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Appendix B: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 476438

Date of Issue: 22/November/2023

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