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An Analysis of Convolutional Neural Network Approach for Face Recognition

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***Abstract*—** Faces represent complex multidimensional mean ingful visual stimuli and developing a computational model for face recognition is difficult. We present a hybrid neural-network solution which compares favorably with other methods. The system combines local image sampling, a self-organizing map (SOM) neural network, and a convolutional neural network. The SOM provides a quantization of the image samples into a topological space where inputs that are nearby in the original space are also nearby in the output space, thereby providing dimensionality reduction and invariance to minor changes in the image sample, and the convolutional neural network provides for partial invariance to translation, rotation, scale, and deformation. The convolutional network extracts successively larger features in a hierarchical set of layers. We present results using the Karhunen–Loeve (KL) transform in place of the SOM, and ` a multilayer perceptron (MLP) in place of the convolutional network. The KL transform performs almost as well (5.3% error versus 3.8%). The MLP performs very poorly (40% error versus 3.8%). The method is capable of rapid classification, requires only fast approximate normalization and preprocessing, and consistently exhibits better classification performance than the eigenfaces approach on the database considered as the number of images per person in the training database is varied from one to five. With five images per person the proposed method and eigenfaces result in 3.8% and 10.5% error, respectively. The recognizer provides a measure of confidence in its output and classification error approaches zero when rejecting as few as 10% of the examples. We use a database of 400 images of 40 individuals which contains quite a high degree of variability in expression, pose, and facial details. We analyze computational complexity and discuss how new classes could be added to the trained recognizer.

***Keywords*—** Photograph Segments, User-friendly environment, Images etc

I. Introduction

The aim of this project is to develop a system for identifying criminals in any investigation department. The project utilizes a technique where images of known criminals are stored in a database along with their details. These images are segmented into various parts such as eyes, hair, lips, nose, etc. These segmented images are also stored in a separate database.

To identify criminals, eyewitnesses are shown the images or slices that appear on the screen. Using these slices, a composite face is constructed, which can then be compared with the stored images in the database. If there is a match of up to 99%, it is predicted that the person being investigated is the criminal.This project aims to provide a user-friendly environment for operators and eyewitnesses to easily design and identify criminal faces.

A. Problem Area Description

The project focuses on the identification of criminals with the assistance of eyewitnesses. It consists of four main modules: Adding, Deleting, Updating, and Identifying Criminals. There are mainly three roles in the project. They are,

- Administrator
- Operator
- Eyewitness

B. Administrator

The administrator is responsible for providing user IDs and passwords, as well as managing user authentication. They can create, delete, and update user IDs and passwords.

C. Operator

The operator belongs to the investigating department and is responsible for entering and maintaining criminal details. They can add, delete, and update criminal information. The operator also constructs the composite face of the criminal using the eyewitness s's input.

D. Eyewitness

The eyewitness plays a crucial role in identifying criminals. They select cropped parts of the criminal's face from a separate database maintained by the operator. The selected parts are then frozen by the operator, and a complete face of the criminal is constructed. The details of the identified criminal are retrieved from the database. Additionally, an imaginary face of the criminal can be constructed using the cropped parts.

II. SYSTEM STUDY

Over the years, the process of face identification has evolved. In the past, law enforcement agencies relied on eyewitness accounts to create sketches or drawings of criminal suspects. However, this method was time-consuming and posed challenges for investigators in apprehending criminals within a reasonable timeframe. To catch criminals, authorities had to manually search through records to determine if any information about the suspect existed. These records were traditionally maintained in books, registers, or files, containing details such as names, aliases, genders, ages, and crimes involved. Each task required significant manual effort and was prone to errors.

A. LIMITATIONS

The existing system had several limitations:

- It required additional manual effort.
- The process of finding criminals was time-consuming.
- The accuracy of identifications was not very high.
- There was a risk of losing files in some cases.
- The method required expertise in drawing.

B. PROPOSED SYSTEM

To overcome the limitations of the existing system, we have developed a system that is highly beneficial for investigation departments. Our proposed system for criminal face identification assigns record numbers to facial slices during face construction. It calculates the maximum number of slices with similar record numbers. The program utilizes the "locate" option to retrieve the personal record of the suspect whose facial slices contribute to the significant portions of the constructed face. Privacy, legality, and continuous improvement are key considerations in our system's implementation.

C. ADVANTAGES

The proposed system offers several advantages:

- It is fast and accurate.
- There is no need for additional manual effort.
- Data loss is minimized.
- Only basic knowledge is required to operate the system.
- No extra hardware devices are necessary.
- It is easy to locate criminals.

D. FEASIBILITY STUDY

Once the problem is clearly understood, a feasibility study is conducted to determine the viability of the proposed system. The study assesses three key areas. They are,

- Technical Feasibility:

This test evaluates whether the proposed system can be developed using existing technology. In our case, we have planned to implement the system using Java technology, which is readily available. Therefore, the solution is technically feasible.

- Economic Feasibility:

This test compares the costs and benefits associated with the proposed system. Development costs may be significant, but the tangible or intangible benefits should outweigh these costs. Since the system can be integrated with existing CCTV cameras without the need for additional hardware, there are no significant economic conflicts. Thus, criminal face identification system is economically feasible.

- Operational Feasibility:

This test ensures that the proposed system is acceptable and can be effectively used by the intended users. Since the system utilizes existing technologies like CCTV cameras and surveillance systems, the criminal face identification system is operationally feasible.

By passing these feasibility tests, it is clear that the proposed system is technically, economically, and operationally feasible.

III. MODULE DESCRIPTION

- Add Image
- Clip Image
- Construct Image
- Identification

A module is a small part of our project. This plays a very important role in the project and in coding concepts. In Software Engineering concept we treat it has a small part of a system but whereas in our programming language it is a small part of the program, which we also called as function in, some cases which constitute the main program.

Importance of modules in any software development side is we can easily understand what the system we are developing and what its main uses are. At the time of project, we may create many modules and finally we combine them to form a system.

A. ADD IMAGE

Add Image is a module that is considered with adding image along with the complete details of the person of whom we are taking image. In this we add Image by importing from the Internet and store them in our system and database. This module is mainly considered for adding details of the criminals like name, age, alias name, gender, location, state, Arrested Date, etc. At the time of the adding image, we give some criminal id to that particular person, so that it can be easily added to the database with any duplication of the data.

B. CLIP IMAGE

This module's main function is to divide the images into different pieces such as hairs, forehead, eyes, nose and lips and store them in the database and also creates the files onto our system.

C. CONSTRUCT IMAGE

Based on the eyewitnesses we are going to construct the images. The witness will give us instruction by looking onto the screen on which there will be the parts of the images like eyes, hairs etc.

D. IDENTIFICATION

This module contains the interface to take the image from above module and it compares or searches with the images already there in the database. If any image is matched, then we identify him/her as the criminal else we add that new image again to the database.

IV. SYSTEM SPECIFICATIONS

A. HARDWARE REQUIREMENTS

System Configuration
Processor : AMD Ryzen 3
Hard Disk : 120 GB
RAM : 4 GB
SOFTWARE REQUIREMENTS
Operating System : Windows Graphical User Interface : Java Swing, AWT. Application Logic : Java 7.
Database : Oracle
IDE/Workbench : Eclipse 6.0.

B. SOFTWARE DESCRIPTION

1) JAVA

Java is a popular programming language commonly used for developing frontend applications. It offers various frameworks and libraries that provide the necessary tools and components for creating interactive and user-friendly interfaces.

One of the prominent frameworks for Java frontend development is JavaFX. It is a rich client platform that allows developers to create visually appealing user interfaces for desktop applications. JavaFX provides a wide range of controls, layouts, and effects to design and build interactive UI components. It also supports CSS for styling and allows the creation of custom UI elements using FXML, an XML-based markup language.

Another popular choice for Java frontend development is Vaadin. It is a web application framework that enables developers to build modern and responsive web interfaces using Java. Vaadin follows a server-side architecture where UI components are rendered on the server and sent to the client-side as HTML. It offers a comprehensive set of UI components and layouts, along with built-in support for data binding and event handling.

C. CRIMINAL FACE IDENTIFICATION SYSTEM USING JAVA

The core steps in building a face identification system using Java involve face detection, feature extraction, and face recognition.

Face Detection: The system locates and identifies faces within an image or video.

Feature Extraction: Unique features are extracted from the detected faces, which is a crucial step in face identification.

Face Recognition: The system compares the extracted features of a detected face with reference faces to determine its identity.

Training the Model: Before deploying the face identification system, it is typically necessary to train the model using a set of labeled face images. During training, the model learns to associate specific features with individual identities, improving the accuracy of face identification.

Application Integration: The face identification system can be integrated into Java applications using libraries and frameworks. The system can process images or real-time video streams to detect and identify faces. The recognized identities can then be utilized for various purposes such as access control or personalized user experiences.

Performance Optimization: Face identification systems may require optimization for efficient processing, especially when dealing with large datasets or real-time applications.

It is important to refer to the documentation and examples provided by the chosen Java libraries and frameworks to understand specific implementation details. Staying updated with advancements in face identification research and techniques can also help improve the accuracy and reliability of the system.

D.HTML

HTML, or Hypertext Mark-up Language, is the standard language used to create web pages. It defines the structure and content of a web page using tags and attributes to describe how content should be displayed in a browser. HTML is used to create headings, paragraphs, lists, tables, forms, images, and other content that can be displayed in a web browser. HTML files are typically saved with a .html or .htm extension and are displayed in a web browser when accessed through a web server or opened directly from a local file. HTML is often used in conjunction with CSS and JavaScript to create rich, interactive web pages and applications.

E. ORACLE

Oracle is a leading enterprise-level relational database management system (RDBMS) developed by Oracle Corporation. It provides a platform for client- server computing and supports distributed databases and distributed processing. Oracle is widely used for its scalability, reliability,

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and comprehensive feature set.

F. STRUCTURED QUERY LANGUAGE (SQL)

SQL is an ANSI standard computer programming language used to query relational databases. The ANSI standard for SQL specifies the core syntax of the language. SQL (Structured Query Language) is a standardized programming language used for managing and manipulating relational databases. It provides a set of commands and syntax for creating, querying, updating, and deleting data from a database. SQL is designed to work with relational database management systems (RDBMS).

G. CRIMINAL FACE IDENTIFICATION SYSTEM USING ORACLE

Developing a criminal face identification system using Oracle would involve utilizing Oracle's technology stack, particularly their database management system (Oracle DB) and their machine learning platform (Oracle Machine Learning). Here's a high-level overview of the steps involved:

Data Collection: Gather a comprehensive dataset of criminal mugshots, ideally from reliable law enforcement sources. Ensure that the dataset covers a wide range of individuals with varying features and criminal histories.

Data Pre-processing: Clean and pre-process the collected data to remove noise, standardize the images, and extract relevant facial features. This step may involve techniques like image cropping, resizing, and normalization.

Feature Extraction: Use facial recognition algorithms to extract key facial features from the pre-processed images. Popular techniques include Eigen faces, local binary patterns (LBP), or deep learning-based methods such as convolutional neural networks (CNNs).

Training the Model: Utilize Oracle Machine Learning (part of the Oracle Autonomous Database) to train a facial recognition model using the pre- processed data and extracted features. This step involves defining a suitable model architecture and training it on the available dataset.

Model Deployment: Once the model is trained, deploy it within an Oracle environment to make it accessible for face identification tasks. You can create a RESTful API using Oracle's Application Express (APEX) or deploy the model using Oracle Cloud services.

User Interface Development: Design and develop a user interface (UI) for the criminal face identification system. This UI will allow users, such as law enforcement personnel, to upload an image of an individual and query the system for potential matches against the criminal database.

Face Matching: When a user submits an image, the system will extract facial features from the input image and compare them with the features stored in the criminal database. Utilize the trained model to perform similarity matching and identify potential matches.

Result Presentation: Present the results to the user, displaying potential matches along with relevant details such as criminal records, images, and any additional information available in the database.

It's important to note that developing an accurate and reliable criminal face identification system requires a significant amount of high-quality training data, robust pre-processing techniques, and ongoing model evaluation and improvement. Additionally, legal and ethical considerations should be taken into account to ensure privacy and compliance with applicable regulations.

V. SYSTEM IMPLEMENTATION

The implementation phase is the final and crucial stage of the project. It involves user training, system testing, and the successful deployment of the developed system. During this phase, users test the system and provide feedback for any necessary changes. The testing process involves using various types of data to thoroughly test the system.

The implementation stage requires careful planning to ensure a smooth transition from the theoretical design to a fully functioning system. Prior to implementation, several preparations need to be made. The system needs to be integrated into the organization's network so that it can be accessed from anywhere. Users are provided with login credentials to access the system. Additionally, the necessary database tables are created within the organization's database domain, and the administrator is granted appropriate roles and permissions for system access.

Once the initial setup is complete, the next step is to train the users on how to effectively use the system. A comprehensive demonstration of all the system's functions is given to the personnel in the examination department, who will be extensively using the system.

VI. CONCLUSION AND FUTURE SCOPE

We have presented a fast, automatic system for face recog nition which is a combination of a local image sample rep resentation, an SOM network, and a convolutional network for face recognition. The SOM provides a quantization of the image samples into a topological space where inputs that are nearby in the original space are also nearby in the output space, which results in invariance to minor changes in the image samples, and the convolutional neural network pro vides for partial invariance to translation, rotation, scale, and deformation. Substitution of the KL transform for the SOM produced similar but slightly worse results. The method is capable of rapid classification, requires only fast approximate normalization and preprocessing, and consistently exhibits better classification performance than the eigenfaces approach [43] on the database considered as the number of images per person in the training database is varied from one to five. With five images per person the proposed method and eigenfaces result in 3.8% and 10.5% error, respectively. The recognizer provides a measure of confidence in its output and classification error approaches zero when rejecting as few as 10% of the examples. We have presented avenues for further improvement. There are no explicit 3-D models in our system, however we have found that the quantized local image samples used as input to the convolutional network represent smoothly changing shading patterns. Higher level features are con structed from these building blocks in successive layers of the convolutional network. In comparison with the eigenfaces approach, we believe that the system presented here is able to learn more appropriate features in order to provide improved generalization. The system is partially invariant to changes in the local image samples, scaling, translation and deformation by design.

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