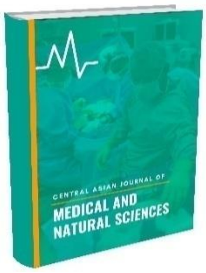
CENTRAL ASIAN JOURNAL OF MEDICAL AND NATURAL SCIENCES



Volume: 03 Issue: 06 | Nov-Dec 2022 ISSN: 2660-4159

http://cajmns.centralasianstudies.org

A Data-Driven Approach for Detecting Attacks in Finger Vein Recognition Using Deep Neural Networks

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Received 6th Oct 2022,
Accepted 5th Nov 2022,
Online 16th Dec 2022

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Abstract: Finger vein recognition offers precision, quickness, sanitation, administration, and privacy as a non-contact biometric approach. Inconsistency between snaps from the same finger reduces software efficacy due to posture variations during finger image capture. Finger posture can also cause ID errors. Finger deformations can be used to determine a genuine or impostor match in finger biometrics. In our study, we use five types of finger deformations and a neural network to determine if an input image of a finger with finger vein data is a match or an attack attempt. Deformed finger vein imagery improves the biometric system's attack detection. Experimental results show that the suggested algorithmic approach outperforms the standard technique in matching and efficiency.

Key words: Finger Vein Detection, Deformed Finger Images, Convolutional Neural Network, VGG16 Jupyter Notebook, Python, Issues Caused by Deformed Finger, Deformed Finger Posture, Dataset Sample.

Introduction

Today, people rely heavily on identity verification. Biometrics is a reliable and easy-to-use authentication method. Biometric proof of identification is used to classify and define individuals [19]. Only a few external elements can damage finger veins, making them a secure form of identification. Due to its characteristics, the finger vein is an important biometric property [20]. Current systems are vulnerable to finger positioning changes, especially roll and pitch [21]. The problem persists despite recent efforts. Existing finger vein recognition methods can be categorised by feature extraction into four classes: region-of-interest-based, minutbased, network, and learning [22]. Traditional machine learning algorithms aren't used to detect finger veins; instead, principal component analysis is used. Recently, Convolutional Neural Nets detected finger veins [23]. These methods require many tagged samples, making them difficult to implement [24]. Current techniques focus on segmenting finger veins. Finger vein biometrics are used to improve identification matching [25].

Finger Vein Detection Process

The finger vein detection process is a multi-step process involving the finger vein sensor and the authentication system [26]. The finger vein image is captured by the sensor system when the finger is placed over the sensor module, where the infrared light is shined over the finger to highlight the finger vein [27]. When the finger vein image is scanned, the process moves to the next stage of pattern extraction [28]. The pattern is extracted based on the shined light, which makes it possible to discern this pattern using the deoxidised haemoglobin in the body [29-34]. The finger vein scanned image is then matched with an image in the finger vein database. The finger vein database has the prior scans of the user trying to authenticate with the system [35]. The images are matched based on the finger vein pattern, and if the pattern is a match, the authentication returns success when it comes to finger vein recognition, more the points of reference are present, the greater the level of security and reliability that will be procured (fig.1).

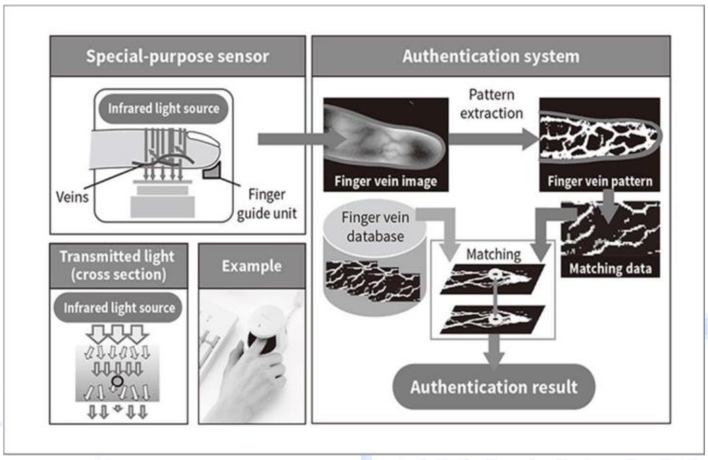

Figure 1: Finger Vein detection [16]

Deformation in Finger

Deformation of the finger is a primary issue in detecting finger vein imagery and is the main factor we deal with in this study [36]. The finger's position may vary widely based on a variety of features. The scales, rotations, translations of the photos, and data obtained may change [37-43]. Even different parts of the same image may have varying depths. Physical variables and individual differences are also considerations to consider [44]. All of the above traits can coexist in a single finger, affecting the uniqueness of selected attributes and matching performance (fig.2).

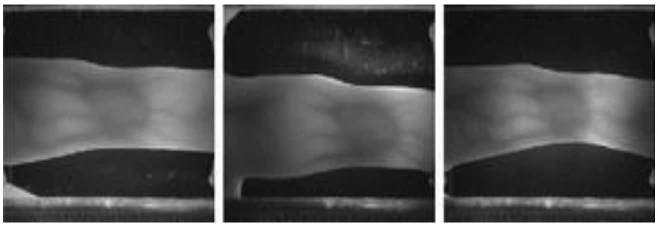

Figure 2: Deformed Finger images [11]

Variations in finger posture affect matchmaking and accuracy. Best matches can also be used. Deformities hinder vein detection and pose a security risk [45]. Deformed finger images could be used to fool the system. Finger vein characteristics may differ between individuals despite being similar [46-49]. Deformed finger imagery is essential for recognising and preventing attacks in finger vein recognition systems. It ensures accurate image recognition and system security against bad actors [50].

Convolutional Neural Network

A Convolutional Neural Network is a method based on deep learning which can accept an input image, ascribe significance to diverse components in the image, and discern among them [51]. When contrast to other classifiers, this requires significantly lower processing [52]. While conventional methods involve the self-engineering of filtrations, the convolutional neural network can grasp these qualities with limited skills (fig.3).

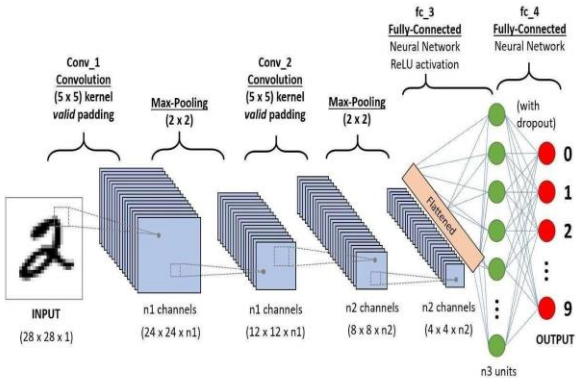

Figure 3: Convolutional Neural Network [17]

The convolutional neural network may successfully grasp the correlations in a picture via filtering [53]. The architecture better matches the dataset owing to the limited number of factors involved and the flexibility of weights. In other words, the system might be instructed to determine the image's intricacy more precisely [54].

VGG16 CNN

VGG16 is a convolutional neural network model. It is attributed to be one of the best-in-class models based on computer vision [55]. The most distinctive characteristic of VGG16 is that rather than many factors, they emphasise generating a three-by-three layer with a single stride and use the similar padding and max pool of two-by-two layers with two strides [56-58]. All through the architecture, this configuration of the layers in convolution and max pool is similar. Ultimately, it possesses two layers, fully complete and an output layer of SoftMax (fig.4).

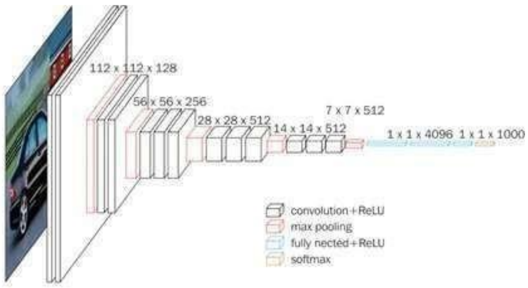

Figure 4: VGG16 [18]

The number of parameters has been significantly shortened. Convolutional Neural Networks are neural networks meant to ascribe the patterns directly from image data with minimal preparation [59].

Jupyter Notebook

Jupyter Notebook is the primary idea used for this project, and it is an interactive web-based computing environment for developing papers associated with a notebook [60]. A Jupyter Notebook is a document based on the web [61-63]. It is an IDE with an ordered list of cells with input and output functions, which can contain code, text, visualisations, and media [64]. A notebook is a document based on JSON that follows a format version and usually ends with the extension of ipynb (fig.5).

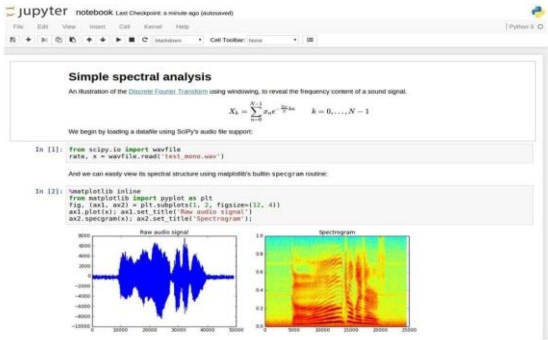

Figure 5: Jupyter Notebook IDE

Python

Python is a general-purpose programming language that uses high abstraction levels [65]. It prioritises readable code and makes copious usage of indents. Its elements in language and OOP elements are aimed at aiding coders in writing concise code which is reliable, irrespective of code size. Python is the primary programming language used in this project implementation [66]. The version of python used is python 3.9.3 (fig. 6).

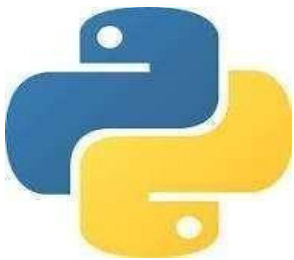

Figure 6: Python

OpenCV and Tensor Flow

OpenCV is a library for processing images, mainly for computer vision. It plays a vital role in real-time operations, which are essential for today's technology. It detects image data. Python can parse OpenCV's array structure with other modules [67-71]. This study loads and manipulates images using OpenCV. TensorFlow is an open-source package for coding application data flow. Math library used for training neural network models. This project trains the VGG16 neural network model with TensorFlow [72]. TensorFlow is a tensor computation and definition framework [73].

Problem Statement

Finger vein identification security isn't perfect despite extensive research. Deformations are difficult to overcome. Rotations, translations, and acquired data may change. Even image depths can vary [74-81]. Physical factors and differences. All of the above traits can coexist in one finger, influencing uniqueness and performance. True matchmaking deformations are caused by differences in finger posture, which impairs accuracy. These deformations can trick the system into believing a spoofed image belongs to a person. This is a rising biometric authentication attack technique [82-85]. Current systems are more vulnerable to rolling and tilt-driven finger positioning perturbations. Despite recent efforts, this problem persists. Existing systems increase capital and operating costs, increasing problem complexity [86]. Classification and predictions require evaluating the finger vein and contours. For accurate detection, the image's finger vein must be identified [87]. Attackers can exploit different types of deformations. The main solution for these problems is to create an architecture that identifies attack attempts by considering finger deformation and an attack prediction module, which predicts whether the image is a match or a spoofing attack (fig.7).

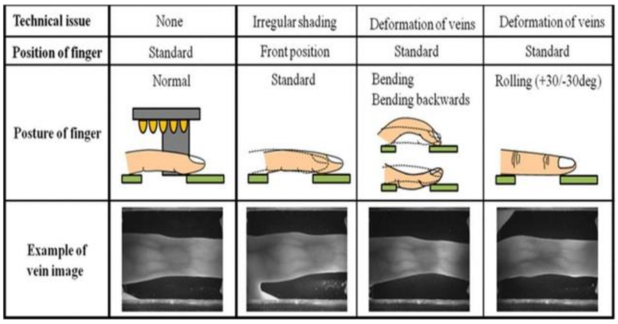

Figure 7: Issues Caused by deformed finger [12]

This project aims to detect the attack on the finger vein recognition system based on the deformation information of the finger: To detect deformations in the finger vein with the maximum accuracy and to effectively classify the five different deformation types [88]. Extract the essential features of a finger vein deformation through various preprocessing techniques using filters from visual images. Accurate and foolproof detection of deformation of the finger and attacks [89]. To use the deep neural networks as a methodology to detect the attacks in the finger vein by impostor matching. To develop a lightweight convolutional neural network with a convolutional block attention module for finger vein attacks recognition. To achieve a more accurate capture of visual structures through an attention mechanism [90].

Literature Survey

The Current systems are vulnerable to finger positioning changes driven by roll and pitch. Despite recent efforts, the issue persists [91]. Existing finger vein recognition methods can be categorised based on feature extraction: region-of-interest-based, minut-based, net-based, and learning methods. Traditional machine-learning techniques are not commonly used to identify finger veins. Instead, principal component analysis and support vector machine is used [92-95]. Recently, CNNs detected finger veins. These methods require many tagged samples, making them difficult to implement. The survey aims to understand other systems' workings. Most CNN-based techniques focus on segmenting finger veins [96]. The proposed mechanism improves identity-matching performance by using finger vein biometrics [97]. Finger vein detection involves image acquisition, preprocessing, feature mining, and identity matching [98-101]. Existing systems ignore finger vein deformation. Deformed fingers can make vein detection and validation difficult. Hackers can access the authentication system, which may contain personal data (fig.8).

Figure 8: Deformed Finger Posture

Xianjing Meng et al. [1] proposed a model that combines texture-based and ensemble approaches to improve recognition. Pixel-level attributes are crawled and then pattern-matched for each pixel. This model was used in high-security databases. Kyoung Jun Noh et al. [2] proposed a framework based on a deep Convoluted Neural Network built with a finger-vein recognition system. This model is computationally intensive and requires a large payload. Shuqiang Yang et al. [3] developed a GAN-based algorithm to recover the vein pattern. It directly learns from the vein image's robust feature representations to restore the finger-vein design, improving verification accuracy.

Xinwei Qiu et al. [4] created a novel approach using blurriness degree and noise distribution to distinguish real and forged images. Custom and public datasets were tested. Lu Yang et al. [5] proposed a model that combines vein pattern recognition with template matching to converge vein patterns and structures. Due to its user-prioritised threshold and tri-branch vein structure, it is highly effective at iterating imposter images and improving finger displacement and image quality. Raghavendra et al.[6] developed a low-cost finger vein sensor that can capture dorsal and ventral images. It has increased efficiency and speed with the best acceptance ratio, but poor application performance and couldn't meet network business demands.

Shuqiang Yang et al. [7] developed a GAN-based algorithm to recover the vein pattern. It directly learns from the vein image's robust feature representations to restore the finger-vein design, improving verification accuracy. Huabin Wang et al. [8] proposed a Weber descriptor integrated with varying Gabor filters to rectify finger-vein texture illumination. Its real-time implementation is complex and hasn't been thoroughly investigated, which slows down its evaluation process. Simon Kirchgasser et al. [9] created an ARH-based template protection scheme with lower recognition performance than warping but lower computation costs. The proposed scheme is error-prone and needs additional configuration to reach its full potential. The proposed scheme is error-prone and needs additional configuration to reach its full potential. S. Veluchamy et al. [10] proposed a biometric system with a multimodal construct that combines finger vein and finger knuckle images. A newly developed FFF optimisation performs a weight-based analysis to acquire the optimum accuracy for the extracted feature's fusion. It's accurate but computationally intensive.

Issues in Existing System

The system being managed by the companies today uses a database to store the information of the fingerprint/vein. Below mentioned are the disadvantages and primary issues an organisation might face with the recognition of attacks in the finger vein recognition system:

- Third-party interference makes the system even less secure.
- Significantly increasing capital and operating expenditures.
- Narrowly specialised knowledge.
- The complexity of its Real-Time Implementation.
- Third-party interference makes the system even less secure.
- Cannot meet current network business demands.
- Improper Feature extraction by the system.
- Ignorance of deformation data.

Summary of Literature Survey

As we move forward, we have analysed all the advantages and disadvantages proposed in the above papers. We have analysed every flaw and disadvantage of the proposed systems [102]. These flaws cannot be fixed as it requires a lot of change in the existing economic system, so we have provided a new method that probably won't have all the flaws mentioned in the previous papers [103]. This system concludes that the survey is done on all the papers and all the existing algorithms which have been taken into consideration. Then, the existing system's advantages and disadvantages have been studied thoroughly to get a desirable output [104].

System Architectural Design

This multi-phase architecture detects attacks in finger vein recognition. A dataset contains images of fingers like the ring, index, thumb, etc [105]. There are five separate finger vein images. The next step is image preprocessing and feature engineering, which involves applying filters, morphology, edge finding, and interpolation to extract useful features from the imagery [106]. Next, contour and edge finding determine the deformed fingers' external features. Downsizing images improves neural network training for a more reliable and accurate system. The dataset is augmented to include various orientations and angles of finger vein imagery. Finally, we train the CNN to identify an attack based on an input image [107-111].

System Architecture

This section discusses the various components of attack detection in finger vein recognition systems. The architecture has been divided into the following sub-steps [112].

Finger Vein Dataset

The finger vein images dataset is the primary dataset used for the project. The dataset contains finger vein image data of five types [113-117]. The five types are based on the deformation and are split into sets based on the deformations type [118]. The dataset also has fingers of different types, like ring and index. Middle and thumb for better detection by the model [119]. The finger vein image dataset will be loaded and manipulated using the cv2 package, which aids in the function of the OpenCV library. The finger vein images contain deformed images to signify the use of deformed fingers for better attack detection and accommodation during recognition [120].

Preprocessing and Feature Engineering

The Next step involved is preprocessing and Feature Engineering. These steps involve extracting and engineering features extracted from the image data [121]. The image is subject to filters like the Otsu filter, Kalman filter, binary thresholding and morphology, where erosion dilation and opening of the images are performed. These filters help extract internal vein images and external features of the image by enhancing them [122]. The steps of finding the edges and contours and applying bounding boxes help capture the external boundaries and features of the fingers, which the previous filters may not express (fig.9).

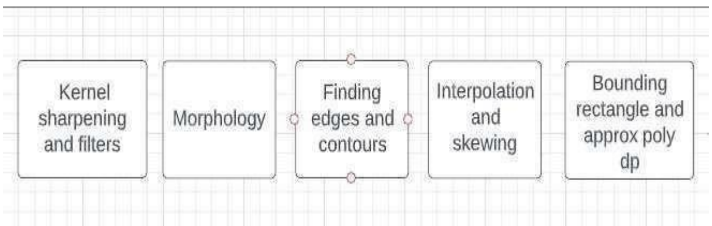

Figure 9: Preprocessing and Feature Engineering

Downsizing Images

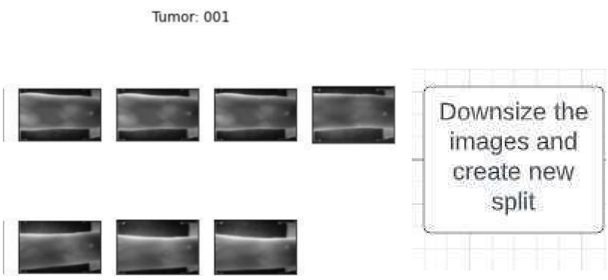

Figure 10: Downsizing

The dataset's downsizing is done to get the best possible images for the neural network training [123]. The downsized images are fewer, so the other image variations can be added for the augmentation step to increase the variety of the dataset [124]. The downsizing also helps in decreasing load and improving accuracy (fig.10).

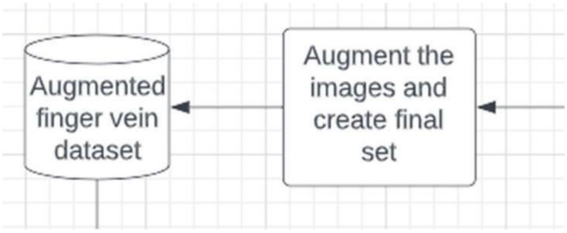

Figure 11: Dataset Augmentation

Augmentation of Dataset

The augmentation increases the dataset's diversity, adding more use cases and possibilities to the trainable images, in our case, finger vein imagery (fig.11). The finger veins images are augmented using the Image Data Generator function, which augments the dataset based on different orientations, angles and postures of the fingers for more accuracy and a better knowledge base in the model. From the augmentation, a dataset is created [125].

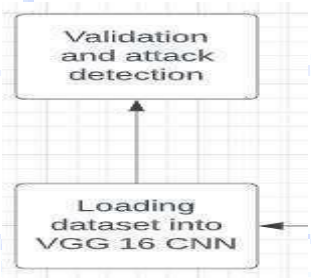

Figure 12 : VGG16 CNN Training

Training using VGG16 CNN

The final augmented dataset is then fed into the VGG16 CNN, which helps validate if a given image of a finger is a hit on the system. The validation results are based on the match using the features and data extracted from finger vein patterns [126]. The five types of sets are assigned as class labels for the data sets. Further, in validating the attack, the user provides an image of a finger vein, and the model returns the result of a match or no match in the system. If the results return as no match, then the image is an impostor match, thereby concluded to be an attack. The Proposed system Architecture is presented in figure 12, which portrays the culmination of all the sub as mentioned earlier steps to complete the architecture for the detection of attacks on the finger vein recognition, signifying the use of deformed finger vein image data [127].

System Module

Dataset for Operations

The dataset used for the study is a finger vein image dataset which is segregated into five types. The deformation of the finger is used as the criteria to differentiate based on the deformation pattern [128]. Not two fingers have the same kind of deformations, so there need to be accommodations for different kinds of deformation with suited image data available [129]. The deformations in the finger images ensure that the accommodations for posture variations are handled, thereby ensuring accuracy and better detection of attacks by the system with increased use cases (fig.13).

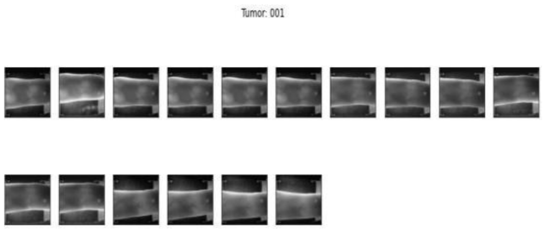

Figure 13 : Finger Dataset [13]

Preprocessing

The next step of the process is Preprocessing of the image data [130]. The preprocessing is done in multiple steps. Firstly, the sharpening of the image is done to increase the pixel density and sharpen the image. Next, the first set of filters is applied to an image of a particular set in the dataset. Otsu's thresholding, Threshold Binary and Adaptive Mean Thresholding are the filters used [131]. These filters are applied to get the features from the finger vein, which are both internal patterns and external features (fig.14).

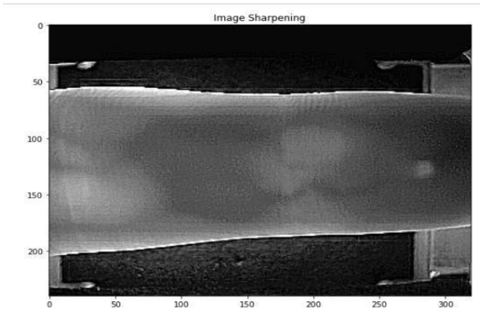

Figure 14 : Sharpening [12]

The Otsu filter involves repeating the threshold values and finding the expanse of the level of thresholds on each side, i.e., in the background and forefront. Equation (1) illustrates Otsu's thresholding, where wi0 and wi1 are the probability of the classes being split by a threshold k, and a20 and a21 are the class-exhibited variances [132-141].

$$a^2(k) = wi\,(t)a^2(k) + wi\,(k)a^2(k) \qquad (1)$$

w 0 0 1 1

The binary threshold filter helps create a binary image derived from a grayscale image. This filter works based on the threshold values provided [142]. An adaptive thresholding filter takes a grayscale image as an input and outputs a binary image based on the smaller regions or segments of the image. The image's background or foreground is set if the pixel value falls below the threshold [143]. The Gaussian blur filter helps obtain image data which is noise-free and smoothened [144-151]. The Gaussian blur filter works on the principle of the gaussian function, which is expressed in equation (2). of work algorithm is not needed here as the super node blockchain (fig.15).

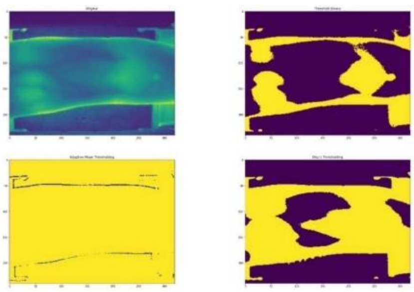
Figure 15 : Filters applied

For an image in the third set of deformations, morphology is performed. There are four kinds of operations performed. The dilation operation enlarges the regional boundary of the pixels in the foreground, thereby increasing the size of the area of pixels in the foreground [152-157]. The erosion operation helps in the erosion of the regional boundary of the pixels in the foreground, thereby reducing the size of the area of pixels in the foreground (fig.16).

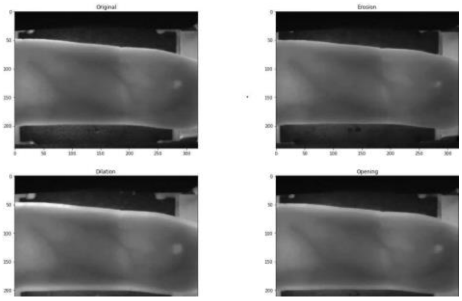

Figure 16 : Morphology

The opening operation aids in the erosion of image data and further induces dilation of the image subject to erosion. The closing operation does the opposite of the opening operation, inducing a dilation, after which the image is eroded. Another set of filters is used to extract the features of an image in the fourth set of deformations [158-161]. The Sobel filter is used forth the detection of edges in the image. The filter is operational, utilising the intensity of the image gradient to the pixels [162-167]. The filter is operational, utilising the intensity of the image gradient to the pixels. The Laplacian filter aids edge detection in an image using the secondary derivative by computing the rate change in the primary derivative (fig.17).

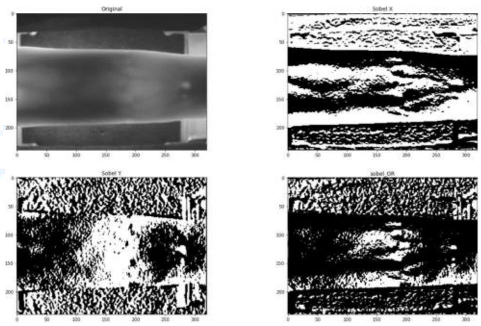

Figure 17: Second Set Filters

Feature Engineering

Feature Engineering is essential for selecting and using the perfect features extracted, which will be helpful for the training of the model [168]. The more features better the model turns out to be. Feature engineering is performed by finding canny edges, contours, skewing, interpolation and finding the biggest contour of the image. Finally, the images are cropped [169]. The canny edge detection filter detects edges in the image data using multiple stages of the algorithm [170]. For an image in the fifth dataset, interpolation and skewing of the image are done. Interpolation is changing the size of an image to determine the pixel value for the newly generated image derived from the original image.

For an image from one of the sets of five deformed finger vein dataset, the Kalman filter, median filter and gaussian filter is applied [171-175]. The Kalman and median filter is essentially used for noise removal from the imagery, utilising a slider which determines the amount of filtration based on the size of the template. Next, an image is subject to evaluation of the number of canny edges and contouring [176-181]. The canny edge detection methodology works on multiple algorithm stages and labels the data (fig.18).

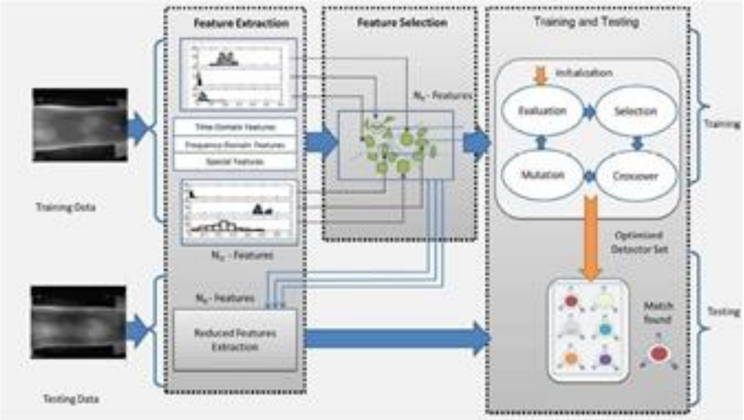

Figure 18 : Flow for feature engineering and matching

The contouring is done to obtain the contours, a defined bound around an object with edges [182-185]. A bounding rectangle and approxpolydp used to define the shape of the contour in the image are applied. These features, especially involving contours and canny edges, are essential when dealing with deformations in finger veins. Further, the images' biggest contour, extreme points and cropping are made. The images are cropped for better detection and efficiency of the system (fig.19).

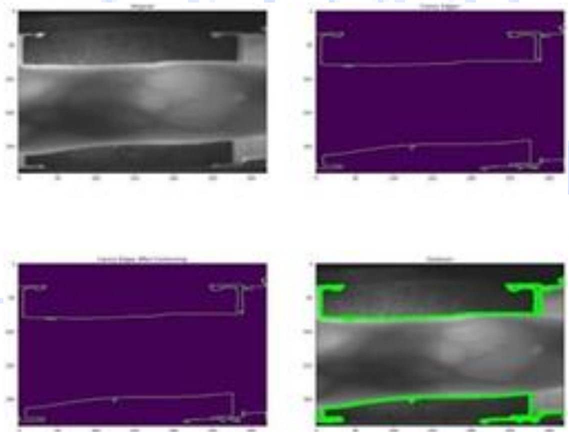

Figure 19 : External Feature Extraction

Training

The images are cropped for better detection and efficiency of the system. The images in each of the five classes in the dataset are downsized and augmented. The augmentation increases the diversity of image data in the dataset. In this particular use case, the finger vein is augmented to various angles and orientations for better accurate results by the model. The Image Data Generator function is used for this purpose.

The final dataset containing the original and augmented images is produced and saved for training and validation in the convolutional neural network. The images are then loaded into the VGG16 convolutional neural network. The different deformations sets are labelled using the class labels split into five classes. The activation function used is Softmax, the optimiser used by the model is Adam, and for loss, categorical cross entropy is employed (fig.20).

```
=================================================================
Total params: 14,893,893
Trainable params: 179,205
Non-trainable params: 14,714,688
_________________________________________________________________
```

Figure 20 : Parameters for VGG16

The neural network performs the function of matching a given image with the image data present in the set based on the features which were extracted and loaded. It takes an image, compares it with the five deformation classes, and validates if the image belongs to one of the five classes. Further, the model is saved and is used to identify if it is an attack attempt based on an input image of the finger vein image (fig.21).

```
Epoch 1/50
4/4 [==============================] - 18s 4s/step - loss: 2.2149 - accuracy: 0.3100 - val_loss: 2.7270 - val_accuracy: 0.2000
Epoch 2/50
4/4 [==============================] - 16s 4s/step - loss: 2.3626 - accuracy: 0.4100 - val_loss: 1.3273 - val_accuracy: 0.6000
Epoch 3/50
4/4 [==============================] - 16s 4s/step - loss: 1.3272 - accuracy: 0.5200 - val_loss: 1.2395 - val_accuracy: 0.5250
Epoch 4/50
4/4 [==============================] - 16s 4s/step - loss: 0.9684 - accuracy: 0.5900 - val_loss: 0.4766 - val_accuracy: 0.9500
Epoch 5/50
4/4 [==============================] - 16s 5s/step - loss: 0.7664 - accuracy: 0.7300 - val_loss: 0.9532 - val_accuracy: 0.6000
Epoch 6/50
4/4 [==============================] - 17s 4s/step - loss: 0.7955 - accuracy: 0.6700 - val_loss: 0.4160 - val_accuracy: 0.8500
Epoch 7/50
4/4 [==============================] - 16s 4s/step - loss: 0.5626 - accuracy: 0.8200 - val_loss: 0.2955 - val_accuracy: 0.9500
```

Figure 21: Training Epochs

The attack detection system, aided with images of finger vein deformation, is elucidated. The steps involve preprocessing of the finger images and feature extraction. After the meaningful features are extracted, it is augmented and downsized to be trained by the VGG16 Convolutional neural network. The neural network validates if an image is a perfect match in the system or is an attack attempt.

Module Implementation

The core system to be built consists primarily of the properties that must be realised in human movement and actions. As a result, the development of this type of system becomes highly useful for the system to understand and then provide a result based on the user’s input. The primary system responsible for the input of human contact and movement is entirely accountable for the system’s configuration. As a result, a suitable system is required to function in a way that allows the user to comprehend how it works, assisting users who are impaired or unable to move. This would assist users in comprehending the computer’s response to the processing and integration of input to produce the desired result. As a result, the user must understand how the system works and acts accordingly.

Overview of the Platform

The proposed system was implemented using Jupyter notebook for python, with an i7 processor of 4.0 GHz,16 GB Ram and 60 GB of hard disk storage. The TensorFlow package is used to train the neural network VGG16 used in the model. The ImageDataGenerator package is essential and is used for augmenting the finger vein images to make the system more accurate and robust. The Sci-kit learn library, particularly the image sub-library, helps use various image manipulation techniques for the image data. The cv2 package incorporates OpenCV, which helps access, load and manipulate the image. The images in each of the five classes in the dataset are downsized and augmented. The augmentation is done to swell the variation of image data in the dataset. In this particular use case, the finger vein is augmented to various angles and orientations for better accurate results by the model. The ImageDataGenerator function is used for this purpose.

Implementation Details

The neural network used in this system is the VGG16 convolutional neural network. The architecture of VGG16 is primarily applied to visual recognition and is based on gradient learning. The architecture is robust and small, reducing the system's load and improving efficiency. The VGG16 is instrumental in decreasing the number of parameters while keeping the performance in mind. The model can deduce the patterns with maximum variations. For instance, using dual layers of filters of 3X3 is equivalent to a single layer of filters of 5X5, and the parameters are significantly reduced. The total parameters for the convolutional neural network model are 14,89,983, training parameters are 179,205, and non-trainable parameters are 14,714,688. The classes are assigned based on deformations. The image dimensions are 320x240 for the neural network for easier training. The batch sizes are 16. The neural network is trained for 50 epochs.

Algorithm

Algorithm 1: Algorithm for the Proposed system

Input: Finger vein imagery classified as 5 different deformation sets
Output: validation if the finger vein images match with the system

```
Load dataset path into the system
for image in each of the five different deformation sets do
    Pre-processing using kernel sharpening
    Apply first set of filters for image in a set
    Perform morphology using operations for image in a set
    Perform interpolation and skewing
    Find canny edges and contour for external features
    Apply bounding rectangle and approxpolydp for external features
end
Get train test split and validation split based on features extracted
for image in dataset do
    Find biggest contour, edges and crop the image data
end
Downsize images in each set and create new split
for images in new dataset do
    augment images and get final augmented datset
end
Load data into VGG 16 CNN and validate if the finger vain imagery is
a match.
```

Elucidates the algorithm for the proposed system

Implementation Screenshots

The illustrations below show the various stages of implementation for the recognition of attack in the finger vein recognition system (figs. 22 and 23).

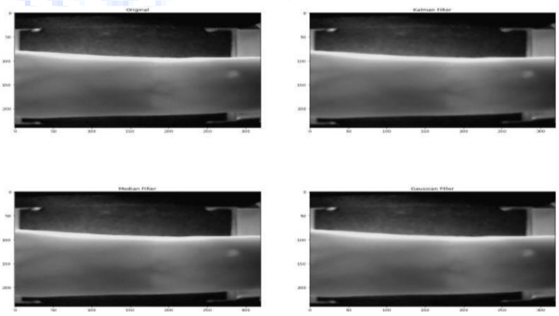

Figure 22: Morphology

Figure 23: Feature Engineering

The Proposed system was successfully implemented, and the algorithm was elucidated, which shed light on different steps involved in detecting attacks on the finger vein recognition system. With the screenshots of implementation, the working flow of the project was further analysed to get familiar with the steps involved in the successful deployment of the system.

Results and Discussion

This chapter will discuss the performance analysis of the neural network-based attack detection in the finger vein recognition model.

Analysis of Result and Output

Figure 24: Count of features in the set

Fig 24 shows the number of features recorded in the first train test and validation split after extracting the features after preprocessing and feature engineering. The train set had 21 features, the validation set had 7, and the test set had 8. The splits yield 100, 40 and 35 images, respectively. This metric is further boosted when the dataset is augmented, and the additional images are added before feeding the data to the VGG16 convolutional neural network. The figure below, Fig. 25 shows the distribution of image ratios for the datasets belonging to the various deformation. The distribution of image ratio is 1.4 to almost 175 images.

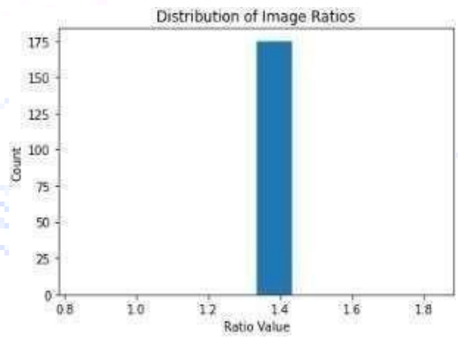

Figure 25: Distribution of image ratios

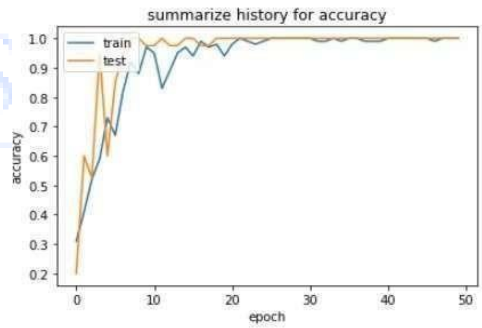

Figure 26: Accuracy history summarisation

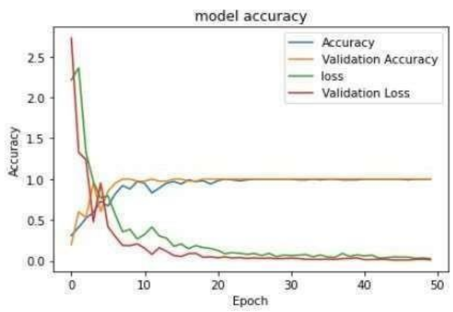

Figure 27: Train test validation accuracy

Figs. 26 to 27 show that the validation accuracy rises for both sets due to the model's efficiency. Also, the loss and validation loss decrease at the end of training. This is because of the feature extraction owing to applying filters, morphology, canny edges and contour detection, interpolation and skewing of the images. The downsizing of images helps choose the best possible image data, and augmentation of the dataset before training by the neural network increases the number of use cases. Further, the neural networks can produce output not exclusive to the input. The neural network architecture can edify its examples and use it properly when similar circumstances occur (table 1).

Search Technique	Average Precision %	Average Recall %	Average Accuracy %	F- Measure
FDCSF [1]	74.12	76.08	75.10	75.08
FVRD [2]	74.02	78.47	75.42	75.22
FPRGN [3]	82.12	85.12	79.62	80.59
Proposed VGG16 System	83.14	86.28	81.21	82.16

Table 1: Comparison of performance with baseline models

The performance of the proposed system has been analysed and discussed in this session. The image distribution ratio, feature count, and dataset split were studied. Ultimately, the neural network's performance based on the accuracy and loss on validation was elucidated with pictorial graph representations for all the results discussed.

Conclusion

In this paper, we propose a convolutional neural network-based approach for detecting finger vein recognition system attack attempts. This model uses a large dataset of deformed finger images to represent finger deformations during scanning. We use five types of deformed finger vein images. Using filters, morphology, and canny edges and contour detection, we extract meaningful features. Downsizing and augmenting the images creates a final dataset split for neural network training. The VGG16 neural network verifies if a finger vein image matches those in the system and predicts an attack attempt. The proposed system provides best-in-class results with higher accuracy and less loss due to the neural network methodology, which works with a variety of use cases and incorporates deformation as an essential feature in identifying matching finger vein imagery and predicting authentication attacks. Though deformation is key to detecting finger vein recognition attacks, our project can be improved. We're improving our neural network architecture to add more trainable parameters. We plan to extract more meaningful data from image data using state-of-the-art filters and morphological techniques. We plan to expand our dataset, adding more normal and deformed finger images for better model training.

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