PalmSecure - Revolutionizing Transport with Biometric Precision

Project Proposal

Group Members:

- Muhammad Talha Bilal (21K-3349)
- Muhammad Hamza (21K-4579)
- Muhammad Salar (21K-4619)

Project Supervisor:

Name: Dr. Muhammad Atif Tahir
Designation: Head of School (Computing)
Email: atif.tahir@nu.edu.pk

Head of Department Details:

Name: Dr. Muhammad Atif Tahir
Email: atif.tahir@nu.edu.pk

Project Details

Project Title: PalmSecure - Revolutionizing Transport with Biometric Precision

Project Duration: August 2024 to May 2025

Project Area of Specialization:

- Biometrics (Palmprint recognition)
- Deep Learning
- Mobile Application Development
- Computer Vision

Project Summary

In today's fast-paced transportation landscape, security breaches and unauthorized access pose significant threats to passenger safety, operational efficiency, and revenue protection. To address this pressing concern, our innovative mobile application harnesses the unparalleled security of palmprint biometrics, revolutionizing identity verification in the transport sector. Leveraging the unique features of palmprints, including ridges, wrinkles, and minutiae, our solution ensures unbeatable security, accuracy, and reliability, while staying ahead of emerging security threats.

Our project aims to develop a cutting-edge palmprint verification system tailored for the transport industry, delivering enhanced security and optimized performance.

System Development
To achieve this goal, we will:

- Develop a functional palmprint verification system utilizing the Comprehensive Competition Network approach
- Train and test the system using a locally collected dataset to demonstrate its effectiveness in improving recognition accuracy
- Evaluate the system's performance and identify areas for enhancement

Mobile Application
The resulting mobile application will:

- Provide a user-friendly interface for palmprint verification and authentication
- Efficiently verify passenger identities
- Protect against identity theft and fraud
- Safeguard passengers, assets, and operations
- Ensure seamless user experience, robust security, and efficient integration with existing transport infrastructure

Key Benefits
Our solution offers:

- Enhanced security through advanced palmprint verification technology
- Improved passenger identity verification and protection
- Increased operational efficiency and reduced risk of identity theft and fraud
- A future-proof transportation landscape

Project Outcome
By systematically developing and refining our palmprint verification system, we will deliver a comprehensive mobile application that sets a new standard for transport security, paving the way for a more secure, efficient, and future-proof transportation landscape.

Project Objective

The primary goal of this project is to overcome the limitations of existing biometric verification systems in the transport industry by integrating cutting-edge palmprint recognition techniques. This innovative approach addresses the shortcomings of traditional biometric methods, including:

- Sensitivity to environmental factors (lighting, temperature, etc.)
- Health concerns associated with contact-based systems
- Suboptimal accuracy due to limited feature extraction mechanisms

Comprehensive Competition Network*: A Deep Learning Solution*
To overcome these challenges, our project leverages the Comprehensive Competition Network approach, utilizing deep learning techniques to:

- Extract multi-order texture and spatial features
- Enhance recognition accuracy and robustness
- Ensure high-performance palmprint verification

Mobile Application: Secure and Efficient Biometric Solution
Our mobile app integration offers:

- Non-contact, hygienic biometric verification
- Efficient passenger identity verification
- Easy deployment and scalability for future transport systems

Future Expansion
This innovative solution has potential applications beyond the transport industry, including:

- Banking and ATM verification systems
- Access control systems for secure facilities
- Identity verification for border control and law enforcement

Project Impact

By developing an advanced palmprint recognition system, we aim to:

- Enhance transport security and passenger safety
- Improve operational efficiency and reduce identity-related risks
- Provide a scalable, future-proof biometric solution for various industries.

Literature Review

Biometric identification has become increasingly prevalent in modern society, with applications in electronic payment, entrance control, and forensic identification. Palmprint recognition has emerged as a reliable and efficient solution for person identification due to its rich biometric information and high antispoof capability. Palmprint images can be categorized into touch-based and touchless, with the latter preferred for their hygiene and convenience, especially during the current epidemic situation.

Palmprint recognition has gained significant attention in recent years due to its high accuracy and reliability. Various approaches have been proposed to improve palmprint recognition, including the Comprehensive Competition Mechanism [1], Coordinate Attention (CA) [2], Competitive Neural Network (CNN) [3], CO3Net [4], and 3D Gabor template with block feature refinement [5] and PalmNet [6].

The Comprehensive Competition Network approach [1] proposes a novel framework for palmprint recognition by introducing a comprehensive competition mechanism. This mechanism enables the network to learn robust features by competing with each other. However, this approach relies on a complex network architecture and requires a large amount of training data.

The CA approach [2] introduces a coordinated attention mechanism to selectively focus on informative regions in palmprint images. This approach has shown promising results in palmprint recognition, but its reliance on supervised training and complex network architecture may limit its generalizability.

The CNN approach [3] proposes a competitive neural network for palmprint recognition. This approach enables the network to learn discriminative features by competing with each other. However, this approach requires a large amount of training data and may not generalize well to unseen data.

The CO3Net approach [4] proposes a coordinate-aware contrastive competitive neural network for palmprint recognition. This approach enables the network to learn robust features by leveraging coordinate information and contrastive learning. However, this approach relies on a complex network architecture and requires a large amount of training data.

The 3D Gabor template with block feature refinement approach [5] proposes a novel framework for touchless palmprint recognition. This approach enables the network to learn robust features by leveraging 3D Gabor templates and block feature refinement. However, this approach may not generalize well to unseen data and requires a large amount of training data.

PalmNet [6] proposes a Gabor-PCA convolutional network for touchless palmprint recognition. This approach has shown promising results in palmprint recognition, but its reliance on pre-trained filters and complex network architecture limits its generalizability.

To overcome the limitations of these approaches, our project proposes the implementation of the Comprehensive Competition Network approach [1]. Comprehensive Competition Network has demonstrated superior performance in palmprint recognition by extracting multi-order texture and spatial features. Comprehensive Competition Network addresses the limitations of existing approaches by providing robust feature extraction mechanisms, eliminating the need for class labels or pre-trained filters, improving recognition accuracy and robustness, and reducing computational complexity and memory requirements.

In conclusion, our literature review highlights the advancements and limitations of existing palmprint recognition approaches. By implementing the Comprehensive Competition Network approach, our project aims to develop a non-contact, hygienic, and efficient palmprint recognition system for the transport industry, providing a robust and generalizable solution for person identification.

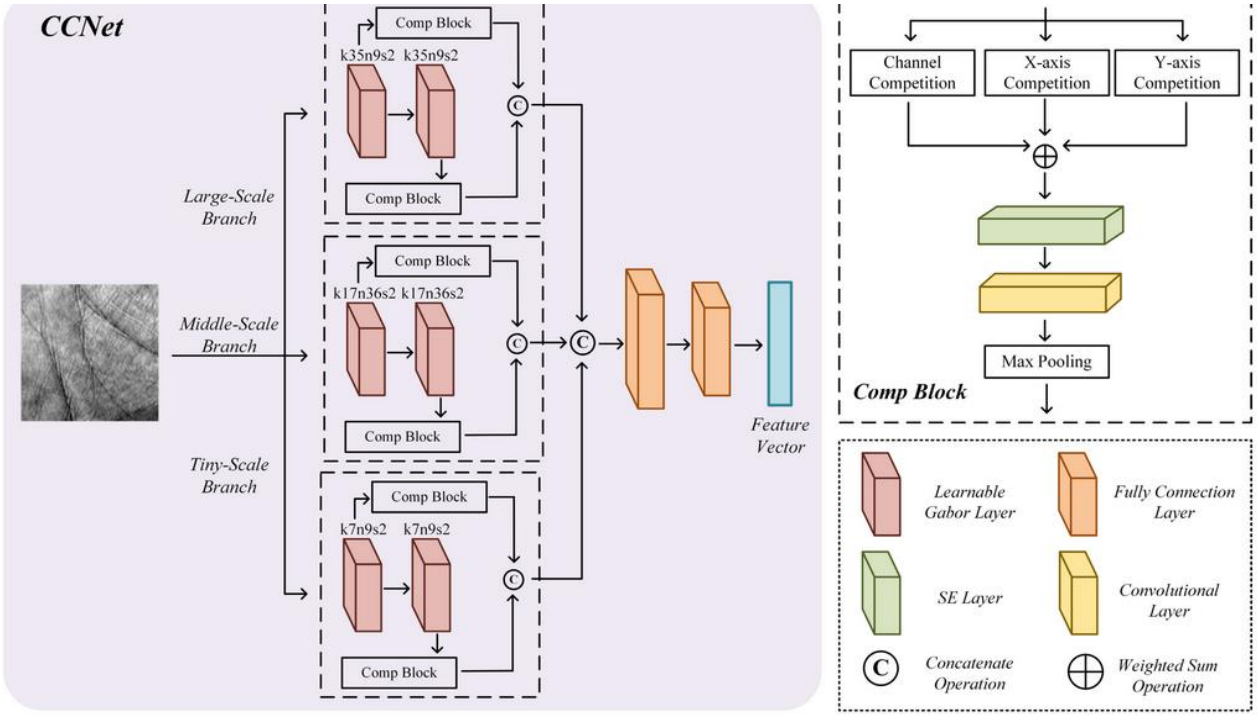


Fig. 1. The whole framework of the proposed CCNet consists of three feature extraction branches for multi-scale texture competition. Each branch contains two learnable Gabor layers. The proposed Comp Block extracts the competition features. 'k', 'n' and 's' represent kernel size, number of filters, and the stride, respectively.

Project Implementation Method

Our project aims to develop a non-contact, hygienic, and efficient palmprint recognition system for the transport industry using the Comprehensive Competition Network approach. The system will be built around the Comprehensive Competition Network architecture, which integrates spatial, channel, and multi-order competition features into a palmprint verification model.

Methodology
The Comprehensive Competition Network methodology involves the following steps:

1. **Data Collection:**
    - Collect a local palmprint dataset for testing purposes
    - Utilize publicly available datasets for training purposes, including:
        - IIT Delhi Touchless Palmprint Database
        - The Hong Kong Polytechnic University Contact-free 3D/2D Hand Images Database
        - CASIA Multispectral Palmprint Image Database
        - Tongji Contactless Palmprint Dataset

2. **Data Augmentation:**
    - Perform data augmentation techniques to increase diversity and robustness, including:
        - Rotation
        - Scaling
        - Translation
        - Illumination variations

3. **Model Training:**
    - Train the model using the augmented dataset
    - The model consists of:
        - Spatial Competition Module (extracts spatial features)
        - Channel Competition Module (extracts channel features)
        - Multi-Order Competition Module (extracts multi-order features)

4. **Model Deployment:**
    - Deploy the trained model using a Docker containerized environment for scalability and ease of deployment.

Mobile Application Development

We will develop a mobile application using React Native to provide real-time verification capabilities. The app will interface with the model to:

1. Capture Palmprint Images:
    - Capture high-quality palmprint images using the mobile device's camera
    - Preprocess images to enhance quality and remove noise
2. Verify Identity:
    - Send preprocessed images to the model for verification
    - Receive verification results from the model
3. Display Results:
    - Display verification results to the user

Tools and Technologies

We will use the following tools and technologies to implement the project:

1. TensorFlow: Build and train the model
2. PyTorch: Build and train the model
3. React Native: Develop the mobile application
4. Docker: Deploy the model in a containerized environment

By following this implementation plan, we aim to develop a robust and efficient palmprint recognition system for the transport industry.

Technical Details

The project's core module, Comprehensive Competition Network, will process palmprint images by extracting multi-scale texture features. We will utilize learnable Gabor filters to extract these features across multiple channels and perform competition mechanisms along both spatial and channel dimensions.

Our mobile app will integrate this technology, allowing for real-time palmprint scanning and verification. Data augmentation techniques such as rotation, scaling, and flipping will be applied to enhance model robustness. A FastAPI-based backend will handle the interactions between the app and the recognition model, ensuring fast and secure data processing.

Details of Final Deliverable

After the project, we will deliver a fully functional mobile application capable of performing real-time palmprint verification. The app will feature a simple, user-friendly interface, enabling users to scan their palms and receive verification results within seconds. Additionally, we will provide a trained model tailored to the specific dataset collected during the project, along with the backend server infrastructure for deploying the model. The application will also include provisions for future expansion into other industries, such as banking and ATMs, by extending the palmprint verification system to these sectors.

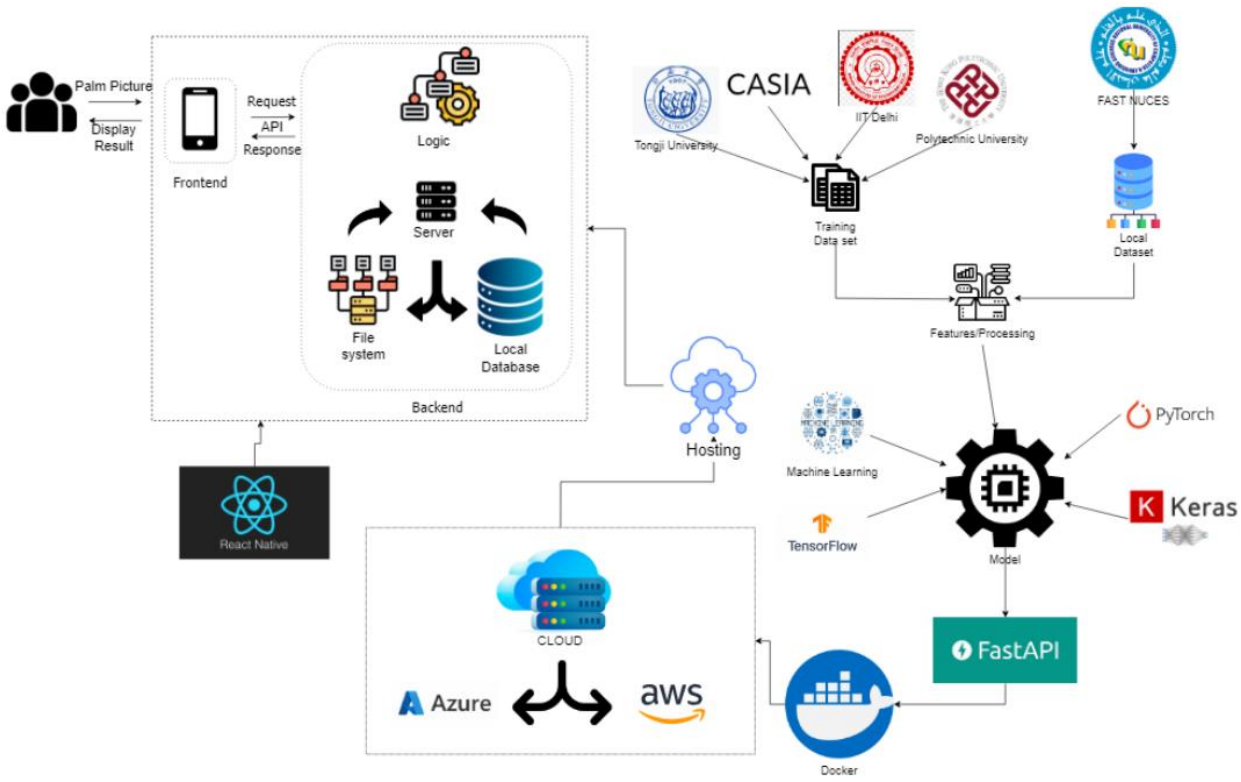
Core Industry

- Transportation - Transportation systems are highly susceptible to security breaches, unauthorized access, and identity fraud. These vulnerabilities pose significant threats to passenger safety, operational efficiency, and the financial integrity of transport operators. This project aims to directly address these challenges through the deployment of a cutting-edge palmprint verification system.

Other Industries

- Banking and Financial Services (Secure ATM transactions with accurate identity verification).
- Healthcare (Ensure accurate patient identification and secure medical record access).
- Law Enforcement (Strengthen border control and identity verification with precise biometric authentication).

System Diagram



Core Technology

- Deep Learning (Comprehensive Competition Network)
- Learnable Gabor Filters
- Mobile Application Development
- Computer Vision

Other Technologies

- Data Analytics (for performance evaluation and enhancement)
- Data Gathering and Cleaning
- Containerization and Orchestration
- User Interface Design Tools
- Cloud Computing
- API Integration

Benefits of the Project

The palmprint verification system will significantly enhance current identity verification processes in the transportation sector by offering a non-contact, hygienic, and secure alternative to traditional methods.

Key Benefits:

- **Enhanced Security**: Reduces the risk of identity-related crimes, such as fraud and theft.
- **Hygienic Alternative**: Provides a non-contact solution, minimizing health concerns.
- **Industry-Wide Applicability**: Adaptable to diverse industries, setting a new standard for security and efficiency.

Impact on Industries:

The implementation of this system will have a profound impact on various industries, including:

- **Transportation**: Improves passenger safety and security, reducing identity-related crimes.
- **Banking and ATMs**: Extensibility to banking and ATMs reduces fraud and improves security standards for sensitive transactions.
- **Healthcare**: Enables accurate patient identification and secure access to medical records.

Contributions to Research and Development:

This project contributes to academic and industrial research by:

- **Academic Contributions**: Providing an efficient solution based on the latest advancements in biometric recognition technology.
- **Industrial Research**: Driving innovation and advancement in biometric technology, paving the way for further breakthroughs.

Sustainable Development Goals

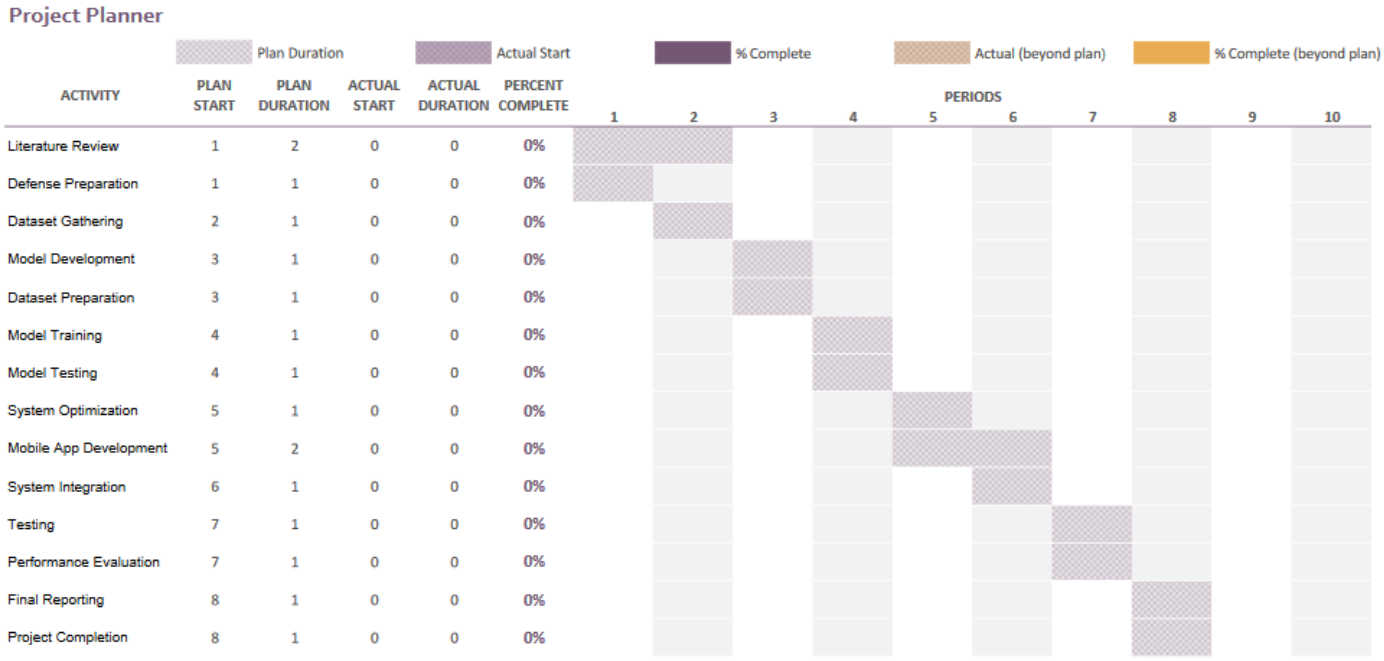
- Industry, Innovation, and Infrastructure (building resilient infrastructure and fostering innovation)
- Sustainable Cities and Communities (making transportation systems safer and more efficient)
- Peace, Justice, and Strong Institutions (promoting strong identity verification to reduce crime and fraud)

Project Key Milestones

Elapsed time in (days or weeks or month or quarter) since the start of the project	Milestone	Deliverable
Month 1	**Literature Review & Defense Preparation** The project begins with a comprehensive literature review on palmprint biometrics and its approaches. The objectives are to identify existing methods, their strengths, and weaknesses, and understand the state-of-the-art techniques in palmprint verification. Tasks include reviewing academic papers, articles, and industry reports, summarizing key findings, identifying gaps in current research, and preparing a detailed report	● Literature Review ● FYP Project Proposal & Defense.
Month 2	**Literature Review & Dataset Gathering** The focus shifts to identifying publicly available palmprint datasets and planning for local dataset collection. The objectives are to identify existing datasets, plan for local data collection, prepare and deliver the FYP defense presentation, and finalize the project plan based on feedback. Tasks include reviewing publicly available datasets, developing a plan for local data collection, finalizing the FYP defense presentation, presenting the defense, and revising the project plan	● Identified Data Sources (public datasets) for training ● FYP Defense Presentation ● Updated Project Plan
Month 3	**Model Development & Dataset Preparation** Model development and dataset preparation take center stage. The objectives are to begin developing the initial version of the palmprint verification model and start collecting local palmprint data. Tasks include developing the initial version of the Comprehensive Competition Network model, setting up	● Initial Prototype of the Model ● Start of Local Dataset Collection ● Preprocessing Pipeline Setup

	infrastructure for local data collection, ensuring ethical standards are met, and beginning local data collection	
Month 4	**Model Training & Testing** The focus is on model training and testing. The objectives are to train the palmprint verification system using collected datasets, test and evaluate system performance, and identify areas for improvement. Tasks include training the model, conducting initial testing, analyzing results, and documenting findings.	● Trained model ● Interim Model Performance Report ● Improvement plan
Month 5	**System Optimization & Mobile App Development** System optimization and mobile app development are the focus. The objectives are to optimize the palmprint verification system, design a user-friendly interface for the mobile app, and develop a secure backend system. Tasks include optimizing the model, designing the UI, developing the backend system using FastAPI, and ensuring security and efficiency.	● Optimized Palmprint Model ● Mobile App UI Prototype ● Model Artifact
Month 6	**App Development and System Integration** App development and system integration take center stage. The objectives are to implement key mobile app features, integrate the model with the mobile app, and conduct integration testing. Tasks include implementing features like real-time palmprint scanning, integrating the model with the app, conducting integration testing, and documenting the process.	● Full Feature Development of the Mobile App ● Integrated Model with Mobile App ● System Integration Testing Report
Month 7	**Testing and Performance Evaluation** App development and system integration take center stage. The objectives are to implement key mobile app features, integrate the model with the mobile app, and conduct integration testing. Tasks include implementing features like real-time palmprint scanning, integrating the model with the app, conducting integration testing, and documenting the process.	● Local Dataset Testing and Report ● User Acceptance Testing (UAT) Results ● Final System Performance Evaluation Report

Month 8	**Final Reporting & Project Completion** The final month focuses on reporting and project completion. The objectives are to prepare the final project report and documentation, present project outcomes, and recommend future work. Tasks include preparing a comprehensive final report, documenting the project process, preparing a presentation, and recommending future work.	• Final Optimized Model and App • Complete Project Documentation • Presentation slides • Final project report



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Literature Review	1	2	0	0	0%
Defense Preparation	1	1	0	0	0%
Dataset Gathering	2	1	0	0	0%
Model Development	3	1	0	0	0%
Dataset Preparation	3	1	0	0	0%
Model Training	4	1	0	0	0%
Model Testing	4	1	0	0	0%
System Optimization	5	1	0	0	0%
Mobile App Development	5	2	0	0	0%
System Integration	6	1	0	0	0%
Testing	7	1	0	0	0%
Performance Evaluation	7	1	0	0	0%
Final Reporting	8	1	0	0	0%
Project Completion	8	1	0	0	0%

References:

[1] Z. Yang, H. Huangfu, L. Leng, B. Zhang, A. B. J. Teoh and Y. Zhang, "Comprehensive Competition Mechanism in Palmprint Recognition," in IEEE Transactions on Information Forensics and Security, vol. 18, pp. 5160-5170, 2023, doi: 10.1109/TIFS.2023.3306104.

[2] Hou, Qibin, Daquan Zhou and Jiashi Feng. “Coordinate Attention for Efficient Mobile Network Design.” in 2021 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 13708-13717, 2021, doi: 10.1109/CVPR46437.2021.01350.

[3] X. Liang, J. Yang, G. Lu and D. Zhang, "CompNet: Competitive Neural Network for Palmprint Recognition Using Learnable Gabor Kernels," in IEEE Signal Processing Letters, vol. 28, pp. 1739-1743, 2021, doi: 10.1109/LSP.2021.3103475.

[4] Z. Yang et al., "CO3Net: Coordinate-Aware Contrastive Competitive Neural Network for Palmprint Recognition," in IEEE Transactions on Instrumentation and Measurement, vol. 72, pp. 1-14, 2023, Art no. 2514114, doi: 10.1109/TIM.2023.3276506.

[5] Xu Liang, Zhaoqun Li, Dandan Fan, Jinxing Li, Wei Jia, David Zhang, Touchless palmprint recognition based on 3D Gabor template and block feature refinement, in Knowledge-Based Systems, vol. 249, 2022, 108855, ISSN 0950-7051, doi: 10.1016/j.knosys.2022.108855.

[6] A. Genovese, V. Piuri, K. N. Plataniotis and F. Scotti, "PalmNet: Gabor-PCA Convolutional Networks for Touchless Palmprint Recognition," in IEEE Transactions on Information Forensics and Security, vol. 14, no. 12, pp. 3160-3174, Dec. 2019, doi: 10.1109/TIFS.2019.2911165.