OXFORD BROOKES UNIVERSITY

Intelligent Self-service Electric Charging System using Face Recognition

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CDUT Sino-British Collaborative Education

BSc Computer Science

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Introduction

Objective of the Project: Develop a FaceEV platform.

Key Technologies Integrated:
(1) Deep learning.
(2) Flask.
(3) Pytorch's MTCNN for accurate face detection.
(4) FaceNet for improved identification verification.

System Benefits: Secure and efficient electric charging system.

Research Insights:
(1) Provides valuable insights for implementing facial recognition across various domains.
(2) Showcases the role of advanced technology in solving modern challenges.

Motivations

Why this project?

The FaceEV project aims to improve the efficiency and security of electric vehicle (EV) charging stations by providing a reliable facial recognition system for user identification.

What is the problem?

(1) Existing systems lack strong identity verification mechanisms.

(2) Potential issues:

a. Fraud

b. Security breaches

c. Inefficient use of charging stations

Why is it interesting?

(1) FaceEV utilizes advanced deep learning and image processing technologies.

(2) Features:

a. Seamless, multi-tiered facial recognition system

b. Accurate user identification using MTCNN, FaceNet, OpenCV, and Dlib

(3) Benefits:

a. Enhanced security and efficiency

b. Provides significant insights for deploying FR

c. Demonstrates innovative use of modern algorithms

CONTENTS

PART ONE

Background Review

Comparison of some face models

Model	Accuracy (LFW)	Limitations
GhostFaceNetV2-1 [5]	0.998667	There are limitations in terms of robustness and widespread applicability in specific application scenarios.
Prodpoly[6]	0.99833	Difficult to assess its performance and application range.
FaceNet[7]	0.996	Despite having good performance, there may still be challenges in dealing with extreme poses, expressions, or obstructions.
DiscFace[8]	0.9983	There may be challenges when there is insufficient training data or when categories are too finely divided.
DCQ[9]	0.998	A lack of detailed information makes it difficult to accurately assess its features and limitations.
EdgeFace-S[10]	0.9978	In pursuing lightweight and efficiency, there may be a sacrifice in recognition accuracy or robustness.
CircleLoss[11]	0.9973	Its performance highly depends on the network architecture and the quality of training data.
EdgeFace-XS[12]	0.9973	In pursuing lightweight and efficiency, there may be a sacrifice in recognition accuracy or robustness.
QMagFace[13]	0.9850	The details and application range of specific technologies may limit their general applicability.
OcularAI-Face[14]	0.945	Focusing on specific areas may mean that the recognition effect is limited when facing full-face obstructions or non-standard expressions.

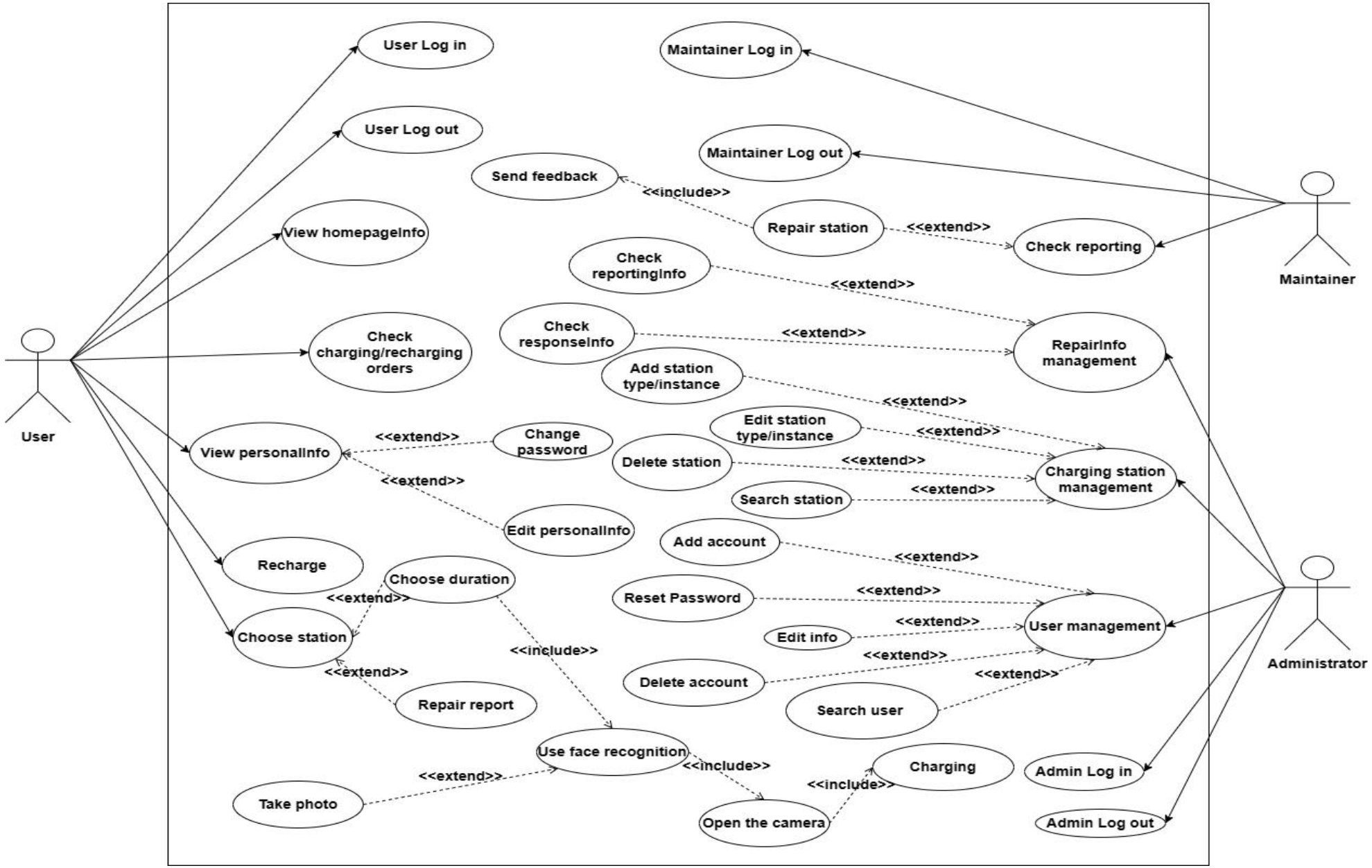
PART TWO

Methodology

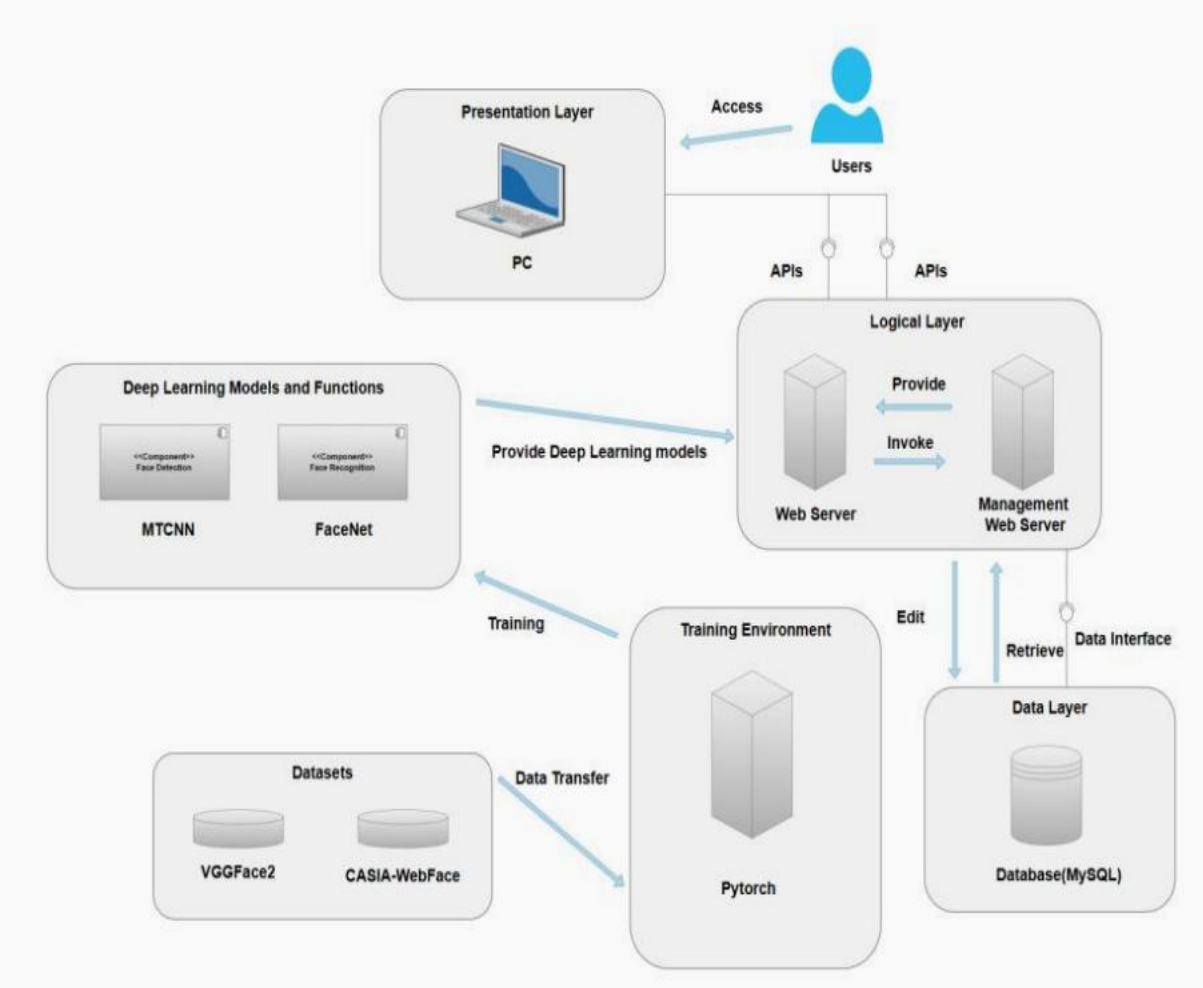
System Design

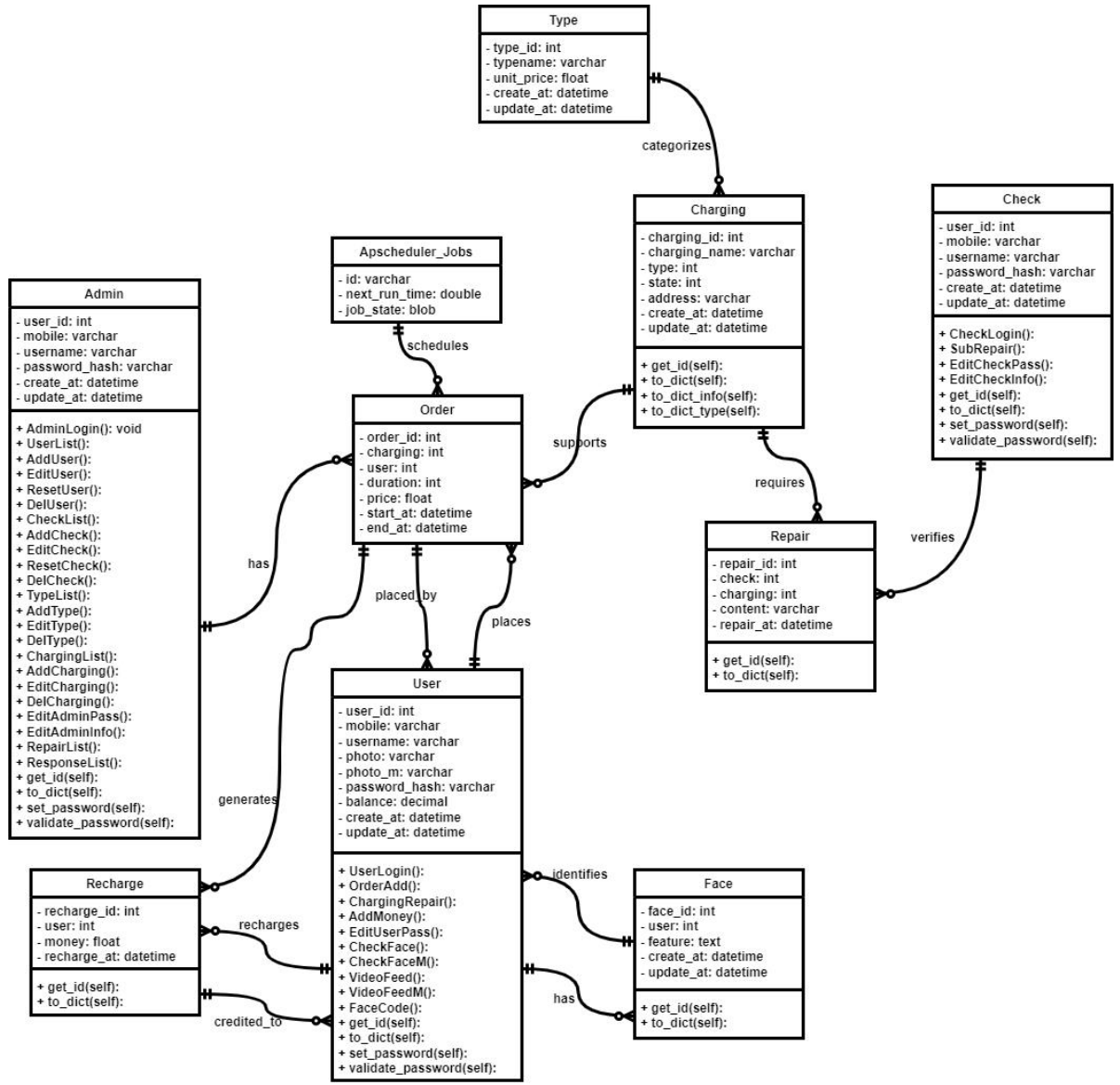
1. User requirement analysis
2. System architecture design
3. Component design
4. The process of face recognition function

User requirement analysis

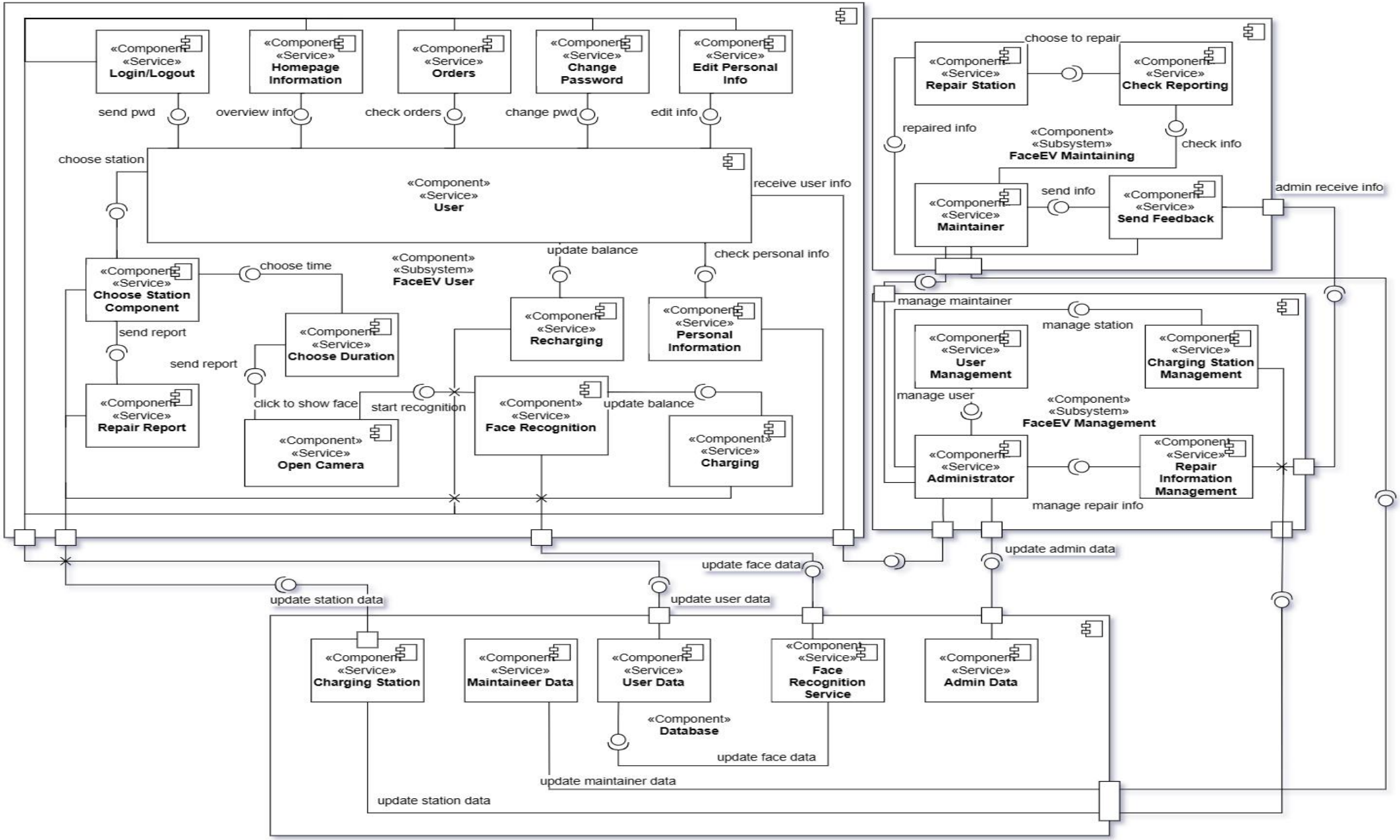


System architecture design

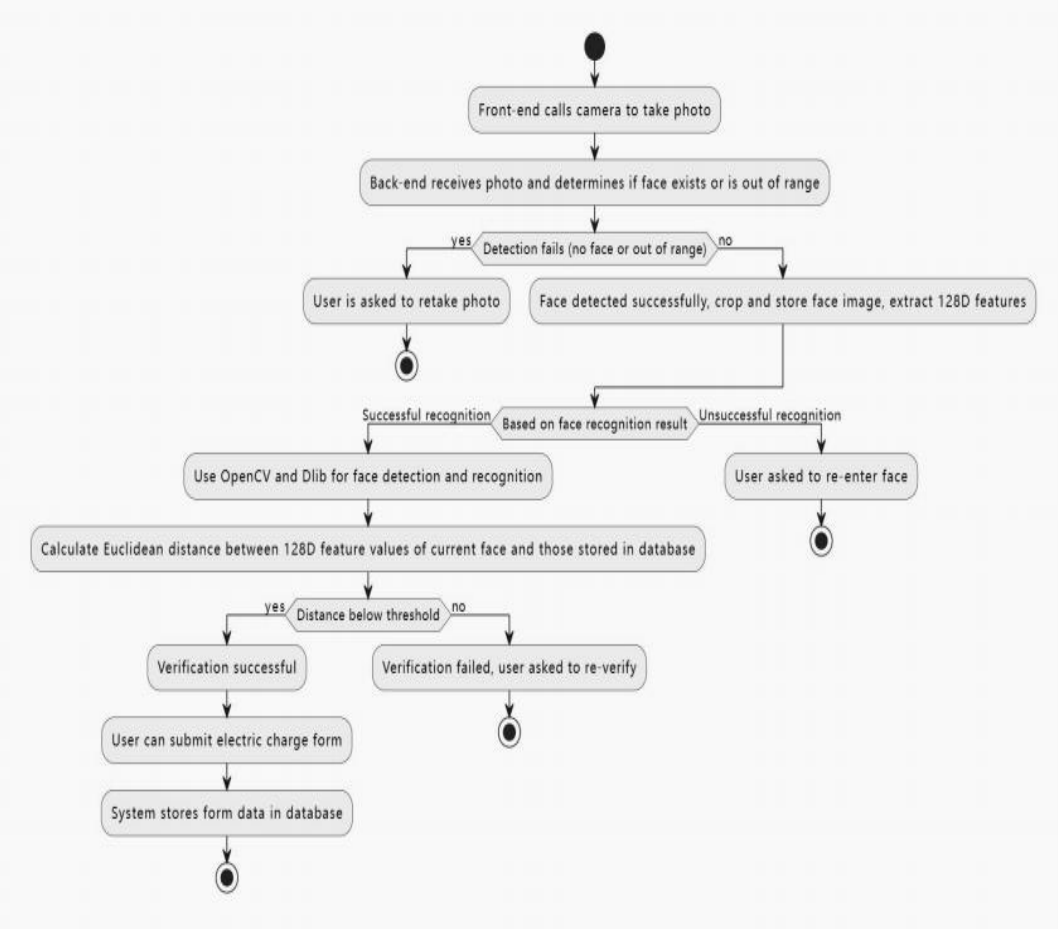


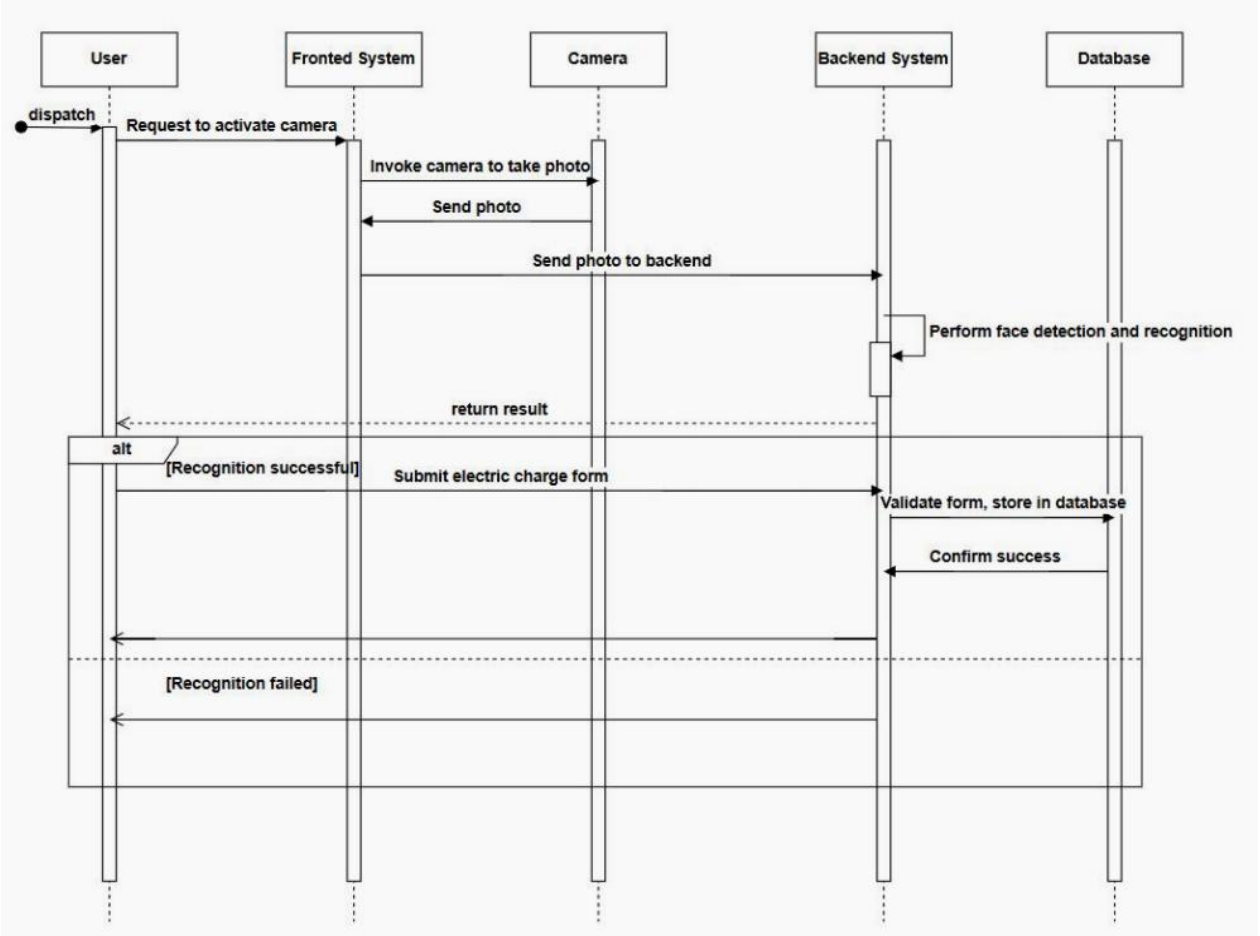


Component design

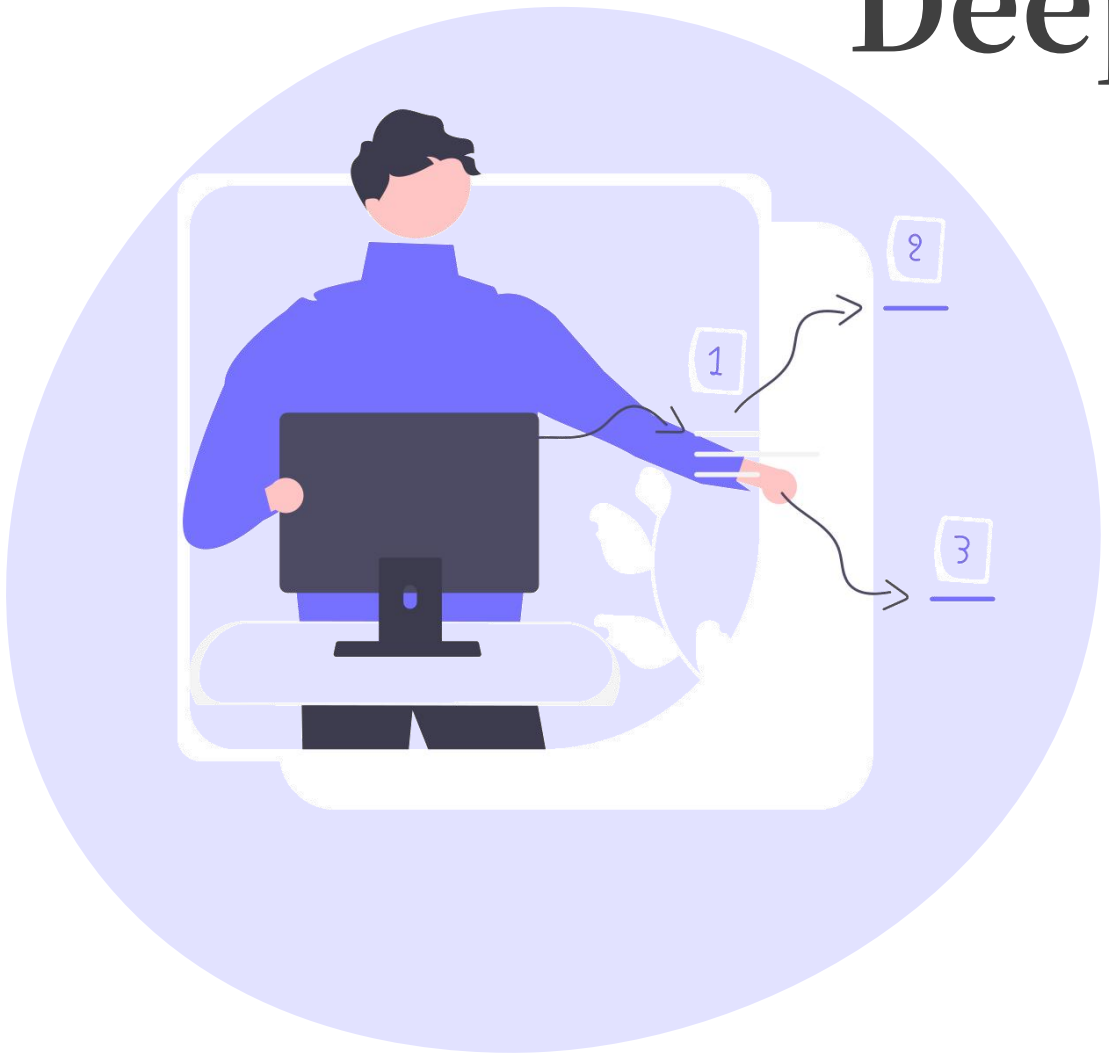


Face recognition process





Deep learning technique



1. Datasets
2. Face Detection
3. Face Recognition

Datasets we use

1. VGGFace2 for pretrained model
2. LFW be as the test dataset
3. CASIA-Webface for fine-tuning model

VGGFace Dateset example

CASIA-Webface Dateset example

LFW Dateset example

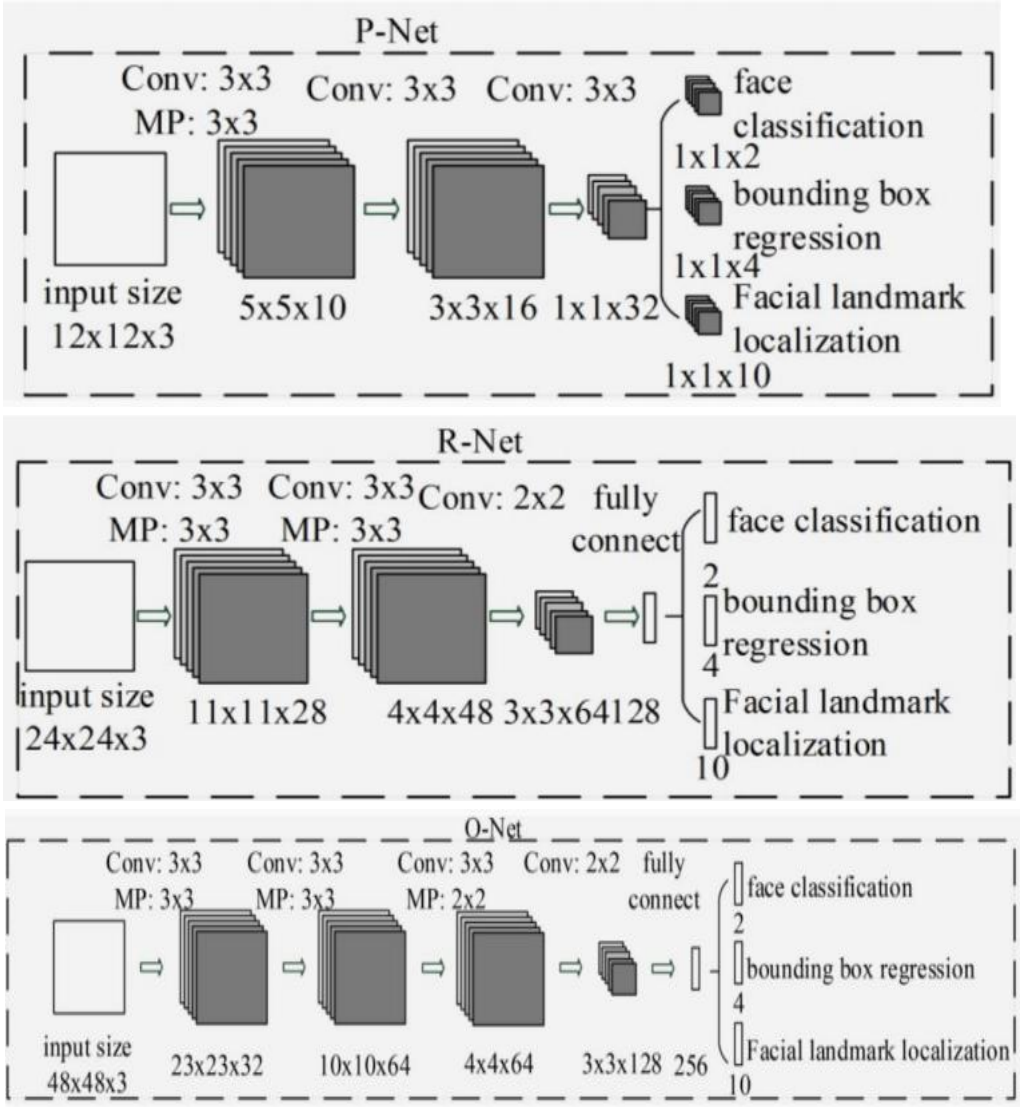
Face Detection

MTCNN (Multi-task Cascaded Convolutional Neural Networks) is a deep learning model for face detection and alignment. It consists of three stages of Convolutional Neural Networks, namely P-Net, R-Net and O-Net.

1. P-Net (Proposal Network)

2. R-Net (Refine Network)

3. O-Net (Output Network)



Face Recognition

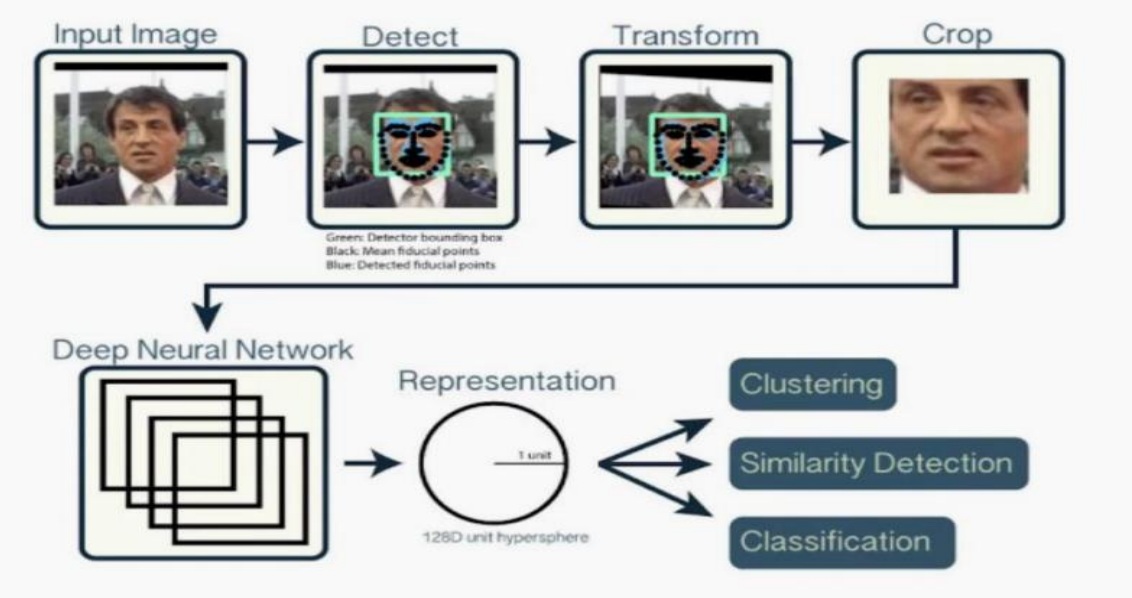
Facial recognition process:

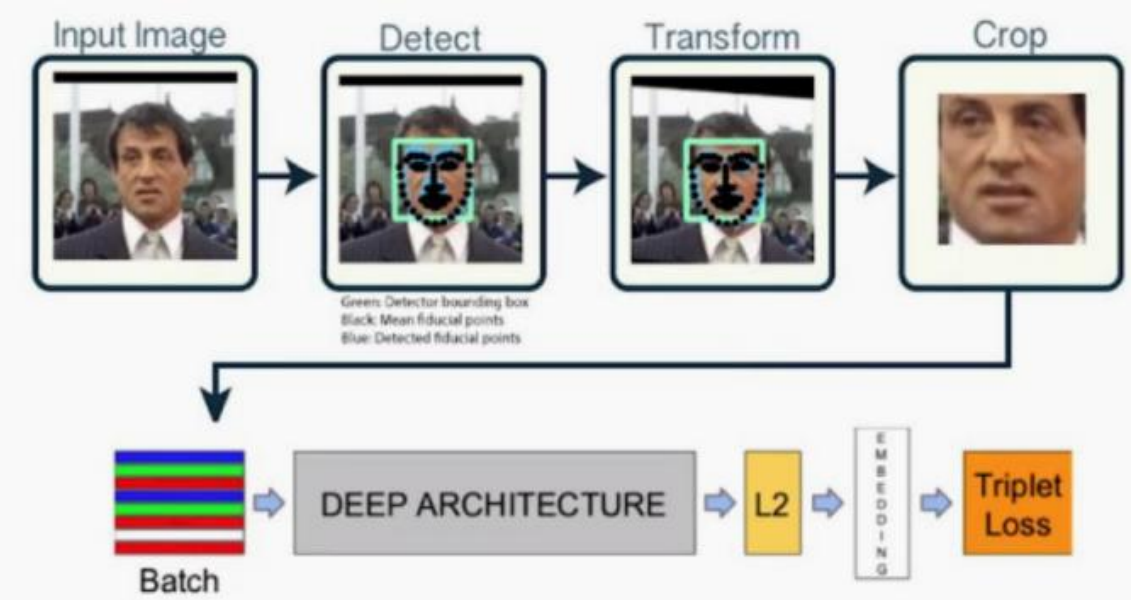
1.Input Image

2.Detection

3.Transformation

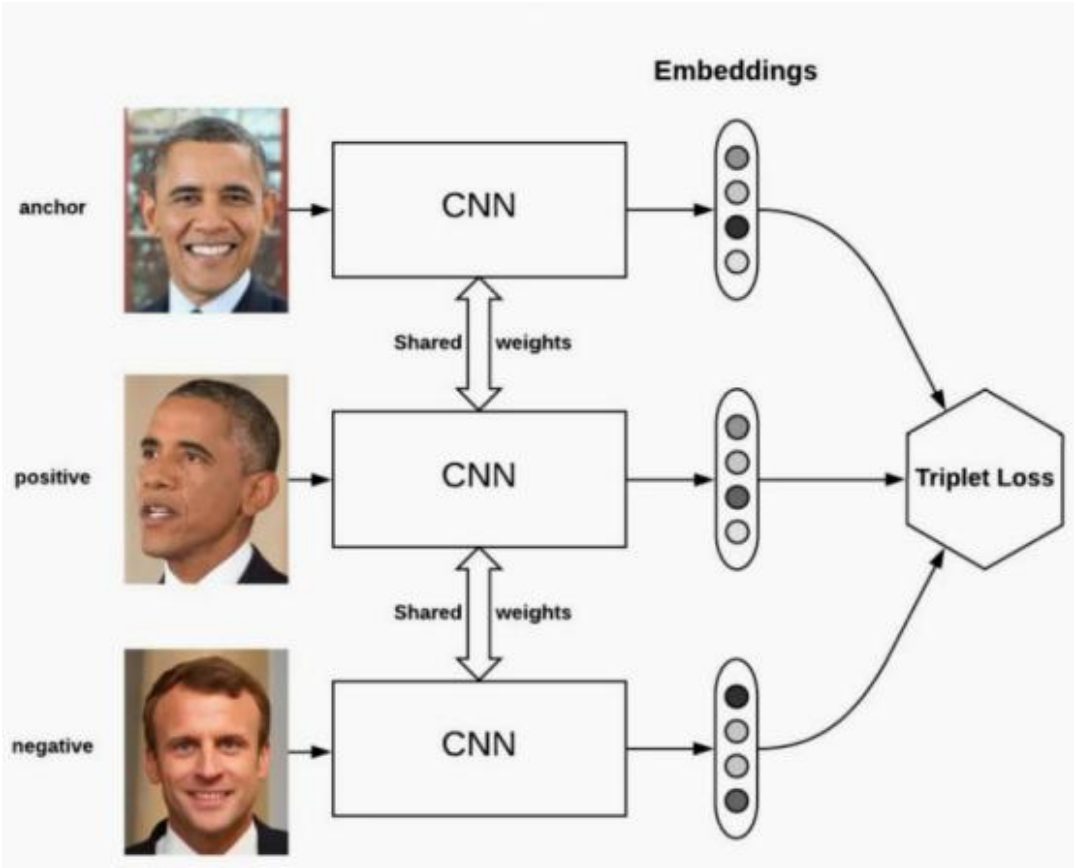
4.Cropping into Deep Netural Network

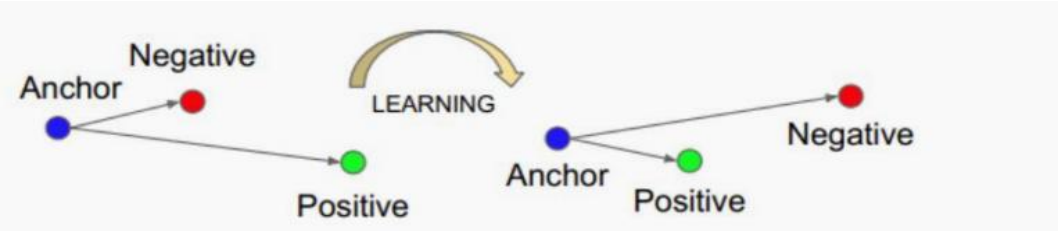




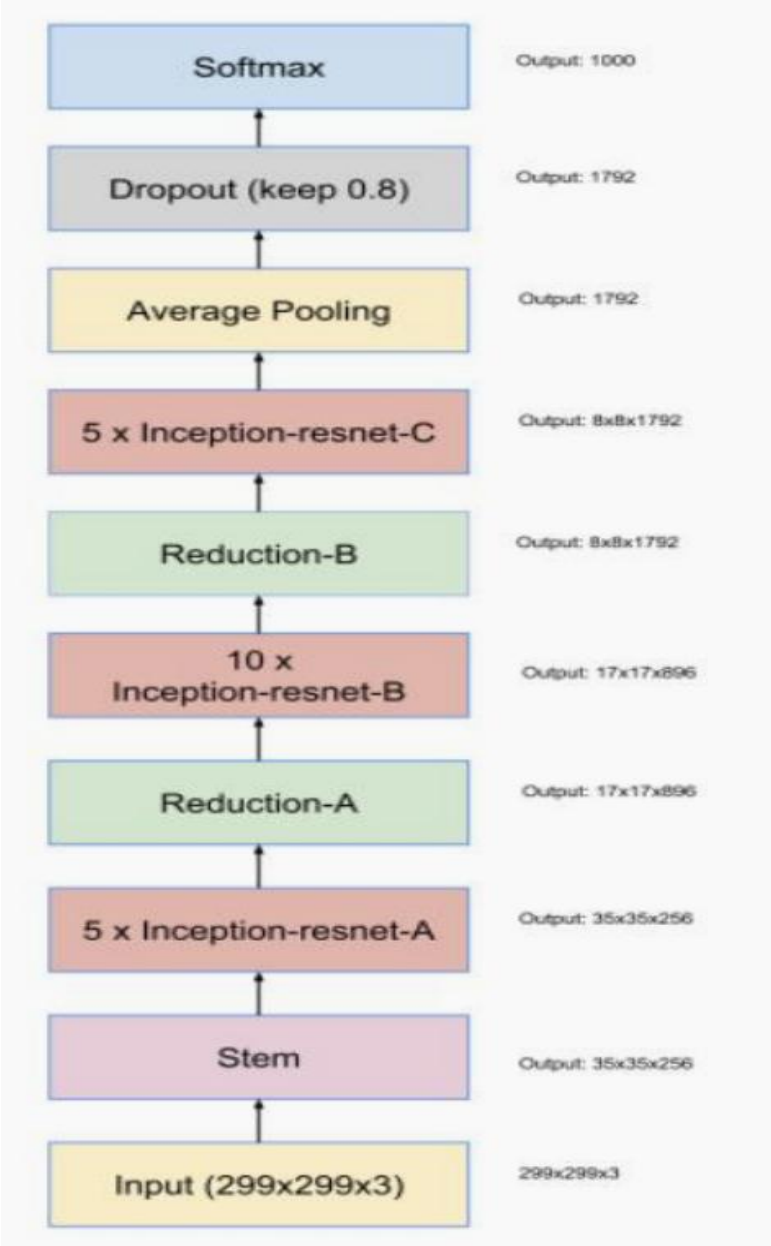
Triplet Loss

1. Enhance feature discrimination
2. Optimise feature space
3. Reduce false matches
4. Improve training efficiency

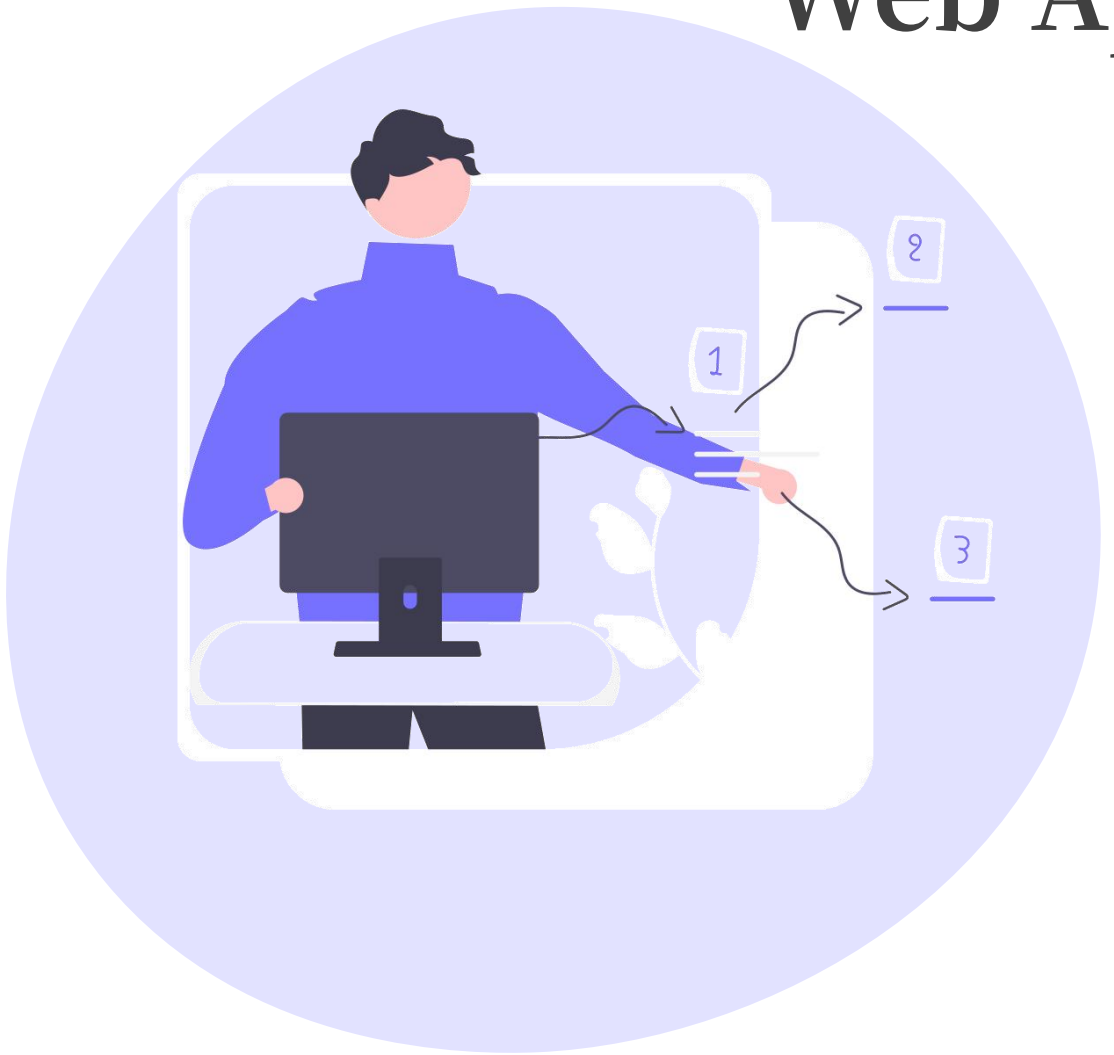




Deep architecture in FaceNet: ResNetv1



Web Application Development



1. Front end development

2. Back end development

Front end development

1. Front-End Design:
- Utilized HTML5, CSS3, and JavaScript to structure web pages.
- Followed several HCI (Human-Centered Interaction) principles for a user-friendly design.

2. HCI Principles:
- User-Centered Design
- Iterative Process
- User Involvement
- Multidisciplinary Teams
- Practical Problem Solving
- Usability Evaluation

3. Application Guidelines:
- Usability
- Efficiency
- Accessibility
- Consistency
- Feedback
- Privacy & Security

Back end development

1. Framework:
- Flask framework

2. Features:
- Provides EV charging functionalities
- Incorporates face recognition

3. Model & Database:
- leverages pre-trained models
- Includes a database system

4. Benefits:
- Combines technologies to enhance charging experience
- Improve system security, and increase user interactivity.

PART THREE

Results

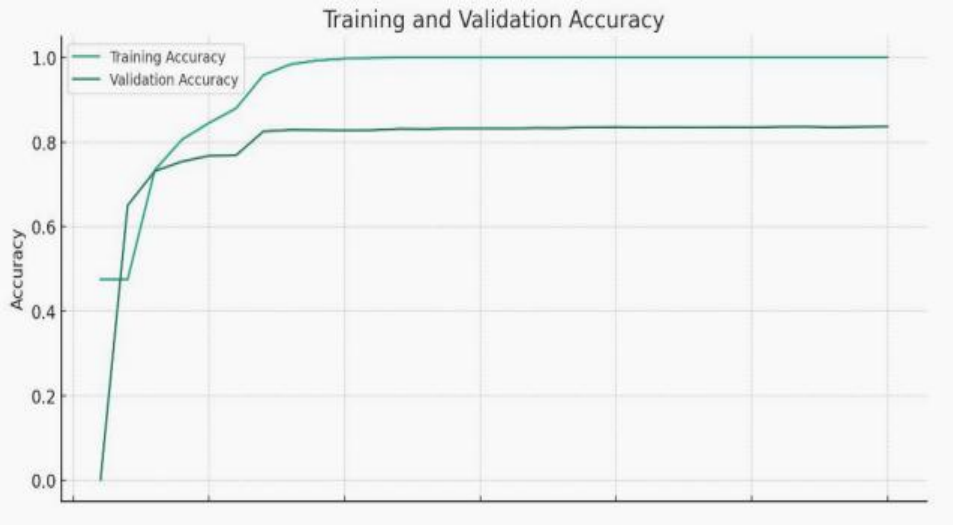
Results

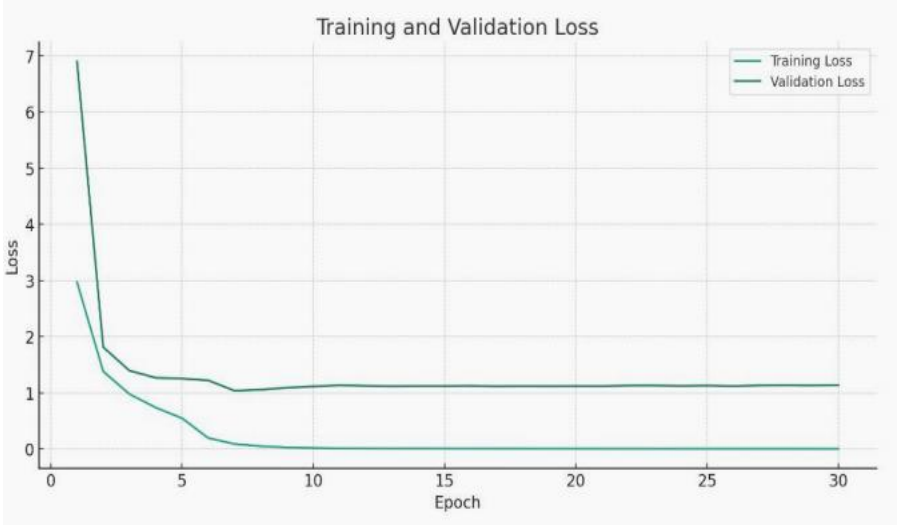
1. Result of Fine-tuned model
2. Result of Web application showcase
3. Result of core function in web application

Result of Fine-tuned model

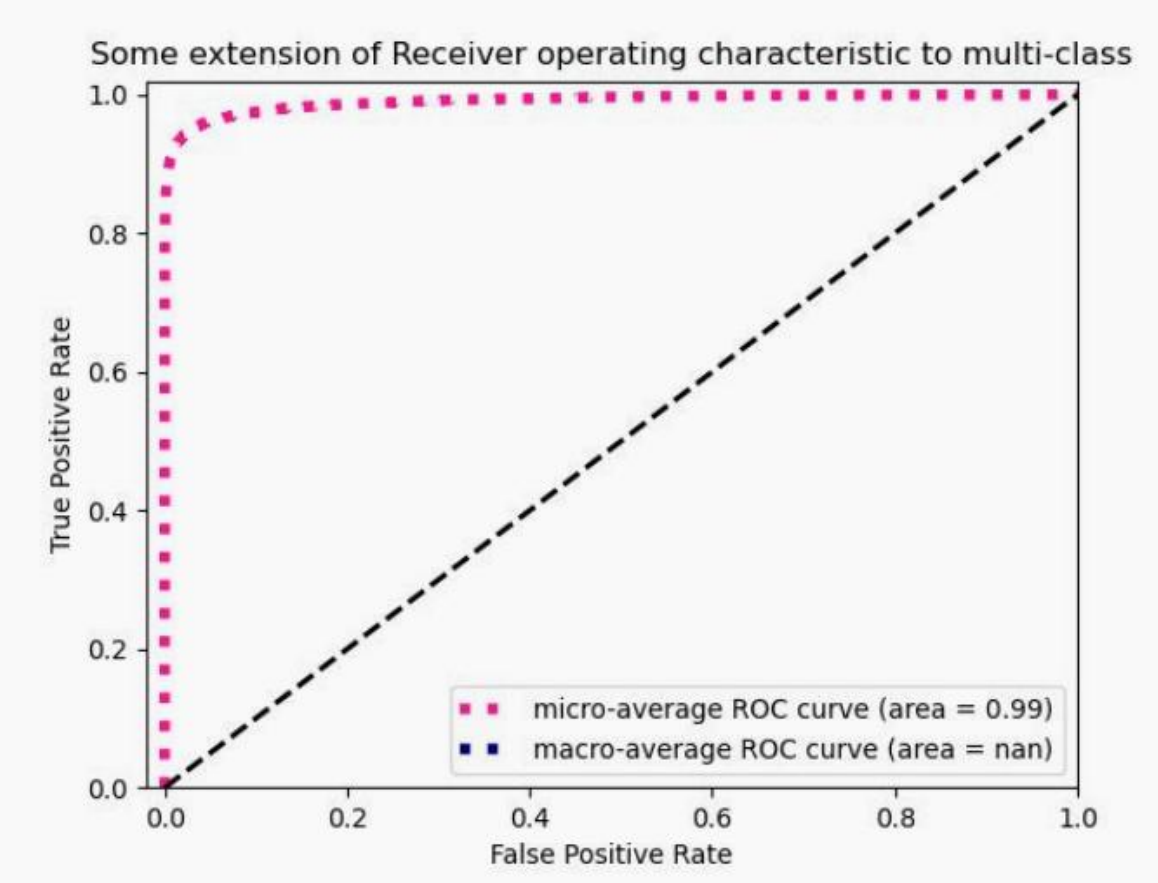
Model	Batch size	Learning rate	Epoch	Num_workers	Accuracy
Model_16batch	16	0.0005	30	2	0.99701601
Model_32batch	32	0.0005	30	2	0.99985451
Model_64batch	64	0.0005	30	2	0.99996364
Model_32num1	32	0.0005	30	1	0.99987268

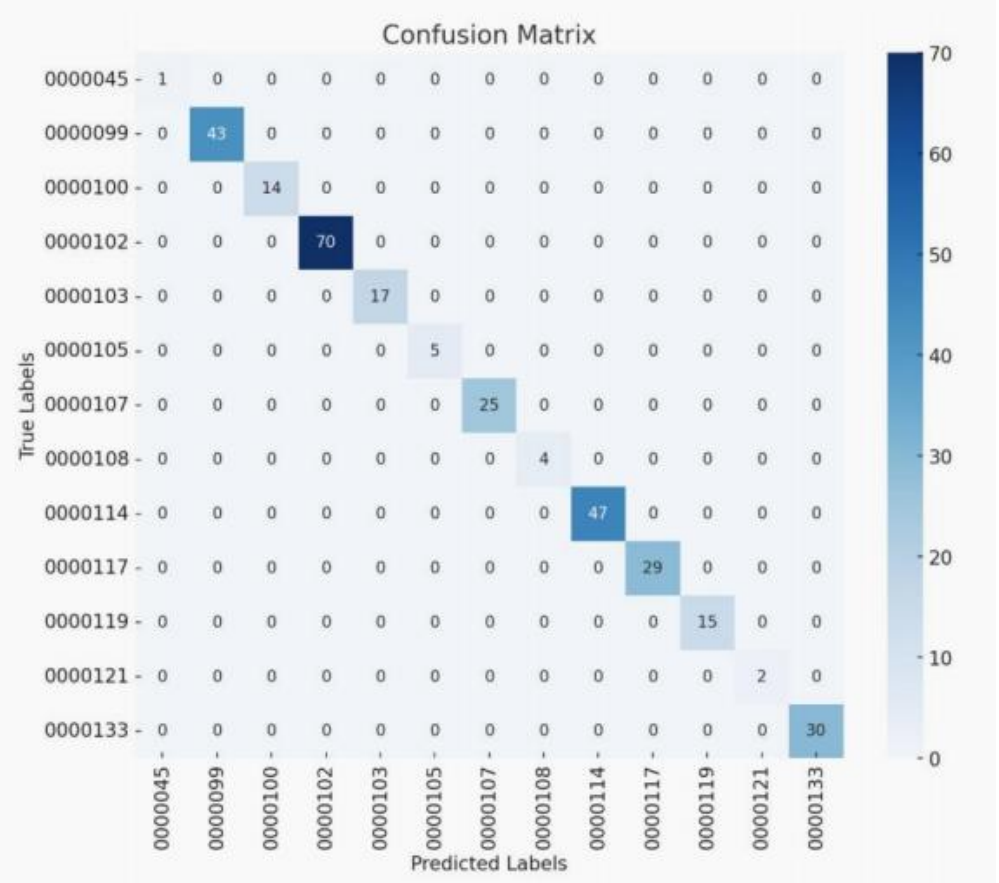
Result of Fine-tuned model



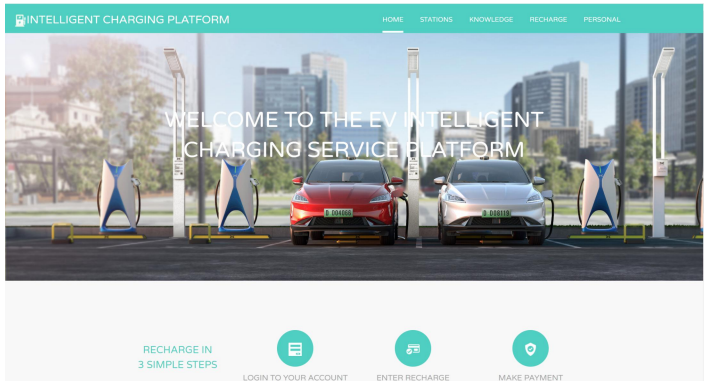


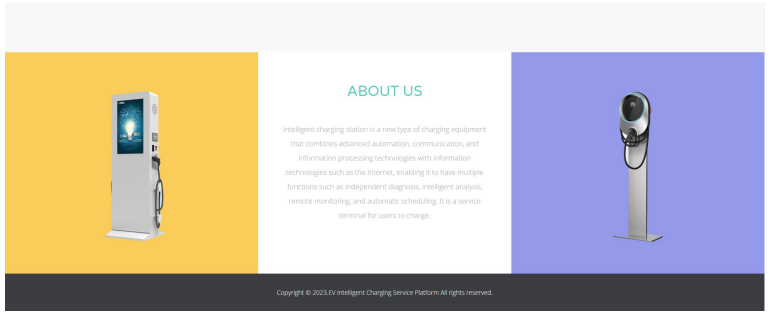
Result of Fine-tuned model

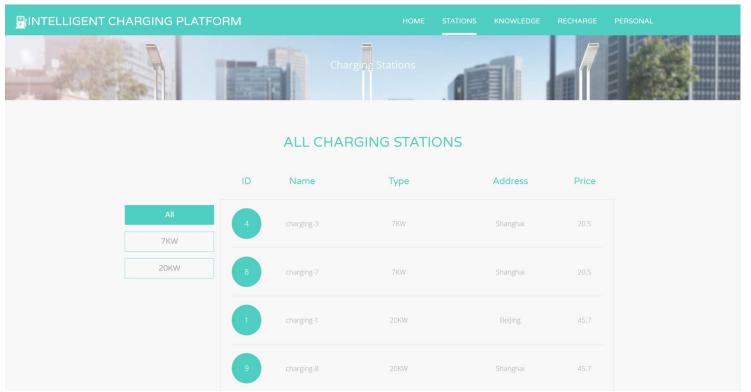


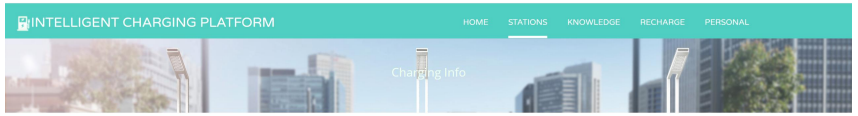


Result of Web application showcase (User)



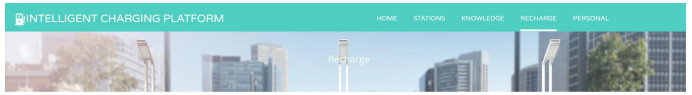






CHARGING INFO

ID : 4 Repair report?
Name : charging-3
Type : 7KW
Address : Shanghai
Price : 20.5
Balance : 10353.30
CHARGING DURATION
CHARGE NOW
CHARGE NOW M



RECHARGE

ID : 5
Name : Daria
Mobile : 13891991919
Balance : 10291.80
Create_at : 2024-02-21 19:06:47
Update_at : 2024-02-21 17:20:56
RECHARGE AMOUNT
PAY NOW

YOUR ORDERS

CHARGING RECORD | RECHARGE RECORDS

ID	Money	Recharge_at
1	100.0	2023-12-04 15:38:36
2	100.0	2023-12-04 16:54:23
3	10.0	2023-12-05 09:13:37
4	100.0	2023-12-07 10:33:21
5	123.0	2023-12-10 19:50:33
9	666.0	2024-02-21 17:23:06
10	666.0	2024-02-21 17:23:12

YOUR ORDERS

CHARGING RECORD | RECHARGE RECORDS

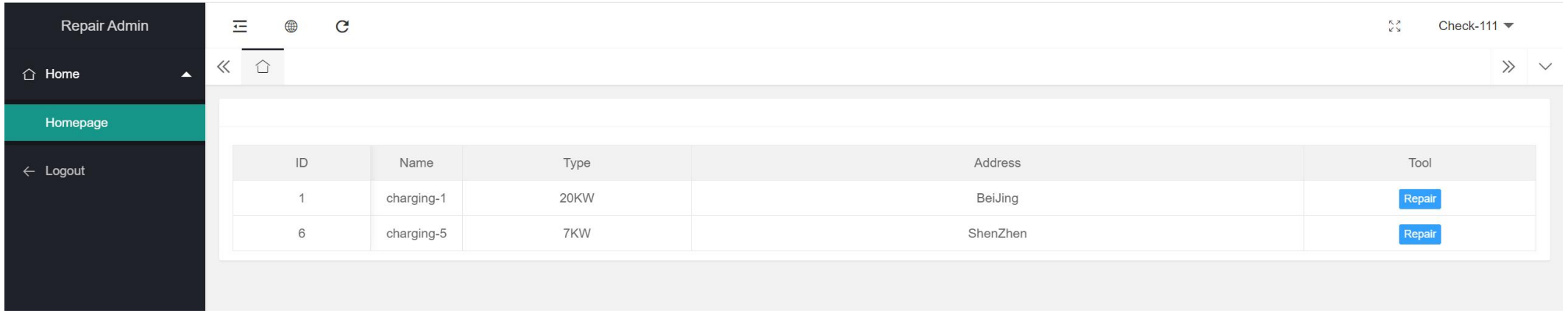
ID	Charging	Type	Duration	Price	Address	Start	End
5	charging-8	20KW	1	45.7	Shanghai	2023-12-04 14:44:06	2023-12-04 15:44:06
6	charging-3	7KW	3	61.5	Shanghai	2023-12-04 14:44:18	2023-12-04 17:44:18
7	charging-2	7KW	1	20.5	Shanghai	2023-12-05 14:10:47	2023-12-05 15:10:47
8	charging-3	7KW	1	20.5	Shanghai	2023-12-06 14:03:10	2023-12-06 15:03:10
9	charging-4	7KW	1	20.5	ShenZhen	2023-12-06 14:07:02	2023-12-06 15:07:02
10	charging-5	7KW	1	20.5	ShenZhen	2023-12-06 14:08:20	2023-12-06 15:08:20
11	charging-2	7KW	1	20.5	Shanghai	2023-12-06 14:19:14	2023-12-06 15:19:14
12	charging-3	7KW	1	20.5	Shanghai	2023-12-07 10:29:34	2023-12-07 11:29:34

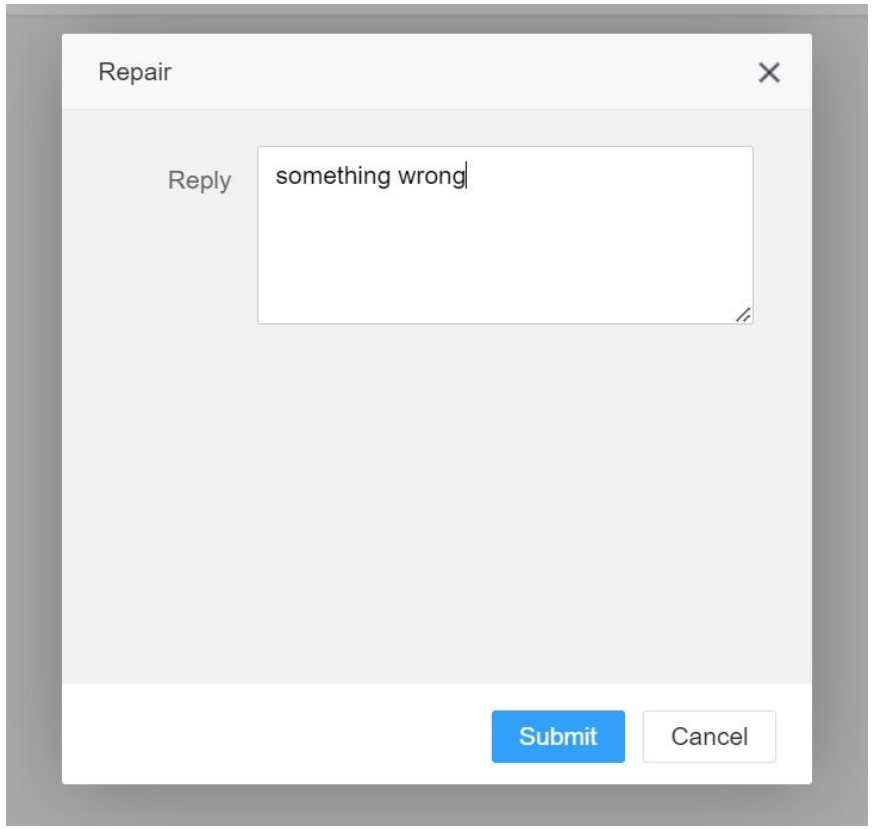
SETTINGS

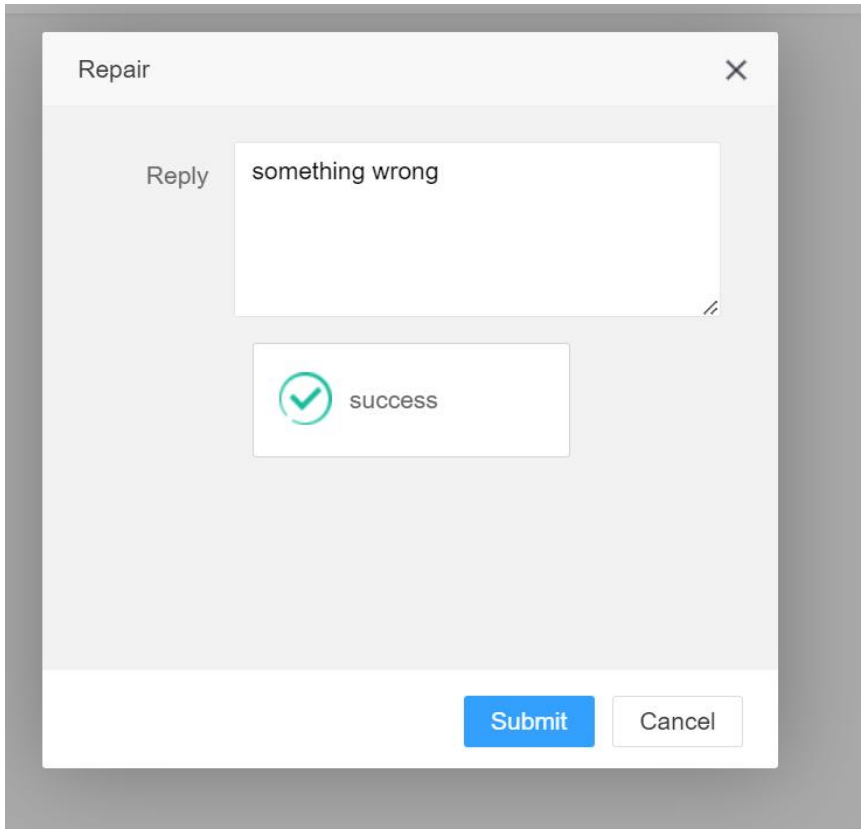
PERSONAL | CHANGE PASSWORD
ID
NAME
MOBILE
SAVE

4. Do not use the charging gun or charging cable with defects, cracks, wear, breakage, or exposed charging cables.
5. Do not remove the gun head during the charging process, and it is strictly prohibited to touch the charging gun core with your hands when charged.

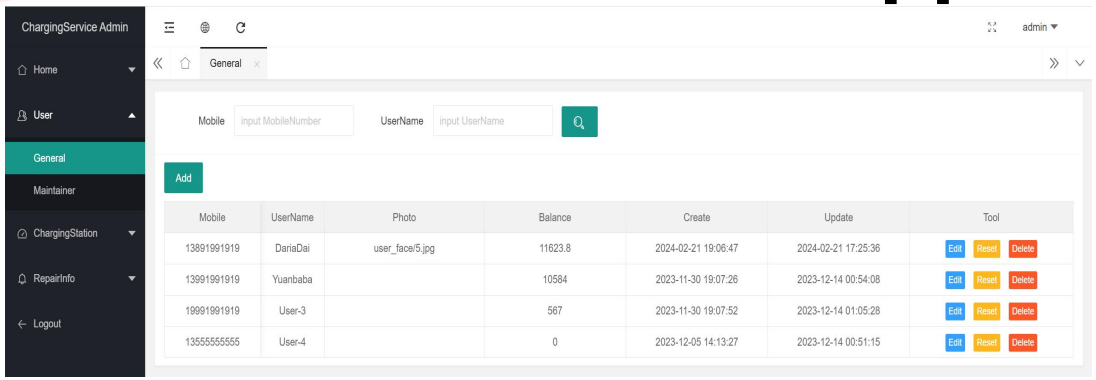
Result of Web application showcase (Maintainer)

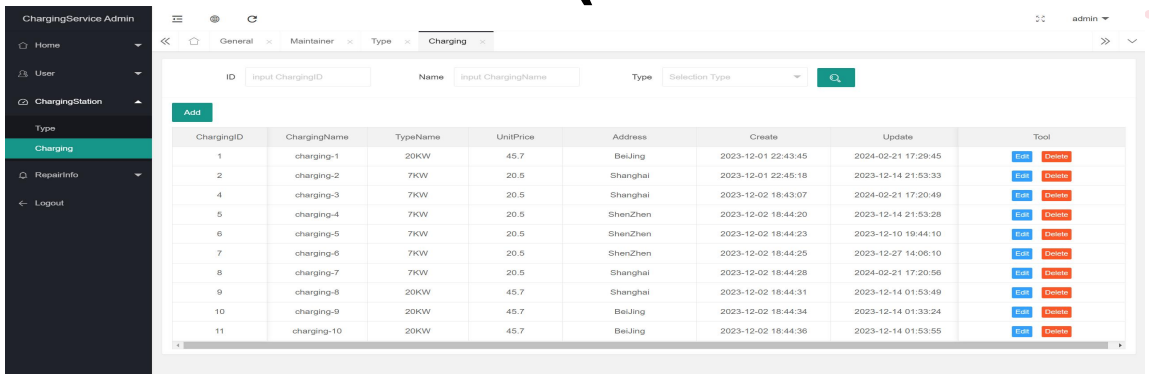


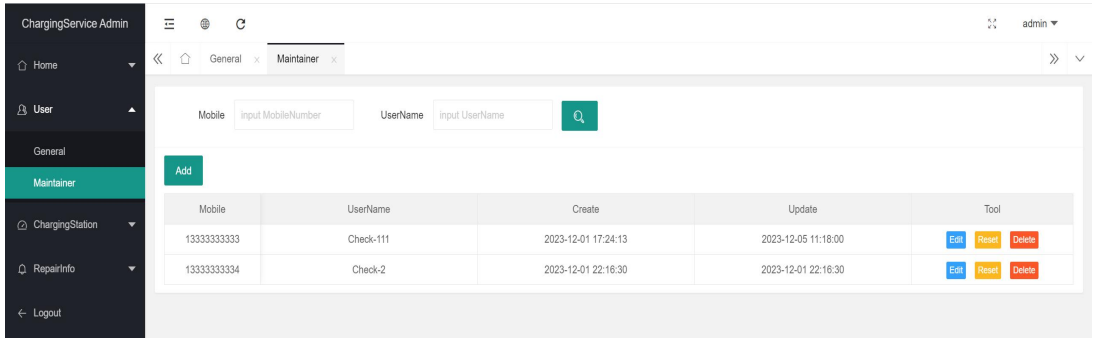


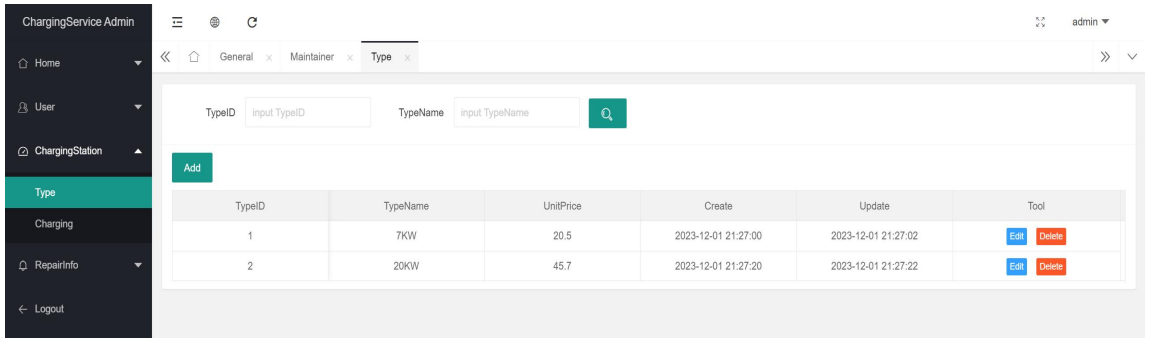


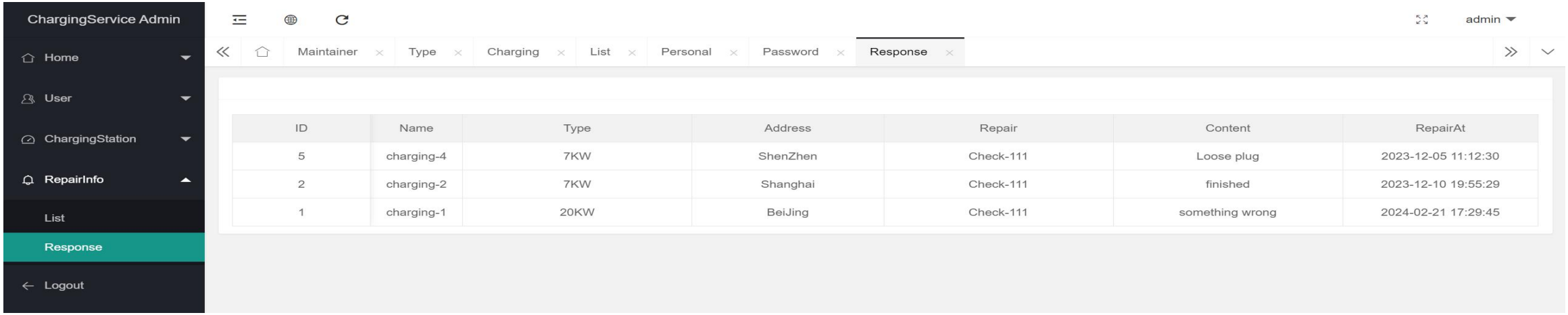
Result of Web application showcase (Administrator)



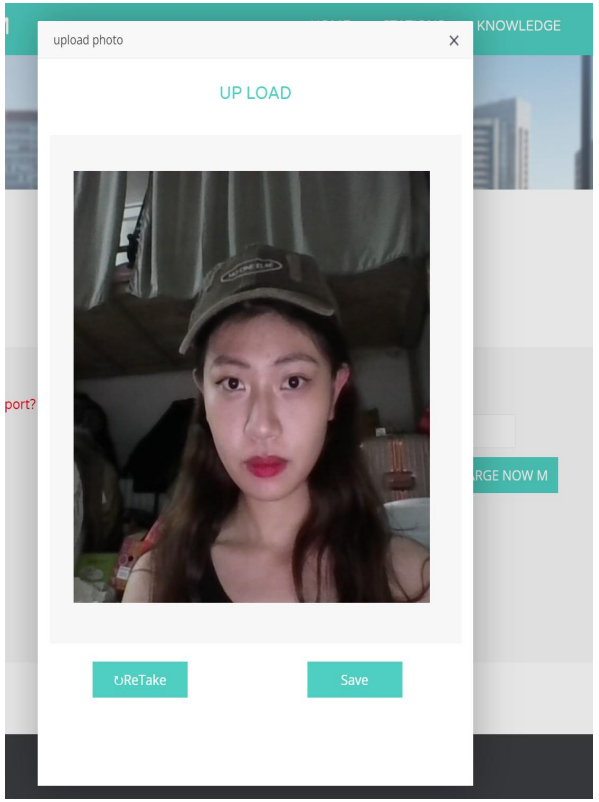


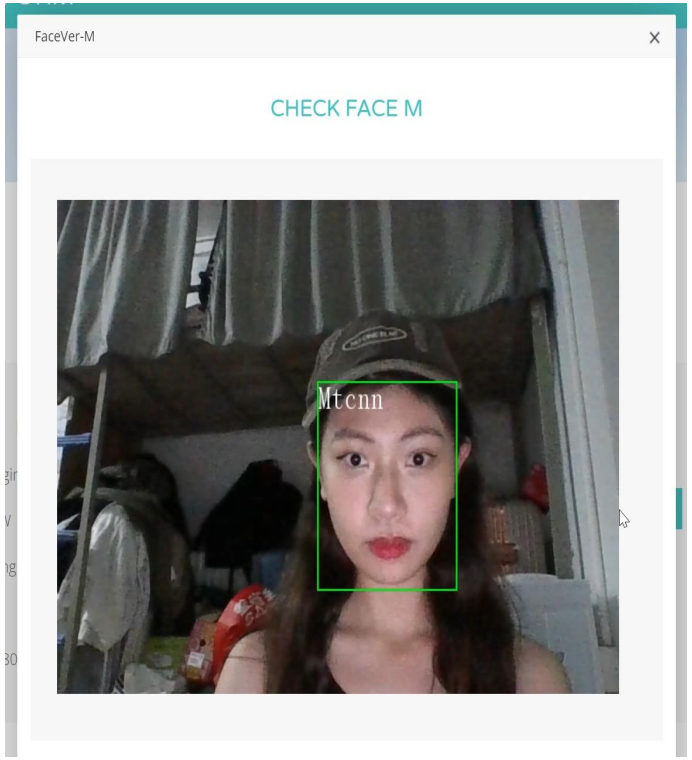


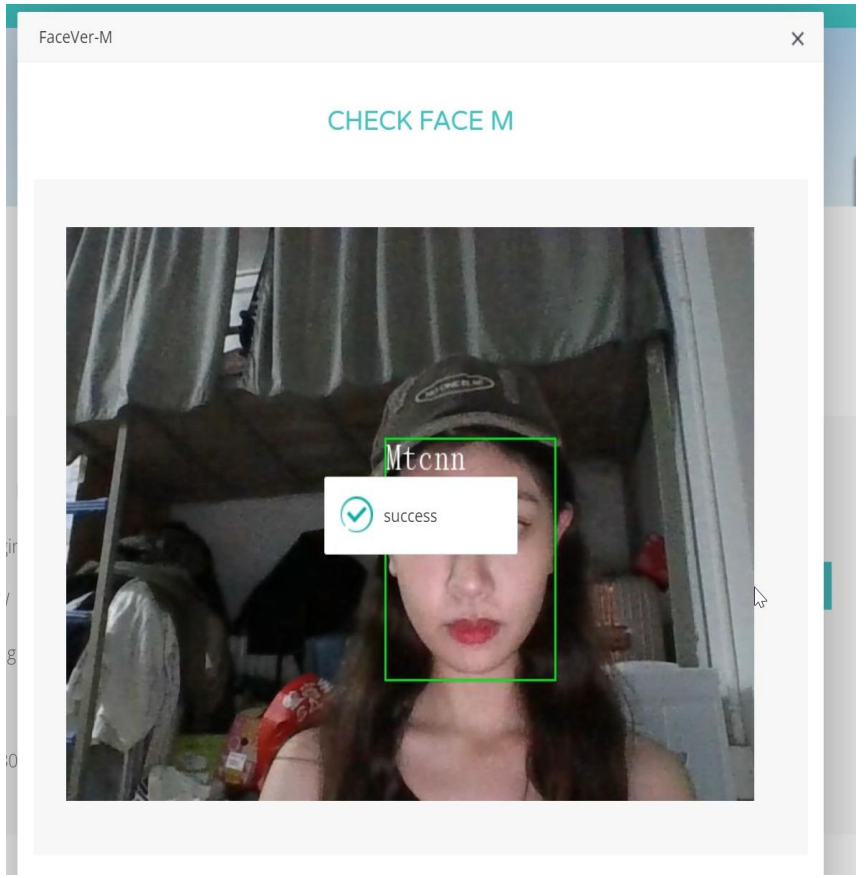




Result of core function in web application







PART FOUR

Conclusion

Conclusion

1. Project Overview
2. Technologies Used
3. Development Strategy
4. Testing & Evaluation
5. Innovation & Future Impact

Future work

1. Optimisation and innovation in deep learning models
2. Integration of a multimodal authentication system
3. Enhanced user experience and interaction design
4. Enhancement of data privacy and security

Thank you !