A Presentation in Big data and AI forum 2024:

Big data and Artificial (data) Intelligence

Enhancing Road Safety: AI-Powered Driver Support System

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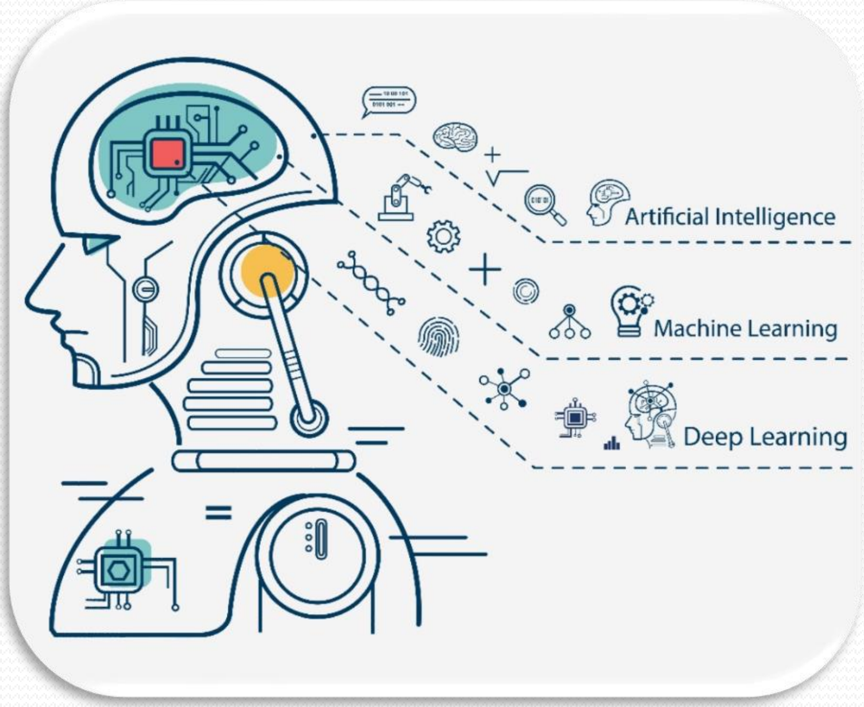
Outline

- Хиймэл оюун ухаан гэж юу вэ?
- Хиймэл оюун ухааны жишээнүүд
- Хиймэл оюун ухаан хэрхэн ажилдаг вэ?
- Хиймэл оюун үнэхээр ухаантай юу?
- Бид хиймэл оюуныг хэрхэн үр ашигтай ашиглах вэ?

Хиймэл оюун ухаан (AI)

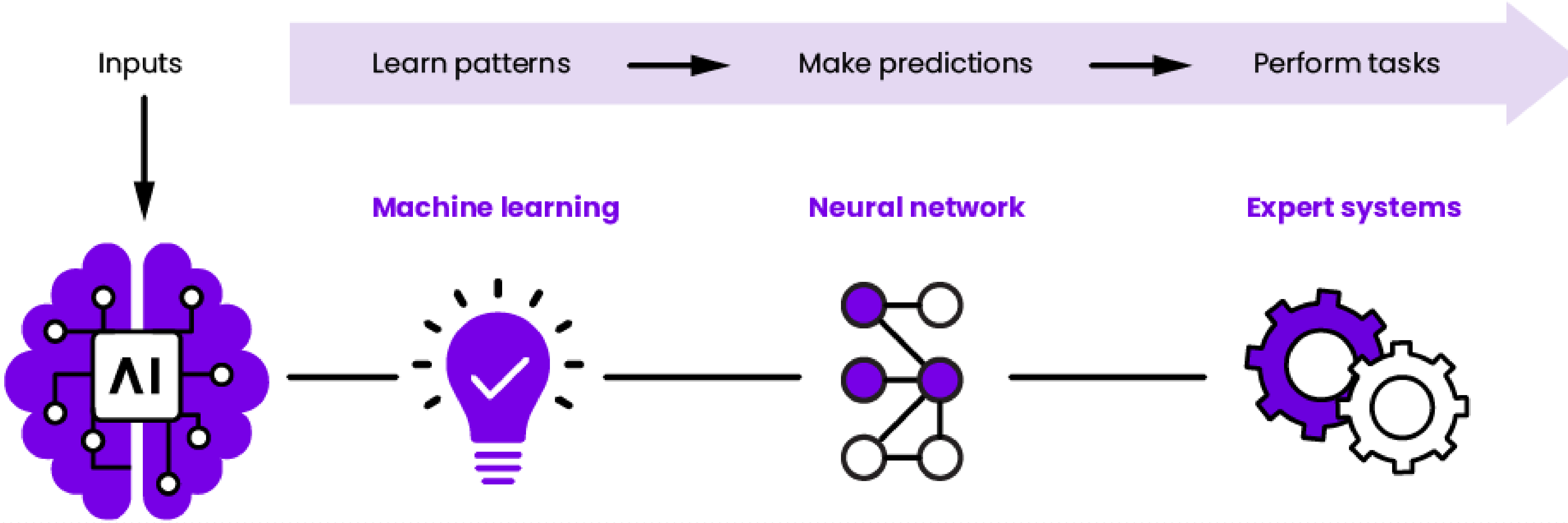
“The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil)

Хиймэл оюун ухаан (AI) гэдэг нь компьютерийн **СЭТГЭН БОДОХ**, **СУРАЛЦАХ**, хүний сэтгэхүйн үйл явц, тухайлбал, **МЭДРЭХ**, **СЭТГЭХ**, **СУРАХ** зэрэг үйлдлийг дуурайлган хийх чадварыг хэлнэ.



Artificial (data) intelligence

AI үнэхээр ухаалаг юм уу?



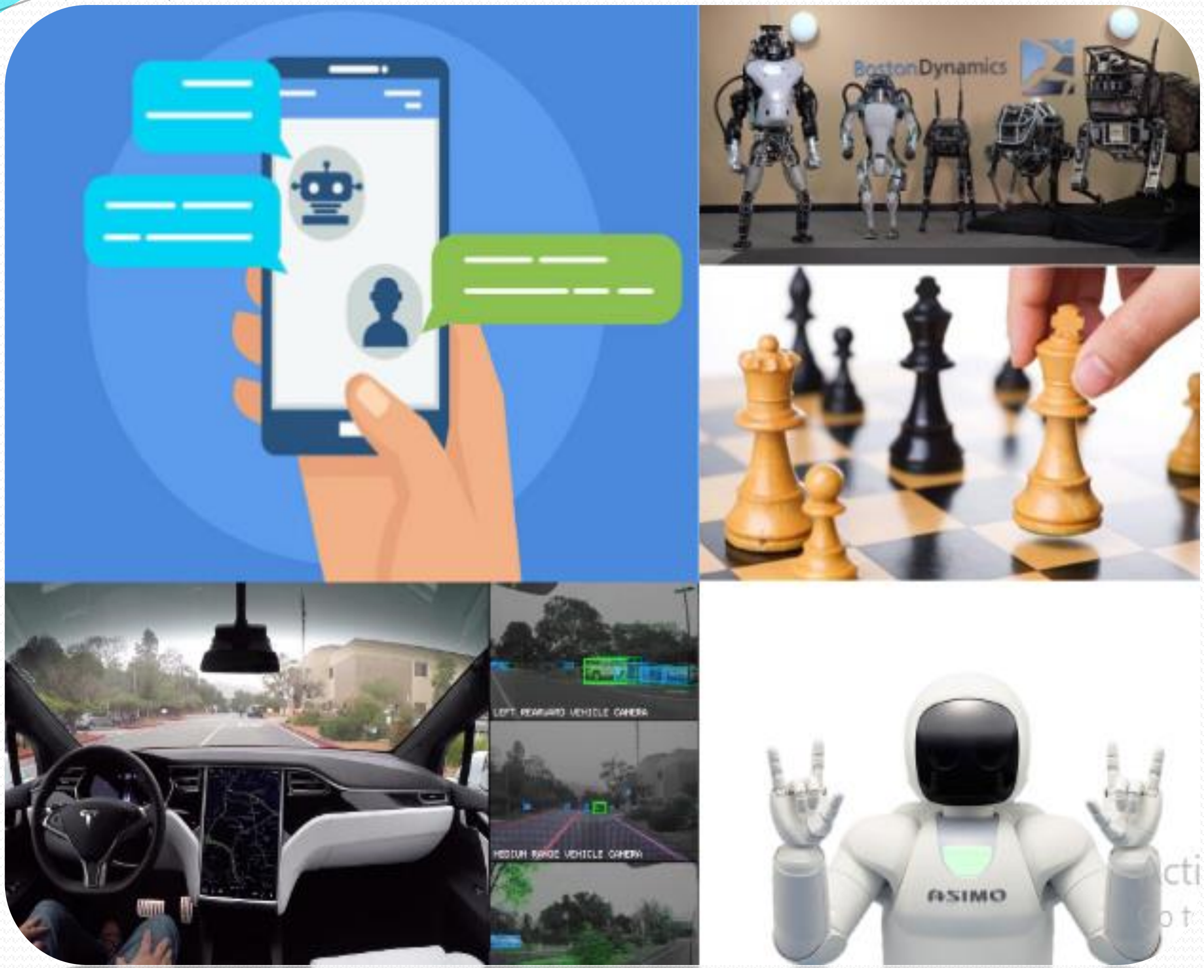
AI систем нь зураг, текст, тоо гэх мэт олон мэдээллийг цуглуулж эхэлдэг.

Өгөгдөл дэх хэв маягийг таньж сурдаг. Яг хүүхдэд янз бүрийн амьтдын зургийг үзүүлж амьтдыг таньж сургахтай адил юм

Сурсан зүйлээ шийдвэр гаргах эсвэл таамаглахад ашиглана.

AI нь бидний туршлагаас хэрхэн суралцдаг шиг илүү их мэдээлэл авч, алдаанаасаа суралцах тусам цаг хугацаа өнгөрөх тусам сайжирдаг.

AI-ийн бодит жишээ



- ❑ **Self-driving car**
- ❑ **Chatbots (*ChatGPT, Bard*)**
- ❑ **Boston dynamic**
- ❑ **Navigation system**
- ❑ **Traffic system**
- ❑ **Health care**
- ❑ **E-Commerce**
- ❑ **Virtual assistant**
- ❑ **Facial recognition**
- ❑ **e-Game…**

Бид AI-ийг хэрхэн үр ашигтай ашиглах:
Safe Driving Support System

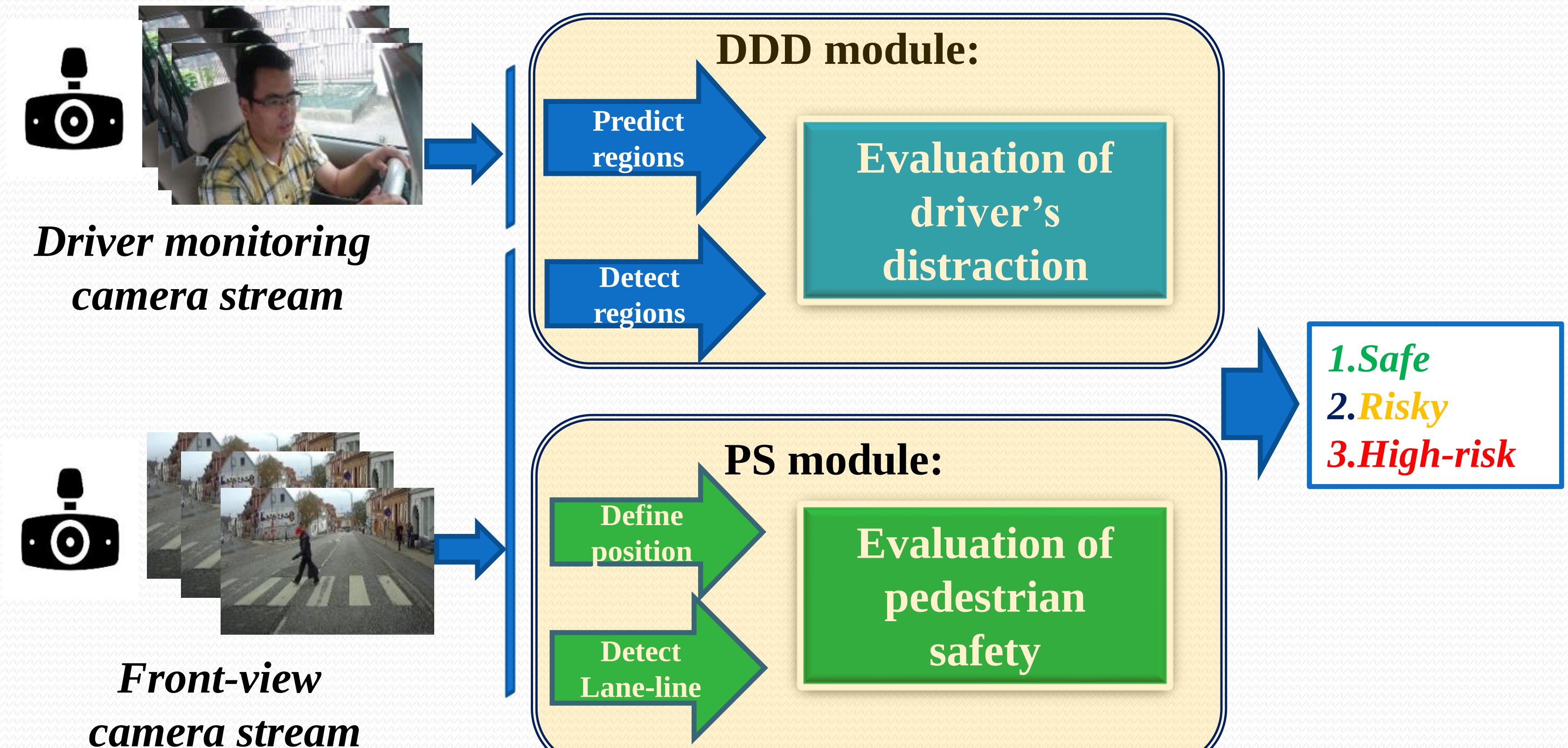
- According to the World Health Organization (WHO), over 1.3 million deaths occur worldwide each year due to traffic accidents alone.
- Traffic accidents are one of the top eight causes of death.
- Moreover, most of the traffic accidents were caused by distracted driving.

- *L. Sminkey. "Road traffic injuries." (accessed Jun. 9, 2023). (2010), [Online]. Available: https://www.who.int/news/item/11-12- 2010 - pedestrians - cyclists - among - main - road - traffic - crash-victims (cit. on p. 1).*

Overview of proposed system:

Our proposed system consists of two main modules:

- **Driver's distraction detection (DDD)** and
- **Pedestrian safety (PS)**.



Overview of proposed system:

Driver's distraction detection module (DDD):

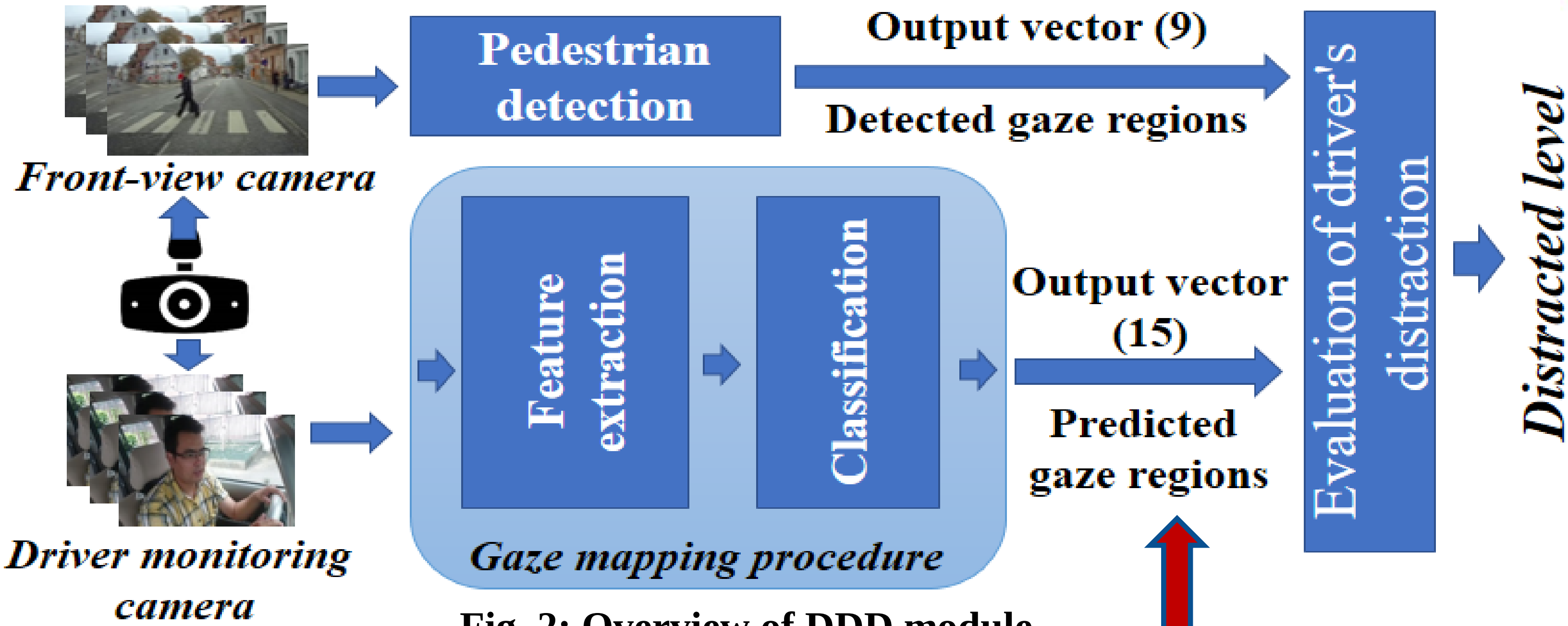


Fig. 2: Overview of DDD module

For gaze mapping methods,

1. **OpenFace** with **SVM**
2. **Domain adaptation method**

Also,

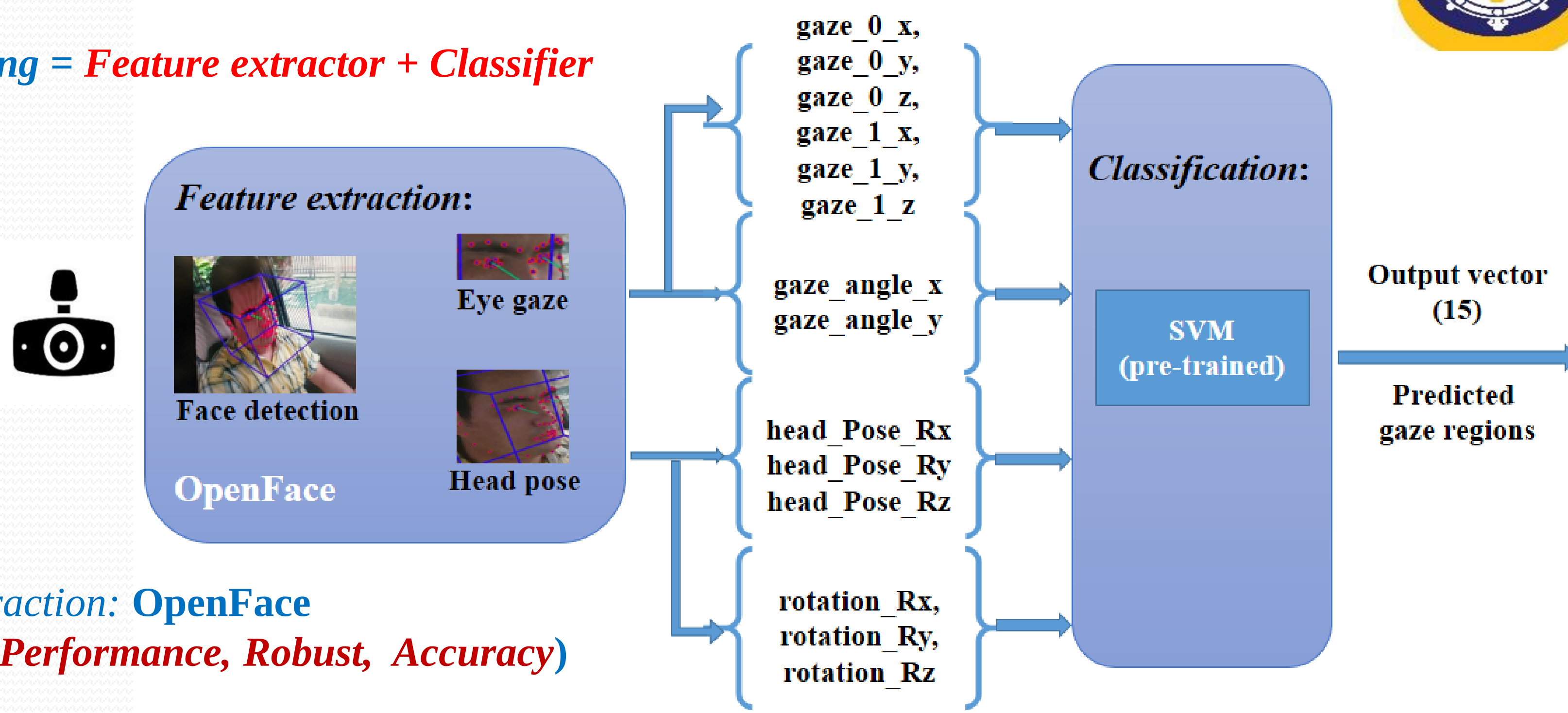
3. **Pedestrian detection**
4. **Evaluation**

Fig. 3: Predefined 15 gaze regions

Proposed methods:

1. Gaze mapping using OpenFace with SVM:

Gaze mapping = Feature extractor + Classifier



Feature extraction: **OpenFace**
(*Performance, Robust, Accuracy*)

Classifier: **SVM classifier (*Performance, Accuracy, Suitable*)**

Parameters (features from OpenFace related to head, and eye gaze):

- ***Eye position:*** *Eye gaze direction vector in world coordinates*
- ***Gaze angle:*** *Eye gaze direction in radians in world coordinates*
- ***Head_Pos_R:*** *The rotation is in world coordinates with camera being the origin (yaw, pitch, roll)*
- ***Head_Pos_T:*** *The location of the head with respect to camera in millimeters (positive Z is away from the camera)*
- ***Rotation_R:*** *Scale, rotation and translation terms of the Parameters of a point distribution model*

Proposed methods:

2. Gaze mapping using Domain adaptation method:

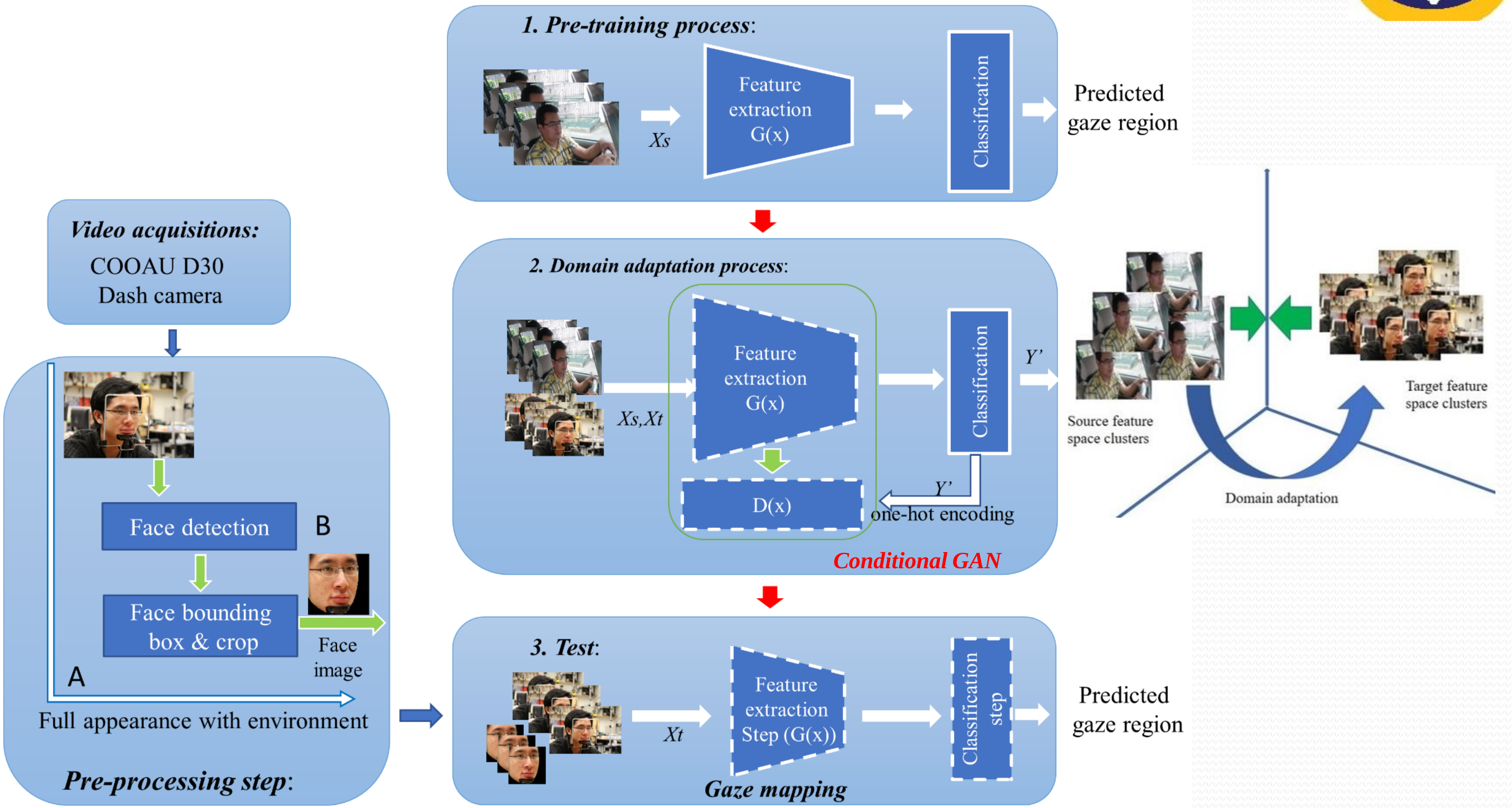
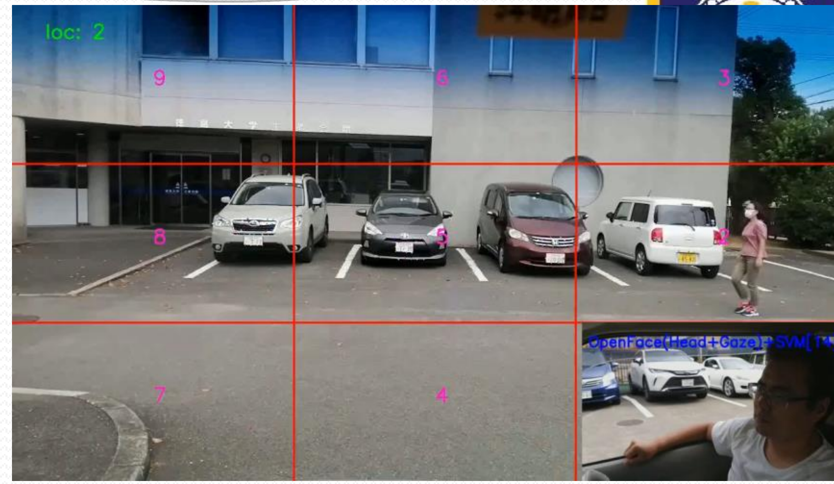
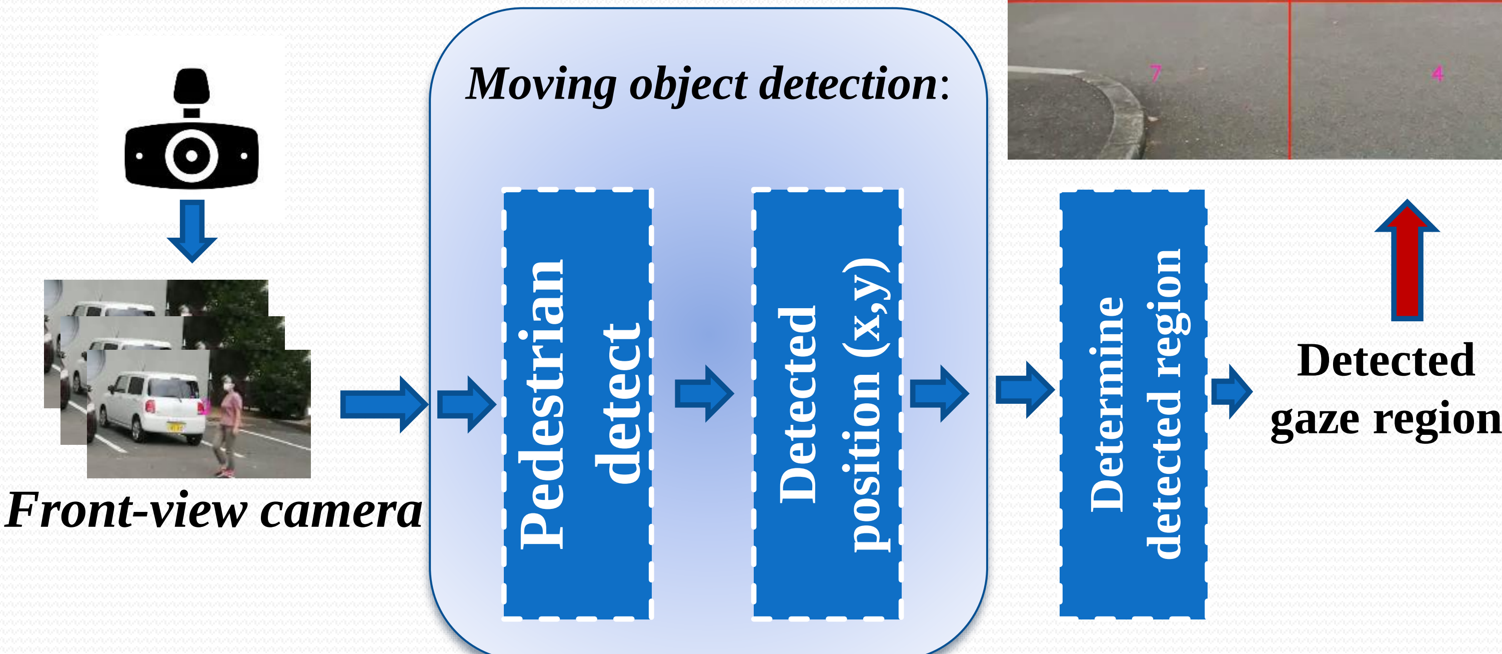


Fig 6. Structure of the gaze mapping using domain-adaptation method

Proposed methods:

3. Pedestrian detection:





We tested 2 method for this procedure,

1. **The Lucas-Kanade dense method**
2. **YOLOv4 model**

Proposed methods:

4. Evaluation of driver's distraction module:

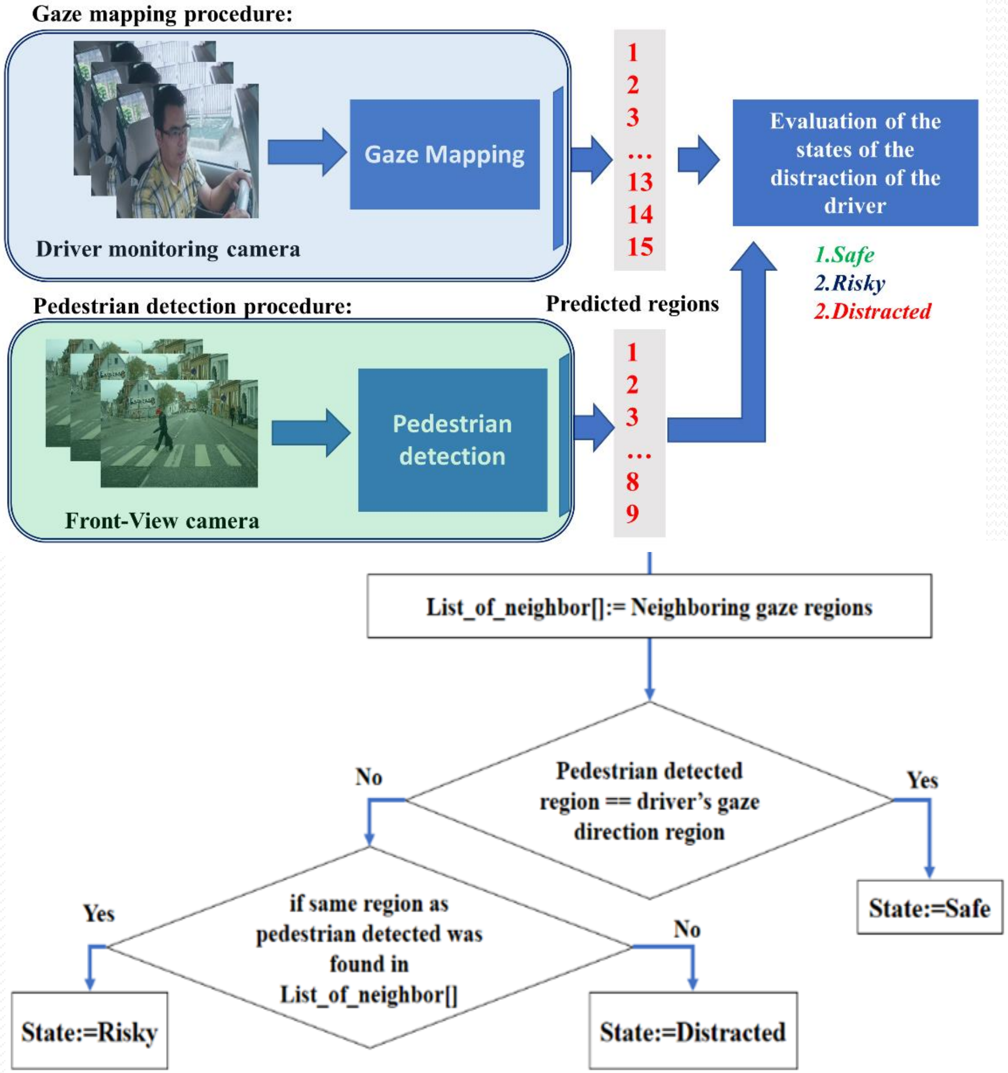


Fig 13. Flowchart of evaluation of the distraction level of the driver

- **Safe State:**

  Driver's gaze region = *Pedestrian region*

- **Risky State:**

  Driver's gaze region = *Pedestrian* **neighbor** *region*

- **Distracted State:**

  Driver's gaze region ≠ *Pedestrian Region And Neighbor regions*

Proposed methods:

Pedestrian safety module:

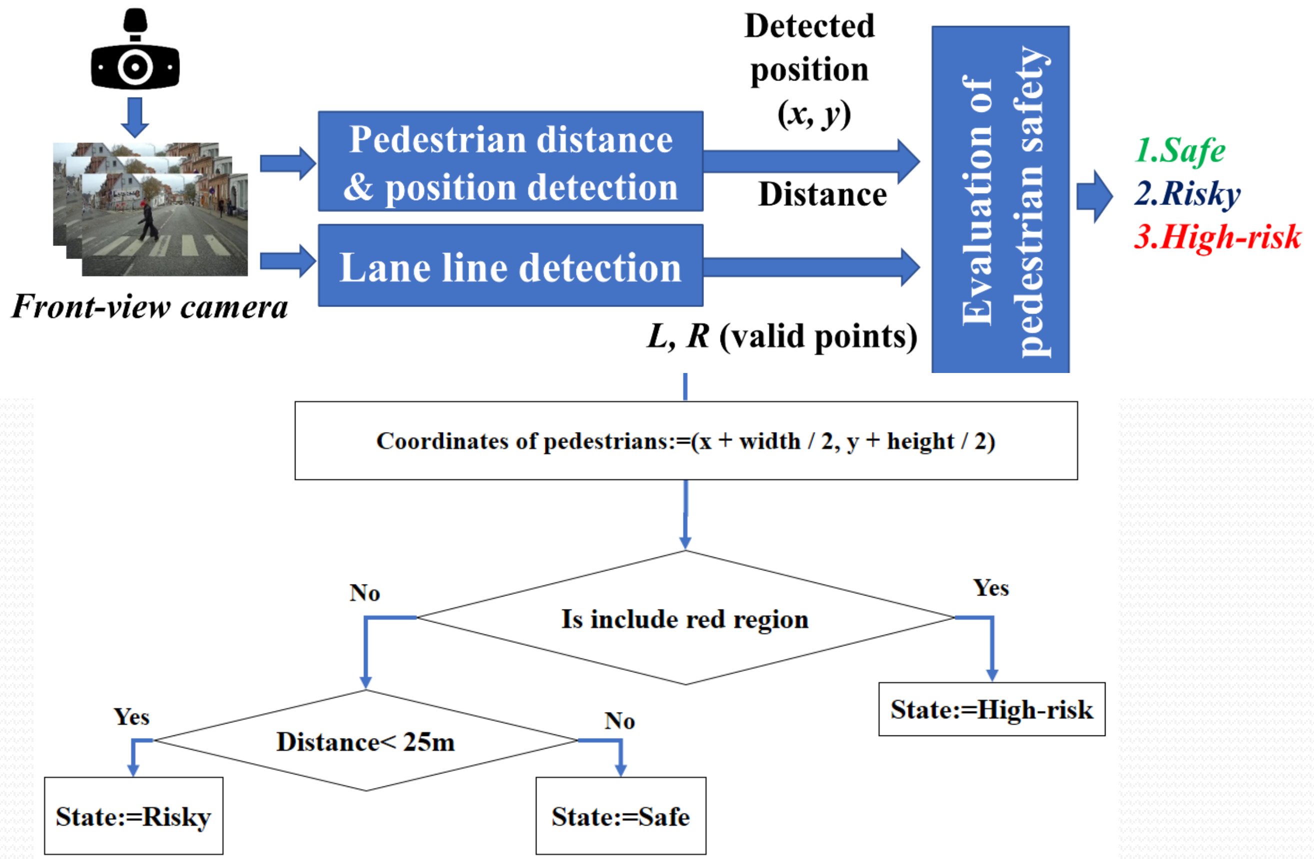


Fig 18. Flowchart of evaluation of risk level of pedestrian

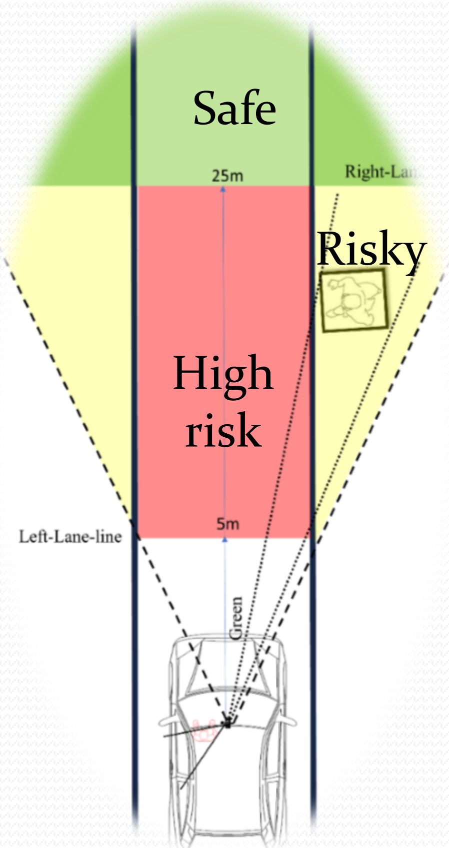


Fig 17. Road sections by risk levels

- *D. Geronimo, A. Sappa, D. Ponsa and A. Lopez, "2d–3d-based on-board pedestrian detection system," Computer Vision and Image Understanding, vol. 114, no. 5, pp. 583–595.*

Experimental Results and Dataset

Experiment and Results

Datasets:

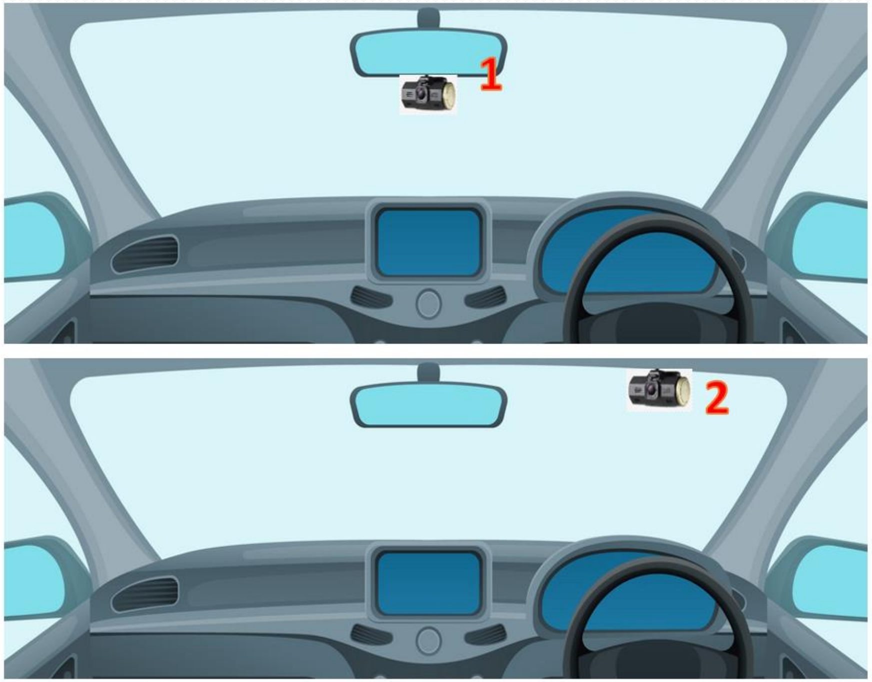


Fig.7: Camera positions: (1) bottom of the rear mirror and, (2) top-front of windshield

1. Driver's Gaze Mapping (DGM) dataset:

- **2** camera positions, with **26625** images with **15** labels.
- In the vehicle, driving condition.

2. Columbia gaze dataset CAVE-DB:

- **56** people with **5880** images
- **105** gaze directions as **5** head poses with **21** gaze directions per head pose.

Experiment and Results

1. DGM Dataset: CP1

- Collected **12,425** images with **15** labels.
- In the vehicle, driving condition.

Fig.8: Predefined 15 gaze regions using Camera position 1

Experiment and Results

1. DGM Dataset: CP2

- Collected **14,200** images with **15** labels.
- In the vehicle, driving condition.

Fig.9: Predefined 15 gaze regions using Camera position 2

Experiment and Results

2. Cave-DB open Dataset:

- *56 people with 5880 images*
- *105 gaze directions as 5 head poses with 21 gaze directions per head pose.*

Fig 10. Chosen 13 gaze direction images considering the driver's gaze in the car environment.

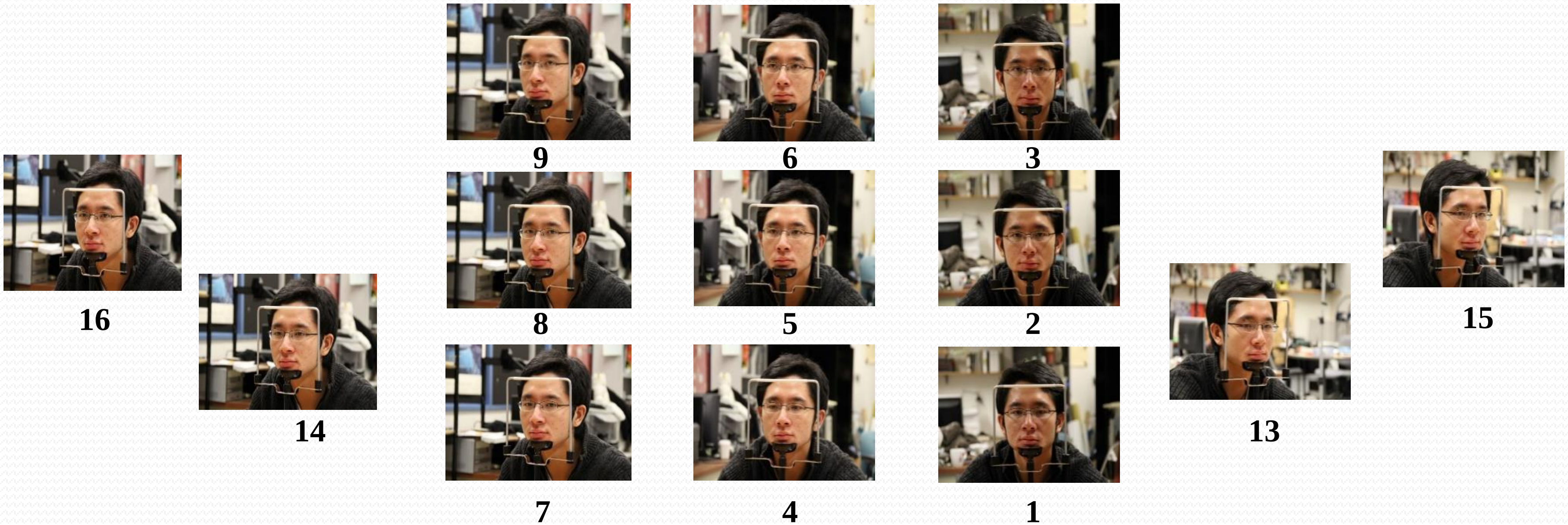


Fig 11. Eye gaze and head pose images selected from CAVE-DB

- *B. A. Smith, Q. Yin, S. K. Feiner and S. K. Nayar, "Gaze locking: Passive eye contact detection for human-object interaction," in Proc. 26th ACM Symp. User Interface Softw. Technol, 271–280*

Experiment and Results

Comparison with existing methods:

***SCER**: Strictly correct estimation rate (%)*
***LCER**: Loosely correct estimation rate (%)*

Table XI. Comparison of the Existing Studies on Cave-DB

<table>
<tr><th rowspan="2">№</th><th rowspan="2" colspan="2">Methods</th><th colspan="2">Accuracy /%/</th></tr>
<tr><th>SCER</th><th>LCER</th></tr>
<tr><td>1</td><td colspan="2">Choi et al. (Study-1 using AlexNet CNN model)</td><td>53.1%</td><td>88.7%</td></tr>
<tr><td>2</td><td colspan="2">Naqvi et al. (Study-2 using VGG CNN model)</td><td>77.7%</td><td>96.3%</td></tr>
<tr><td>3</td><td colspan="2">Lee et al. (Study-3 using MOSSE tracker)</td><td>44.0%</td><td>85.1%</td></tr>
<tr><td>4</td><td rowspan="2">Gaze mapping using OpenFace with SVM</td><td>Strategy using triple features</td><td>80.4%</td><td>98.3%</td></tr>
<tr><td>5</td><td>Strategy using quadruple features</td><td>85.6%</td><td>98.7%</td></tr>
<tr><td>6</td><td rowspan="2">Gaze mapping using Domain adaptation method</td><td>Strategy using full appearance</td><td>81.3%</td><td>96.6%</td></tr>
<tr><td>7</td><td>Strategy using face image</td><td>93.5%</td><td>98.9%</td></tr>
</table>

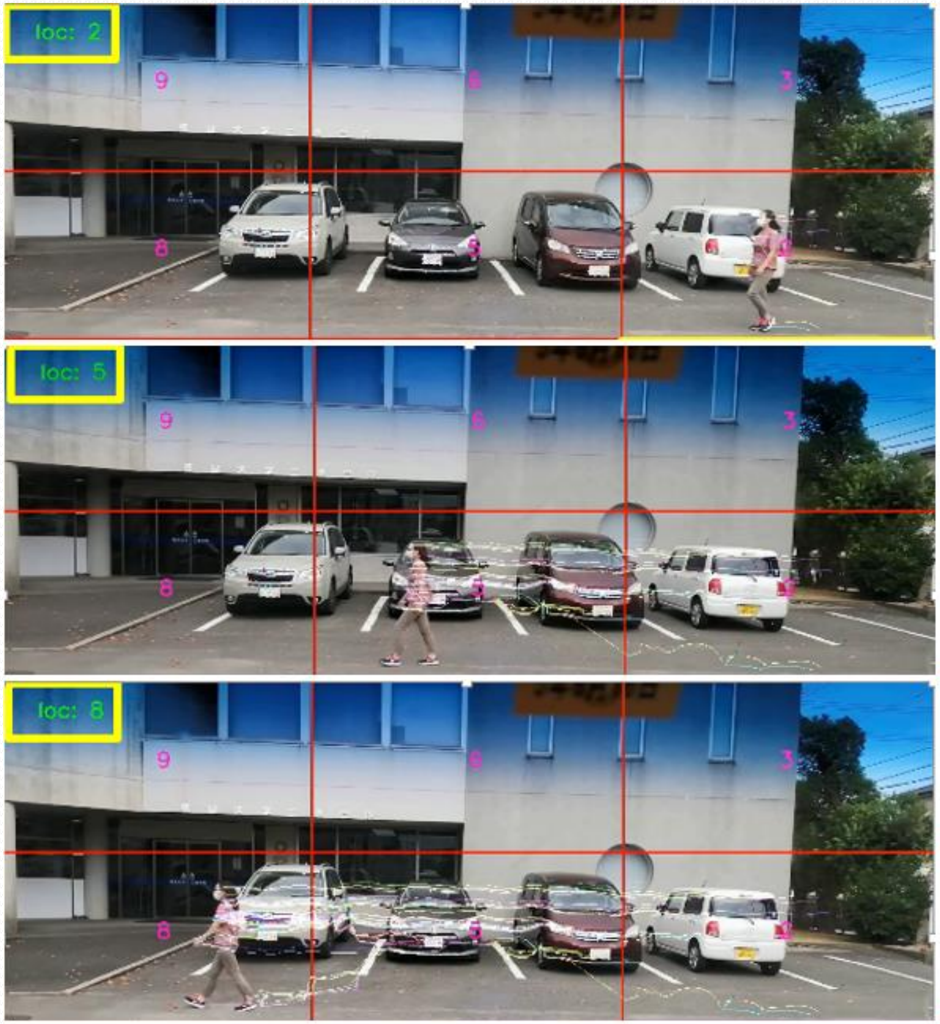
1. I. H. Choi, S. K. Hong and Y. G. Kim, "Real-time categorization of driver's gaze zone using the deep learning techniques," in Proceedings of the International Conference on Big Data and Smart Computing, 143–148 .

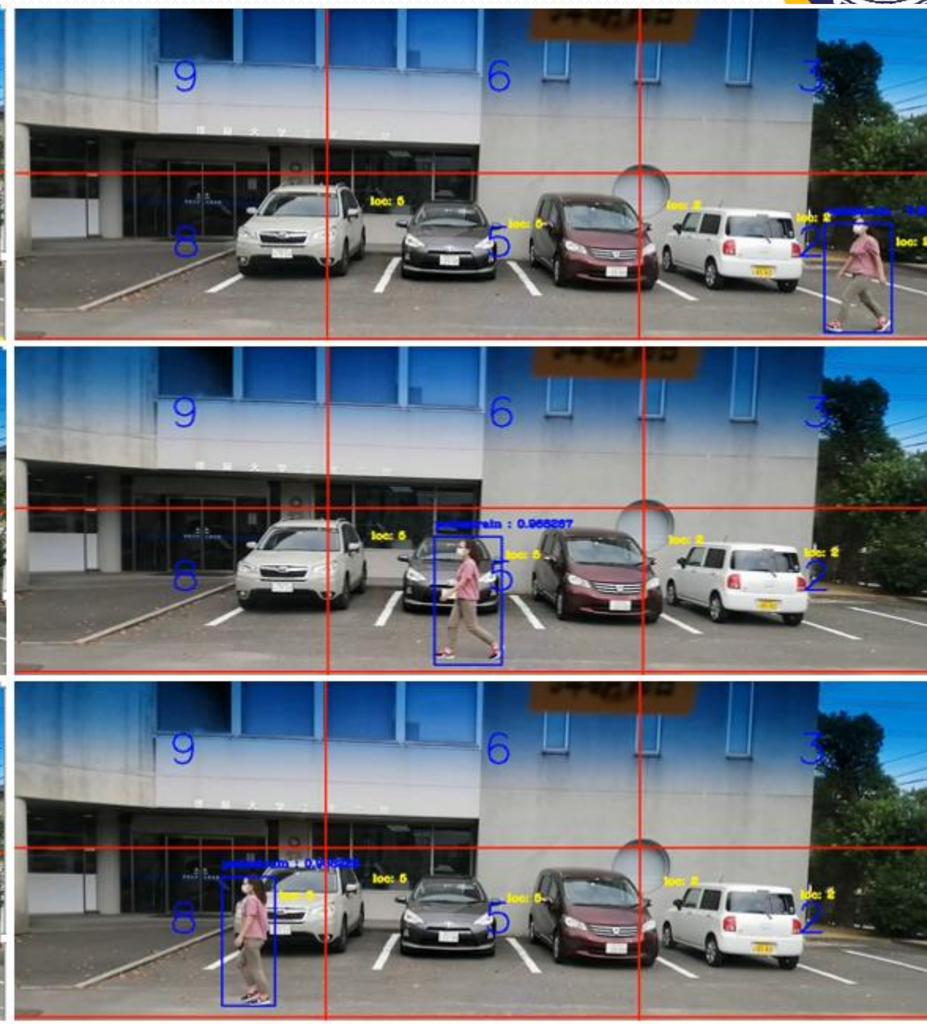
2.R. Naqvi, M. Arsalan, G. Batchuluun, H. Yoon and K. Park, "Deep learning-based gaze detection system for automobile drivers using a NIR camera sensor," Sensors, vol. 18, no. 2, p. 456

3.S. J. Lee, J. Jo, H. G. Jung, K. R. Park and J. Kim, "Real-time gaze estimator based on driver's head orientation for forward collision warning system," IEEE Transactions on Intelligent Transportation Systems, vol. 12, no. 1, pp. 254–267

Experiment and Results

Pedestrian detection:





Pedestrian detection using Lucas-Kanade method

Pedestrian detection using YOLOv4

Experiment and Results

Evaluation of driver's distraction module:

Fig. 15: Evaluation scenes of the combination of gaze mapping and pedestrian detection

Pedestrian route on video:

8 → **5** → **2** → **1**

TABLE XII. EVALUATION OF THE COMBINATION OF PEDESTRIAN DETECTION AND GAZE MAPPING

Gaze regions	*Procedures*					
	Pedestrian detection		*Gaze mapping (OpenFace+SVM)*		*Gaze mapping Domain adaptation*	
	Detect	State	Detect	Pred.d	Detect	Pred.d
8	Yes	8	Yes	8	Yes	8
5	Yes	5	Yes	5	Yes	5
2	Yes	2	Yes	2	Yes/No	5/2
1	Yes	1	Yes	2	No	2

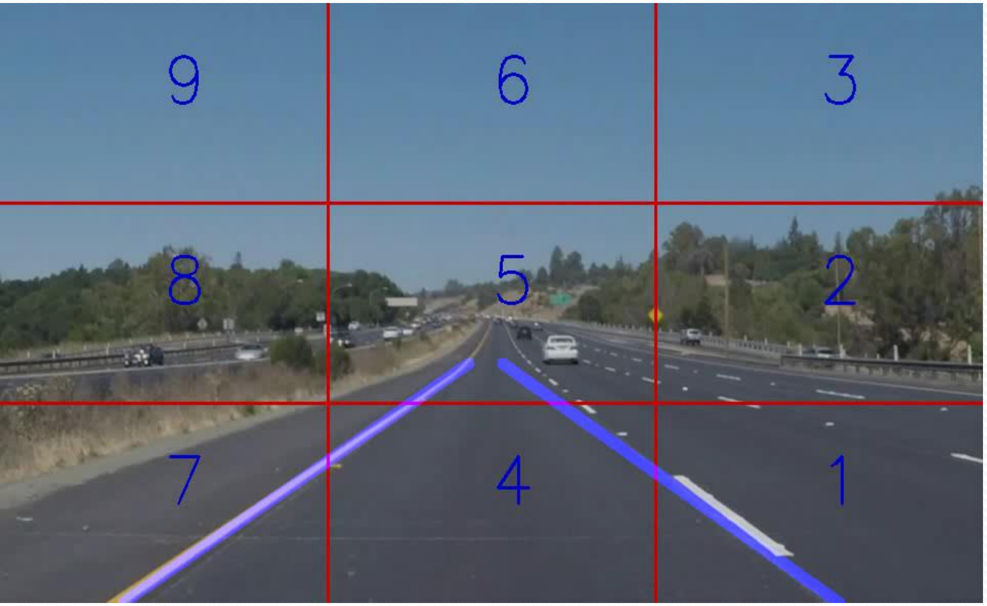
Pedestrian detection: **Pedestrian detection using YOLOv4 model**

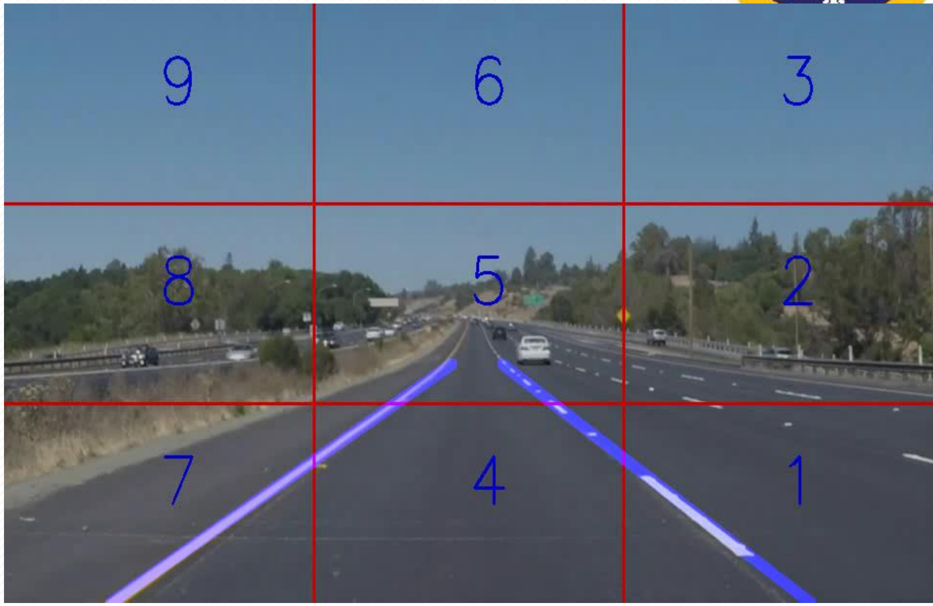
Gaze mapping (OpenFace+SVM): **Gaze mapping using OpenFace with SVM using quadruple features.**

Gaze mapping (domain adaptaion): **Gaze mapping using domain adaptation (using face image)**

Experiment and Results

Evaluation of pedestrian safety module:





Vid 1. Feature-based method

Vid 2. Cao et.al's method

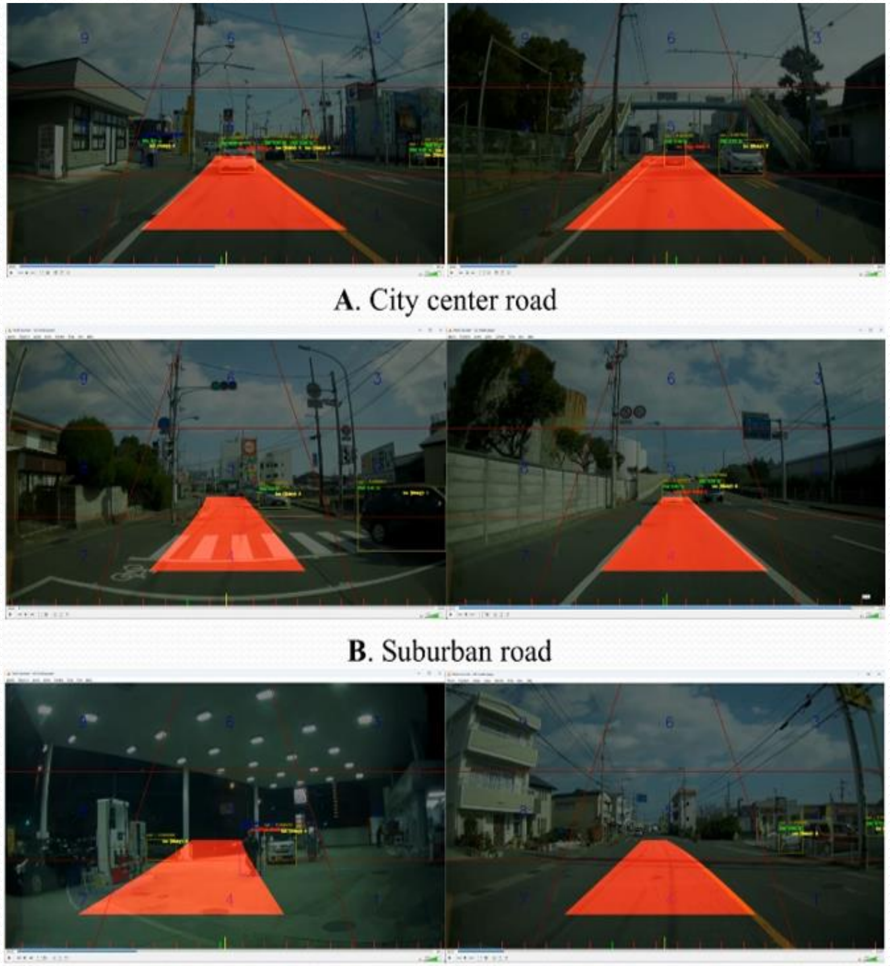
Pedestrian safety:

1. ***Pedestrian detection*** = **YOLOv4 model**
2. ***Lane line detection*** = **The third-order B-spline curve model *(Cao et.al method)***

- *J. Cao, C. Song, S. Song, F. Xiao and S. Peng, "Lane detection algorithm for intelligent vehicles in complex road conditions and dynamic environments," Sensors, vol. 19, no. 14, p. 3166, 2019*

Experiment and Results

Evaluation of pedestrian safety module:



A. City center road

B. Suburban road

C. Blurred or no lane line road

Fig. 16: Evaluation scenes of the combination of gaze mapping and pedestrian detection

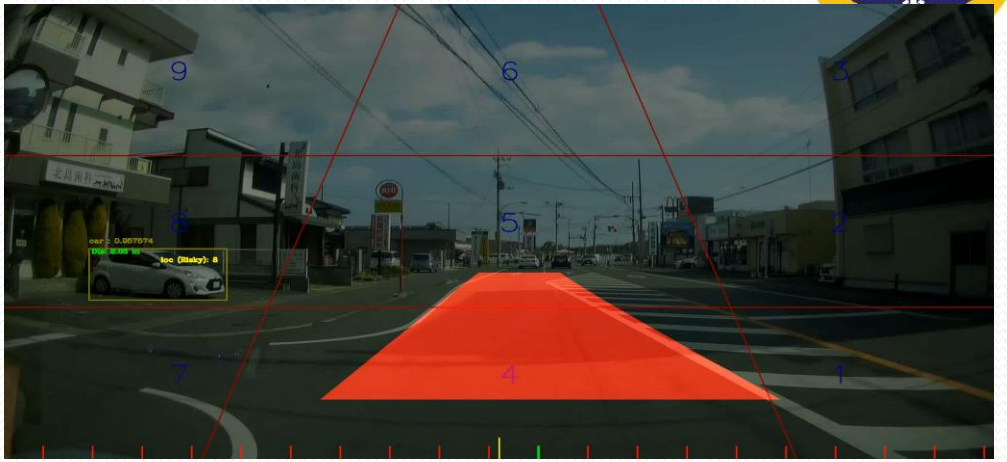


TABLE XIII. EVALUATION OF PEDESTRIAN SAFETY MODULE ON ROAD VIDEO WITH DIFFERENT ENVIRONMENT

Video types	*Accurate Recognition Rate (%) of the lane line*	*Accurate Recognition Rate (%) of pedestrian distance & position*
City center	96.07%	94.24%
Suburban	98.45%	80.97%
Rural	92.85%	84.15%
Average:	***95.79%***	***86.45%***

Conclusion and Future works

Conclusions:

We investigated Driving Support System, designed to address the distracted and safe driving.

Gaze mapping:

- **We investigated which camera positions effective in gaze estimation.**
- **Also, which features are more effective in gaze mapping.**
  (gaze angle, head_pos_R, rot_R, and eye position WO-Z)
- **Proposed and tested:**
  - **Gaze mapping using OpenFace with SVM classifier**
    *(Quadruple combination: SCER **85.6%**, LCER **98.7%**).*
  - **Gaze mapping using Domain adaptation method**
    *(Strategy using face image: SCER **93.5%,** LCER **98.9%**).*

Pedestrian Safety:

- **Implement and tested YOLOv4 and Lucas-Kanade dense method**
- **Lane line detection accuracy of 95.79% and a pedestrian distance and position detection accuracy of 86.45%**

Future work:

Gaze mapping using face generalization method:

- We will prioritize the improvement of gaze mapping by utilizing the face generalization technique in this task. By doing so, we aim to create a highly effective gaze mapping method without requiring *any additional training* or configuration (**Zero-shot** gaze mapping).

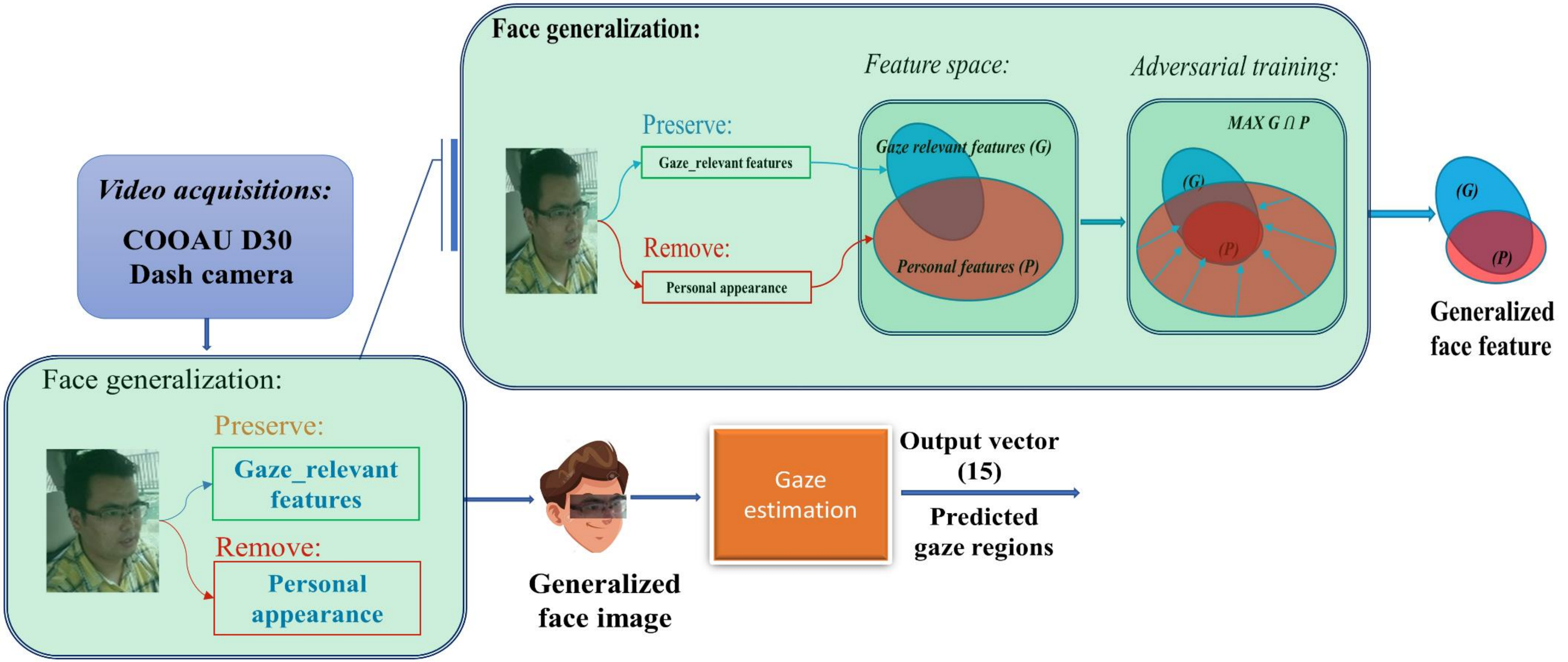


Fig. 19: Overview of gaze mapping using face generalization method

Thank you for your kind attention