

Driver Fatigue Detection System

Students

Handenur Çalışkan Electronics Engineering
Nur Hüseyin Mechatronics & Computer Science and Engineering

Supervisors

Mustafa Ünel
Gökhan Alcan

Company Advisor

Berzah Ozan

ABSTRACT



Figure 1: Extracting facial features of driver [1]

In order to train our algorithm, we have used a publicly available dataset called DROZY [2]. By classifying drowsiness levels between 1 (extreme alert) and 9 (extreme sleepy), fatigue behavior of the driver is evaluated and little warnings that will not interrupt the driver is given accordingly.

The aim of this project is to design and develop a non-intrusive driver fatigue detection system. The machine learning algorithm that we have developed understands drowsiness of the driver via 2D and 3D visual sensors. Intel RealSense and Microsoft Kinect technologies are used for this purpose. Fatigue of the driver is detected through some facial feature points that are extracted from the driver's face (Figure 1).

INTRODUCTION

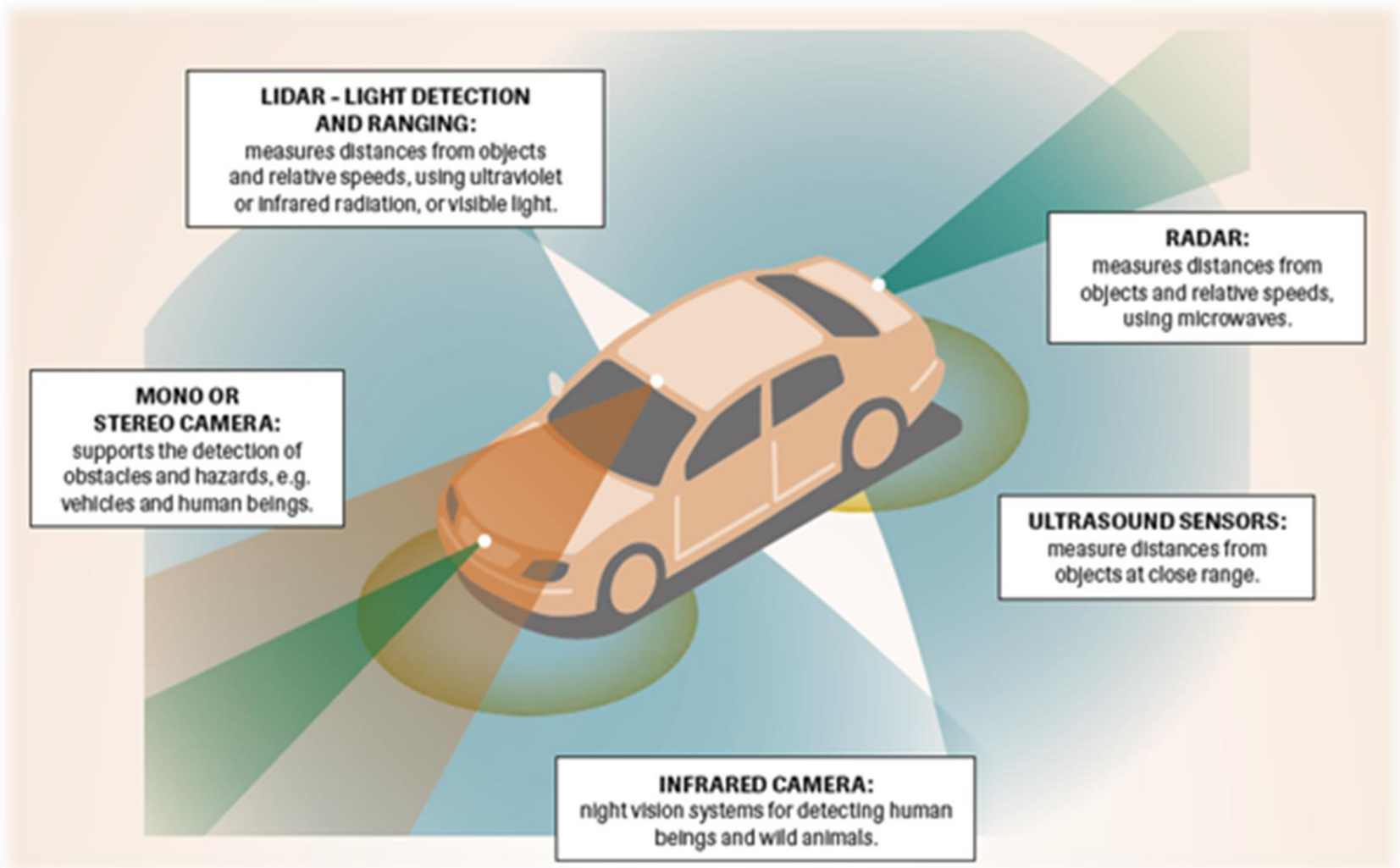


Figure 2: ADAS sensors [3]

- Advanced Driver Assistance Systems (ADAS) are intended to increase the safety of the driver, prevent the accidents, and enhance the driving comfort.
- ADAS consists of several physical sensors as shown in Figure 2.
- Driver's distraction from the road by drowsiness and lack of attention cause serious accidents. Scientific studies conclude that approximately 25% of all major motorway accidents are caused by driver fatigue [4].
- This project aims to contribute to driver assistance systems by developing a machine learning technique to detect driver fatigue using computer vision technologies.
- There are some facial expressions that indicate drowsiness such as head nodding, eye gaze, eye closure rate/time.
- In our system, we utilize only facial landmark points that are extracted from 3D images obtained by RealSense camera. Moreover, it is observed that the landmark points coming from eyes and mouth are the most informative features to determine the drowsiness level, and only the selected subset of these features are employed in machine learning.

CONCEPTUAL DESIGN

1. Hardware Design

The optimal camera location was decided based on camera field of view for tracing driver's face properly while not occluding the view point of the driver.

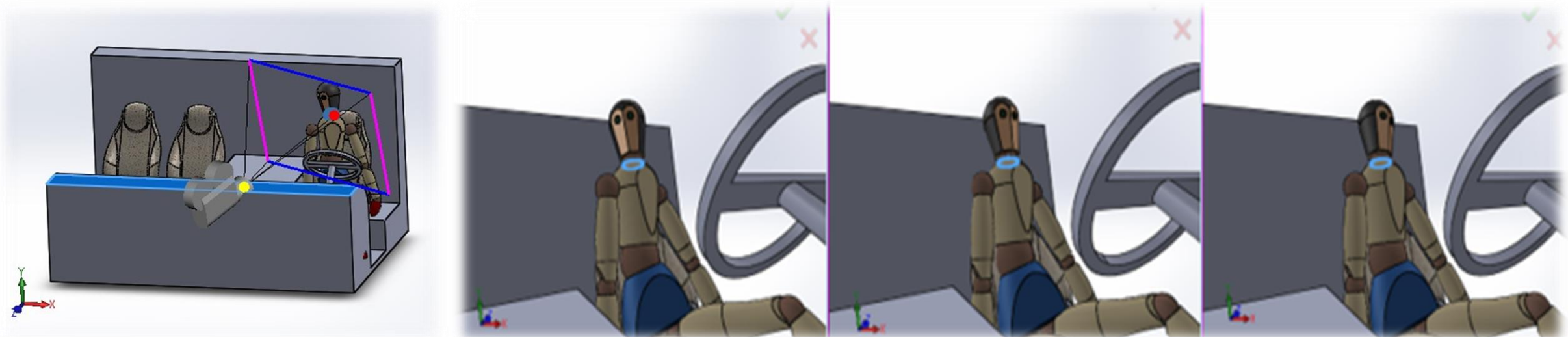


Figure 3: Selected camera placement and snapshots of camera view different head pose of the driver

2. Software Design

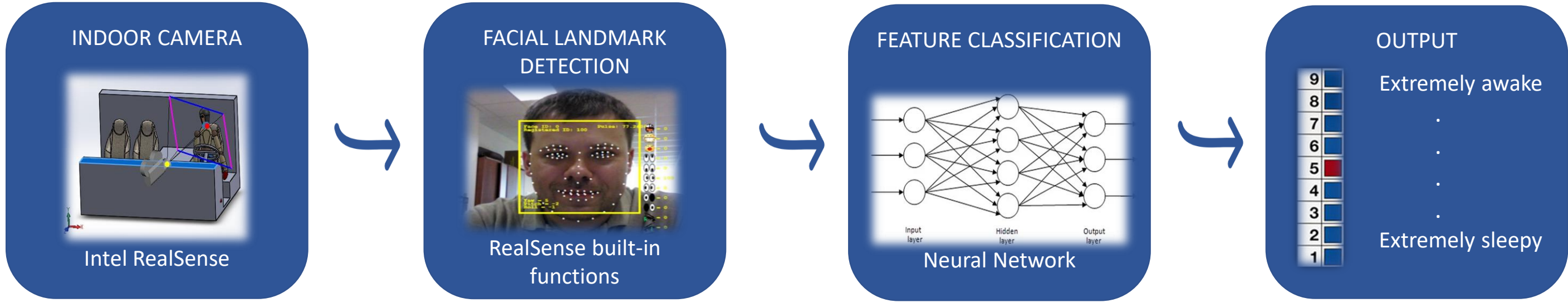


Figure 4: Modular structure of the software design [5], [6]

DROZY Dataset and Implementation

- The dataset consists of video recordings obtained from Kinect v2 camera.
- 68 facial landmark points (Figure 5) with their 2D locations in pixels and 3D in mm are included.
- 36 recordings from 14 subjects have a target value of a given recording scaled by Karolinska Sleepiness Scale (KSS). KSS ranks the vigilance level of a person from 1 (extremely awake) to 9 (extremely sleepy) gradually.
- We used one hidden layer neural network with the inputs of 3D coordinate points of the features.
- To reduce the input data:
 - Instead of using X, Y, Z coordinates of the landmark points, we used their distance from the camera as a feature.
 - Landmarks that would be less related with drowsiness were excluded. Only eye and mouth landmarks were utilized.
- After reduction in both temporal and spatial dimensions, we have reduced the number of frames from 17.900 to 2.000, and the number of features from 204 to 20.
- One hidden layer neural network with 15 neurons is constructed and scaled conjugate gradient back propagation algorithm is used to learn the weights in the network.
- Input data is divided into two parts: 80% for training and 20% for validation.

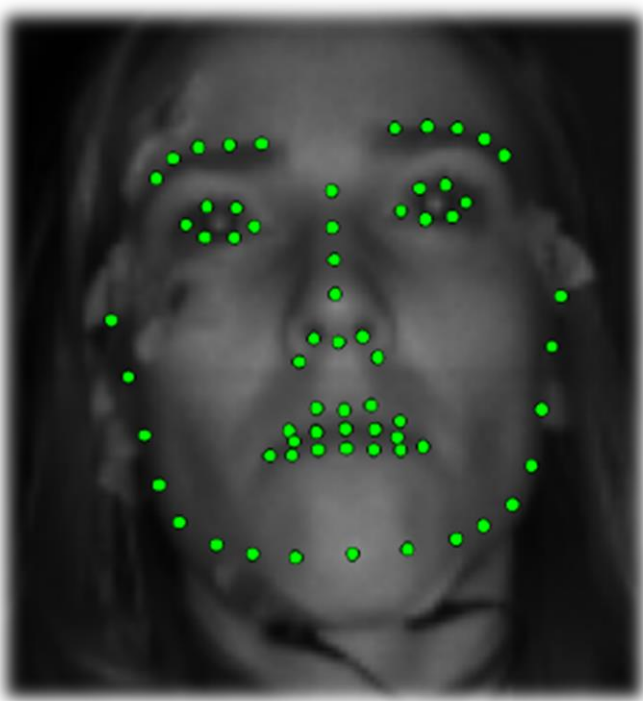


Figure 5: Facial landmark points [7]

RESULTS & DISCUSSION

- Increasing number of neurons are tested in a single-layer neural network and the training and the validation accuracies are tabulated in Table 1. The number of neurons in the network is decided as 15.

Number of Neurons	Epoch Number	Training Accuracy	Validation Accuracy
5	71	76.7%	65.9%
8	72	92.0%	86.4%
10	72	91.5%	79.5%
13	72	96.0%	88.6%
15	72	95.5%	90.9%

Table 1: Performances of the models for different number of neurons

- Training and validation performance of the selected network in terms of cross-entropy are given in Figure 6.
- The distributions of the samples for training and validation are depicted in Figure 7.
- 95.5% training and 90.9% validation accuracies are obtained on DROZY Dataset as shown in Figure 8.
- The true labels and the predicted labels for different male and female subjects and their snapshots from the recordings are shown in Figure 9.

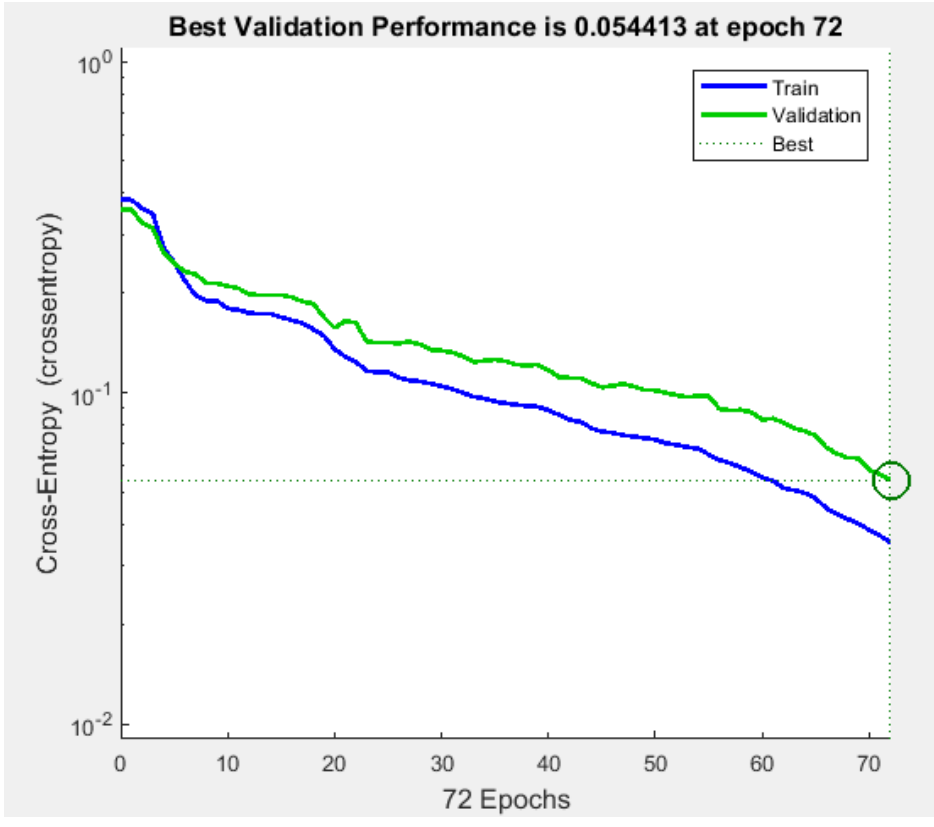


Figure 6: Performance of the network in terms of CE

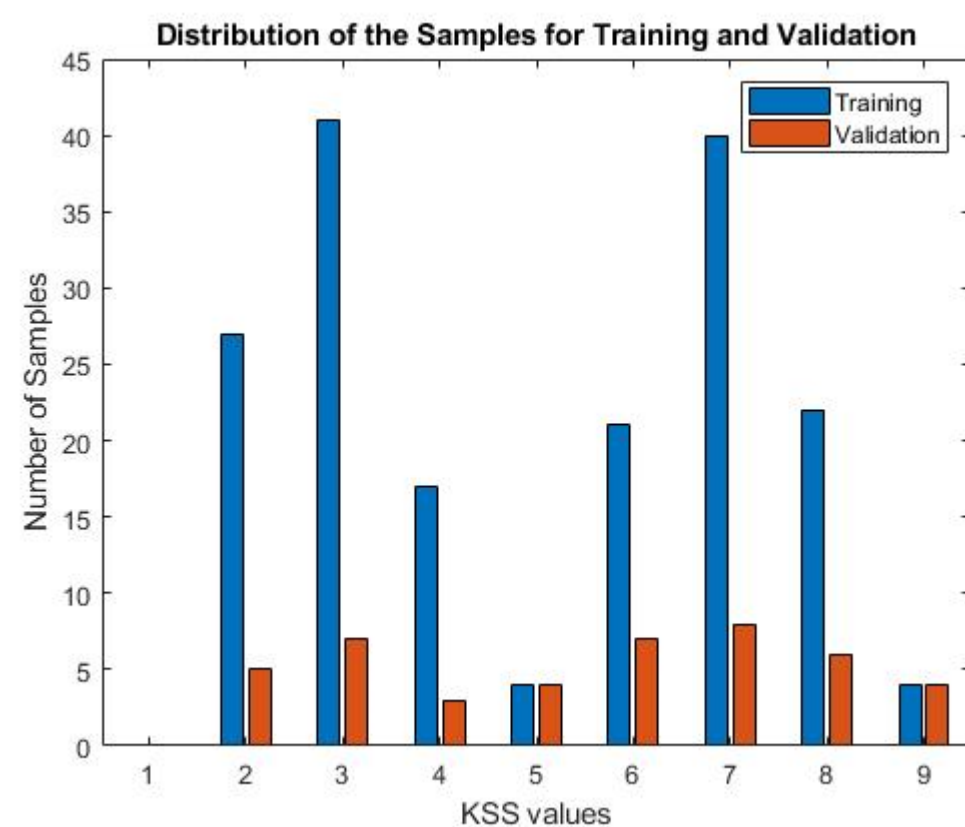


Figure 7: Distribution of the samples

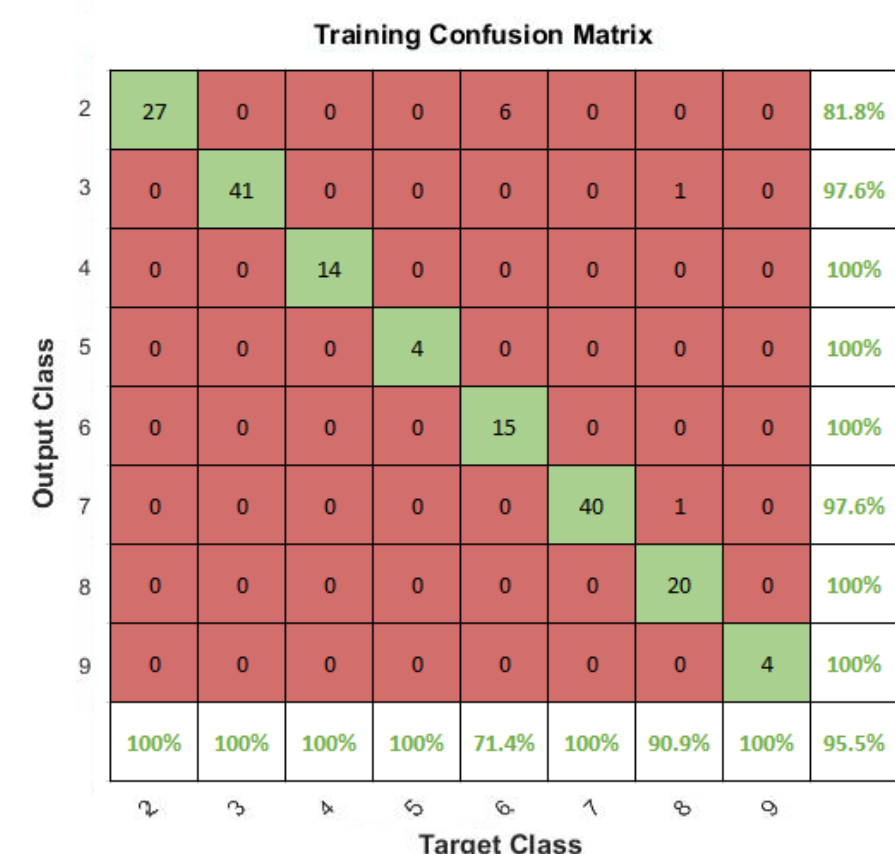


Figure 8: Confusion matrices for training and validation results

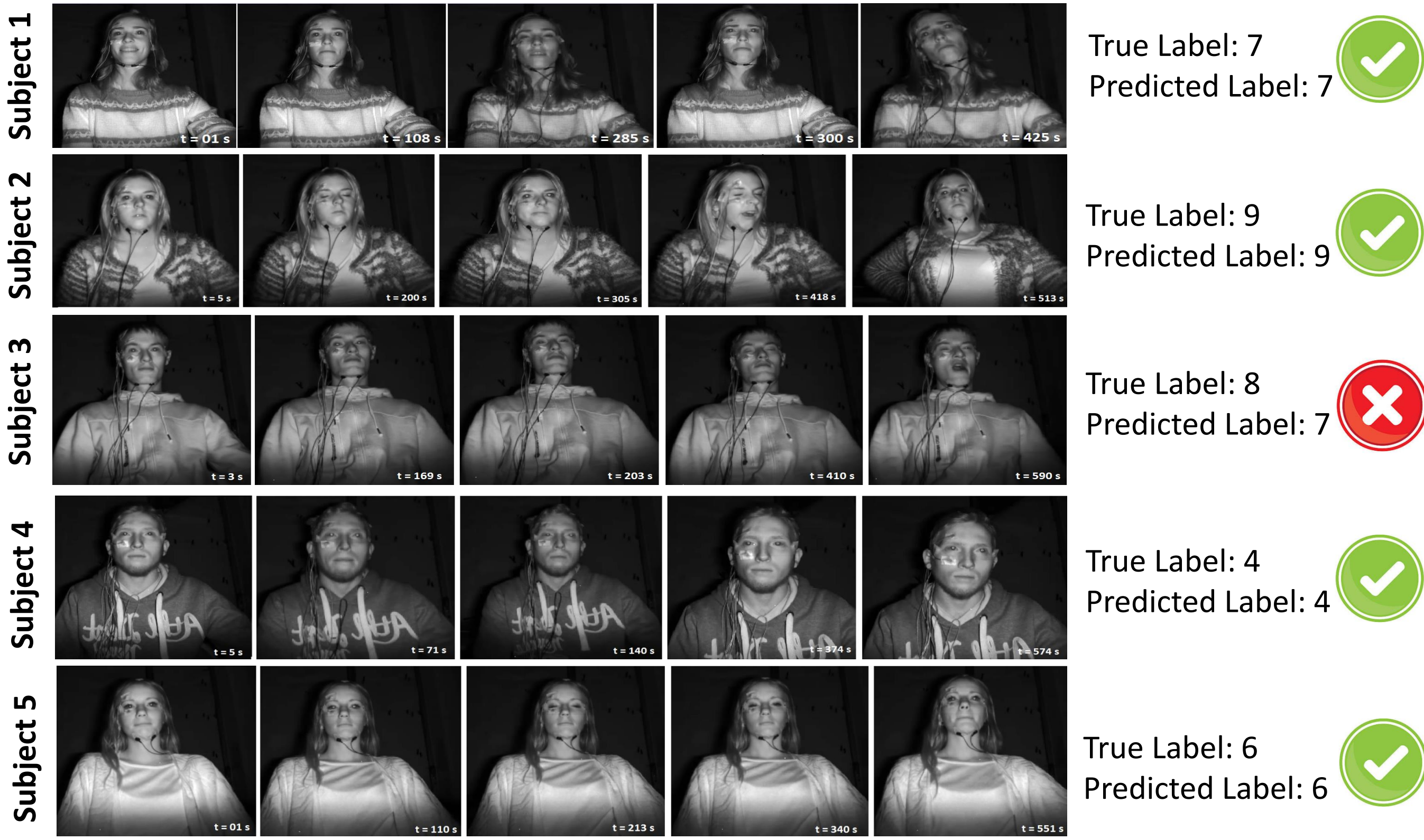
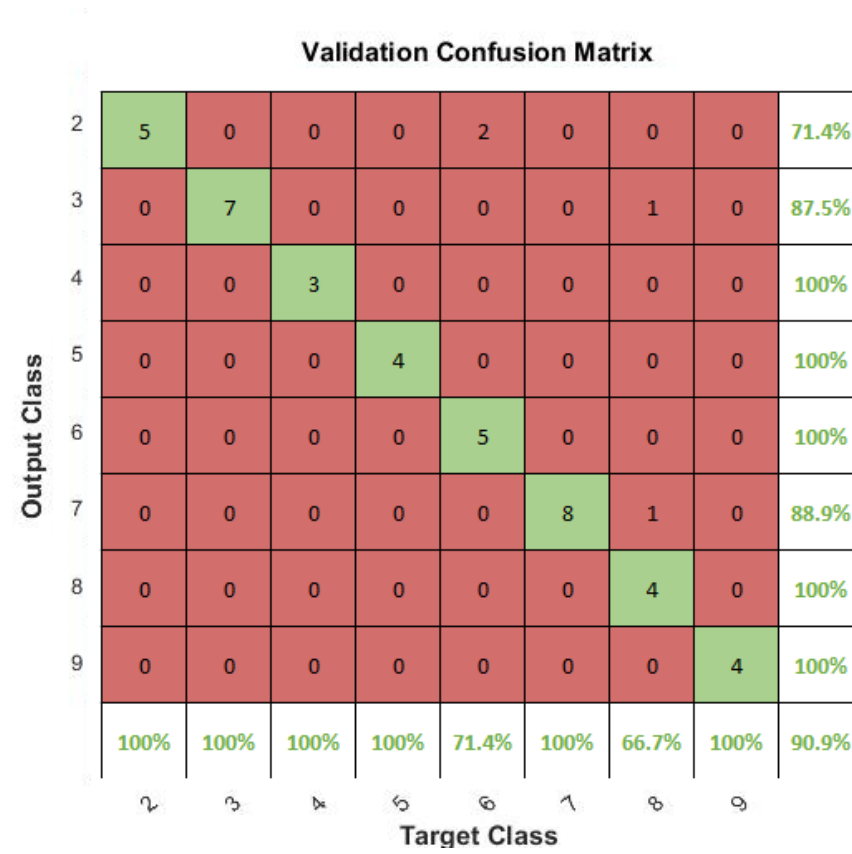


Figure 9: Results of the algorithm for different subjects

- The classification of driver drowsiness level is achieved with the accuracy higher than 90% regardless of gender.
- It is observed that the drowsiness level with the KSS value of 8 could be misclassified due to the close similarity of the features with the KSS value of 7.
- In the training phase, the KSS value of 6 was not learnt properly, so it has also high probability to be misclassified.

CONCLUSION & FUTURE WORK

- Driver drowsiness is monitored by visual sensors using Intel RealSense and Microsoft Kinect technologies. Facial landmark points of the driver were extracted from 2D and 3D images.
- Single hidden-layer neural network classifier which uses 3D locations of the selected facial landmark points throughout the video sequence as inputs was designed to classify the drowsiness level of the driver between 1 (extremely awake) and 9 (extremely sleepy).
- Our algorithm has achieved 95.5% training and 90.9% validation accuracies on DROZY dataset.
- As a future work, the lane changes of the vehicle can be traced to increase the accuracy of the system.

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