Fast and Accurate Facial Landmark Localization in Depth Images for In-car Applications

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Abstract

A correct and reliable localization of facial landmark enables several applications in many fields, ranging from Human Computer Interaction to video surveillance. For instance, it can provide a valuable input to monitor the driver physical state and attention level in automotive context.

→ We tackle the problem of **facial landmark localization** through a deep learning-based approach.

→ It is more reliable than state-of-the-art competitors specially in presence of light changes and poor illumination, thanks to the use of **depth images** as input.

→ The developed system runs in **real time**.

→ We also collected and shared a **new realistic dataset** inside a car, called **MotorMark**, to train and test the system. In addition, we exploited the public *Eurecom Kinect Face Dataset* [1] for the evaluation phase.

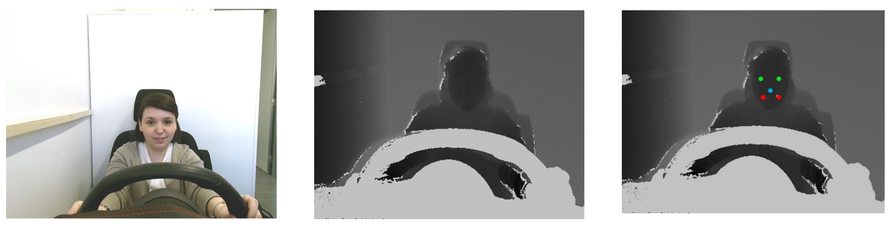


Figure 1. RGB, depth and facial landmarks

MotorMark dataset

We collected a dataset that includes **RGB** and the corresponding **depth images**, annotated with facial landmark coordinates on RGB and depth images. Frames are acquired through a *Microsoft Kinect One*.

Main features:

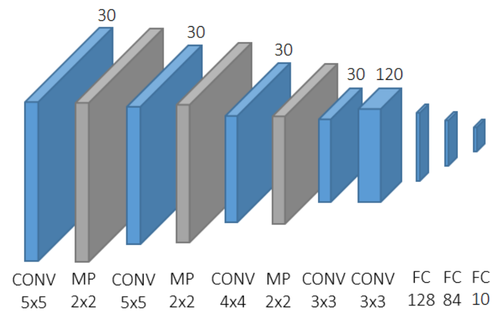
→ **Deep oriented**: is composed by more than 30k frames. A variety of subjects is guaranteed (35 subjects in total);

→ **Automotive context**: we recreate an automotive context. The subject is standing in a real car dashboard and performs real inside-car actions;

→ **Variety**: subjects are asked to follow a constrain path to rotate their head in fixed position or to freely move their head. Besides, subjects can wear glasses, sun glasses and a scarf, to generate partial face and landmark occlusions;

→ **Landmark annotations**: the annotation of 68 landmark positions on both RGB and depth frames is available, following the ISO MPEG-4 standard. The ground truth has been manually generated.

Proposed Method



INPUT

Depth images with this pre-processing:

- Contrast Limited Adaptive Histogram Equalization algorithm;
- Values scaled, mean and variance are 0 and 1;
- A fixed window containing the head is cropped and all the cropped images are resized to 64x64 pixels;

DEEP MODEL

Shallow model (real time performance)

- 5 convolutional layers;
- 3 Max-pooling layers ;
- 3 fully connected layers;
- Activation function: *tanh;*
- L_2 loss;

OUTPUT

10 coordinates (*x,y*) of 5 facial landmarks

- Nose tip, eye centers and mouth corners;
- Ground truth coordinates are normalized in the range [-1, 1], accordingly to the specific activation function of the output network layer;

Results

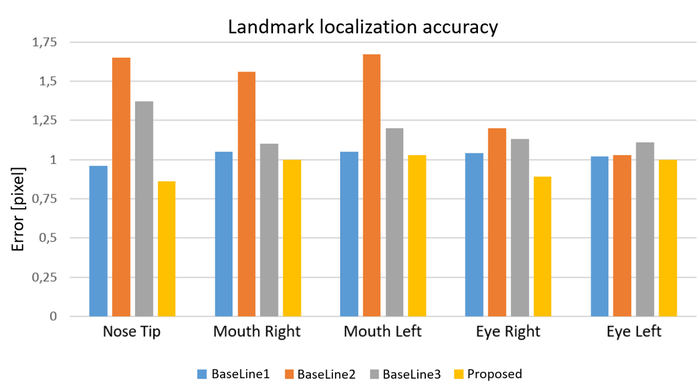
Method	Nose Tip	Mouth Right	Mouth Left	Eye Right	Eye Left	Avg Err
Zhao *et al.*	4.4±2.2	5.4±3.2	5.4±3.2	4.2±2.1	4.2±2.2	4.7±2.6
Our	3.3±4.5	3.5±3.7	3.4±3.9	3.5±4.1	3.4±4.0	3.4±4.0

Table 1 Results on *Eurecom Kinect Face dataset*, expressed as the mean error and the standard deviation in pixels w.r.t the ground truth, normalized by the interpupillary distance. (Zhao *et al.* [2])

Results on *MotorMark* dataset expressed as the mean error and the std in pixels w.r.t the ground truth, normalized by the interpupillary distance.

Different tests have been carried out:

1. Smaller window cropped from head center
2. Bigger input images (128x128)
3. Background suppression applied
4. The proposed method



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References

[1] Min, Rui, Neslihan Kose, and Jean-Luc Dugelay. "Kinectfacedb: A kinect database for face recognition." IEEE Transactions on Systems, Man, and Cybernetics (2014)

[2] Zhao, Xi, et al. "Automatic 2.5-D facial landmarking and emotion annotation for social interaction assistance." IEEE transactions on cybernetics (2016)

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