Facial Expression Recognition Based on Artificial Neural Network for Detecting User Fatigue

Sang-Kwon Sim and Jun-dong Cho

Mobile Design & Automation (LAB)
Department of Electrical and Computer Engineering.
Sungkyunkwan Univ.

Outline

- **Introduction**
- **Related Work**
- **Overall System Configuration**
- **Simulation Result**
- **Conclusion**

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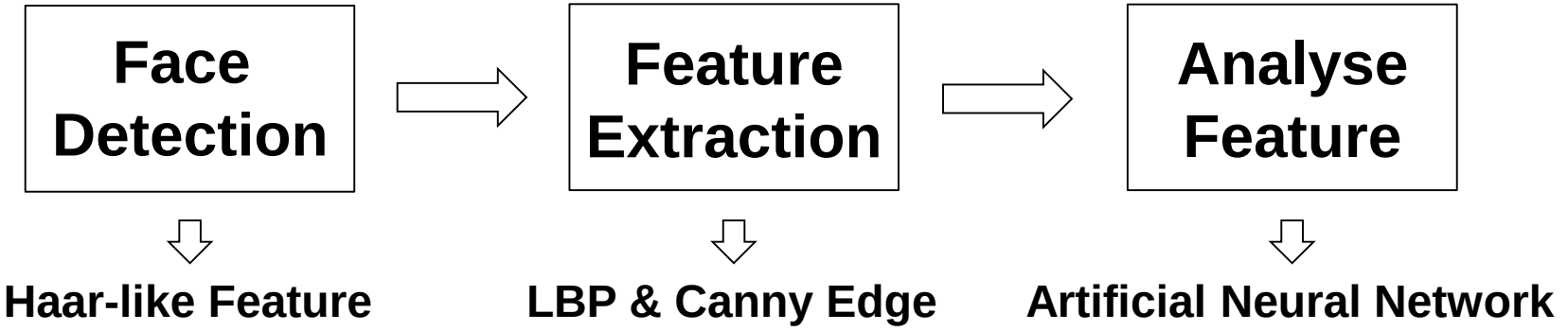
Introduction

- Paul Ekman classifies six basic expressions of Anger, Disgust, Fear, Happy, Sadness, Surprise
- This paper recognizes three types of expression of Anger, Happiness and Neutral
- The expression recognition sequence proceeds to face detection step in the image, feature extraction stage in the recognized face image and the last step in analyzing and recognizing the extracted feature.



Introduction

- **Existing facial expression recognition with dynamic images and a static images**

Author	Method	Test	Recognition Rate
Edwards[3]	PCA and LDA based on Mahalonobis distance	200 images 25 people	74%
Hong[8]	Elastic graph matching	More than 175 images 25 people	81%
Huang[9]	PCA of emotional 2D space and minimum distance classifier	90 images 15 people	84.5%
Lyons[10]	Label graph vector PCA and LDA	193 images 9 people	75~92%
Hara[11]	234×50×6 backpropagation neural network	90 images 15 people	85%
Zhang[12]	646×7×7 RPROP propagation	213 images 9 people	90%
Pantic[13]	Expert system rules	256 images 8 people	91%

Existing expression recognition with static image

Author	Method	Test	Recognition Rate
Essa[14]	Spatio-temporal motion-energy template	30 images 8 people	98%
Wang[92]	The average of feature trajectories B-Spline	29 images 8 people	95%
Black[88]	Intermediate predict the motion of facial features	70 images 40 people	88%

Existing expression recognition with dynamic image

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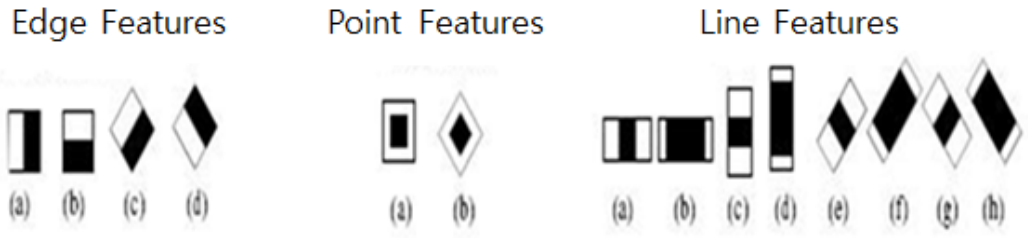
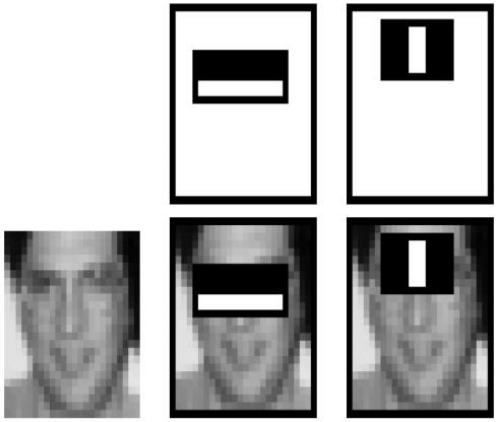
Related Work

1. Haar-like Feature



(a) Basic feature mask of Haar-like



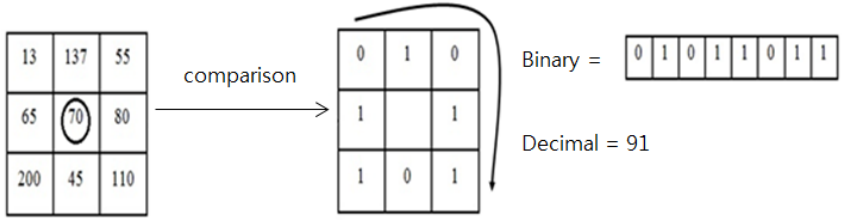
(b) The detection of the eye region features using Haar-like

Haar-like is a fast operation, because the only required operation is the sum in the process of obtaining a feature value, but little robust for feature descriptor of occlusion.

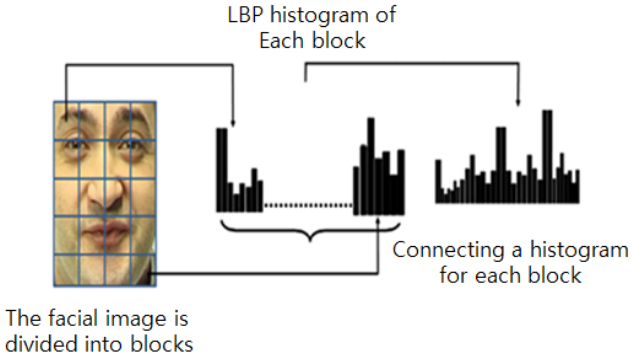
For example, when we catch the characteristics of a person for the eye area like Fig (b), this feature is detected as people's face, because the eye area is generally darkened rather than surrounding area.

Related Work

2. LBP(Local Binary Pattern)



(a) **LBP operation process**



(b) **LBP operation process in block**

LBP is robust for changing in illumination.
We compare the central value to the neighboring value, and large value is assigned 1, other one is assigned zero like (a).

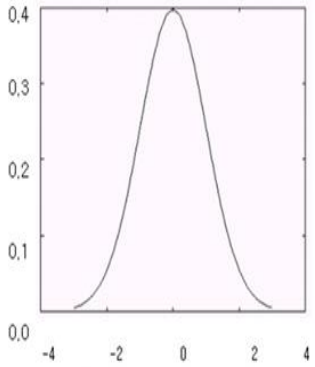
We divides the image into m×n images of a smaller block for local feature extraction and calculates LBP histogram in the smaller block. All LBP histogram connections are used as feature descriptors for the entire image.

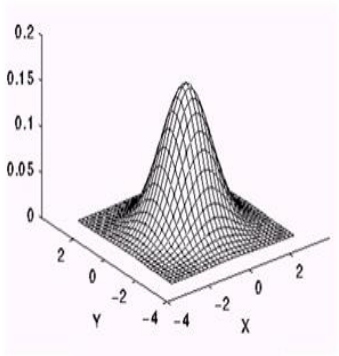
In other word, LBP uses each histogram with a texture model.

Related Work

3. Canny Edge Detection & Gaussian Blur

Gaussian Blur is used for removing noise of an image.

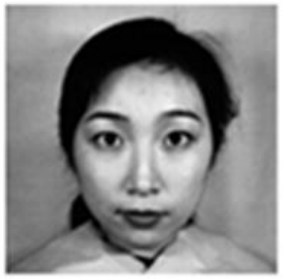




$$G(x) = \frac{1}{\sigma\sqrt{2\pi}} exp \frac{-x^2}{2\sigma^2} \qquad G(x,y) = \frac{1}{2\pi\sigma^2} exp \frac{-(x^2+y^2)}{2\sigma^2}$$

(a) The one-dimensional and two-dimensional Gaussian distribution function.

Canny Edge Detection detects edge using differentiation.



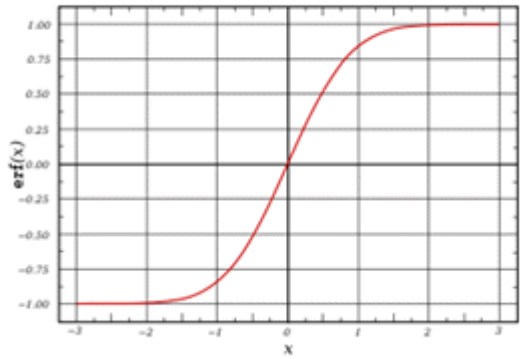
Original image

Canny edge operation image

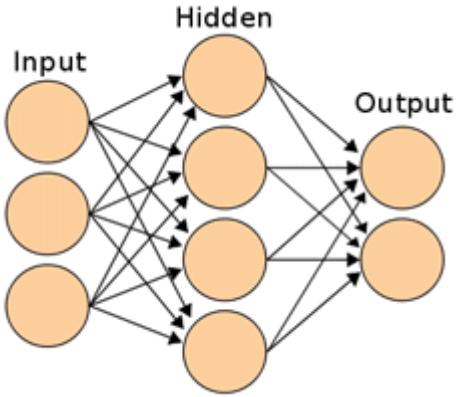
(b) Image canny edge operation is applied to original image.

Related Work

4. Artificial Neural Network Classifier



(a) Sigmoid function



(b) Basic structure of Neural Network

Using the sigmoid function, we need binary value.

Learning the Weight of Artificial Neural Network, we Identify the layer like Fig (b), and we are learning to converge to a specific image from last layer.

Related Work

5. Error backpropagation learning algorithm

Phase 1 : Propagation	
Forward Propagation	Computes the resulting value from the input data and calculates an error at each node results.
Back Propagation	Analyzing the error calculated in the result node, calculate how each weighted value of the previous layer had a much effect.
Phase 2 : Weight Update	
Update the weights using the delta rule. Procedure is repeated for all weight values to the input layer from the layer and the result is repeated until the determination cycle is that convergence.	

Error backpropagation learning algorithm consists of two steps.
First, propagation phase → "Error and variation calculation"
Second, weight update phase → "Update weight"

Error backpropagation algorithm only checks the error and minimizes the error using 'Gradient Descent Method Based Approach'.
Information is updated in the reverse from output layer : Back Propagation

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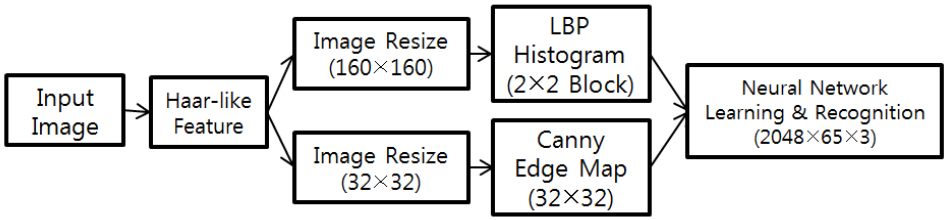
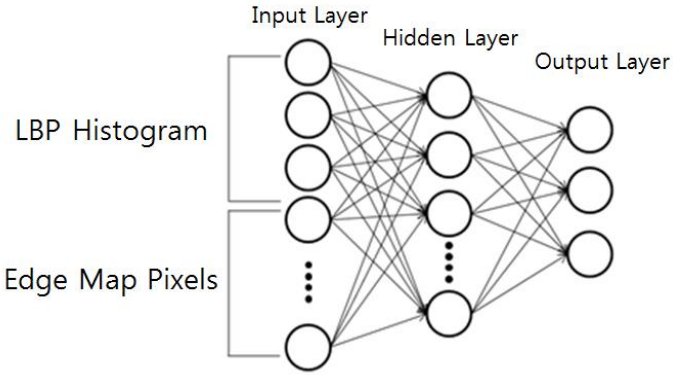
Overall System Configuration



(a) **Overall system configuration**



(b) **Proposed Neural Network structure**

LBP feature value,
Image pixels(8 bits), 4 block → LBP information quantity = 1024(4×256)

Canny Edge Detection feature value,
Edge Map(32×32) → Edge information quantity = 1024

Learning neural network by using information of a total of 2048

The proposed neural network architecture consists of 2048 of input node, 66 of hidden node and 3 of output node.

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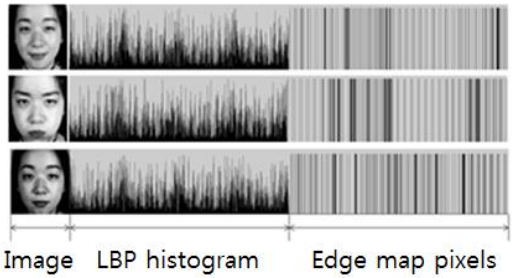
Simulation Result



(a) Neural network input value

Emotions	Expressionless	Happiness	Anger
Block Weight optimization(park)	73.2	73.6	83.6
LBP+adaboost(Zilu & xieyan)	73.6	76.1	85.4
Proposed Method	75	80	83

(b) Compared face recognition rate

No wear glasses
No beard
The front face

⇒ **JAFFE database**

Result recognition rate = above 75%.
Proposed average recognition rate = 79.3%

Expressionless(neutral), Happiness, Anger

⇒ **3 kinds of expression, 30 data learning**

Average recognition rate of Park = 78.4% ⇒ **Improve 1.13%.**

Average recognition rate of Zilu & xieyan = 76.8% ⇒ **Improve 3.15%.**

Progress tests using Leave-one-out

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Conclusion

- **With low erworkload, we have identified a better performance than the conventional method.**
- **We apply the proposed algorithm using extracting a specific part only that affects the expression rather than the entire face image.**
- **We plan to increase the recognition rate using the method of learning data of the bio-signal devices such as EEG, ECG and PPG in artificial neural network classifier.**

Q&A