Recognition of Eye Direction Using Separability Filters

in Touch-type Training

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Abstract
We propose a method to extract the face area from a trainee’s picture using mosaic templates and recognize a trainee’s eye direction using separability filters in touch-type training using a camera. The recognition of a trainee’s eye direction enables us to give a trainee warnings and appropriate advice, and these warnings and advice assist a trainee to learn touch-typing quickly. On the experimental results for twenty trainees’ black-and-white pictures, we obtained an 83% recognition rate.

1 Introduction
The capability of typing quickly is very helpful in studying and using IT (information technology). Nowadays the capability is becoming more and more important because many people use computers for calculating, writing, reading and so on, and the keyboard is the most common device to input characters. Users can type on a keyboard and train themselves in their own manner, because the keyboard is easy to use. However, typing in one’s own manner has a speed limit which is much lower than typing in a proper manner. Furthermore, users’ own training ways are not adaptable, that is, using their own typing style, the users would be able to type certain words or sentences quickly, but not so many. By the recognition of a trainee’s eye direction using a camera[1], it is possible to warn and give advice when a trainee looks at improper places. These warning and advice must be effective for trainees to learn touch-typing quickly.

2 Process of an eye direction recognition
1. Extracting the face area from a trainee’s picture
   Taking a picture of the upper half of the trainee’s body using a camera which is placed on top of the display in the middle, and extracting the face area from the picture.
2. Extracting features and recognizing an eye direction
   Extracting features from the picture of a trainee’s face area, then recognizing the eye’s direction.
3. Warning and advising

Warning with sound and giving appropriate advice when a trainee looks at improper places. Warnings concentrate one’s attention on the training, and giving advice is effective for fast learning.

In this paper, we deal with the processes (1) and (2). To be applicable for most touch-type training methods, the process (2) recognizes eye directions as follows: looking at the display or not, looking at the keyboard or not.

3 Extraction the face area

In this section, we propose a method to extract the face area from a picture of the upper half of trainee’s body using mosaic templates.

The process of making mosaic templates is as follows.
1. Extracting head areas and face areas from trainee’s pictures by hand.
2. Mosaic processing of head areas and face areas.
3. Making the n mosaic templates for each area by a k-means clustering algorithm.

The process of extracting the face area by template matching is as follows.
1. Mosaic processing of a picture of the upper half of trainee’s body.
   A block size per mosaic is W, pixels width and W, pixels length.
2. Scattering the trainee’s picture using the mosaic templates for the head area and extracting the head area.
3. Scattering the head area using the mosaic templates for the face area and extracting the face area.

4 Recognition of eye direction

In this section, we propose a method to recognize eye direction using separability filters. The process of recognition is as follows.

4.1 Extracting possible candidates for irises

We extract candidates for irises by scanning a face area using the separability filters. Fukui proposed the circle separability filter to extract irises [2]. On the other hand, we propose an arc separability filter to imitate the actual
shape of an iris as shown in figure 1. Changing the filter's dimensions and position, we take as possible candidates for irises areas which have high separability $S$. Equation (1) gives $S \ (0.0 < S \leq 1.0)$. If an iris is extracted using the separability filter, the inside of the filter is dark and the outside is bright. Therefore, we select the $m$ candidates which satisfy the condition that the difference of average darkness value between the inside pixels and the outside pixels is greater than $\delta \ (|PI - PO| \geq \delta)$ as shown in figure 2.

$$S = \frac{a_{1}(\bar{P}_{1} - \bar{P}_{m})^{2} + a_{2}(\bar{P}_{2} - \bar{P}_{m})^{2}}{\sum_{i=1}^{N} (\bar{P}_{i} - \bar{P}_{m})^{2}} \ (1)$$

Figure 1: Proposed separability filter.

Figure 2: The difference of average darkness value between the inside and the outside of the filter.

4.2 Identifying irises

Figure 3 shows the method to identify two irises from the candidates. We identify two irises which satisfy $\alpha_{x, \text{max}} > |r_{x} - l_{x}| > \alpha_{x, \text{min}}$ and $|r_{y} - l_{y}| < \alpha_{y}$. If no candidates are selected, we recognize that the trainee is looking at the keyboard. Where $(r_{x}, r_{y})$ is the center position of a right iris and $(l_{x}, l_{y})$ is the center position of a left iris.

Figure 3: Identifying two irises.

4.3 Recognition of an eye direction

If a trainee looks at a display, we assume $S$ is high because a camera can take irises. Hence, if $S$ is higher than or equal to $\beta$, we recognize the trainee is looking at the display. If $S$ is less than $\beta$, we recognize the trainee is not looking at the display. On the other hand, if a trainee looks at the keyboard, we assume $S$ is low because an eyelid covers an iris or irises are not taken in a picture. Hence, if $S$ is less than or equal to $\gamma$, we recognize the trainee is looking at the keyboard. If $S$ is greater than $\gamma$, we recognize the trainee is not looking at the keyboard.

5 Experiments

We made experiments to evaluate the proposed method with the following conditions: (a) taking twenty moving pictures of the upper half of trainee's body. None of the trainees wore glasses. Fifteen trainees could not touch-type, (b) the pictures were black-and-white, 256 picture elements, (c) using twenty still pictures when a trainee looked at the display and fifteen still pictures when a trainee looked at the keyboard. These still pictures are extracted from the moving pictures, (d) leave-one-out cross validation using a personal computer with 1.7GHz CPU.

Table 1 shows the conditions of making mosaic templates. The block size ($W_{x} \times W_{y}$) was the following: 75*75 pixels for the head area and 25*25 pixels for the face area.

Table 1: Experimental conditions of mosaic templates.

<table>
<thead>
<tr>
<th></th>
<th>mosaic processing width * length</th>
<th>the number of templates</th>
</tr>
</thead>
<tbody>
<tr>
<td>head area</td>
<td>4 blocks * 5 blocks</td>
<td>6</td>
</tr>
<tr>
<td>face area</td>
<td>12 blocks * 12 blocks</td>
<td>6</td>
</tr>
</tbody>
</table>

We used three kinds of separability filters. The dimensions ($d_{x} \times d_{y}$) were the following: 20*12 pixels, 24*13 pixels and 26*14 pixels. The other parameters were as follows: $m=20$, $\alpha_{x, \text{max}} = 195$, $\alpha_{x, \text{min}} = 100$, $\alpha_{y} = 20$, $\beta = \gamma = 0.2$ and $\delta = 10$.

First, we made experiments for extracting the face area using mosaic templates. All trainees' face areas were extracted. The extracting time for a picture was less than one second. Next, we made experiments for recognizing eye direction. We obtained an 83% recognition rate.

6 Conclusions

In this paper, we propose a method to extract the face area using mosaic templates and recognize eye direction using separability filters in touch-type training. On the experimental results for twenty trainees' black-and-white pictures, we obtained an 83% recognition rate.

We have the following plans to get a higher recognition rate: (a) studying the dimensions and shape of a separability filter, (b) making it applicable for trainees who wear glasses and blink.

Acknowledgement

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References