An Experiment of Identification of Seal Impression by Pattern Matching

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Abstract

In the Japanese social activities,seal impression plays an important role instead of the person's signature generalley used in the foreign parts. This paper is the first report on a experiment of an identification of seal impression by computer. Usually,seal identification have been carried out by visual perception. It will be obvious as a result of this experiment that identificaion by computer is better than by visual perseption. The process of this is consisted of a probability model.

1.Introduction

In Japan, a seal impression is used to identify the person who brings the seal in place of their signatures. A problem described here is whether two seal impressions are made from the same or different seal. Otherewise it is to detect the difference of two seal impression's shape, that is, it may be judged that different seal impressions are made by different seals.

But quite similar impressions are often submitted to identify,which are difficult to recognize the difference of. By example,they may be produced with the Automatic Seal Engraving Mashine using the same tracing paper of a character. In the above case, it forces the author to examine human ability of the identification. And we begin to form a evaluation function which express the difference of two seal impressions and we put it by the sum of Euclidian distance of their corresponding points. An algorithm to identify them by computer is programmed with the defined function.

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It consists of the following steps: i) to match two impressions, ii) to detect the differences, iii) to sum up and evaluate them. Comparing human ability and a method of direct matching by computer, we get useful results to identify them.

2. The Experiment of Human Ability of Identification

The following experiment was carried out for the purpose of comparing the human ability of seal identification with the capability of this new method by computer.

Five amateurs and four experts were selected and each of them was required to classify one hundred similar impressions to each original seal. Here,five original seals (two of a character YAMADA and three of character YOSHIKAWA) were made by the machine on the basis of two original characters respectively. The result of the experiment is shown in Table 1.

decision	person	rate of mistaking
different seals under same seal	amateur	0.15**
	expert	0.01**
same seal under different seal	amateur	0.31*
	expert	0.21*

** significant level =0.01, * =0.05

Table 1. The experiment of human ability of seal identification

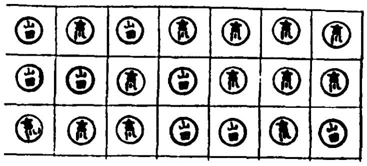


Fig.1. Sample impression for the experiment

3. The Method of Identification by an Evaluation Function

Seal impression is divided into $n \times n$ meshes for performance of the identification method suggested,here,by computer. By gray level of each mesh,it is classified to three classes D_0,D_1 and D_2corresponding to the low, the middle and the high level,respectively. In other words,when a mesh is classified to D_0, it means to belong to the background of impression. In the same way a mesh classified to D_2 belongs to the character of it. When a mesh is classified to D_1, it means to belong to the background or the character.

For the practical use, we number the k-th mesh k, where k=1,...,m (m=n n). Let D_r^k be the class of k-th mesh of registered seal impression and D_c^k the seal impression for check. Let E be evaluation function which decides whether a couple of impressions are same or not.Evaluation function

E is defined as follows;

$$\left.\begin{array}{l} D_r^k = D_2 \ , \ D_c^k = D_2 \\ D_r^k = D_1 \ , \ D_c^k = D_1 \\ D_r^k = D_0 \ , \ D_c^k = D_0 \end{array}\right\} W^k = 1$$

$$\left.\begin{array}{l} D_r^k = D_2 \ , \ D_c^k = D_0 \\ D_r^k = D_0 \ , \ D_c^k = D_2 \end{array}\right\} W^k = 0$$

$$\left.\begin{array}{l} D_r^k = D_1 \ , \ D_c^k = D_0 \\ D_r^k = D_2 \ , \ D_c^k = D_1 \end{array}\right\} W^k = p$$

$$\left.\begin{array}{l} D_r^k = D_0 \ , \ D_c^k = D_1 \\ D_r^k = D_1 \ . \ D_c^k = D_2 \end{array}\right\} W^k = q$$

where W^k is the weight function $(0 \leq p,q \leq 1)$ and $E = \sum_k W^k/m$, $m = n \times n$. The closer to one evaluation function E is, the more matched a couple of impressions are. The closer to zero, the less matched.

It is, therefore, reasonable to take a threshold, by which we decide whether a couple of impressions are same or not, that is, if the value of evaluation function E is larger than threshold, then a couple of impressions are same, and if the value of E is smaller than it, then they are not.

By way of example, we estimate the mean and the standard deviation of enaluation function E in order to decide threshold,from the data of two couples of impression, where p=0 and q=0.

		error of the first kind α	error of the second kind β
person	amateur	0.301	0.141
	expert	0.210	0.066
computer		0.023	0.021

Table 2. Comparison the human ability and the the capability of this method

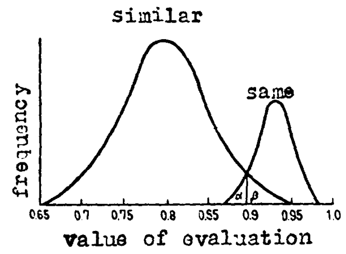
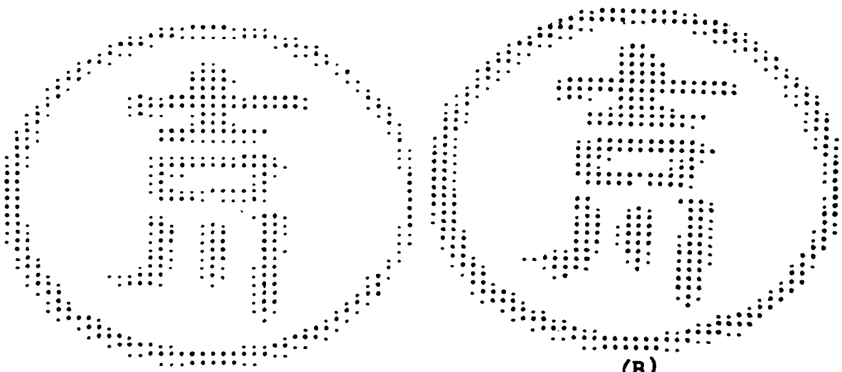


Fig.2 Frequency of the value of E

As a result, with a couple of impressions of the same seal they are estimated as follows,

$$\mu = 0.931, \quad \sigma = 0.01765$$

with those of the similar seals we have



(A) (B)

Fig.3. A Couple of Impressions of Similar Seals

$\mu = 0.797$, $\sigma = 0.04324$.

Next,let α and β be error of the first kind and error of the second kind, respectively. By assumption of normality, we get values of and at Table 3, caluculated by table of normal distribution.

The threshold is obtained as 0.895 on the conditions that the value of α † β is minimized under α is neary equal to β . In this case the values of α and β were 0.0228 and 0.0207,respectively.

Finally, we have the result (shown in Table 2) comparing the human ability of identification in section 2 with the capability of this method in this section by the values of two kind of errors,α and β .

Example

Impressions made from two similar seals shown in Fig.3 although there are surly slight differences between those gray levels, they are hardly recognized. But it is possible to recognize those slight differences by the value of evaluation function E: As the value of evaluation function E is 0.891 and smaller than that of the threshold 0.895 in the section 2, a couple of them in Fig.3 are decided that they are different seals.

4. Conclusion

It is concluded that this new identification method is superior to the identification by visual perception in the point of accuracy of decision.

As the exapmple in the picture section shows, this new method is useful to descriminate a couple of slight different impressions. That is to say it is effective enough to identify the quite similar seals made by the Automatic Seal Engraving Machine.

5. Acknowledgement

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threshold values of E	α	β
0.855	0.0052	0.0336
0.890	0.0133	0.0262
0.895	0.0228	0.0207
0.900	0.0427	0.0158
0.886	0.0062	0.0322
0.887	0.0073	0.0301
0.888	0.0084	0.0287
0.889	0.0099	0.0274
0.894	0.0197	0.0217
0.896	0.0262	0.0197
0.897	0.0294	0.0188

Table 3. The Values of Two Kinds of Error α and β