Recognition for Alphabet Using Vector Scanning

Vector Space for Alphabet and Mutual Distances

by

Shuji OGAWA* and Moriyuki MATSUO**

*Graduate Student, Course of Electrical Engineering,
Graduate School of Engineering, Tokai University
**Professor, Department of Information Media Technology,
School of Information Technology and Electronics, Tokai University

Abstract

In this paper, it is considered a pattern from to be drawn each letter of the printed alphabet on the two-dimensional space and the new scanning method by using the rotation vector is clarified.

Next, some character patterns are made by expansion, reduction or inclining a letter. Then, each character pattern is scanned by rotation vector respectively. As a result alphabet space is composed. In the space, the distance between each letter is found.

Keywords: Mutual –distance. Printed- alphabet. Character-pattern. Vector-scanning. Alphabet- space

1. Introduction

Recently, the handwritten character recognition technology is also remarkably. On the other hand, the mechanism of recognition as man's intellectual seeing has not been elucidated though it is advancing as the technology develops into the research of the recognition theory yet. Man's character recognition ability is recognized a pattern without big, small and inclining, and depending on a geometrical transformation of the distortion etc. To elucidate this mechanism, it is considered pattern from be drawn each character of the printed alphabet on two-dimensional space and proposes a new method of scanning it. An intersection of a part of the character pattern and rotation vector is found while rotation vector is scanning. In addition, the distance from the origin to the intersection is measured, and the value is taken. It is assumed to be an amount of the feature of the character pattern for the sum total of the distance from the origin.

Next, the character pattern of n-piece is made by expansion, reduction or inclining one letter, and of each is scanned in a similar method. Then, the amount of the feature of pattern of n-piece is obtained for the same letter. This amount of the feature is projected and one letter is projected to n-dimensional vector space.

Finally, doing similar operation on all letters of the alphabet composes

n-dimensional alphabetic space. Then, the distance between letters is found in this space.

2. Definition and the character pattern of a letter as image

The image treated in this paper is assumed to be a set of the element, which is the gray level with integer value distributed on two-dimensional space;

$$\mathbf{A} = \{a_{ij} \mid i, j = 1,2,\Lambda\ ,m\} \qquad (2.1)$$

Where a_{ij} is a pixel.

The character pattern as a letter drawn in two-dimension is as follows:

$$\alpha_r \quad (r=1,2,\Lambda\ ,R) \qquad (2.2)$$

That is, α_r is a sets of the pixels distributed in two-dimension.

$$\alpha_r = \{a_{ij} \mid i, j = 1,2,\Lambda\ ,m\} \qquad (2.3)$$

The character pattern is a figure which consists of the point and the segment drawn as white on the black ground. Therefore, the character pattern takes the following values ;

$$a = \begin{cases} 1 & (\text{white character}) \\ 0 & (\text{black ground}) \end{cases} \qquad (2.4)$$

Although a letter α_r is composed of some pointes and segments it is assumed to compose them of two or more pixels even when it is isolated.

3. A type of the character pattern and its the scanning

3.1 A type of the character pattern

Let a character pattern of α_r is $[\alpha_r]_{UV}$. The table 3.1 shows combination of U and V. That is, a character pattern which becomes a standard for the character is assumed to be a neutral pattern, and it is assumed to be located as a printed letter in the direction of regularly. The one that the character pattern is inclined right and left respectively is made the left and the right. Moreover, what makes the one with standard of a neutral pattern an inside, expands them, and reduces is shown largeness and the smallness respectively. As a result, nine different character patterns are made from one letter.

Table 3.1 Combination of the character pattern.

U \ V	Left	Neutral	Right
Large	LL	LN	LR
Middle	NL	NN	NR
Small	SL	SN	SR

3. 2 Scanning of the character pattern

To extract the feature of the letter α_r, the image **A** is scanned in the following methods, and inclusion a_{ij} in α_r is picked up a_{ij}. Where $a_{ij}=0$ is disregarded.

A rotation vector $\mathbf{v}(\theta_k)$ with the center point $\left(\frac{m}{2},\frac{m}{2}\right)$ in the plane is defined. Where $0 \le \theta_k < 2\pi$.

$$|\mathbf{v}(\theta_k)| = \frac{m}{2} \qquad (3.1)$$

$$\theta_k = \left(\frac{2\pi}{N}\right)\cdot k \quad (k=0,1,2\Lambda,N-1) \qquad (3.2)$$

Where N is arbitrary.

Let an intersection of the pixel $\{a_{ij}\}=1$ in the character pattern from α_r and the vector is $P_{r,k,l}$ Where $l=1,2,\Lambda,L$.

It is assumed the distance $|P_{r,k,l}|$ from the origin to the intersection.

Next,

$$s_r = \sum_{k=0}^{N-1}\sum_{l=1}^{L}|P_{r,k,l}| \qquad (3.3)$$

is found.

$$x_r = \frac{s_r}{\max|P_{r,k,l}|} \qquad (3.4)$$

Then expression (3.3) is calculated for the standardization.

4.. Extraction of feature vector

4. 1 Vector conversion and alphabetic space

The following vector $\mathbf{x}$ is obtained for all combinations U and V ;

$$\mathbf{x} = \left\{ x_{UV} \Big|_{\substack{U=1,2,3,\Lambda,p \\ V=1,2,3,\Lambda,q}} \right\} \qquad (4.1)$$

Let $n = pq$.

$$\mathbf{x}_r = (x_1, x_2, \Lambda, x_n)_r \qquad (4.2)$$

As a result, the vector corresponding to the letter α_r is obtained. The letter α_r will be characterized by the n-dimensional vector $\mathbf{x}_r$ if the number of combinations of U and V is assumed to be n now, and the letter is projected to one point of n-dimensional space as for it.

Thus, 26 letters in the alphabet are projected on n-dimensional space respectively. Therefore, this n-dimension space is called alphabetic space.

4. 2 Norm and distance of vector

Norm of vector in alphabetic space is given as follows ;

$$\|\mathbf{x}_r\| = \left(\sum_{i=1}^{n} x_i^{\,2} \right)^{\frac{1}{2}} \qquad (4.3)$$

Moreover, the distance between two letters can be defined as follows;

$$d(\alpha_{r'}, \alpha_{r''}) = \left(\sum_{i=1}^{n} (x_{r'}, x_{r''})^2 \right)^{\frac{1}{2}} \qquad (4.4)$$

5. Generation of character pattern and the scanning

5. 1 Generation of character pattern

The printed letter handled in this paper is made by Gothic type letter on the plane of 32×32 pixels. This letter has been expanded on the plane of 256×256 pixels. Next, a character pattern is made thinning and it is assumed character pattern $[\alpha_r]_{UV}$, where U=Middle, V=Neutral.

In addition, the character pattern is reduced by 67% to U=Small and expanded by 133% to U=Large. It is assumed V=Right by inclining the character pattern of the above-mentioned to the right at angle of ten degree and V=Left to the left at angle of twenty degree.

Therefore, it is assumed U and V have three kinds of patterns in expression (4.1). Then generated the character pattern of nine piece of one letter α_r.

5. 2 Scanning of character pattern

The character pattern which generated by the method where described in paragraph 5.1 is scanned by the rotation vector as a scanning line. The fulcrum of rotation vector as scanning line is at the center of the plane with 256×256 pixels. The fulcrum is assume the origin of the coordinate axes. The scanning line has the size in expression (3.1) . In addition, the sum total is obtained like expression (3.3) for the distance from the origin at the intersection of the scanning line and a part of the character pattern at that time. Furthermore it is assumed to be one index on the character pattern by expression (3.4) for x_r.

5. 3 Composition of alphabetic space

A similar scanning to the paragraph 5.1 is done to all the combinations of U and V, and the index of U×V=9 piece is requested. Nine-dimensional vector of which they are assumed to be an element is obtained for the letter α_r. The result of the request is shown in Table 5.1 for 26 letters.

Table 5.1 Nine-dimensional Vector and norm for the letters

	LL	LN	LR	ML	MN	MR	SL	SN	SR	Norm
A	250	174	245	241	164	211	279	171	220	661
B	476	332	420	476	332	401	448	335	424	1226
C	346	221	293	351	236	294	302	220	266	854
D	363	246	314	356	253	324	321	254	344	934
E	347	258	307	352	254	330	361	252	278	922
F	217	182	227	226	188	237	251	186	208	644
G	441	223	290	334	234	279	322	226	273	895
H	300	212	278	302	217	256	278	213	251	775
I	190	152	171	187	132	179	182	141	173	506
J	201	138	173	201	137	160	190	133	177	510
K	269	171	266	259	169	220	248	167	204	669
L	185	136	139	184	137	145	183	139	152	471
M	383	263	312	374	262	348	268	366	349	985
N	327	211	275	306	208	260	292	210	254	791
O	432	294	380	410	291	392	406	290	367	1099
P	300	222	278	334	218	312	296	220	260	823
Q	387	238	367	415	235	330	336	232	320	973
R	302	217	300	316	220	324	216	300	276	833
S	470	272	403	437	274	355	388	254	307	1076
T	192	156	172	202	143	179	158	151	179	514
U	284	191	250	256	195	225	275	188	240	709
V	193	127	193	217	137	184	202	144	175	531
W	284	204	310	299	209	241	315	204	264	787
X	251	146	195	264	139	212	242	146	184	609
Y	184	112	151	183	112	157	194	117	158	465
Z	265	186	222	268	183	233	260	183	233	685

5．4 Distance between letters

The distance between each letters is calculated in the space by using expression (4.4). The result is shown in Table 5.2

Table 5．2 The distance between letters

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	0	569	208	285	269	64	259	128	164	157	50	200	363	141	443	180	323	230	426	169	60	137	130	88	200	56
B	–	0	375	295	311	587	354	451	721	717	562	757	286	437	134	409	267	423	186	714	519	696	445	623	763	542
C	–	–	0	101	89	226	100	87	352	347	193	388	192	71	250	58	130	135	230	346	157	326	106	252	393	174
D	–	–	–	0	80	300	126	166	430	426	277	468	131	154	172	129	93	159	184	423	232	407	171	338	473	252
E	–	–	–	–	0	283	126	155	418	416	263	454	170	141	184	109	113	172	185	414	221	394	156	322	461	241
F	–	–	–	–	–	0	287	144	144	147	81	183	366	164	460	188	347	222	450	145	88	125	159	101	190	70
G	–	–	–	–	–	–	0	157	401	393	244	433	202	129	235	149	143	197	201	396	206	378	171	300	438	230
H	–	–	–	–	–	–	–	0	272	267	116	309	244	33	326	69	208	132	311	266	76	247	57	182	315	97
I	–	–	–	–	–	–	–	–	0	32	173	54	489	288	594	319	473	340	577	33	207	50	288	124	63	182
J	–	–	–	–	–	–	–	–	–	0	166	51	489	282	591	318	467	343	571	47	201	41	281	113	56	176
K	–	–	–	–	–	–	–	–	–	–	0	211	351	129	435	169	308	212	410	172	64	144	128	89	211	63
L	–	–	–	–	–	–	–	–	–	–	–	0	526	324	632	358	511	381	613	68	242	81	324	152	46	217
M	–	–	–	–	–	–	–	–	–	–	–	–	0	238	193	211	173	164	221	476	310	469	263	409	537	325
N	–	–	–	–	–	–	–	–	–	–	–	–	–	0	311	68	192	141	292	284	88	263	64	191	329	111
O	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	281	151	304	100	589	393	570	322	497	637	416
P	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	168	118	273	314	135	294	93	224	363	145
Q	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	208	124	466	277	444	204	370	512	297
R	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	305	327	187	320	165	271	390	195
S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	572	377	550	307	473	616	401
T	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	205	60	286	128	85	179
U	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	184	92	124	248	43
V	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	260	93	75	158
W	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	199	327	120
X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	148	95
Y	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	223
Z	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0

6． Conclusions

In this paper, it is considered patterned from to being drawn each character of the printed alphabet on two-dimensional space and the new scanning method by using the vector is clarified.

Next, the nine character patterns are made by expanding, contracting and inclining from the same letter. Then, each character pattern is scanned by rotation vector. Further, each letter of alphabet is expressed as nine-dimensional vector respectively. As a result alphabet liner space is composed. In this space, distance between each letter have found.

It is necessary to request similarity between each letter in the space as a problem in the future. Moreover, the method of extracting the nearest letter is clarified by considering alphabet space obtained here to be a standard space, and projecting an unknown character like a hand-written character etc. in this space. Finally, the application of pattern recognition technology by using this method is expected.

Reference

1) Michimasa Kobayashi ; "Linear Algebra Using Mathematica", Asakura bookstore(Mar.15,1997)