A Global Sign-Logo Recognition System by Color-Shape-Based Similarity Computations for Images

YUKI TOYOSHIMA † SHIORI SASAKI ‡ and YASUSHI KIYOKI †

† Faculty of Environment and Information Studies, Keio University 5322 Endo,Fujisawa,Kanagawa,252-8520 Japan

‡ Graduate School of Media and Governance, Keio University 5322 Endo,Fujisawa,Kanagawa,252-8520 Japan

E-mail: † ‡ {t09651yt, sashiori, kiyoki} @sfc.keio.ac.jp

Abstract

In this paper, we present a sign-logo recognition system for detecting meanings of signs and logos existing in a global real space. First, this system finds out the category of a sign-logo image input to the system by the similarity computations with images in the database focusing on the color and shape features of images. Second, the system searches for the information corresponding to the specific sign-logo image. This system makes it possible for a user to find out the meaning and the related information of sign-logos based on the user's location. This paper also presents several experimental results for sign-logo recognition functions by using actual sign-logo images. Those results clarify the feasibility and the applicability of our system in real world spaces.

1. Introduction

In recent years, it is becoming possible to integrate media information resources and mobile processing facilities. The new multimedia and mobile environment extends the possibility of what people can do in their daily lives. For example, content-based image retrieval is often used for information retrieval because the user can obtain the information related to places and things from images in the real world. Information retrieval technology is now becoming a part of our daily life, and in the future of our global world, the need of applications that help people overcome borders of language and physical abilities is expected to be high.

In this paper, we represent an implementation method of a system to recognize the meanings of sign-logos in the real world by analyzing the color and shape of images. Our system recognizes the sign-logo images of the image data by using the color and shape information of the inserted image, and detects the meaning information of the image. To find out the meaning to the sign-logo in the real world, the user takes a screen shot of the image on the application, and inputs the image in the system.

This system extracts the color and shape information of the image input by a user, and calculates the similarity between the input image and the images inside the database, and provides the top results in a ranking. By selecting the right image from the candidates, the user is able to acquire the meaning of the sign-logo.

This system is designed from the idea to create a database of existing sign-logos in the real world. Sign-logos treated in our system need not to be defined in advance, and the client side does not need to equip a reading system to recognize the standardized code like QR code system. Our system recognizes the color and shape of sign-logos that differ in countries and cultures and provides the appropriate meaning information by using the geographical location information of the user.

2. Related work and the features of our system

To realize our idea, we focus on the point that the meanings of sign-logos are formed from the combination of colors and shapes as common elements around the world. Another point is that there are elements, which differ from countries to countries, and cultures to cultures, other than the common elements.

For example of a common element around the world, according to the JIS Safety Color regulation [3], the meanings of basic 8 colors are as follow: Red: fire extinction, prohibition, stop, high risk of danger, Orange: danger, security facilities for sail and air Yellow: warning, Green: safety, evacuation, health, aid, progress, Blue: mandatory, precaution, Purple: radiation, White: passage, order, Black: word, mark (Figure 1).

In a global sense, there is a survey about the commonality of traffic sign systems around the world using the combination of color and shape by the United Nations Special Commission [4]. This survey indicates that the certain combinations of color and shape in traffic sign systems have a commonality in the meaning such as Red Circle: prohibition, rule, Yellow Triangle: warning, Green Rectangle: aid, Blue Square/Rectangle/Circle: mandatory.

The characteristic of our system is to support the commonality and diversity of sign-logos between countries/regions/cultures, and enables the user to acquire the appropriate meaning information of the sign-logo focused by using the user's location information. The user is not only able to acquire the meaning information, but is able recognize sign-logos all over the world and cross the borders.

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Figure 1 Safety Color regulated by JIS ([3])

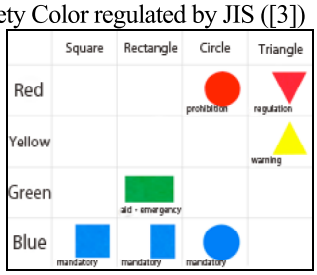

Figure 2 Survey about the traffic sign systems by the United Nations Special Commission (made from [4])

There is difference in cultures and countries in ways of using color and shape in sign-logos, and how people feel about a certain color or shape. Our system supports this diversity, and also outputs the common information that can be positioned as a universal information provision system.

3. Basic Method

3.1 System Structure

The system structure of our system is shown in Figure 3. There are two functional subsystems in this system, (1) color-shape-based image similarity computation system (CBIR) and (2) relational database of image-related meaning information. First, the color and shape information of the image is extracted. Second, the in the color-shape-based CBIR system computes the similarity between the input image and the image from the sign-logo database. In this step, the location information from the GPS of the user is used for the provision of candidate images in the results. From the retrieval result and user location, the images is ranked in similarity and shown. Then, the user selects the image that the person is looking for out of the ranked images. Finally, the meaning information of the selected image is collected by pattern matching from relational database of image-related meaning information.

The two main features of our system are shown in Figure 4. In the first step, as a pre-processing, the system extracts the color and shape information of the target images and puts them into one database with the metadata of meaning, category, country, regions. In the second step, the system extracts the color and shape information of the input image, and by using the color information and shape information within the database,

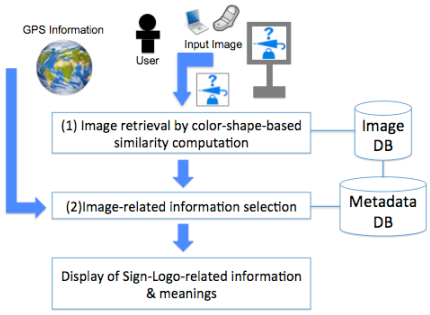

Figure3 System Structure Component

the system calculates the similarity values between the images. In the third step, the system provides the calculation results as a ranking of similar images. In the fourth step, a user chooses a sign-logo image which he/her is searching for from the ranking of candidate images. In the fifth step, the system shows the user about the meaning information of the sign-logo.

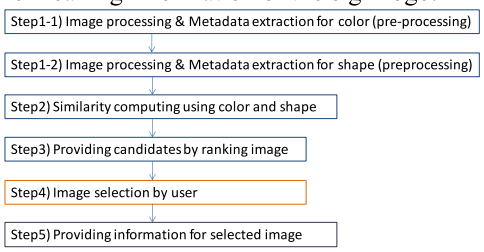

Figure 4 Image similarity computation and the candidates selection process

3.2 Image Similarity Computation Method

In this system, we apply the image similarity computation method using the Pillar Algorithm [5][6] using color and shape information, which has already been proposed.

This image similarity computation method [5][6] is consists of 4 processes: Pillar Algorithm that clusters the pixels within the image, image color analysis process, image shape analysis process, and image structure analysis process. The characteristic of the Pillar Algorithm is to make the fast extraction of image color, shape, and structure possible. Pillar Algorithm is used for optimization of K-Means clustering and the method to optimize the initial centroids for K-Means, ensuring high performance both in precision and computational time in extracting metadata and image similarity computation.

Since analyzing sign-logos in the real world on our system needs precise real time procession, we decided this image similarity computation method [5][6] is appropriate to apply. We use only color and shape of images in the metadata extraction, because the structure information of images is not helpful in recognizing the sign-logos that we focus on in this research.

4. Implementation

This system is structured by the combination of (1) Image Similarity Computation System (CBIR) and (2) Image related

meaning information database. About the feature in (1), we implement this by using the Image Similarity Computation System mentioned in 2.2, and going through the image processing of color and shape on Step1-1, Step1-2, and the similarity computation on Step1, Step3. About the feature in (2), we implement Step5 in Figure2 by creating a sign-logo database on PostgreSQL.

In the plot type system of this implementation method, we defined 5 attributes for each sign-logo such as the name (image ID), type (type), category (category), country (country), meaning (meaning). Figure 5 is an example.

image id	type	category	country	meaning
information.jpg	sign	public	Japan	information center
schoolexist.jpg	sign	road	Europe	schools exist
greenseal.jpg	symbol	product	Japan	pet bottles
petbottlemark.jpg	symbol	product	America	green seal

Figure 5 Relational database of the Sign-Logo meaning information

Figure 6 Interface of the CBIR system and an example of the result

Figure 6 is showing the interface of the CBIR feature. On this interface there are 3 boxes where the user can change the weight parameters such as color weight, shape weight, and structure weight. This brings a change in the results, however in the case of sign-logos, we only focus on color and shape parameters. This result shows the sign-logos that are similar to what the user selected as the query.

(2) The Image meaning information providing feature to show the meaning of the sign-logos is made separate from the CBIR feature, which is made by using the Table 1 database on PostgreSQL. This feature makes the retrieval of meaning and information of sign-logos possible. (Figure 7)

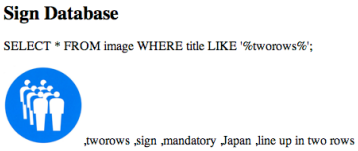

Figure 7 Example of the meaning information for an image

5. Experiments

In the experiment to test this system, we focus on the commonality and diversity of color, shape, and meanings of sign-logos. Through this experiment we verify the feasibility and possibility of this system.

For the experiment, we collected 227 sign-logos from 5 regions (Japan, America, Germany, Europe, WorldWide). The 227 images contains 176 images from Japan, 9 images from America, 1 image from Germany, 10 images from Europe, and 30 images from WorldWide. In addition, 14 categories are set, such as public, road, product etc.

5.1 Experiment 1: Accuracy Experiment on the Image Similarity Computation Feature

This experiment is based on the hypothesis on sign-logos meaning consisting of color and shape combination.

In experiment 1, we examined the accuracy of the image similarity computation. Comparing the results of the image retrieval by (1) only focusing on color, (2) only focusing on shape, and (3) focusing on both shape and color, we determine the accuracy of this feature of our system. We counted the number of correct answers (Precision) within the top 10 results. The graph below shows the result of testing the 227 images as the query image in the retrieval (Figure 8).

The rate of the correct images focusing on color was 86.17%, shape was 46.52%, both color and shape was 38.55% in average. As Figure 7 shows, the result of (1) had the highest rate of correct answers. In fact, in all the cases of (1) the case of focusing on color, (2) the case of focusing on shape, (3) the case of focusing on color and shape, the same image as the query came to the top result. Comparing case (1) and (2), the reason why (1) had the higher rate of correct answers is because the variation of color is more less then the variation of shape. Also, the images that contain rare colors or shapes had 1 as the result of numbers of correct images. On the other hand, images that contain popular colors and shapes that have many similar images within the database had 10 as the result of numbers of correct images.

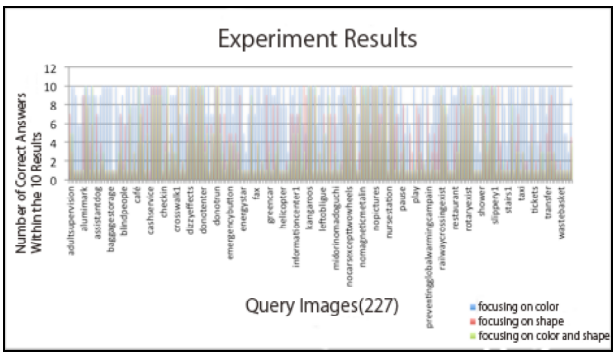

Figure 8 Result of Experiment 1: An experiment on the precision of the CBIR system (We tested 227 images as the query, and counted the numbers of the images that are correct.

5.2 Experiment 2: Verification of the function to provide the image-related meaning information

Here we verify the feature to provide the image-related meaning information of sign-logos by comparing the commonality and diversity of the meaning information of the image retrieved from the image similarity computing. In this experiment, we are not using the location of the user. In Experiment 1, we set a hypothesis that meaning of sign-logos consist of the combination of color and shape. From Experiment 2, we broke down this hypothesis into many cases (Figure 9.) Figure 9 is showing the combination case of the features of the two images and the hypothesis. For instance, case 1 represents the case where two images having the same color and same shape would have meanings that match. On the other hand, case 9 represents the case where the two image having different color and shape having different meanings. (However, in reality, the case where images that have different color and shape that has the same meanings.) Also, case 2 is representing a case where the two images having the same color and slightly different shape, would have meanings that either match or become slightly different but almost the same.

Case	Color	Shape	→	Meaning
1	○	○		○
2	○	△		○, △
3	○	×		○, △, ×
4	△	○		○, △
5	△	△		○, △, ×
6	△	×		△, ×
7	×	○		○, △, ×
8	×	△		△, ×
9	×	×		×

○ : Same
△ : Almost the Same but Slightly Different
× : Different

Figure 9 Hypotheses on combination cases of the query image and images in database

5.2.1 Experiment 2-1

In Experiment 2-1, we examined the possibility of our system in supporting diversity (Figure 10, Figure 11). The degree of similarity shown in Figure 10 and Figure 11 uses the method in [5][6], so the color is calculated by focusing on the cosign scale, and the shape is calculated by using an original method of calculating distance. These two are combined and the average is used in the calculation. The similarity degree is based on the distance, so it means the lower the value, the more similar the image gets.

Figure 10, Figure 11 is the result of a retrieval focusing on the color and shape of the inserted query image. Figure 10 shows the result of nosmoking.jpg (color: red, black shape: circle meaning: “no smoking in this area” country: Japan), Figure 11 shows the result of nosmoking1.jpg (color: orange shape: circle meaning: “no smoking in this area” country: America). Both queries have the shape: circle, and meaning “no smoking in this area” in common. Figure 10 is showing that images with the red color circle with a cross come as the top results. In Figure 11, besides the image that came in 2nd place with the different color but same image as the query, the top results all had the color orange.

	query	color	shape	structure		
		0.5	0.5	0		
ranking	picture	name	category	country	meaning	similarity
1		nosmoking	prohibition	Japan	no smoking in this area	3.33E-16
2		noelectricdevice	hospital	Japan	no electric devices allowed	4.5584
3		nopictures	prohibition	Japan	no pictures allowed	4.6189
4		donotrun	prohibition	Japan	do not run	4.82699
5		nometalaccessirues	hospital	Japan	no metal accessories allowed	4.88841

Figure 10 Ranking result of experiment 2-1: image nosmoking.jpg (color: red,black, shape: circle, meaning: “no smoking allowed”, country: Japan) as the query

	query	color	shape	structure		
		0.5	0.5	0		
ranking	picture	name	category	country	meaning	similarity
1		nosmoking1	prohibition	America	no smoking in this area	5.55E-16
2		nosmoking	prohibition	Japan	no smoking in this area	7.0569
3		train	transportation	America	train	7.1402
4		energysavingmark1	symbol	Japan	energy saving mark	7.7791
5		informationcenter1	public	America	information center	7.783425

Figure 11 Ranking result of experiment 2-1: image nosmoking1.jpg (color: orange, shape: circle, meaning: “no smoking allowed”, country: America) as the query

In the case of Figure 10, the system reacted to the combination of the colors red and black. On the other hand, in the case of Figure 11, the system reacted more on shape, which lead to the result of having images with the similar meaning come at the top. In experiment 2, we found out the existence of the case with two images with the same shape and different color, having the same meaning.

5.2.2 Experiment 2-2

In experiment 2-2, we focused on case 3 in Figure 9 and compared two images with the same color and different shape (Table 5, Table 6).

Figure 12, Figure 13 is the result of a retrieval focusing on the color and shape of the inserted query image. Figure 12

shows the result of caution.jpg (color: yellow, black, shape: triangle, meaning: “caution”, country: Japan), Figure 13 shows the result of otherdangers.jpg (color: yellow, black, shape: rhombus, meaning: “caution”, country: Japan).

	query	color	shape	structure		
		0.5	0.5	0		
ranking	picture	name	category	country	meaning	similarity
1		caution	product	Japan	caution in general	4.44E-16
2		cautionshock	product	Japan	be careful of electric shock	1.750315
3		cautionhot	product	Japan	be careful of high tempature	3.272085
4		ceiling	warning	Japan	watch out for ceiling	4.86053
5		falling	warning	Japan	be careful not to fall	5.334005

Figure 12 Ranking result of experiment 2-2: image caution.jpg (color: yellow, black, shape: triangle, meaning: “caution in general”, country: Japan) as the query

	query	color	shape	structure		
		0.5	0.5	0		
ranking	picture	name	category	country	meaning	similarity
1		otherdangers	road	Japan	caution in general	2.22E-16
2		roadconstruction	road	Japan	road construction ahead	5.19197
3		ammoexist	road	Japan	ammo existing ahead	6.394199
4		crosswind	road	Japan	watch out for animals	6.443398
5		railwaycrossingexist	road	Japan	railway crossing ahead	6.585525

Figure 13 Ranking result of experiment 2-2: image otherdangers.jpg (color: yellow, black, shape: rhombus, meaning: “caution in general”, country: Japan) as the query

Both queries have the color: yellow, black in common. Although the categories of the two images differ, the meaning can be considered almost the same. These sign-logo images have the same color, different shape, and almost the same meaning. For both images, the images with the similar shape to the query resulted to be in the top results, and the meaning differs when it is looked as a whole. In experiment 3, we found out that meanings change due to the combination of color and shape, and the existence of the case where two images with the same meaning, different shape, has the similar meaning.

5.2.3 Experiment 2-3

In experiment 2-3, we focus on case 2 in Figure 9 and compare two images with the same color and shape (Figure 14, Figure 15).

Figure 14, Figure 15 is the result of a retrieval focusing on the color and shape of the inserted query image. Figure 14 shows the result of donotenter1.jpg (color: red, shape: circle, meaning: do not enter”, country: Europe), Figure 15 shows the result of carsdonotenter.jpg (color: red, shape: circle, meaning: “cars do not enter”, country: Japan). Both queries have the color: red, shape: circle in common and the meanings are similar.

In this case, the two images have the same color and shape, the retrieval result should become the same, but however the results differ after the third result. The reason this occurred is because of the thin line around the circle of the image in Figure 15. The system can react to these kinds of small differences. In experiment 4, we found out about the existence of the case where the two images have the same color having the similar meanings.

	query	color	shape	structure		
		0.5	0.5	0		
ranking	picture	name	category	country	meaning	similarity
1		donotenter1	road	Europe	do not enter	5.00E-16
2		carsdonotenter	road	Japan	cars do not enter	7.599975
3		bumpyroadsexist	road	Europe	bumpy road ahead	10.1923
4		informationcenter1	public	Japan	information center	10.4789
5		nomobile	hospital	Japan	no mobiles allowed	10.52025

Figure 14 Ranking result of experiment 2-3: image donotenter1.jpg (color: red, shape: circle, meaning: “do not enter”, country: Europe) as the query

	query	color	shape	structure		
		0.5	0.5	0		
ranking	picture	name	category	country	meaning	similarity
1		carsdonotenter	road	Japan	cars do not enter	5.55E-16
2		donotenter1	road	Europe	do not enter	7.599975
3		nocarsexcept twowheels	road	Japan	no cars allowed except two wheels	8.1689
4		nobicycles	road	Japan	no bicycles allowed	8.88665
5		nothroughfare	road	Japan	no throughfares	8.99445

Figure 15 Ranking result of experiment 2-3: image carsdonotenter.jpg (color: red, shape: circle, meaning: “cars do not enter”, country: Japan) as the query

5.2.4 Experiment 2-4

In experiment 2-4, we focus on case 5 in Figure 9 and compare two images with the similar color and shape, and test the possibility of the support in diversity in our system (Figure 16, Figure 17).

Figure 16 shows the result of police.jpg (color: blue, shape: human, meaning: “police”, country: Japan), Figure 17 shows the result of crewroom.jpg (color: blue, shape: human meaning: “room for train crews”, country: Japan). We compared the two images having the color: blue,cyan, shape: human as the simular factor, but the two images have different meanings. In both results, 3 out of 5 images are the shape of human, and this result shows how this system supports complicated shapes. In experiment 5 we found out about the system being able to support complicated shapes, which leads to accurate recognition of the sign-logo.

	query	color	shape	structure		
		0.5	0.5	0		
ranking	picture	name	category	country	meaning	similarity
1		police	public	Japan	police	7.22E-16
2		crewroom	transportation	Japan	room for train crews	10.28885
3		handicap	car	Japan	handicapped person driving	10.8352
4		hostmate	public	Japan	facility for hostmates	10.9634
5		carsonly	road	Japan	road for cars only	11.1662

Figure 16 Ranking result of experiment 2-5: image police.jpg (color: blue, shape: human, meaning: “police”, country: Japan) as the query

	query	color	shape	structure		
		0.5	0.5	0		
ranking	picture	name	category	country	meaning	similarity
1		crewroom	transportation	Japan	room for train crews	5.00E-16
2		police	public	Japan	police	10.28885
3		freedial	service	Japan	free telephone numbers	10.9391
4		hostmate	public	Japan	facility for hostmates	11.0634
5		monorail	transportation	Japan	monorail	11.16605

Figure 17 Ranking result of experiment 2-5: image crewroom.jpg (color: cyan, shape: human, meaning: “room for train crews”, country: Japan) as the query

6. Analysis of the experimental results

In the experiment, we used sign-logos from different countries to verify the feature of our system that absorbs the diversity from the image, and extracts the commonality. In experiment 1, we performed an accuracy experiment on the CBIR function in the system. In experiment 2 to 5, we made a hypothesis for each case of the combination between characteristics of two images, and compared the results. In experiment 2-1, we compared two query images with different color, same shape, and same meaning. In experiment 2-2, we compared two query images with different shape, same color, and same meaning. In experiment 2-3, we compared two query images with different shape, same color, and same meaning. In experiment 2-4, we compared two query images with the same color and shape having different meanings. By stating a hypothesis for each case and making experiments, we were able to make sure that the system supports the diversity of sign-logos between countries, and is able make receiving the meaning information of the sign-logo from the user’s location possible. From the experiments we found out that in the point of meanings of sign-logos being expressed by color and shape, the results of the experiments match the information [3] [4]. However, in experiment 2-4, we found out that sign-logos with the same color and shape do not always have the same meanings. Adding the location information to the sign-logo that is inserted into the system can solve this diversity.

There is a need for a quantitative experiment on accuracy (user study), and implementation of an application for smartphones that uses this system in the future. If this sign-logo system becomes popular and people around the world use it, the change in the definition standards and the way sign-logos are used. However, to implement this system, there is a problem of sign-logos that we need to overcome.

7. Conclusion

In this paper, we have presented a cross-cultural meaning recognition system for sign-logos in a real space. First, this system finds out the category of input sign-logo images by the similarity computations with images in the database focusing on the color and shape features of images. Second, the system searches for the information corresponding to the specific sign-logo images. By using this system, a user is able to obtain the meaning and related information of sign-logos based on the user’s location as well as the information of sign-logos around the world.

As our future work, we will implement a real application for smart-phone with the meaning recognition mechanisms of sign-logo. In addition to the system stated in this paper, we plan to create a system that also considers the GPS information of the user. By using the GPS information, the system can select the numbers of the retrieval results appropriately by country. One of the challenges in the implementation of real application is that the backgrounds of sign-logos are changed according to situations and surroundings in the real world. Even though it is the same sign-logo, the colors and shapes can look different due to the shooting angle, place, and situation.

The expected situations for usage of our system are public and international places, such as airports, stations, and stops. There are often descriptions in other languages added to sign-logo on signboard, in addition to the native language description for that country. By using our system and its application, the sign-logo will be able to provide the meanings by itself, which brings the significant change to the way people use sign-logos.

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