# Object Retrieval by Query with Sensibility Based on the KANSEI-Vocabulary Scale

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**Abstract.** Recently the demand for image retrieval and recognizable extraction corresponding to KANSEI (sensibility) has been increasing, and the studies focused on establishing those KANSEI-based systems have been progressing more than ever. In addition, the attempt to understand, measure and evaluate, and apply KANSEI to situational design or products will be required more and more in the future. Particularly, study of KANSEI-based image retrieval tools have especially been in the spotlight. So many investigators give a trial of using KANSEI for image retrieval. However, the research in this area is still under its primary stage because it is difficult to process higher-level contents as emotion or KANSEI of human. To solve this problem, we suggest the KANSEI-Vocabulary Scale by associating human sensibilities with shapes among visual information. And we construct the object retrieval system for evaluation of KANSEI-Vocabulary Scale by shape. In our evaluation results, we are able to retrieve object images with the most appropriate shape in term of the query's KANSEI. Furthermore, the method achieves an average rate of 71% user's satisfaction.

## 1 Introduction

In the oncoming generation of computing, the demand for tools of information retrieval for human sensibilities or tastes and of KANSEI recognition and extraction has been increasing rapidly.

KANSEI in Japanese means by sensibility that is to sense, recall, desire and think of the beauty in objects [1]. KANSEI is expressed usually with emotional words for example, beautiful, romantic, fantastic, comfortable etc [2]. The concept of KANSEI is strongly tied to the concept of personality and sensibility. KANSEI is an ability that allows humans to solve problems and process information in a faster and personal way. KANSEI of human is high-level information, the research of KANSEI information is a field aimed at processing and understanding how the human's intelligence processes subjective information or ambiguous sensibility and how the information can be executed by a computer [3].

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Study of KANSEI-based image retrieval tools have especially been in the spotlight. However, those researches are still based on the retrieval of lower-level visual information such as features of color, shape and texture [4]. Retrieval of such lower-level information has difficulty catching higher-level information such as intentions or sensibilities of users. And then, in experimentation with human sensibilities, the area of KANSEI-based image retrieval systems has been limited and content-based using visual features such as texture, shape, pattern, and especially color, which are the most popular sources for experiment, or feature-based such as those using recognition system, but such retrievals have had some trouble in checking and recognizing images appropriate for the user's purposes or tastes in higher meaning [5]. To solve this problem, we try the study of KANSEI about shape among visual information.

In order to cope with these limiting barriers, we have attempted to associate visual information with human beings' sensibilities through a relational sample scale, which is made by linking the visual information (color, shape, texture, and pattern) with the KANSEI-vocabulary of human beings'.

First, for the scale we collected and classified the most common shapes and defined what the most standard shapes are. On the other hand, we found a relationship between shape and KANSEI-vocabulary. As a result we were able to produce a KANSEI-Vocabulary Scale for shapes and the related KANSEI-vocabulary. And then we construct the object retrieval system for evaluation based on KANSEI-Vocabulary Scale by shape. In our evaluation results, we are able to retrieve object images with the most appropriate shape in term of the query's KANSEI. Furthermore, the method achieves an average rate of 71% user's satisfaction.

We believe that such a result will allow us to realize a KANSEI-based information system and will be helpful for ontological construction based on visual information and KANSEI-vocabulary. The final purpose of our study is the creation of a KANSEI-Vocabulary Scale based on visual information such as color, shape, texture, and pattern, to form a new KANSEI information system that can understand, retrieve, and recognize human beings' sensibilities and for an ontological system based on visual information and KANSEI-vocabulary. This study develops a vocabulary scale with shapes and sensibilities as one of a series of studies for the purpose, and the scale will be part of the basis of intelligent image retrieval techniques depending on the user's intention and KANSEI.

## 2 Theoretical Bases for Our Research

### 2.1 Definition of Shape

Shape means a plane two-dimensional space made by lines and indicates either a 'silhouette' or 'outline'. It is formed by both external angles and a frame axis and expressed the feelings by looking at its inner-shape. Shape has the dimensions of length and width by definition but not of depth. Form is the shape of a thing, its look and bearing, or a body and obtained figure, and is a unity, unified wholeness, or organization which creates a partial order for the entire body of a thing. Form is a three-dimensional trace of the wheels in a dynamic definition. A form is a final shape made by points and lines; a shape is an original feature of a form, and an appearance is a thing made by elaborated combination of the surfaces of the form and its angles. In other words, form means the volume, the three-dimensional mass, or the outline of a thing that can be caught visually. It is also proposed in philosophy that it is the outward pattern of a given thing in a substantial nature.

Geometry is defined as 'the science of dealing with the size and shape of a thing' or 'an area of mathematics limited to mathematical features of space'.

In Rudolf Archaism, a geometrical form is a natural metaphoric or refined form created by ideological thoughts of human beings [6]. This form can be changed into a circle, triangle, square, etc., each of which can be computed mathematically with a ruler and a compass. It can also be called an artificial abstract form changed simply from a complex nature. In other words, this geometrical form gives us systematic, simple and plain feelings, but it originates from nature. Therefore it is occasionally considered to be a concept against natural form.

The precise geometrical forms were made with a method which has a mathematical or physical structure. The method became a standard of measuring beauty, which is now used in related research and help make sense of space intuitively. Although these forms seem to be a bit complex, they can be recognized and reproduced in the same way as the original form. It might not be able to objectively explain the whole contents of the original forms, but it can comprehend their implications in the forms, because the simplicity and rationality of geometrical form are strict rules in themselves. In general, design consists of conceptual elements, visual elements, relational elements, and constructional elements [7].

**Table 1.** Elements of Form

| Elements of form | Constituent elements |
|---|---|
| Conceptual Elements | Point, Line, Plane, Volume |
| Visual Elements | **Shape**, Size, Color, Texture |
| Relational Elements | Position, Direction, Spatiality, Gravity |
| Constructional Elements | Vertex, Edge, Face |

In visual information there are three forms, conceptual, geometrical, and natural form. Geometrical form means an artificial abstract form changed through from into simplicity. The geometrical and natural forms are included organic forms, while natural forms have no defined standard. Therefore all the forms can be classified on the axis of the geometrical form. A shape is created with planes, that is, a shape and a form are created with planes. To show the formation of shape and form, the planes of shape are put into the main elements in the first experiments of our study.

**Table 2.** Classification of Form

| | | Soft | Hard | Combination |
|---|---|---|---|---|
| plane | Cool | Circle | Triangle<br>Equilateral Triangle<br>Isosceles Triangle<br>Isosceles Right Triangle<br>Obtuse Triangle<br>Quadrangle<br>Square<br>Rectangle<br>Rhombus<br>Parallelogram<br>Trapezoid | Segment of a Circle<br>Half Circle<br>Sector<br>Rounded Triangle<br>Rounded Rectangle |
| | Warm | Ellipse | Polygon | Rounded Polygon |
| Cubic | Cool | Sphere<br>Hemisphere | Cube<br>Triangular Pyramid<br>Square Pyramid<br>Pentagonal Pyramid<br>Triangular Prism<br>Cuboid<br>Pentagonal Prism<br>Triangular Dipyramid<br>Square Dipyramid<br>Pentagonal Dipyramid | Cone<br>Elliptic Cone<br>Cylinder<br>Elliptic Cylinder |
| | Warm | Torus | Prism<br>Pyramid<br>Dipyramid<br>Polyhedron | Concurrence Form<br>Opposition Form<br>Piercing Form |

### 2.2 Technique for Application in Object Retrieval

**Gradient Vector Flow (GVF) Snake for Detection of Shape's Contour:** We use the gradient vector flow (GVF) snake for detection of objects in our proposed system [8][9]. This method begins with the calculation of a field of forces, called the GVF forces, over the image domain. The GVF forces are used to drive the snake, modeled as a physical object having a resistance to both stretching and bending, towards the boundaries of the object. The GVF forces are calculated by applying generalized diffusion equations to both components of the gradient of an image edge map.

The GVF external forces make its snake inherently different from previous snakes. Because the GVF forces are derived from a diffusion operation, they tend to extend very far away from the object. This extends the "capture range" so that snakes can find objects that are quite far away from the snake's initial position. The same diffusion creates forces which can pull active contours into concave regions.

**Tangent Space Representation (TSR) for Similarity Measure of Shape:** The polygonal representation is not a convenient form for calculating the similarity between two shapes, an alternative representation such as TSR, is needed. For all coming steps it will not use the polygonal representation of the shape, but it will transform it into tangent space [10][11]. A digital curve C is represented in the tangent space by the graph of a step function, where the x-axis represents the arc-length coordinates of points in C and the y-axis represents the direction of the line segments in the decomposition of C. That calls each horizontal line segment in the graph of the step function a step. It traverse a digital curve in the counter clockwise direction and assigns to each maximal line segment in the curve decomposition a step in the tangent space. The y-value of a step is the directional angle of the line segment and the x-extend of the step is equal to the length of the line segment normalized with respect to the length of the curve.

What we got in the former step are turned into their Tangent Space Representation because this technique is invariant, to scaling (we normalize the length of the curve), rotation and translation, and finally the shapes are ready to be indexed [12]. Then, we measure similarity between shapes using indexing values.

# 3 The Creation of KANSEI-Vocabulary Scale by Shape

## 3.1 KANSEI-Vocabulary Scale Measurement According to Shape

Now experimental subject shapes are extracted on the basis of the forms analyzed in the previous section. They include twenty shapes. KANSEI words are based on the forms which are collected. We used SD (Semantic Differential) technique through replication or statistics [13]. The process for the creation of a KANSEI-Vocabulary Scale has two steps.

Firstly, after the sample subject group composed of 280 people was shown images of shape, we asked them to describe their feelings with adjectives by looking at each given image. Secondly, all the adjectives collected from step 1 we are classified according to their frequency of use. Thirdly, among the collected words, those that do not express feelings or are not demonstrative words are removed despite their high frequency, with eight words left according to their frequency.

**Table 3.** The Part of 1st KANSEI-Vocabulary by Shape

| Shape Image | KANSEI-Vocabulary |
|---|---|
|  | plentiful, full, mild, perfect, relaxed, safe, satisfied, warm |
|  | offensive, cold, crooked, dizzy, irritative, retrogressive, strange, uncomfortable |
|  | ambiguous, confused, nervous, strange, unique, unstable, vague, worried |
|  | abundant, balanced, comfortable, flexible, liberal, soft, tender, soft and yielding |

※ The images shown in the above table can be different from the images used in the real experiment for vocabulary selection.

In the second step, another sample group of 250 people were employed to measure the degree of KANSEI that is show in vocabulary. The standard was five inter valscales. The effects of size, color, aftereffect, and outward environments were controlled to reliably measure the KANSEI scales of each image of shape or line. We are asked to check their own KANSEI scale on the answer sheet after looking at each of the 20 images. Figure 1 shows a sample of measurement of the KANSEI scale: the KANSEI scale of 'plentiful' is 75%, the fourth in five degree section which consists of a 0~100 scale, while '100' means there is no difference between the KANSEI degree and the given KANSEI word, and '0' means there is no similarity between them.

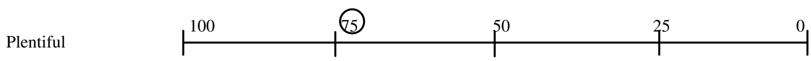


**Fig. 1.** Example of the KANSEI-Vocabulary Scale

The KANSEI-Vocabulary Scale by shape is produced with the KANSEI scale data measured over the 250 subjects by factor analysis. The purpose of factor analysis is to account variables with the common underlying dimensions which consist of the elements of variables by analyzing the correlations of the multiple variables. In this study the method is employed because it minimizes the information loss of many words, limits to minor factors, and gives a result in essential factors of KANSEI-vocabulary by analyzing the relations among all the KANSEI-vocabulary words and the relations between each shape and its related KANSEI-vocabulary.

### 3.2 KANSEI-Vocabulary Scale by Shape

The above procedures for the KANSEI-Vocabulary Scale by shape are represented. The procedures produced the result of the KANSEI-Vocabulary Scale by shape as shown in Figure 2.

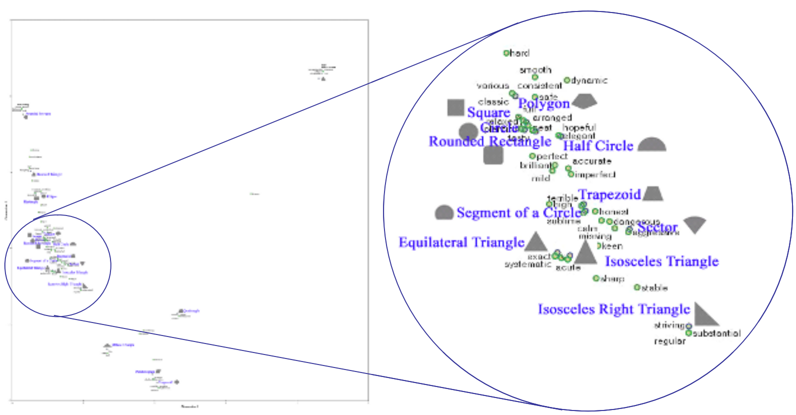


**Fig. 2.** KANSEI-Vocabulary Scale by Shape

Figure 2 is the KANSEI-Vocabulary Scale of shape (= plane). The result from the procedures of the KANSEI-Vocabulary Scale by shape shows that the features of each shape are closely related to human beings' sensibilities and decides the distance of dimension among the words of the KANSEI-vocabulary. Figure 2 shows that the people of the sample group are more sensitive to curved shapes than the other shapes and felt similar sensibilities to the given shapes. As the values of shape and KANSEI of the given shapes are similar in spite of the different shapes, they are in close proximity. In other words, the factors of curve rather than those of line influence people's sensibilities as well as the factors of shape.

Table 4 represents the KANSEI words and some coordinates of shape on our Scale, which are applied to various areas by means of the distances between the shapes and each KANSEI word and the measure of the distance among the shapes.

**Table 4.** Scores in Planar Dimension

| Name of Plane | Score in Dimension | | KANSEI-Vocabulary | Score in Dimension | | KANSEI-Vocabulary | Score in Dimension | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | | 1 | 2 | | 1 | 2 |
| Circle | -0.537 | 0.103 | plentiful | -0.547 | 0.107 | irritative | 3.361 | 2.325 |
| Ellipse | -0.585 | 0.720 | full | -0.556 | 0.145 | retrogressive | 3.361 | 2.325 |
| Triangle | 3.305 | 2.234 | mild | -0.451 | -0.028 | strange | 2.352 | 0.716 |
| Equilateral Triangle | -0.435 | -0.291 | perfect | -0.513 | 0.019 | uncomfortable | 3.361 | 2.325 |
| Isosceles Right Triangle | -0.031 | -0.527 | relaxed | -0.547 | 0.107 | exact | -0.443 | -0.303 |
| Isosceles Triangle | -0.397 | -0.301 | safe | -0.505 | 0.208 | sharp | -0.316 | -0.374 |
| Obtuse Triangle | 0.332 | -1.326 | satisfied | -0.547 | 0.107 | threatening | -0.423 | -0.308 |
| Quadrangle | 1.320 | -0.858 | warm | -0.547 | 0.107 | precise | -0.443 | -0.303 |
| square | -0.532 | 0.128 | cozy | -0.595 | 0.750 | pricking | -0.443 | -0.303 |
| Rectangle | -0.663 | 0.697 | crushing | -0.595 | 0.750 | systematic | -0.443 | -0.303 |
| Rhombus | 1.037 | -1.768 | dynamic | -0.406 | 0.262 | missing | -0.259 | -0.213 |
| Parallelogram | 0.967 | -1.657 | flexible | -0.728 | 1.291 | regular | -0.031 | -0.549 |
| Trapezoid | -0.355 | -0.135 | natural | -0.595 | 0.750 | honest | -0.319 | -0.159 |
| Polygon | -0.565 | 0.211 | smooth | -0.505 | 0.272 | stable | -0.190 | -0.402 |
| Segment of a Circle | -0.349 | -0.157 | wonderful | -0.595 | 0.750 | striving | -0.031 | -0.549 |
| Half Circle | -0.424 | 0.082 | recursive | -0.595 | 0.750 | substantial | -0.031 | -0.549 |
| Sector | -0.213 | -0.216 | offensive | 3.361 | 2.325 | unstable | 0.787 | -1.123 |
| Rounded Triangle | -0.742 | 1.012 | cold | 3.361 | 2.325 | active | -0.404 | -0.313 |
| Rounded Rectangle | -0.503 | 0.098 | corrked-curved | 3.361 | 2.325 | acute | -0.404 | -0.313 |
| Rounded Polygon | -0.846 | 1.761 | dizzy | 3.361 | 2.325 | destructive | -0.404 | -0.313 |

## 4 Architecture and Experiment of the Object Retrieval System

In this section, we propose the architecture of object retrieval and we perform experiment using constructed retrieval system. Our system's purposes are the application of retrieval based on KANSEI-Vocabulary Scale by shape and the evaluation of scale according to user's feedback. Also, this system has made a significant attempt of subjective and semantic retrieval by user's KANSEI. Next figure 3 is architecture of our system.

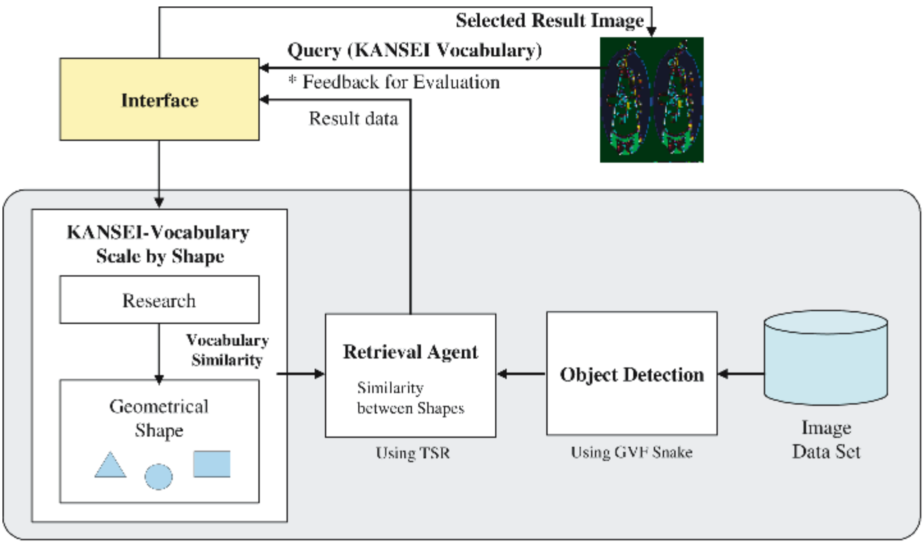


**Fig. 3.** Architecture of Objective Retrieval System

Architecture of object retrieval show that 1) user queries sensible adjective in the system. And then, 2) find the most nearest geometrical shape about user's query in KANSEI-Vocabulary Scale by shape. Next phase is 3) the measure similarity between finding geometrical shape and object's images in dataset. In 3) phase, we used the method of contour detection and similarity between shapes. Contour detection of object uses the Gradient Vector Flow (GVF) Snake and similarity measure uses the Tangent Space Representation (TSR). Above methods are presented in section 2.2. Using these phases, our system matches most adaptive shape and retrieve the object images based on user's query. Finally phase is 4) user's feedback according to query results in the last step. And we evaluate our scale using the user's satisfaction rate.

We experiment the object retrieval according to 15 queries (KANSEI-Vocabulary) and then measure satisfaction to 20 people-oriented. Our experiment is the meaning of possibility that is applied to retrieval based on KANSEI-Vocabulary Scale and evaluation of our scale by shape.

## 5 Experimental Results and Evaluation

Using the system of section 4, we evaluate user's satisfaction rate of our proposed KANSEI-Vocabulary Scale. We present the part of experimental results in the following figure 4. User queries KANSEI-vocabulary that is 'comfortable'. User wants retrieval of object that is feeling comfortable. Figure 4 shows the result of running this query.

We orderly retrieve images by the minimum value because of the lower value, the more similarity. The explanation by details is as follows:

$$Min[\alpha \times S_{TSR}(F, I)] = Min[D_{|F-V|} \times S_{TSR}(F, I)] \quad (1)$$

Where, S is similarity using TSR between F (geometrical shape image) and I (object image). As $\alpha$ is the weight value about each shape, we measure D (distance) between F and V (Vocabulary) in KANSEI-Vocabulary Scale.

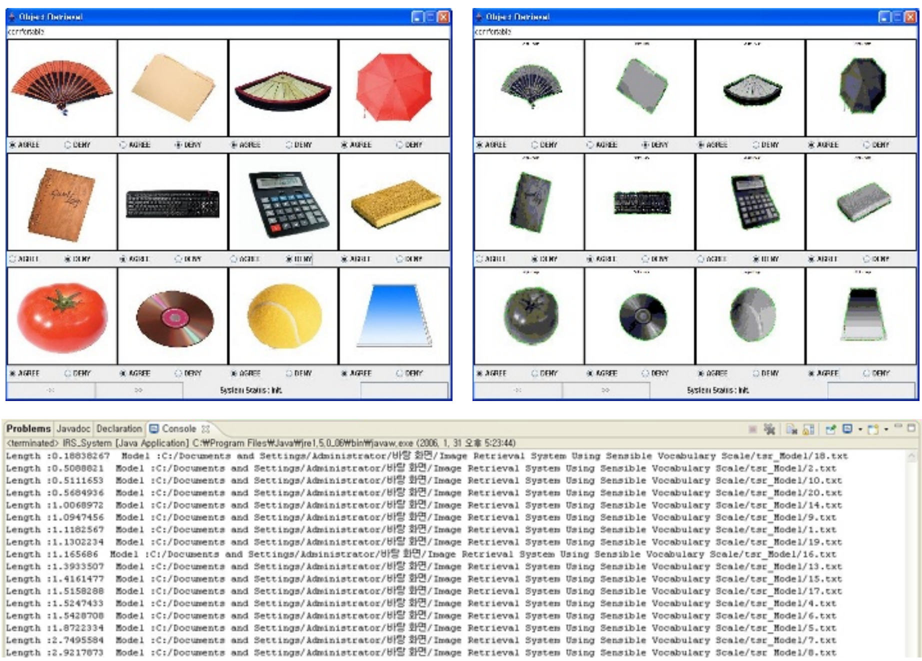


**Fig. 4.** Part of Experimental Results

The third part of Figure 4, the console tab shows the result of similarity measure using Tangent Space Representation (TSR). We know the nearest shape which is 'rounded triangle' from 'comfortable' and show values of similarity between object images and 'geometrical shape'.

The first two parts of the above figure are result windows. Left window is result of original image and right one is the result image of contour detection. We present 2 results which included images of contour detection. Because it helps user to understand which scale only bases on shape and then its results are considered KANSEI by shape. Image is formed visual information as color, shape, texture, pattern, etc. so, user's satisfaction rate is influenced by other factors.

In this experiment, user's satisfaction indicates much difference from low-rate to high-rate according to KANSEI-vocabulary. The reason of difference is that KANSEI strongly depends on personal disposition and object image includes color, pattern and special design of its, etc.

In experimental result, user's satisfaction is not so high, because it includes other features of visual information. However, we are able to retrieve object images with the most appropriate shape in term of the query's KANSEI. Our scale achieves an average rate of 71% user's satisfaction.

## 6 Conclusions

In this study we suggested a KANSEI-Vocabulary Scale by observing the relationships among KANSEI words and shapes which are those of the visual information. This scale can be used effectively in KANSEI-based image retrieval according to the user's intentions and in part on the basis of intelligent information research corresponding with KANSEI. We experiment for application of image retrieval based on our scale and construction of object retrieval system for evaluation of user's sensible satisfaction by shape. This experiment helps construct our KANSEI-based image retrieval system, which is applied to various sections including product design and object production, whose main property is shape, to measure user's recognition degree and evaluation.

In our future works, we will expand the range of visual information (not only shape) and will study the KANSEI of combined visual information for intelligent image retrieval. This study continues to work in texture and pattern as well, which will also contribute to the final construction of sensibility-ontology based on the relation of visual information and KANSEI-vocabulary. The results will allow knowledge retrieval, ontology-based information retrieval, and intelligent image retrieval because the KANSEI-vocabulary relation obtained from visual information induces a fixed quantity of KANSEI data.

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