

# ON THE SYMBOLIZED REPRESENTATION OF INNOVATIVE BICYCLE WITH FUNCTIONAL ELEMENTS CHARACTERISTICS FOR CREATIVE DESIGN

Nien-Te Liu<sup>1</sup> and Chang-Tzuoh Wu<sup>2</sup>

<sup>1</sup>*Department of Product Design, Shu-Te University, Kaohsiung 824, Taiwan*

<sup>2</sup>*Department of Industrial Design, Kaohsiung Normal University, Kaohsiung 824, Taiwan*

*E-mail: ntlou@stu.edu.tw; ctwu@nknucc.nknu.edu.tw*

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## ABSTRACT

This paper proposes representations for bicycles. Innovative bicycles are analyzed and arranged one by one to find functional elements of creative characteristics. The elements of bicycles can be classified into three kinds: functional elements, form elements, and material elements. For the functional elements, they are classified into 14 kinds, where controlling, moving, and input elements are necessary for bicycles. By using symbols, bicycles can be represented simply and quickly for innovation design.

**Keywords:** bicycle; symbolized representation; creative functional elements.

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## REPRÉSENTATION SYMBOLIQUE D'UNE CONCEPTION CRÉATIVE DES ÉLÉMENTS CARACTÉRISTIQUES FONCTIONNELS D'UNE BICYCLETTE

### RÉSUMÉ

Cet article propose des représentations de bicyclette. Les éléments innovateurs d'une bicyclette sont analysés et arrangés un par un pour trouver les caractéristiques créatives des éléments fonctionnels. Les éléments d'une bicyclette peuvent être classés en trois groupes : les éléments fonctionnels, les éléments de forme, et les éléments matériels. Pour les éléments fonctionnels, ils sont classés dans 14 groupes : les éléments de commande et de déplacement sont essentiels. En utilisant des symboles, les bicyclettes peuvent être représentées simplement et rapidement pour une conception innovatrice.

**Mots-clés :** bicyclette ; représentation symbolique ; éléments fonctionnels créatifs.

## 1. INTRODUCTION

Bicycles are vehicles with a long history. There are many researches about bicycles. Some papers focus on the creative design of mechanism or form of bicycles. Many innovative concepts of bicycles are presented and some of them are manufactured. Most of the references about the innovative bicycles are patents [1–6]. Studies about design methodology of innovative bicycles are lacking [7, 8]. Research about creativity in innovative product development has been proposed in [9]. Moreover, bicycles have complicated structures and lack symbolized representations. So, designers will spend a long time on concept development and have more obstacles in the design process. Therefore, if there is a systematic representation for representing bicycles properly and simple, the creative design of bicycles will be more easily and feasibly.

For these reasons, this paper collects and studies every kind of bicycles. And, the creative elements and their relationships are arranged. The purpose of this paper is to propose systematized and easy representations. Thus, according to the representations, designers can design and develop their concepts easily and quickly.

## 2. ANALYSIS OF BICYCLES

### 2.1. Definition

By arrangement of references, the definition of bicycle has both a wide sense and a narrow sense of definition:

1. Wide sense definition: a device driven by human-power;
2. Narrow sense definition: a vehicle using human-power as the energy source, and with the following devices:
  - a) A frame having enough strength;
  - b) Two or more wheels;
  - c) Seats;
  - d) Driving, controlling, and braking devices.

For increasing the possibility of design concepts, this paper concentrates on the creative design of bicycles and takes the wide sense of definition.

### 2.2. Classification of Creativity Elements for Bicycles

The construction of bicycles can be classified into transmission system, variable system, brake system, steering system, frame system, and wheels. For creative design, this kind of classification will constrain creative thinking by machine system. To avoid this problem and to consider the characteristics of creative design, this paper collects 233 bicycles with creativity characteristics. The creativity characteristics of all collected bicycles are retrieved, induced, analyzed, and arranged. All the creativity characteristics can be classified into three kinds of elements, including functional elements, form elements, and material elements.

#### 2.2.1. Functional Elements

Functional elements refer to the elements with design characteristics of functionality, or the possible characteristics or accessories can be added on bicycles. Functional elements can be chosen as one function or more functions and make changes to a bicycle to create new creativity characteristics. Therefore, the selected creativity characteristics from all collected bicycles for this research must fit the definition of functional elements. And, the construction system of bicycles can be considered as functional elements.

This study collects 233 innovative bicycles, analyzes their creativity characteristics, and classifies functional elements into 14 kinds. The functional elements can be classified to go a step further. The description of every kind of functional elements is listed as following:

- A. Control: the elements of operating and steering, including: 1. control handle, 2. Paddle, 3. the moving of center of gravity of body.
- B. Moving: the bicycle can move by the elements, including: 1. wheel, 2. ball, 3. caterpillar band.
- C. Input: the input way of riders for bicycle moving, including: 1. the pace of translation, 2. foot rotation, 3. hand rotation, 4. The pace of stampede.
- D. Adjustment: to change the angle or direction of the part or system, to adjust or change the position set, including: 1. bending, 2. rotation, 3. reverse, 4. folding, 5. disassemble, 6. modify, 7. transform, 8. move, 9. connecting, 10. merge, 11. combine, 12. direction, 13. angle, 14. stretch.
- E. Learn: the learning development for different ages, putting learning function into bicycle, including: 1. balance, 2. toddler, 3. the pace of thrust, 4. teamwork, 5. individual, 6. fitness, 7. intelligence development, 8. interpersonal.
- F. Leisure and sports: select a function or operation to merge into bicycle, including: 1. sailing, 2. skateboard, 3. surfing, 4. stunt, 5. time trial, 6. skiing, 7. boating, 8. tug-of-war, 9. travel, 10. sliding machine, 11. human drive vehicle, 12. water sports.
- G. Bionic: imitate something for form, action, or habit, including: 1. wheelchairs, 2. jogging, 3. scissor, 4. Swiss army knife, 5. sled.
- H. Storage: for storing something, including: 1. shopping, 2. basket, 3. cradle, 4. lading, 5. transportation, 6. compartment, 7. cargo rack, 8. baggage, 9. backpack, 10. trunk, 11. cart, 12. collection, 13. carrying, 14. hiding.
- I. Toy: the combination with funny elements, including: 1. toy brick, 2. games, 3. interaction, 4. music.
- J. Technology and electronics: including: 1. electricity, 2. light, 3. solar energy, 4. household appliances, 5. battery set, 6. flashlight, 7. car lights, 8. controller, 9. nano-technology, 10. measurement device.
- K. Flexibility: the function of buffer, including: 1. spring, 2. pneumatic, 3. hydraulic, 4. anti-shock, 5. air cushion, 6. aeration.
- L. Safety: giving rides to protect, assist or comfort features, including: 1. seat belt, 2. training wheels, 3. safety lock, 4. coated, 5. shield, 6. anti-crash, 7. anti-slide, 8. shell, 9. fender, 10. seat back, 11. brake, 12. reflective article, 13. seat cushion.
- M. Others: Special requirements, including: 1. tent, 2. massage, 3. advertising.
- N. Frame: For some bicycles, frame is the necessary functional element, and other functional elements directly or indirectly connected with the frame.

Because of having machine characteristics, control, moving, and input are the essential elements for bicycles.

Table 1. The table of form elements.

Classification	Form elements
Bionic	Train, sailing, shopping cart, animal, scissors, mantis, grasshopper
Geometry	Circle, triangle
Letters of alphabet	T, X, Y, C
Color	Color
Others	Light, cute, size, simplify, simple, streamlined, lightweight sled, lines, sleek, stylish, light, arc, fresh, transparent, bright, lively, sense of science and technology, mechanical sense, agile, symmetrical, balanced, sharp, jumping, speed

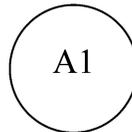


Fig. 1. The symbol representation for control handle.

### 2.2.2. Form Elements

Form elements refer to the form characteristics of appearance form of bicycles. Bicycles can be considered as a geometric form combined with principles of aesthetics. By the combination of form elements, the form of bicycles is generated. Analyzing the collected innovative bicycles, the form elements can be arranged and are shown in Table 1. The form elements can be classified into five kinds of elements, including bionic, geometry, letters of alphabet, color, and others.

### 2.2.3. Material Elements

Material is one of the important elements for design and innovation. There are many different materials invented in different times, and new manufacture technologies are generated. Therefore, this research analyzes and arranges the material of existing innovative bicycles. The material elements usually include paper, plastic, aluminum alloy, steel, carbon fiber, and titanium alloy.

## 3. REPRESENTATIONS

### 3.1. Representation for Functional Elements

Because of the many functional elements, symbols are used to represent these functional elements quickly and simply. Functional elements are represented by circles with the classification numbers and item numbers. Thus, every functional element can be represented quickly and simply. For example, A1 means control handle and its symbol is shown in Fig. 1.

### 3.2. Types of Construction

Innovative bicycles are considered as the combination of functional elements. Therefore, the main body is discussed and checked first. Main body is the foundation of construction of element combination. By observing the appearance of innovative bicycles, the construction of innovative bicycles can be classified into two types: bicycles with frame and bicycles without frame.



Fig. 2. The innovative bicycle “Rotating Folding” with frame.



Fig. 3. The innovative bicycle “Neo-board” with frame.

For the first type, frame is the main body and all the other functional elements are connected with the frame. Thus, for the first type of innovative bicycle, frame is the essential element. And, control, moving, and input are three other essential elements. By adding the other functional elements, the innovative bicycle can be constructed.

Figure 2 shows the innovative bicycle “Rotating Folding”. The folding element is connected with frame. When the bicycle is folded, its main body cannot be determined. When the bicycle is expanded and used, the main body can be distinguished clearly.

Figure 3 shows the innovative bicycle “Neo-board”. It is easy to observe that this bicycle is constructed by the frame connected with wheels and other elements.

The first type of construction takes the frame as the main body and is with two wheels connected. Thus, a rectangle is used to represent the frame, and  $N$  for being classified into the  $n$ th type. Besides, two moving elements are noted inside the rectangle symbol. Thus, the representation for the first type is shown in Fig. 4.

For the second type of construction, the bicycle has no frame. Usually, there are few functional elements for this type of construction.

Figure 5 shows the innovative bicycle “Xiclet”. Its moving element B1 and control element A1 are connected with each other directly and there is no frame for the bicycle.

The second type of construction can be drafted from control, moving or input element, then, other functional elements are connected. Thus, its three starting representations are shown in Fig. 6.

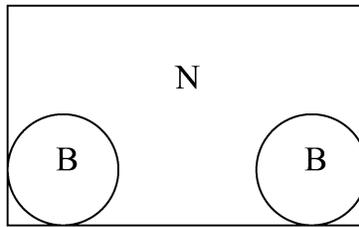
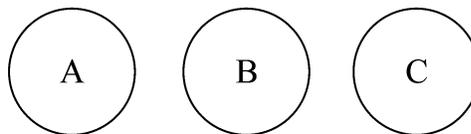


Fig. 4. Representation for the 1st type of construction.



Fig. 5. The innovative bicycle “Xiclet”.



(a) Control (b) moving (c) input

Fig. 6. Representation for the 2nd type of construction.

### 3.3. Relationship of Functional Elements

When analyzing the connected relationship of elements, there are two kinds of relationships. The first kind is “combination”. This means that the parts of the bicycle can be replaced for assembling. Thus, the parts are replaceable elements and do not affect the overall performance of the bicycle.

The innovative bicycle “Snow Leopard” is shown as in Fig. 7. In this bicycle, the part wheel can be replaced by the sled board. Thus, the wheel has the relationship of “combination” with the frame.

The second kind of relationship is “mergence”. It means the parts of the bicycle cannot be replaced and is fixed with its connected object. In the other words, the two connected elements are fixed together. Thus, the part is not a replaceable element. If an element has the relationship of mergence with another element, it usually means the two elements are in the same part of the bicycle.

The innovative bicycle “TRIX” is shown in Fig. 8. TRIX is designed with a storage space in the front of the bicycle for working, carrying or shopping. The function of compartment is merged with the frame and



Fig. 7. The innovative bicycle “Snow Leopard”.



Fig. 8. The innovative bicycle “TRIX”.

cannot be removed. Thus, the storage element has the “mergence” relationship with the frame.

For distinguishing the combination and mergence in the representations, a dotted line is used to represent the function of combination, and a solid line is used to represent the function of mergence. The representations for the two relationships are shown in Fig. 9.

### 3.4. Characteristics of the Symbolized Representation

As mentioned above, a bicycle can be treated as the construction of functional elements. Thus, a bicycle can be decomposed into a lot of elements and relationships between elements. It means that an innovation bicycle can be created by new elements or new combination of elements and relationships. If there are some constraints for picking out elements and relationships, an innovative bicycle will be created.

In the past, an innovation mechanism was usually created by the creative mechanism design method [10], but it was suitable only for topology structure and motion requirements. For some innovative designs that only new application and purposes are care, topology structure and motion requirements are unknown and unimportant, the creative mechanism design method are not suitable. For these cases, therefore, the symbolized representation is a suitable method.

## 4. EXAMPLES

According the above representations, an innovative bicycle can be represented by symbols of elements and relationships.

(a) Combination

(b) mergence

Fig. 9. Representation of relationship of functional elements.

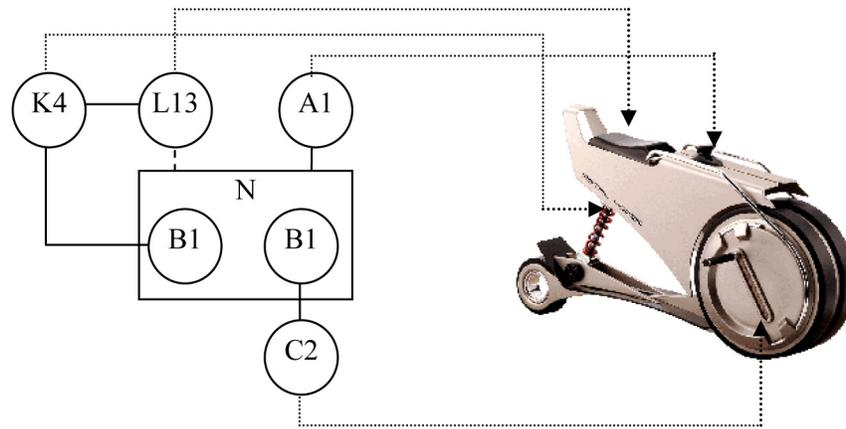


Fig. 10. "Metal Horse" and its representations.

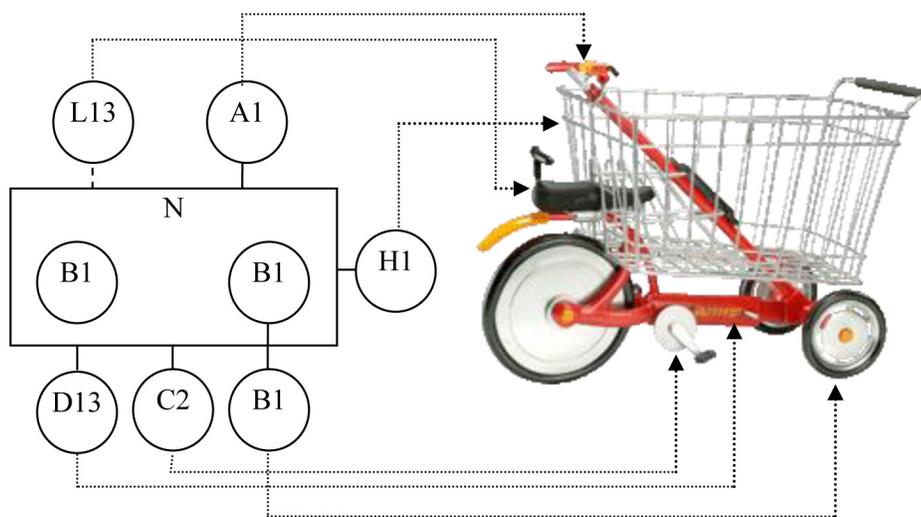


Fig. 11. "Shopper" and its representations.

#### 4.1. Example 1 "Metal Horse"

The innovative bicycle "Metal Horse" and its representations are shown in Fig. 10. "Metal Horse" is an innovative bicycle with frame, and with front and rear wheel B1. Therefore, its construction is first type.

The functional elements of "Metal Horse" include front and rear wheel B1, handle element A1, foot rotation C2, anti-shock element K4, and seat cushion L13.

A1 is merged with frame, C2 is merged with B1, K4 is merged with another B1, L13 is combined with frame, and L13 is merged with K4. According to the mention above, the representations for "Metal Horse" are shown in Fig. 10.

## 4.2. Example 2 “Shopper”

The innovative bicycle “Shopper” and its representations are shown as in Fig. 11. Shopper is an innovative bicycle with frame, there are front and rear wheels B1. Therefore, its construction belongs to the first type.

The functional elements of “Shopper” include front and rear wheel B1, handle element A1, the second front wheel B1, foot rotation C2, angle D13, shopping H1, and seat cushion L13.

A1 is merged with frame, two front wheels B1 are merged with each other, C2 is merged with frame, D13 is merged with frame, H1 is merged with frame, and L13 is combined with frame. The representations for “Shopper” are shown in Fig. 11.

## 5. CONCLUSIONS

This research collects and analyzes the innovative bicycles and proposed systematic representations. These results are described as follows:

1. This research collects 233 innovative bicycles and retrieves their creative characteristics.
2. The creative characteristics of bicycles are classified into functional elements, form elements, and material elements.
3. The construction of bicycle can be classified into two types: bicycle with frame and bicycle without frame.
4. The relationships of functional elements are classified into two kinds: mergence and combination.
5. The functional element representations for bicycles with creative characteristics are proposed in this paper, and bicycle can be symbolically represented using the representations for creativity development.

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