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# CREATIVE BEHAVIORAL PATTERN DESIGN USING ANALOGICAL METHOD

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## ABSTRACT:

In this report, the authors propose a method of designing behavioral patterns analogically. We applied this method to design a wavelike behavior of a robot arm based on the movement of a snake. In order for the behavioral pattern being designed by the analogical method to have more creativity, we introduced behavioral criteria to extend this behavior design method.

**KEYWORDS:** Analogy, Behavioral Pattern, Behavioral Evaluation Function

## 1. INTRODUCTION

In recent years, studies on behavioral design have been conducted in the fields of robotics, animation, computer games and movies. However, there has been little study focusing on creative behavioral pattern design.

Conventional behavioral pattern design is directly dependent on the designer's personal imagination and experience. Therefore, interesting, novel and creative behavioral patterns are difficult to design and produce at present. It is necessary to propose an effective method and tools for designing behavior.

The authors propose a method of designing behavioral patterns analogically. In this method, a base object is selected by analogy when a designer wants to design a behavior for a target object.

We applied this method to design a wavelike behavior of a robot arm (target object) based on the movement of a snake (base object). It is forecast that the behavior being designed by the analogical method is lacking in creativity. Therefore, it is considered that creative behavioral patterns cannot be designed by just the analogical method. In order to solve this problem, we introduce behavioral criteria to extend this behavior design method.

## 2. ANALOGY

Analogy is both the cognitive process of transferring information from a particular subject (the base object) to another subject (the target object), and the linguistic expression corresponding to such a process (Juthe, A. 2005).

Greek philosophers such as Plato and Aristotle actually used a wider notion of analogy. They saw analogy as a shared abstraction. Analogous objects share not necessarily a relation, but also an idea, a pattern, a regularity, an attribute, an effect or a function.

On the contrary, Bacon, and later Mill, argued that analogy should simply by a special case of induction (Shelley, C. 2003). In their view, analogy is an inductive inference from common known attributes to another probable common attribute, which is known only about the source of the analogy, in the following form.

**Premises**

a is C, D, E, F and G.

b is C, D, E and F

**Conclusion**

b is probably G.

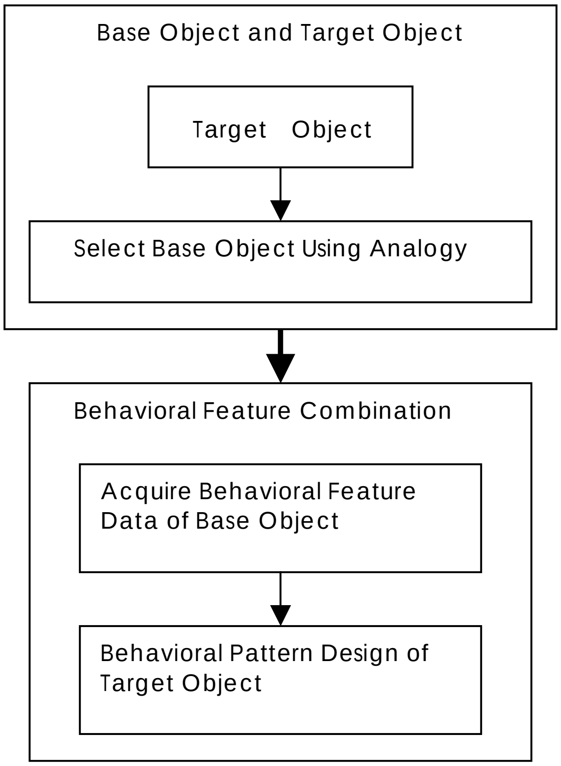



Fig. 1 Behavioral Design Using Analogy

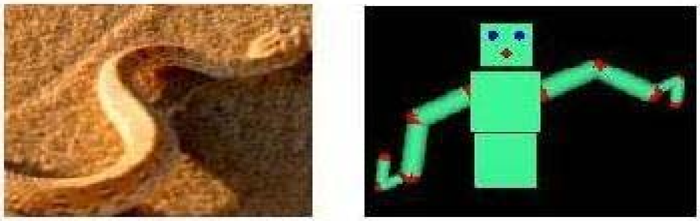
In this study, we will show how we design behavioral patterns using analogy by the following process. Figure 1 shows the process of behavioral design using analogy.

## 3. BASE OBJECT AND TARGET OBJECT

In order to solve the problem of designing behavioral patterns, analogy is defined as the relationship between the base object and the target object.

In this study, we take the example of designing a wavelike behavioral pattern of a robot arm, where the robot arm is defined as the target object.

A snake is selected as the base object. Figure 2 shows the structure of analogy based on the relationship and similarities between the snake and the robot arm.



| | Snake | Robot's arm |
|---|---|---|
| **Category** | Animal | Human robot's arm |
| **Form** | Cylindrical form | Cylindrical form |
| **Movement** | Movement like wave | Probably move like a wave |

Fig. 2 Structure of Analogy

We obtain the following form based on inductive inference.

**Premises**

The snake is an animal with a cylindrical body and moves like a wave.

The robot arm is a cylindrical form, with 4 joints.

**Conclusion**

The robot arm can probably move like a wave.

# 4. BEHAVIORAL PATTERN SIMULATION

## 4. 1. IMAGE PROCESSING

In this stage, we acquire the behavioral feature points from a movie of snake movement by image processing. The image processing program uses OpenCV with VC++6.0 on Windows XP Professional. OpenCV (Open Source Computer Vision) is a library of programming functions mainly aimed at real-time computer vision. Figure 3 shows the feature point pursuit of the snake movement.

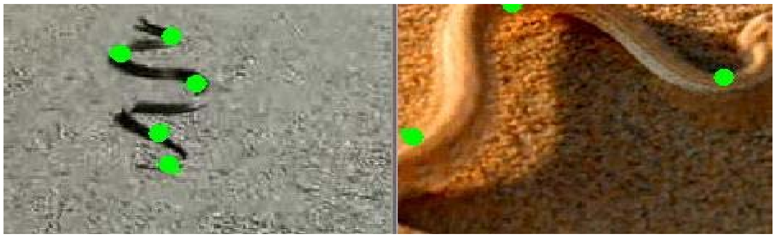


Fig. 3 Feature Point Pursuit of Snake Movement

Start 1 Movement Image 1

Start 2 Movement Image 2

Fig. 4 Two Start and Movement Images of Snake

## 4. 2. TYPE OF BEHAVIORAL PATTERN

In this study, two behavioral patterns are designed. The images of two types of snake movement are shown in Figure 4.

Here, we design the behavioral pattern of the robot on the basic of the feature point data acquired from the movie.

## 4. 3. SIMULATION

A robotic simulation is created using OpenGL, as shown in Figure 5. In this study, two types of behavioral patterns are designed. The images of the two types of movement of the robot are shown in Figure 6.

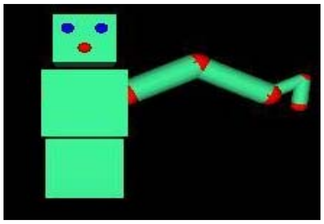
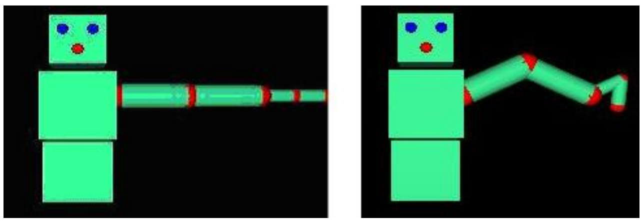
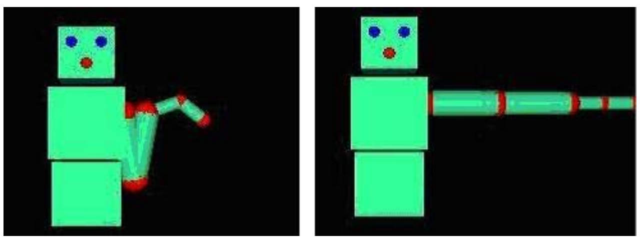


Fig. 5 Simulation of Robot Using OpenGL



Start 1 Movement Image 1



Start 2 Movement Image 2

Fig. 6 Two Start and Movement Images of Robot

## 5. CREATIVE BEHAVIOR DESIGN METHOD

We designed the behavioral pattern of the robot arm based on the feature point data acquired from the movie of snake movement. However, the behavioral pattern designed using only the above data is extremely singular, lacking in creativity and perhaps incongruous with the designer's intention.

Therefore, it is considered that creative behavioral patterns that are in line with the designer's intention cannot be designed by just the analogical method. It is necessary to propose a more effective method of designing behavior.

### 5. 1. ABSTRACT IMAGE

In the first stage of the design process, the designer may envision some novel, interesting or creative abstract images, but cannot easily convey them to the computer be cause of the difficulty of expressing such abstract images. It is important to express on the computer, the abstract image envisioned by the designer. In other words, for effective use of the computer, it is important to understand the abstract images thought out by the designer.

### 5. 2. ABSTRACT BEHAVIORAL IMAGE UNDERSTAND AND EVALUATION

In this study, it is believed that if the computer could understand the abstract behavioral images envisioned by the designer, then the behavioral patterns can be generated by operating these abstract behavioral images.

Moreover, if the behavioral pattern generated by the computer is not in line with the designer’s intention, the designer must evaluate the behavioral pattern and the computer must understand the evaluation by the designer. Moreover, the behavioral pattern must be regenerated by the computer on the basis of the evaluation by the designer.

## 6. INTERACTIVE EVOLUTIONARY CALCULATIONS

In order to solve the above problem, we extend the method of behavior design using analogy by introducing Interactive Evolutionary Computation (IEC), because IEC adopts evolutionary computation based on subjective designer evaluation. In the design domain, IEC is actively used to visualize the image in the designer’s mind (Masui T. 1992).

### 6. 1. BEHAVIORAL CRITERIA AND BEHAVIORAL EVALUATION FUNCTION

In this study, the behavioral criterion is defined as an abstract image of a behavior expressed by a designer. During its transmission, the behavioral criterion usually carries information on what the designer wants to do and judges whether the behavior is performed well.

In addition, behavioral patterns are designed by operating the underlying behavioral criteria through computer calculation. For such operation, we regard behavior criterion as behavioral evaluation functions in mathematical forms. The behavioral evaluation function can not only include the characteristics of behavioral pattern and express the abstract image envisioned by the designer, but can also evaluate and generate the optimum behavior by evolutionary calculation.

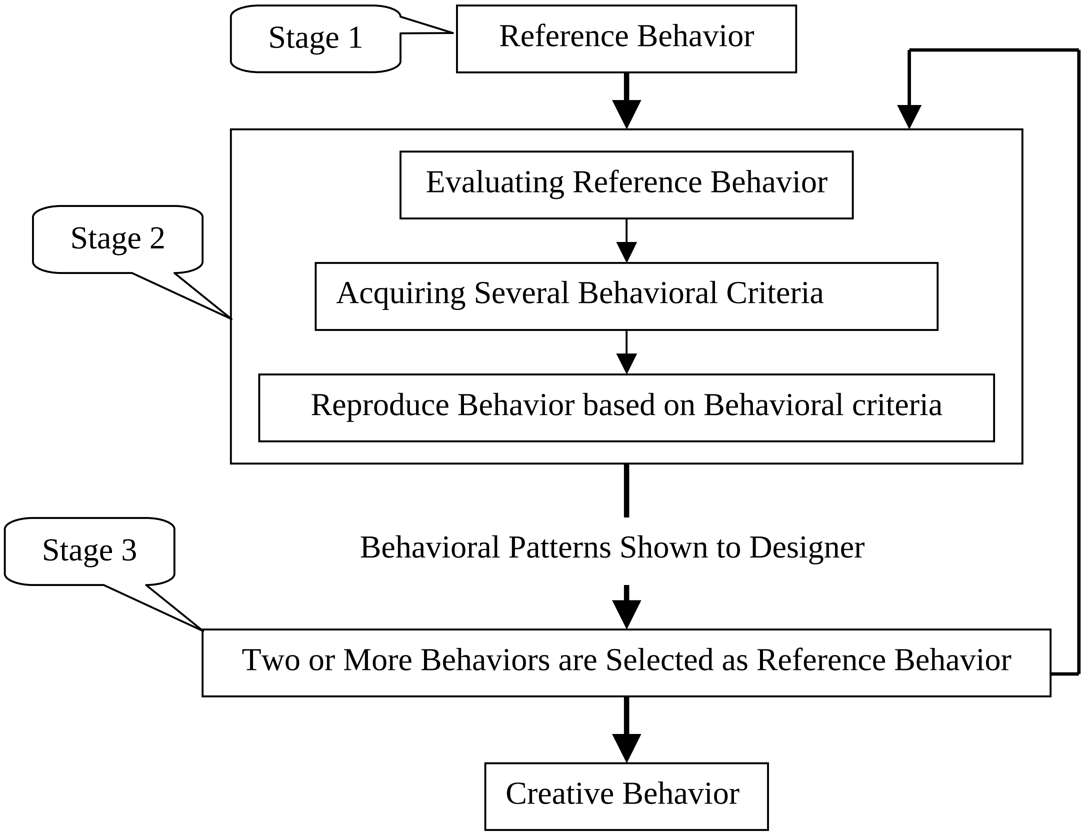



Fig. 7 Flowchart of Creative Behavioral Design based on IEC

## 6. 2. AUTONOMOUS ACQUISITION OF CRITERIA

In our previous work (An, M., Kagawa, K. and Taura, T. 2003, An, M., Taura, T. and Nagai, Y. 2005), we proposed a method of autonomous acquisition of criteria by evolutionary calculations. The characteristic features of the method lie in the process of obtaining the evaluation function from a reference behavior.

## 6. 3. BEHAVIOR DESIGN BASED ON IEC

In the method of behavior design using analogy extended by introducing IEC, in the first stage, a behavior is selected as the reference behavior. In the second stage, we acquire several basic behavioral criteria for evaluating the reference behavior. Then the behavior is reproduced on the basis of the learned primitive behavioral criteria. In this stage, evolutionary calculation is used to acquire the optimum behavior. In the third stage, two or more behaviors that be evaluated by the designer are selected as the reference behaviors to produce new behavioral criteria.

Until the final generation, the loop between the second and third stages is repeated. The flowchart of this method is shown in Figure 7.

## 7. CONCLUSION

We have proposed a method of designing creative behavioral patterns using analogy. New robotic behaviors can be created by this method. This method does not depend on the designer's personal experience with behavioral pattern design, but creates novel behavioral patterns based on behavioral features of a base object. Moreover, we introduced IEC to extend this behavior design method.

In future tasks, we plan to design behavior using the extended method of creative behavior design using IEC proposed by us. We also plan to investigate various human behaviors using other base objects and to establish an interactive behavior design system that enables the design of novel behaviors based on base objects or motion databases and complex behavioral criteria.

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