

THE EXPLANATION OF PATTERN RECOGNITION MODEL WITH COGNITIVE PSYCHOLOGY

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ABSTRACT:

Based on the fundamental theory of visual cognition mechanism and cognitive psychology, a brief introduction about the visual pattern recognition model is presented in this paper. Three pattern recognition models, i.e., template-based matching model, prototype-based matching model and feature-based matching model are built and discussed separately. In addition, the influence of object background information and visual focus point to the result of pattern recognition is also discussed with the example of recognition for fuzzy letters and figures. After the analysis, it is pointed out that the theory of cognitive psychology is meaningful for guiding the computer pattern recognition research work.

1. INTRODUCTION

With the technology development and integration of photogrammetry, remote sensing (RS) and geographic information system (GIS) going further, a new branch of information science, that is, the geoinformatics was risen and has been developed rapidly. The integration of geoinformatics with the earth science, information science, computer science, artificial intelligence, expert system etc., which forms a huge complicated system concerning the acquisition, processing, storing, representation, distribution and application of information about the earth. For image information processing only, a great progress has been made on the aspect of technology and algorithm during the past several decades, but there still exist a lot of difficulties concerning the automatic classification, pattern recognition, image analysis and understanding, the representation of information and the utilization of knowledge etc.. Generally speaking, the knowledge level on these issues is far lag behind the human's cognitive level at present. Taking the pattern recognition from image as an example, a number of difficult issues arise in visual pattern recognition, including the problem of what kind of features should be used (2-D or 3-D, edge-based or filter-based), how to deal with missing features (e.g., due to occlusion or shadows), and how to deal with variations in the image resolution, scale, spectrum and temporal elements (Robert A W & Frank C K, 2000). With the research work of above issues going deep, we realize that the cognitive science, especially the cognitive psychology can give us some inspire for the solution of some above mentioned problems.

The origin and development of cognitive science has a history of several decades, but it is only in recent years that the theoretical research about cognitive science has obtained enough attention in the field of geoinformatics (WANG J, 2001). At present, the theory of cognitive science has been generally acknowledged as the important component parts of fundamental theory of geo-spatial information science. In this paper, the author try to build three theoretical models of visual pattern recognition based on the basic theory of cognitive psychology

(that is the essence of cognitive science), and the related visual perception mechanism will also be discussed.

2. ABOUT THE COGNITIVE PSYCHOLOGY

Cognitive psychology is one of the branches of psychology, and it is also the main component parts of cognitive science. Cognitive psychology takes the human brain's mechanism for information processing as its theoretical core, i.e., to compare the human brain with the computer, and treat the human brain as an information processing system that works like a computer. The main research area of cognitive psychology concerns the psychological or cognitive process of perception, attention, mental image, memory, thought, language learning and pattern recognition as well as the organization of knowledge etc.. The main purpose of above research is to reveal the human's internal psychological mechanism, that is, how is the information obtained, stored, processed and applied by human's brain (WANG G & WANG A, 2001, Jone B B, 2000).

Generally speaking, the cognitive process includes the procedures of information acquisition and information processing (i.e. the thought) as well as the subjective information generation (also called regeneration). To understand this issue in narrow sense, cognition is the process of knowledge state changes, i.e., the process of subjective information generation. Fig.1 shows above relationship and the general model of cognitive process.

3. PERCEPTION AND PERCEPTION PROCESSING

Cognitive psychologists treat the most cognitive process as "perceptive". Perception process accepts the sensate input and transforms it into abstract codes. In the field of cognitive psychology research, there exist two opposite theories about the cognitive process of perception. The first standpoint thinks that the perception has close relationship with human's knowledge and experience, that is, people's ability of object recognition in the natural environment is based on his or her available

knowledge about the outside world, the knowledge about natural scenery and their spatial relationship guide people's perception activity. The second standpoint thinks that perception is direct and has nothing to do with the knowledge or experience, that is, the stimulation of outside world to human's sensory organ is complete, it can supply with rich information, people can use this information to recognize the object in the real world without using of the past experience. However, With the development of cognitive science research going deep, cognitive psychologists have enough reasons to think that perception depends on the past experience and knowledge, perception information is the result of mutual action between reality stimulation and memory information.

Since the cognitive psychology stress the importance of past experience and knowledge as well as the reality stimulation about the outside world in the process of perception generation, so it thinks that perception process should include two mutually related processing approaches, i.e., the bottom-up processing and the top-down processing. The bottom-up processing starts with the external stimulation, it focuses on the analysis of smaller perception elements first, and then moves to the perception analysis of larger elements. After a series of continuously processing, it gives the explanation of sensation stimulation. The top-down processing is a knowledge-guided perception processing, the higher level processing controls the lower level processing. Lindsay and Norman (1977) called the former as data-driven processing and the latter as concept-driven processing. The bottom-up processing and the top-down processing are two different approaches opposite in processing direction. Without the effect of stimulation, top-down processing can only bring about illusion. On the contrary, it is hard to cope with the situation of double meanings or uncertainty for some stimulation if only based on the bottom-up processing. If the united perception result is expected, it is necessary to integrate above two approaches.

4. PATTERN RECOGNITION

The perception research of cognitive psychology mainly concentrates on the issue of pattern recognition, especially on the visual pattern recognition. Human's pattern recognition can be treated as a typical perception process, it depends on human's available knowledge and experience. Modern cognitive psychology has presented several theoretical models about Human's pattern recognition, such as template-based matching model, prototype-based matching model and feature-based matching model, some of these models are greatly affected by the artificial intelligence (AI). A further research and deeply understanding of these theoretical models is

meaningful to the pattern recognition issues concerning the field of computer vision and geoinformatics.

4.1 Template-based Matching Model

The core of template-based matching model is that in human's memory, there should exist plenty of various duplicates about the real world pattern, these duplicates are called templates, they are formed from the past living experiences. The real world patterns and the templates are corresponding to each other. When an outside stimulation effects on human's sensory organ, the stimulation information will be coded first and then compare it with the stored templates, in order to find the best matching pair. The template with the best matching is likely the pattern of that stimulation, so the pattern can be recognized.

According to the basic viewpoint of template-based matching, it is necessary to have the corresponding templates be stored in the memory in advance in order to recognize a special pattern. However, the real world patterns are various and may be different on the aspect of shape, size and direction etc., which means for each distinct case there should exist a corresponding template, otherwise, the recognition of pattern will fail. In this case, in order to realize pattern recognition correctly, people are required to store countless templates in the memory, which will greatly increase the burden of memory, and it is also contradictory to human's high flexibility in the process of pattern recognition. In order to overcome this shortcoming, some scholar suggest to add a pre-processing process to the template-based matching, that is, to adjust the shape, size and direction of stimulation in the initial stage of pattern recognition, and standardize them in order to greatly reduce the number of templates. To do like this seems logical, but the problem is how to adjust the stimulation from outside world if we have no any idea of what is the pattern to be recognized in advance?

In fact, template-based matching is a kind of bottom-up processing model. In order to make the pre-processing efficiently, the top-down processing model should be considered. Human's perception contains the mutual related bottom-up and top-down processing mechanism, only when the template-based matching is integrated with the mechanism of top-down processing, the matching model can be complete. Fig.2 shows a relatively completed template-based matching model.

Even though the template-based matching model can explain the human's process on pattern recognition, but it is hard to explain such an indisputable fact that how people can rapidly recognize a new, unfamiliar model.

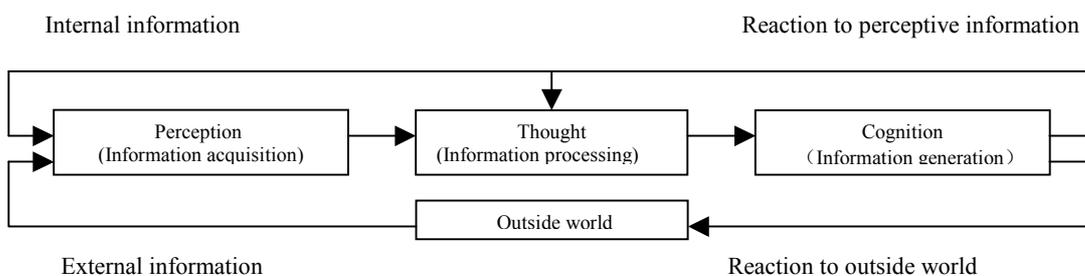


Figure 1. General model of cognitive procedure

4.2 Prototype-based Matching Model

The prototype-based matching model was presented in order to remedy the shortcoming of template-based matching model. The main characteristic of template-based matching model is that, it thinks what stored in human's memory is not the templates of outside world pattern, but the prototypes of real world objects. These prototypes reflect the basic features of certain kind of objects. Through the separation of the structure of complicated objects into simple components, then adoption the matching for components' prototypes, in order to realize the pattern recognition purpose. For this reason, the prototype-based matching is also called component-based matching sometimes.

According to the viewpoint of prototype-based matching model, outside stimulation is only needed to compare with the prototypes during the pattern recognition process. Due to the reason that prototype is a kind of summarized token, so the accurate matching of above comparison need not to be strictly satisfied, only approximate matching is required. Even if there exist some difference on the aspect of shape, size and direction for certain objects, all these objects can still be recognized through the matching with prototypes. Which means the new and unfamiliar patterns can also be recognized so long as the related prototypes are available, it makes the human's ability of pattern recognition more flexible in order to suit the environment changes. Fig. 3 shows a kind of prototype-based matching model. For the prototype-based matching model, the key is whether the prototypes are available or not, this is still a disputed issue at present. Besides, the prototype-based matching model only contains the bottom-up processing and without the top-down processing, this is obviously a drawback. Compare with the template-based matching model, the top-down processing mechanism seems more important to the prototype-based matching.

4.3 Feature-based Matching Model

Pattern consists of a certain number of elements or component parts by a specified relationship. These elements or component parts are usually called features, and the relationship among

them can also be called features sometimes. Feature-based matching model thinks that all complicated stimulation is composed of differentiated and separated features. Through the calculation of feature's existence, and then compare this calculation value with the list of known feature's value, in order to accomplish the pattern recognition.

Feature-based matching model emphasizes the importance of feature and feature analysis. The successfulness of feature-based matching depends on the separation degree of stimulation. The status and function of the features here is similar to that of template in the template-based matching, i.e., the feature can be treated as a tiny template or a component template. But feature-based matching is different from template-based matching after all, it has certain advantages: firstly, due to the reason that the recognition in this case is based on the features and their relationship, so it is not necessary to consider the stimulation changes caused by the difference of size, shape and direction etc., which can avoid the difficulty and burden of pre-processing process and make the recognition more flexible; secondly, the same features can be appeared in different patterns, which can greatly lighten the burden of memory; finally, due to the reason that feature extraction, analysis and information integration are all required for the recognition purpose, which makes the feature-based matching process be provided with the learning ability in certain degree. But unfortunately, when different patterns have the same features, which will make the recognition hard to realize, even cause the wrong recognition.

Compare with other pattern recognition models, the feature-based matching model do has the greater flexibility, but it also belongs to the bottom-up processing, it is short of the top-down processing mechanism. According to the general understanding of cognitive psychology to the perception process, it is impossible to add the top-down processing program into the feature-based matching model, at least from the theoretical viewpoint it does so. So does the prototype-based matching model.

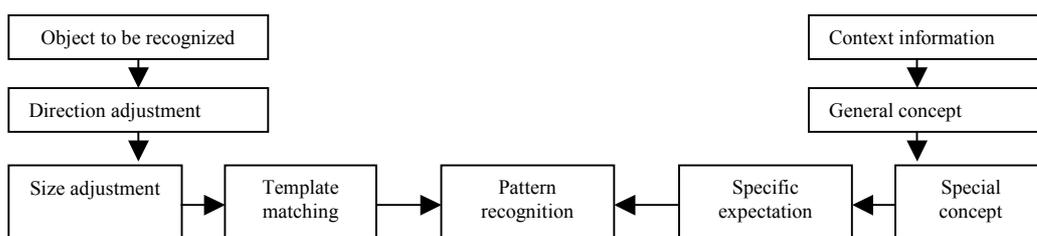


Figure 2. Template-based matching model

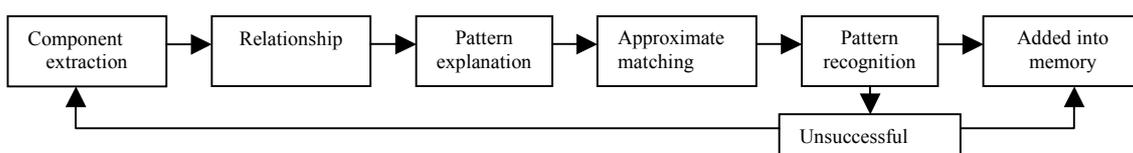


Figure 3. Prototype-based matching model

5. OBJECT BACKGROUND AND SUPERIORITY EFFECT

The purpose for the research of object background is to find out the possible effect of object background information to the recognition result during the visual perception process. In fact, in many cases of pattern recognition process, the object background information can be used for the processing of feature analysis. Fig.4(a) shows a set of handwritten form letters and figures. The top stimulation in this figure can be regarded as "15" or "is", the recognition results here are totally depends on their background information. From this example, we know that the analysis of background information is beneficial for obtaining a correct result in pattern recognition. The cognitive psychologists call this phenomenon as "Superiority Effect".

For further study purpose, we take another set of fuzzy letters and figures as an example. Fig.4(b) is a set of printing form characters. When the top character in Fig.4(b) is recognized individually, it is hard to determine that it is a figure "0" or an English letter "o". However, when it appears in a string of figures or an English sentence, it can be correctly recognized with easy. This further explains the importance of context information to the result of pattern recognition and the superiority of entirety processing.



Figure 4. Fuzzy letters and figures

The using of background information doesn't mean that the "Superiority Effect" is always available. During the visual cognitive process, the different of visual focus point will greatly affect the recognition result. If the position of visual focus is changed in the context or graph, the "Superiority Effect" will not appear sometimes, in this case, the efficiency of pattern recognition will also be affected. The concept of visual focus point is called "selective attention" in the cognitive psychology, it belongs to the research scope of initiative vision in the field of computer pattern recognition, the detail about this will not be discussed here.

The research of "Superiority Effect" is one of the hot spot in cognitive psychology at present. On one hand, it concentrately reflects some important issues on perception and pattern recognition, such as the organization of perception, the effect of experience and knowledge, the mechanism of bottom-up processing and top-down processing etc.; On the other hand, "Superiority Effect" can help us to understand the human's instinct that are different from the machine pattern recognition. To further understand the "Superiority Effect" needs to integrate the viewpoints of psychology, physiology, artificial intelligence and some other disciplines.

6. CONCLUSION REMARKS

From the perspective of geoinformatics, the main purpose of theoretical research of pattern recognition model based on the cognitive psychology can be concluded as two points: 1) To understand the human's visual cognitive mechanism; 2) Taking

this visual cognitive mechanism as the theoretical guidance, to develop an image understanding system which can automatically constitute the scene description from the image data. At present, the understanding degree and the research profundity of us to the visual cognitive mechanism is far lag behind the development of the means of image information processing. How to make the computer be endowed with some basic functions of human beings' visual cognitive mechanism, this is the expectation that people are crave for. The basic theory of human's visual cognitive mechanism and computer vision is still in the process of searching and forming, we should strengthen the research of fundamental theory in this field.

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