Artificial Intuition Reasoning System (AIRS) and Application in Criminal Investigations

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Abstract. Intuition is a special function of human brain, and it is an urgent task to establish a reasoning system with intuitive characteristics in the field of artificial intelligence. The purpose of this paper is to establish a formal model of intuitive reasoning based on the analysis of the characteristics of intuitive reasoning in criminal investigation. At the same time, it provides an artificial intuition model for constructing inference machine of criminal investigation. First, a novel framework of intuitive reasoning system is established based on the principles of memory mapping and perceptual inversion. Secondly, according to the fuzzy perception of experience and knowledge, a formalized criterion which accords with humans intuitive reasoning is established, namely the intuitive characteristic index. Finally, the artificial intuition reasoning model is used to analyze a crime investigation case. The results show that the reliability of this artificial intuitive reasoning system is 85% in practical application, and this intuitive reasoning process is a learning system of experience and knowledge. If this intuitive reasoning system can simulate human brain's intuitive reasoning after limited intuitive training and learning.

1. Introduction
The research idea of this paper comes from the research project of fuzzy reasoning system design for crime detection [1]. In the research of this project, a crime detection inference model is established by using the method of intuitionistic fuzzy set [2]. Although the inference model involves the intuitive reasoning problems in criminal investigation, but in the design of computer reasoning system, and there is no real implementation investigators intuitive behavior, that is to say, the reasoning model is a rule-based system logical reasoning based on intuitionistic fuzzy sets, doesn't really reflect the intuitive behavior in the process of criminal investigation. In fact, intuitive reasoning is a meaningful research question in artificial intelligence. Whether we can build a computer reasoning system with intuitive behavior —— artificial intuition has been paid much attention in many research fields. Many literatures show that formal description of intuitive reasoning is the key to the design and implementation of artificial intuition [3, 4]. Since perception and memory are the essential characteristics of intuition, they are associative and illogical [5]. Therefore, an intelligent system with intuitive reasoning must have a mathematical model that can describe memory and perception.

The main contribution of this paper is to put forward the concept of intuitive reasoning system with the relation between memory and perception, establish an intuitionistic characteristic index based on fuzzy optimal perception and fuzzy non-optimal perception, and provide a novel formal description method for artificial intuition system.

This paper is organized as follows. Section 2 proposes the relationship model of intuitive reasoning with memory and perception, which is the basis of this study. Section 3 a novel description method of intuitionistic characteristic index is established. Section 4 provides an application example of criminal intuitive reasoning. Finally, Section 5 draws a conclusion and further work.
2. The Basic Framework of Intuitive Reasoning

Literature [6], based on factor space theory (Peizhuang Wang, 1981), puts forward a principle of association between memory mapping and perceptual inversion, and applies it to the design of crime investigation inference system, with satisfactory results [7]. The basic ideas of this research shows that human intuition comes from the memory and perception of things, and, the intuitive ability of an object's judgment depends on relationship of memory and perception. In fact, the memory and perception are two important functions of the person, both of which determine the memory and perception space of things.

We suppose that $U$ is a things (object), there exists memory space $S^m(U, f^m, X(f^m))$ and perception space $S^p(U, f^p, X(f^p))$, which $f^m$ is a factor sets of memory, $f^p$ is a factor sets of perception, $X(f^m)$ is a set of memory state, $X(f^p)$ is a set of perception state, and thus, we have the following definition: [8]

**Definition 2.1** Let $U$ be a sets of object, if $S^m(U, f^m, X(f^m))$ be a memory space, $S^p(U, f^p, X(f^p))$ be a perception space for $u \in U$, there is an intuitive space $S^I(U, f^I, X(f^I))$ in relationship of $S^m$ and $S^p$, which $f^I$ is an sets of intuition, $X(f^I)$ is a sets of intuitive state, and the intuition of object $u \in U$ is determined by the relationship $R(f^m, f^p)$ of $f^m$ and $f^p$, without loss of generality, we have $I(u) : R(f^m, f^p) \rightarrow f^I$.

The basic framework for defining 2.1 is shown in figure 1:

![Figure 1. The basic framework of intuitive reasoning](image)

Definition 1 indicates that a person with intuitive reasoning ability must have intuitive learning ability, which is reflected in the relationship between memory mapping and state inversion. To be specific, memory space and perception space are the preconditions for intuitive judgment and reasoning of things, and memory space and perception space are interrelated. An intuitive reasoning is formed through the connection process from perception to memory and from memory to perception, so it can be called associative reasoning. It can be found from figure 1 that intuitive factors are obtained through the interaction between memory factors and perceptual factors, and then intuitive states are generated by intuitive factors.

3. Artificial Intuition Reasoning System

3.1 Intuition Feature Index (IFI)

Traditional research shows that intuition is a function of knowledge and experience. That is to say, intuition is a mapping, according to the definition of factor space, factors are mappings, so intuition is a factor in knowledge and experience. Because knowledge and experience factors exist in the memory factor space, the intuitive judgment and decision-making of people are based on the perception of memory factors. Thus, the key of intuitive judgment is the perception analysis of the memory factor space associated with things.

This study shows that there are three kinds of situations based on memory perception: complete memory perception, incomplete memory perception, and no memory perception. Specifically, (1) If the perception of things is a complete memory perception, then the intuition factor space is the memory
factor space. (2) If the perception of things is incomplete memory perception, then the intuition space is not a completely memory space. (3) If the perception of things is a non-memory perception, then the intuition space is a perception space with no memory. Definition 2 gives a formal description of intuition based on memory and perception.

Definition 3.1 Let $S^p = (U, f^p, X(f^p))$ be a perception space based on memory space $S^m = (U, f^m, X(f^m))$, where $f^p$ has positive perception and negative perception, as well as the degree of the positive perception is $\rho^+(u) \in [0, 1]$, the degree of the negative perception is $\rho^-(u) \in [-1, 0]$, then $R(f^m, f^p) = R(\rho^+(u), \rho^-(u)) = I(u)$ be called a intuition feature index (IFI), and IFI is determined by the relationship between memory and perception, so it can also be called the degree of connection. $C(u) = I(u)$, without loss of generality, we have

$$I(u) = \begin{cases} 1 & \rho^+(u) = 1, \rho^-(u) = 0 \\ 0 & \rho^+(u) = 0, \rho^-(u) = 1 \\ \frac{1}{2}[1 + (\rho^-(u) - \rho^+(u))], & 0 < \rho^+(u) - \rho^-(u) < 1 \\ 0.5 & \rho^+(u) = \rho^-(u) \end{cases}$$

The definition with nature comes to following:

(1) If $\rho^+(u) = 1, \rho^-(u) = 0, I(u) = 1, h(u) = 0$ then $S^m = S^p, f^p = f^m$, that is, the memory factor determines the intuition of the object, the judgment of the object will produce intuition without hesitation. In other words, the memory space of the object has complete knowledge and experience.

(2) If $0 < \rho^+(u) - \rho^-(u) < 1, 0 < I(u) < 1, 0 < h(u) < 1$, then $S^p \subset S^m, f^p \subset f^m$, that is, the object has some memory factor. In other words, the memory space of the object has incomplete knowledge and experience.

(3) If $\rho^+(u) = 0, \rho^-(u) = 1, I(u) = 0, h(u) = 1$, then $f^m = \emptyset, f^p = \emptyset$, that is, the objects have no memory space, the object has the greatest hesitation, no intuition. In other words, the memory factor of the object has no relevant knowledge and experience.

Definition 3.1 gives a measure of trust intuition. In fact, the main task of artificial intuition system is to simulate human's intuitive reasoning process. In an artificial intuition system of things, the memory space has the characteristic information and intuitive experience information of things, and the perceptual space has the perceptive characteristic information of things under different conditions. For a certain judgment and research problem, the inference mode of artificial intuition is the choice of multiple intuitions to realize this problem.

3.2 Artificial Intuition Reasoning System

The reasoning system is the core issue of intelligent system research such as artificial intelligence and expert systems. For the inference system of deterministic objects, the mathematical model-based inference algorithm determines the credibility of the inference system. However, for inference systems with uncertain behavioral characteristics, traditional inference algorithms cannot achieve satisfactory reliability. In recent years, the research of uncertainty-based inference systems based on fuzzy sets has been deeply developed, especially in the study of intuitionistic reasoning. Many literatures explore the establishment of intuitionistic fuzzy inference algorithms from different angles. For example, intuitionistic fuzzy sets are used to establish problematic intuitive decisions [9], rule-based intuitionistic fuzzy inference engines, etc. [10, 11].

However, the current research has not really solved the problem of formal description of intuitive reasoning. The artificial intuition inference system established in this paper provides a meaningful path for the study of intuitionistic reasoning model from a certain angle. In fact, the artificial intuition reasoning system is a learning system based on the set of intuition states of memory and perception. The intuition of an object (event) is based on the perceived reliability of memory, which combines different
perceptual beliefs to form an intuitive decision. The basic operational framework of the artificial intuition reasoning system is given as follows:

**Definition 3.2** Let $S^p = (U, f^p, X(f^p))$ be a perception space based on memory space $S^m = (U, f^m, X(f^m))$. In the artificial intuition system, if there is intuitive experience information based on memory and perception, then there must be a mapping-inversion learning process of memory and perception. The process of mapping and inversion is a learning system with different degrees of connection between memory and perception. By training and selecting the correlation degree and intuitionistic characteristic index, a satisfying intuitionistic inference result can be obtained. The specific learning algorithm is as follows:

$$S^m \xrightarrow{p} S^p \xrightarrow{f^p(u)} f^l(u) \xrightarrow{X(f^l)} TX(f^l).$$

The actual operational structure of Definition 3.2 is shown in Figure 2:

![Figure 2. The basic framework of artificial intuition reasoning system](image)

In the definition 3, trusted intuition is an intuitive state with the maximum correlation between memory and perception, that is $TX(f^l) = \max\{I_1(u), I_2(u), \cdots, I_n(u)\}$.

4. Experimental Analysis and Results
This paper chooses a typical case to analyze the artificial intuition experiment [9]. Experimental process is as follows: For the field investigation information of homicide cases in a certain area, the police with criminal investigation experience are selected to input the intuitive judgment of each crime scene investigation on the reasoning system of criminal investigation with human-machine interaction interface, and the reasoning results of credible intuition are obtained through the learning and evaluation process of intuitive characteristic index.

4.1 Crime Factors Discovery
The investigators intuitively judge the factors that generate the criminal factors of the crime scene. Through the intuitive learning process, the decision-making intuition from the factor intuition to the characteristics of the offender is generated [12, 13]. Suppose the criminal factor set is
\[ X = \{ x_1 = \text{Case}, x_2 = \text{Time}, x_3 = \text{Scene}, x_4 = \text{Tools}, x_5 = \text{State}, x_6 = \text{Reason}, x_7 = \text{Human} \} \]

**Figure 3.** Coordinate frame of crime factor

### 4.2 Evaluation of Intuitive State Credibility

According to the crime factor information provided by the crime scene investigation, the crime attribute category to which each investigator's intuition status belongs is evaluated. Assume that the crime attribute category has three categories, A, B, and C [14]. Through artificial intuition learning, if the category of the intuition state of each crime factor belongs to the consistency, and under the condition of supplemental information, the set of intuition states is monotonous, and Intuitive feature indices have consistent credibility, and then a credible intuition result is obtained [15]. The experimental process and results of this paper are as follows:

| Investigator | \( R(f^m, f^n) \) | \( f^i(x_1) \) | \( f^i(x_2) \) | \( f^i(x_3) \) | \( f^i(x_4) \) | \( f^i(x_5) \) | \( f^i(x_6) \) | \( f^i(x_7) \) |
|--------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Investigator 1: \( R(f^m, f^n) \) | 0.63 | 0.75 | 0.64 | 0.82 | 0.88 | 0.77 | 0.93 |
| Investigator 2: \( R(f^m, f^n) \) | 0.67 | 0.82 | 0.67 | 0.66 | 0.59 | 0.90 | 0.75 |
| Investigator 3: \( R(f^m, f^n) \) | 0.88 | 0.97 | 0.67 | 0.84 | 0.65 | 0.80 | 0.69 |

\[ R(X(f^m), X(f^n)) \]  

| Investigator 1: \( R(X(f^m), X(f^n)) \) | 0.88 | 0.89 | 0.87 | 0.90 | 0.94 | 0.96 | 0.86 |
| Investigator 2: \( R(X(f^m), X(f^n)) \) | 0.86 | 0.95 | 0.84 | 0.86 | 0.91 | 0.90 | 0.93 |
| Investigator 3: \( R(X(f^m), X(f^n)) \) | 0.90 | 0.85 | 0.85 | 0.94 | 0.90 | 0.82 | 0.86 |

Intuitive reasoning of criminal attribute category after supplementing crime scene information:

| Investigator | \( T(f^i(X)) \) | \( T(f^i(X)) \) | \( T(f^i(X)) \) |
|--------------|----------------|----------------|----------------|
| Investigator 1 | 0.98 | 0.95 | 0.97 |
| Investigator 2 | 0.05 | 0.03 | 0.03 |
| Investigator 3 | 0.02 | 0.03 | 0.03 |

The intuitional reasoning of criminal investigation is: A
5. Conclusions
This paper provides a novel approach to the formalization of intuitive reasoning from the perspective of the connection between memory and perception. The basic feature of this method is to emphasize the mutual integration and learning of memory-perception. Research shows that exploring the essence of people's intuition and evaluating the credibility of intuition reasoning, designing and developing artificial intuition inference system is a meaningful topic to tap people's intelligence, use and develop intuition ability. The experimental results show that the results are satisfactory. At the same time, the intuitive measurement method of the artificial intuition inference system needs to be continuously improved in the specific intuitive practice.

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7. References
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