

Research on Empowering Urban Rail Transit Security with Intelligent Recognition of Individual Extreme Behavior

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Abstract:

Introduction: Individual extreme crime is one of the important risks of urban rail transit, and accurately identifying individual extreme behavior can effectively enhance the ability of police department to keep the safety of urban rail transit. At present, the early warning of individual extreme crimes generally adopts the integral method, which heavily relies on the experience of the police to assign values and cannot objectively and accurately describe the relevant factors that affect individual extreme behavior.

Objectives: This paper plans to propose a fuzzy reasoning warning method for identifying individual extreme behavior, providing a reference for public security organs to improve the security level of urban rail transit.

Methods: This studies a fuzzy processing method that conforms to the objective facts of individual extreme behavior, using a membership function to represent fuzziness and objectively describe the characteristics of individual extreme behavior and its influencing factors.

Results: This paper overcomes the limitation of relying heavily on individual police experience by extracting features from a large amount of case data to establish a membership function.

Conclusions: This paper's reasoning is based on accurate description of natural language, and the reasoning process overcomes subjectivity. The reasoning results contain more information, which can effectively improve the public security organs' ability to accurately identify individual extreme behavior and warning level.

Keywords: intelligence, security, individual extreme behavior, membership function, fuzzy reasoning, urban rail transit security protection.

INTRODUCTION

In the face of unprecedented changes, strategic opportunities and risks coexist, and uncertain and unpredictable factors increase. Malignant cases of indiscriminate harm to innocent people by criminal individuals in public places continue to break out both internationally and domestically, causing extremely negative social impact. This type of individual extreme crime is committed alone without the assistance of gang members, resorting to extreme violent behavior to retaliate against society. This type of individual extreme crime that transcends modern rational certainty has a random target and fuzzy influencing factors.

Urban rail transit has the characteristics of multiple stations, long routes, and wide prevention and control coverage [1-3]. It has dense pedestrian flow and enclosed space. As the backbone of urban public transportation, once individual extreme crimes occur, it will inevitably cause the greatest casualties and trigger public panic [4-5]. At present, the public security organs generally use the integral early warning of individual extreme crimes.[6-7] Due to individual differences among police officers, it is difficult to accurately judge the reliability and effectiveness of information sources, and relies heavily on personal experience to assign values that are not accurate or objective. It cannot objectively and accurately describe the relevant factors that affect individual extreme behavior, resulting in inaccurate prediction and evaluation results.

Phenomena and things with uncertainty are widely present in nature and human society. The membership function can not only objectively characterize the fuzziness in the field of natural sciences, but also describe the fuzziness of individual extreme behavior and its influencing factors. By extracting features from a large amount of case data and using the membership function to characterize this and that, it solves the problem of relying heavily on personal experience. By establishing a fuzzy reasoning system, a fuzzy reasoning warning method for identifying individual extreme behavior is proposed, which provides a reference for public security organs to improve the security level of urban rail transit [8-10].

AMBIGUIZATION OF INDIVIDUAL EXTREME BEHAVIOR AND ITS INFLUENCING FACTORS

In natural science research, fuzzy set theory is the main tool for dealing with fuzzy uncertainty, and membership functions are used to represent the properties of things[11-12]. As a subjective evaluation, human evaluation has many vague concepts, and ambiguity is a significant characteristic of human natural language. A fuzzy language FL is defined as a quadruple in equation(1).

$$FL = (U, T, E, N) \quad (1)$$

Among them: U is the entire object of the language theme, that is, the domain of discourse. T is a fuzzy set of linguistic components. E is a string set of language components, which is an embedding set for t , and T is a fuzzy subset on E . The fuzzy relationship N between e and u is called the naming relationship.

The words, phrases, or sentences used by police officers to describe extreme personal behavior and its influencing factors are essentially fuzzy variables. Language operators are modifiers added before language, also known as fuzzy operators, which can be divided into three types: tone operators, fuzzification operators, and decidification operators.

(1) Tone Operator H_λ ($\lambda \geq 0$)

The mood operator is used to express the degree of certainty in language. If there is a fuzzy set A and a mood operator H_λ on the domain U , and the new fuzzy set obtained by mapping is B , then $B = H_\lambda(A)$ and $\mu_B(U) = [\mu_A(U)]^\lambda$.

(2) Fuzzification Operator F_c

The fuzzification operator is used to turn clear semantics into fuzzy meanings, which can be achieved through similarity transformation, usually using a normal distribution function, that is $B = F_c(C)$, and:

$$\mu_B(x) = \begin{cases} e^{-(x-c)^2}, & |x-c| \leq \delta \\ 0, & |x-c| > \delta \end{cases} \quad (2)$$

(3) Discriminative Operator D_a

The discriminative operator is used to affirm fuzzy values, that is $B = D_a(A)$.

$$\mu_B(x) = \begin{cases} 0, & \mu_A(x) \leq a \\ 0.5, & a < \mu_A(x) \leq 1-a \\ 1, & \mu_A(x) > 1-a \end{cases} \quad (3)$$

MEMBERSHIP FUNCTION

In reality, language statements do not have clear boundaries. Unlike classical sets where feature functions only allow 0 or 1, membership functions in fuzzy sets can take any value on the closed interval $[0,1]$, which represents the degree to which an element belongs to the fuzzy set.

The fuzzy set X on the domain A is described by its membership function, which is the mapping $\mu_A: X \rightarrow [0,1]$. For $\mu_A(x)$, it is called that x belongs to the membership degree of the fuzzy set A .

$$A = \{(x, \mu_A(x)) \mid x \in X\} \quad (4)$$

The forms of membership functions mainly include piecewise linear functions and nonlinear functions. Nonlinear membership functions mainly include Gaussian, sigmoid, S-shaped, parabolic, etc. Gaussian and sigmoid

membership functions have good smoothness, no zeros in the graph, and clear physical meanings, making them the most commonly used membership functions for describing uncertainty.

GAUSSIAN MEMBERSHIP FUNCTION

The expression of the Gaussian membership function is shown in equation (5), and its main parameters are the center a of the function and the width of the function curve, as shown in Figure 1.

$$y = \exp \left[-\frac{(x-a)^2}{2\sigma^2} \right] \quad (5)$$

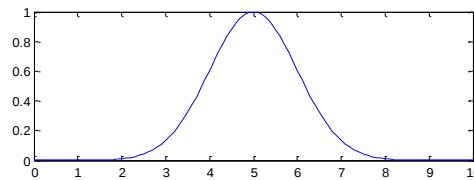
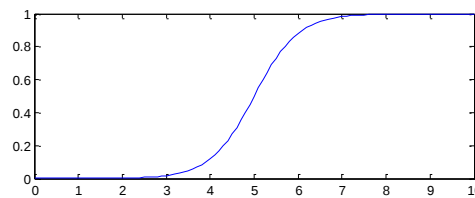


Figure 1. Gaussian Membership Function

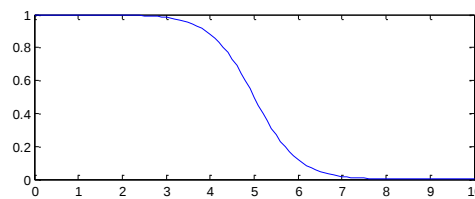
SIGMOID MEMBERSHIP FUNCTION

The expression of the sigmoid membership function is shown in equation (6), which is applicable to the membership function of language values modified with "very" and "very not". It is determined by two parameters, b and c . When b is positive, the sigmoid membership function curve opens to the right; When b is negative, the sigmoid membership function curve opens to the left, as shown in Figure 2.

$$y = \frac{1}{1 + \exp[-b(x-c)]} \quad (6)$$



(a) $b > 0$



(b) $b < 0$

Figure 2. Sigmoid Membership Function

FUZZY INFERENCE SYSTEM

Fuzzy reasoning system is an advanced intelligent system based on fuzzy mathematics, which uses rule language to describe knowledge and experience, and makes judgments through fuzzy reasoning. Fuzzy reasoning includes three major elements of artificial intelligence: inference, learning, and association. Fuzzy reasoning systems are essentially a function mapping from input space to output space. The fuzzy rule library is the core of the fuzzy reasoning system. The fuzzy reasoning machine activates a fuzzy subset in the fuzzy rules, and fuzzification converts the input values of the fuzzy reasoning system into fuzzy sets. The result of defuzzification is the output value of the fuzzy reasoning system.

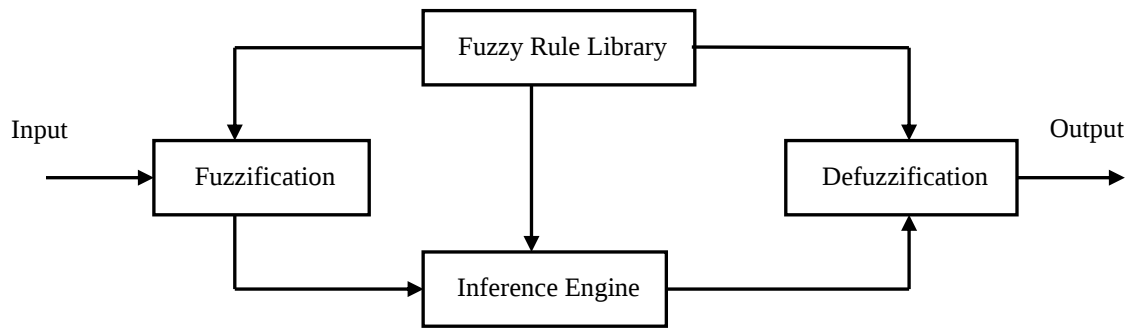


Figure 3. Structure of the Fuzzy Inference System

Reasoning is the way of human thinking, which infers unknown judgments from known conditions and uses fuzzy logic to deal with uncertainty caused by uncertain phenomena and the fuzziness of things. Fuzzy reasoning is a method of reasoning.

FUZZY REASONING RULES

Fuzzy logic can take any value on the closed interval $[0,1]$, and fuzzy set theory introduces generalized hypothetical reasoning (GMP rule): premise 1: if x is A , then y is B , premise 2: x is A' ; Conclusion: y is B' .

Generalized Hypothetical Reasoning (GMP rule) is widely used in fuzzy reasoning systems. Let U and V be the domain of the basic variables x and y , and R be the fuzzy relationship that describes the fuzzy implication "if A is B " on the domain $U \times V$. For a given $A' \in U$, the conclusion $B' \in V$ derived from A' is equation(5).

$$B' = A' \circ R \quad (5)$$

In equation (5), " $\circ$ " Represents fuzzy synthesis operation.

DEFUZZIFICATION

Resolving ambiguity is the process of converting fuzzy reasoning results into exact values. The centroid method is generally used to solve fuzzy problems, and the centroid of the area enclosed by the output membership function curve and the horizontal axis is taken as the accurate value of the output of the fuzzy reasoning system. That is equation(6).

$$u^* = \frac{\int u \mu_{B'}(u) du}{\int \mu_{B'}(u) du} \quad (6)$$

When the output membership function is discrete, equation (6) is like equation(7).

$$u^* = \frac{\sum u_i \mu_{B'}(u_i)}{\sum \mu_{B'}(u_i)} \quad (7)$$

OUTPUT OF FUZZY REASONING SYSTEM

Assuming that the fuzzy set in the fuzzy inference rules is a B' standard fuzzy set with a center of $\bar{y}'$, the form of a fuzzy inference system with a fuzzy rule library, a product inference machine, and a centroid average solution fuzzifier is equation(8).

$$f(x) = \frac{\sum_{i=1}^m \bar{y}' \left(\prod_{i=1}^n \mu_{A'}(x_i) \right)}{\sum_{i=1}^m \left(\prod_{i=1}^n \mu_{A'}(x_i) \right)} \quad (8)$$

The form of a fuzzy system with a fuzzy rule library, product inference engine, Gaussian fuzzer, and centroid averaging defuzzifier is equation(9).

$$f(x) = \frac{\sum_{i=1}^m \bar{y}' \left[\prod_{i=1}^n \exp \left(-\frac{(x_i - \bar{x}_i')^2}{a_i^2 + (\sigma_i')^2} \right) \right]}{\sum_{i=1}^m \left[\prod_{i=1}^n \exp \left(-\frac{(x_i - \bar{x}_i')^2}{a_i^2 + (\sigma_i')^2} \right) \right]} \quad (9)$$

Using the minimum inference engine, the fuzzy inference system is equation(10).

$$\begin{aligned} \mu_{B'}(y) &= \max_{i=1}^m \left\{ \prod_{i=1}^n \exp \left[-\frac{\left(\frac{a_i^2 \bar{x}' + (\sigma_i')^2 x_i}{a_i^2 + (\sigma_i')^2} \right)^2}{\sigma_i'^2} - \frac{\left(\frac{a_i^2 \bar{x}' + (\sigma_i')^2 x_i}{a_i^2 + (\sigma_i')^2} \right)^2}{a_i^2} \right] \mu_{B'}(y) \right\} \\ &= \max_{i=1}^m \left\{ \prod_{i=1}^n \exp \left[\frac{(x_i - \bar{x}_i')^2}{a_i^2 + (\sigma_i')^2} \right] \mu_{B'}(y) \right\} \end{aligned} \quad (10)$$

RESULTS

As a subjective description of extreme human behavior and its influencing factors, it has uncertainty. The Gaussian membership function and Sigmoid membership function curves are smooth and have clear physical meanings, making it an ideal model for characterizing the fuzziness of natural language. This article overcomes the limitation of heavily relying on individual police experience by extracting features from a large amount of case data to establish a membership function. According to fuzzy reasoning rules, the center of gravity of the output membership function curve and the area enclosed by the horizontal axis is taken as the accurate value of the output of the fuzzy reasoning system. The fuzzy reasoning system is established, and the reasoning is based on accurately describing natural language. The reasoning process overcomes subjectivity, and the reasoning results contain more information, which can effectively improve the ability of public security organs to accurately identify individual extreme behavior and early warning level.

STATEMENT

According to the confidentiality requirements of public security work, this article is published after declassification, and its content is limited to relevant theories and methods, and does not involve public security work secrets.

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