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Research on the Quality Evaluation Method of Mobile Emergency Big Data Based on the Measure of Medium Truth Degree

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Abstract: Mobile emergency services are better able to meet the needs of frequent public emergencies; however, their data quality problems seriously affect decision-making. In order to reduce the interference of low-quality data and solve the problem of data quality ambiguity, this paper first summarizes the five characteristics of mobile emergency big data. Second, based on the characteristics of mobile emergency big data, four data quality dimensions are defined with reference to existing research and national standards and combined with the measure of medium truth degree to give single-dimension and multi-dimension data quality truth degree measure models. Finally, a subjective-objective, qualitative-quantitative mobile emergency big data quality evaluation method based on the measure of medium truth degree is formed. The validity and practicality of the method are also verified by examples of algorithmic analysis of fire text datasets from Australian mountain fire data and the Chinese Emergency Incident Corpus. The experiments show that the method can realize quantitative mobile emergency big data quality assessment, solve the problem of data quality ambiguity, and reduce the interference of low-quality data, so as to save resources and improve the analysis and decision-making ability.

Keywords: mobile emergency; MMTD; big data quality evaluation; mobile emergency big data

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1. Introduction

In recent years, global public emergencies have occurred frequently, and traditional fixed emergency services have found it difficult to meet the complex and dynamic emergency needs. Mobile emergency services, on the other hand, can realize emergency command, on-site diagnosis and treatment, even disposal, material delivery, engineering construction, and other emergency services regardless of geographical location because of the advantages of variable location, mobility, flexibility, and forward decision-making, supporting rapid planning of emergency response beforehand, extremely fast execution of emergency services during the event, and rapid feedback of emergency results afterward. Given the immediacy, agility, and accuracy of mobile emergency services in emergency command and emergency protection, it inspires the attention and research of many scholars.

Among them, Li et al. [1] discussed mobile emergency material distribution and mobile emergency facility location settings. Kirci et al. [2] developed mobile applications to collect information before and after an earthquake. Cicek and Kantarci [3] provide a systematic review of mobile swarm intelligence techniques for disaster management. Since disasters are dynamically propagated, Medeiros et al. [4] established a group energy-sensing UAV system to manipulate the UAV to collect information about moving and changing objects and people. Lin et al. [5] used intelligent robots to detect and rescue people during earthquakes. Huang et al. [6] studied the emergency medical rescue vehicle-mounted mobile CT to solve the problem of remote mountainous and high-altitude areas with sudden natural disasters. After a disaster, the convenient, flexible, and responsive characteristics of UAVs are well suited for post-disaster package delivery, communication support, and other tasks that allow for rapid recovery of disaster areas [7]. Mobile devices running intensive applications throughout mobile emergency services can be resource constrained, and mobile edge computing can overcome this problem [8]. For example, mobile devices generate a large amount of data in applications with huge energy losses. To solve the energy consumption problem, Li et al. [9] proposed an energy-aware task offloading algorithm with deadline constraints in mobile edge computing to reduce the energy consumption of mobile devices. However, offloading workflow tasks to mobile edge computing servers is vulnerable to external security threats. Huang et al. [10] proposed a secure and energy-efficient offloading strategy for computation (SEECO) to address the security issue. It is clear from this that there has been a small amount of research on mobile emergency response, but research on mobile emergency data quality has not been addressed. Mobile emergency big data also has the "3V" characteristics of big data, and quality assessment can not only filter errors and poor quality data but also find the source of data problems based on low-quality data, which can help to improve the speed of analysis of subsequent data and the accuracy of decision-making judgment.

Since there is still a gap in the quality evaluation of mobile emergency big data, studies on emergency data evaluation are being sorted out. Among them, Daneshkohan et al. [11] used a questionnaire and SPSS software to analyze data quality in primary health care; Peterson et al. [12] used an expert review method to evaluate the quality of emergency data on websites; Mehrdad et al. [13] used a questionnaire and SPSS software to evaluate the accuracy, completeness, timeliness, clarity, and accessibility; all these methods are subjective evaluations; there is a subjective color, not an objective color, and the results are not reliable enough. So, how to evaluate objectively and quantitatively is the problem to be solved. Drawing on research in data quality, multiple data dimensions are used to quantitatively evaluate data quality by combining subjective and objective assignments. Among them, Zhao Xing et al. [14] proposed a full data quality assessment method based on quality standard metrics based on the combined subjective and objective weights; Mashoufi et al. [15] used an objective method to assess the data quality of emergency medical services; Wang Mingzheng et al. [16] used an AHP-based integrated determination method of multiple indicator weights to qualitatively and quantitatively analyze and quantify data quality; and Han Kyungwoo et al. [17] proposed a fact-based quality assessment method to assess the quality of Web document content data. The above methods determine different quality dimensions and indicators for different data, but they do not take into account the fuzzy nature of data quality and cannot evaluate the data meticulously and scientifically. And, to deal with the fuzzy phenomenon prevailing in engineering practice and scientific research, Hong Long et al. [18] established a method to measure the degree of logical truth value, namely MMTD (measure of medium truth degree), in the context of a mediated mathematical system, which can solve the fuzzy problem of data quality and was extended to the exploration of big data quality by Zhong Suyang [19]. An objective and quantitative data quality evaluation method has been formed and has been applied in several fields. Among them, typical ones include Cheng Weiqing et al. [20], who formed a non-intrusive single-ended objective evaluation method for predicting VoIP perceived service quality based on truth degree and stream characteristics to evaluate network call quality; Pan Xi et al. [21], who combined fuzzy mathematical evaluation methods to assess software quality; and Tang Ying et al. [22], who combined entropy theory to establish a comprehensive evaluation method for mediated truth degree to assess the quality of residential projects. Such data quality evaluation methods based on MMTD have been recognized in various fields and also provide a referenceable experience for conducting mobile emergency big data quality analysis.

In this paper, a quality evaluation method for mobile emergency big data based on the combination of subjective and objective, qualitative, and quantitative analysis of MMTD is proposed. First, the characteristics of mobile emergency big data are summarized and analyzed according to the existing research status in mobile emergency. Then, the data quality dimensions are determined by combining the Information Technology Data Quality Evaluation Index (GB/T 36344-2018) and the characteristics of mobile emergency big data, and then each dimension of the data quality is analyzed qualitatively by using mediating logic and fuzzy hierarchical analysis, and the function value formula of each dimension is designed, which will make a good preparation. Then, mediator logic and fuzzy hierarchical analysis are utilized to qualitatively analyze the dimensions of data quality, and the function formula of each dimension is designed to pave the way for quantitative evaluation of mobile emergency big data. Finally, the mediator truth degree measure is used to establish single-dimension and multi-dimension evaluation models for mobile emergency big data, and an example analysis is carried out to verify the effectiveness of this method in solving the ambiguity of data quality. By evaluating data quality, emergency responders can directly discard low-quality data in rescue work, thus reducing interference and speeding up analysis and decision-making. In addition, the low-quality data can be analyzed after the disaster to find the reasons for its low quality, so as to provide a good basic guarantee for the next disaster relief.

2. Feature Analysis of Mobile Emergency Big Data

In the process of mobile emergency services, big data resources not only come from spatiotemporal data, disaster data, natural geographic data, and socio-economic data formed by emergencies but also include a large amount of data information generated by mobile emergency facilities that provide emergency command, on-site diagnosis and treatment, even disposal, material delivery, engineering construction, and other services. This kind of data has the basic characteristics of big data, such as large scale, many kinds, fast update speed, and low-value density. And, due to the suddenness, complexity, randomness, and uncertainty of emergency events, it also has the unique characteristics of strong data proliferation, large data variability, and weak data integrity.

2.1. Strong Data Surge

The proliferation of mobile emergency big data comes from the suddenness of emergencies on the one hand, and emergencies have a certain degree of concealment and chance, and the process of generation is all relatively sudden. As shown in Figure 1, it is difficult to predict the time, situation, and scale of its occurrence. And, at the moment of the event, it often causes the sudden activation of mobile emergency facilities, while the preparation stage of mobile emergency needs the support of data resources related to the emergency, and the first operation of many kinds of mobile emergency services will also form a large amount of data information far beyond the usual. On the other hand, mobile emergency facilities will be fully mobilized to save lives and properties after the formation of an emergency disposal plan and response strategy. This will suddenly add a large amount of process information and process data, especially in the mid-event segment where mobile emergencies generate sudden and unpredictable phase tasks that will also lead to a surge in data volume.

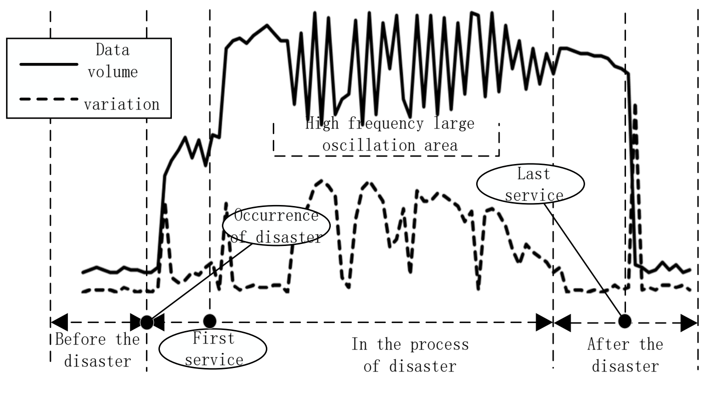

Figure 1. Feature analysis of mobile emergency big data.

2.2. High Data Variability

Mobile emergency big data, which is mainly based on mobile emergency facility information and its related scheduling, decision-making, process, and status, is in a "quiet state" when there is no emergency response service, and the data volume tends to be calm and fluctuates little. However, there is a surge in the occurrence of emergency events and the first service, especially in the mid-event stage when the frequency of updating, integration, and correction of data resources is greatly accelerated due to frequent mobile emergency decision-making and dispatching, thus showing a significant shock and rapid changes in data volume. And, it may be subject to greater changes brought by the entry of external mobile emergency facilities until the incident is effectively handled and enters the post-incident phase before the data volume stabilizes and rapidly decreases to daily scale data volume after the last service. Usually, the reduction of mobile emergency big data at the moment of the last service is the sum of the increase at the moment of the emergency and the moment of the first service, while only a specific area shows high frequency and large shocks in the mid-event phase.

2.3. Data Integrity Is Weak

Mobile emergency big data weakens the integrity of data due to the suddenness and high unpredictability of emergencies. This is mainly reflected in the sudden moment of disaster, when part of the video, audio, and image information, etc., cannot be collected in time, and because there are inevitably areas that cannot be covered by information collection equipment and practical scenarios that are difficult to implement by high-tech means, thus causing the shortage of mobile emergency big data in terms of basic data reserves. In addition to this, mobile emergency service systems usually have limited storage capacity to improve portability and mobility, and rolling storage restricts the integrity of data. In particular, emergency services are often under the jurisdiction of different administrative departments, and original data are lost to varying degrees after multiple parties and multi-level data fusion or integration. More importantly, the unsound information exchange mechanism at the beginning of the construction of mobile emergency systems also leads to a lack of integrity to some extent.

2.4. Large Amount of Data Processed

An important component of mobile emergency big data is the processing data generated by mobile emergency equipment such as drones, emergency rescue vehicles, and emergency robots that are frequently deployed after an emergency event. Compared with traditional fixed equipment, mobile emergency equipment has the advantages of mobile flexibility, rapid support, and easy operation. It also fully supports the rapid collection of data on disaster status, emergency processes, etc., so that the implementation of emergency response strategies can be traced at any time. Such big data include process link data, execution process data, disaster status data, rescue status data, etc. It is usually characterized as a diverse time series with spatial attributes, and time is used as a link to reflect the different stages of mobile emergency services to assist in immediate and accurate emergency decision-making.

2.5. High Data Correlation

Traditional fixed emergency equipment can only collect data within its limited scope, or even only observe the side or part of things at the time of the disaster, not being able to obtain information from multiple perspectives, and the resulting data is somewhat one-sided. In contrast, in mobile emergency scenarios, all kinds of data resources not only exist in the time dimension of development clues but also retain location relationships in space. And it also stores information chains from various mobile emergency devices, which are cross-fused with each other at the point of time and on the spatial plane and are closely connected with the development of events and the progress of rescue. The degree of its data relevance is much higher than that of finance, transportation, and agriculture, especially given the large amount of process data that constantly records the development direction and change trend of disaster situations that rely on each other, support each other, and are closely related.

3. Theory of Measure of Medium Truth Degree

In 2006, based on the treatment method proposed by Zadeh [23] to solve the problem of fuzzy phenomena and the principle of mediation proposed by Zhu [24], Hong [18] proposed the method of measuring medium truth degree and the method of establishing the relationship between the numerical value and the predicate truth degree value after numericalization. Since there will be transition intervals in the process of data evaluation in which there is a fuzzy phenomenon, the evaluation of the data will not be detailed and accurate enough. This method can deal with the fuzzy problem in the process of data evaluation and process the data qualitatively and quantitatively to evaluate the data more accurately.

For the measure of the truth value and degree value of good or bad of a single indicator, if the set $X = \{x_1, x_2, x_3, \cdots, x_l\}$ is the set of this indicator, the subsets $T \subset P^n$ and $F \subset P^n$ satisfy: $f(x) \in T \Leftrightarrow R(x)$ and $f(x) \in F \Leftrightarrow \neg R(x)$, f is some function of this indicator and the degree of good or bad, and the predicate R, and the good or bad of R can measure the degree of good or bad of this indicator. If the predicate $\neg {}^{+}R$ means particularly bad, $\neg R$ means bad, R means good, ${}^{+}R$ means particularly good, and $\sim R$ means transition between bad and good degrees, then in the "true value region" T and "false value region" F, there are standard degrees α_T and α_F corresponding to R and $\neg R$. According to the truth-value correspondence between the values and predicates in Figure 2, by calculating the distance ratio function $h_T : f(x) \to P$ between this indicator x and the predicate R, the degree of truth value relative to the good degree of the indicator can be obtained.

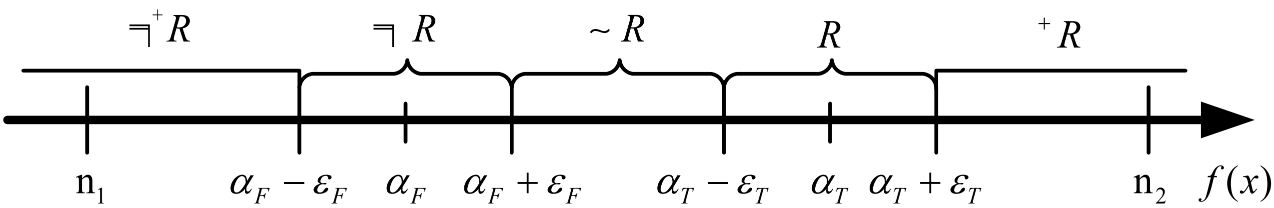

Figure 2. Correspondence between values and predicates.

$$h_T(y) = \begin{cases} -d(y, \alpha_F - \varepsilon_F)/d(\alpha_T - \varepsilon_T, \alpha_F - \varepsilon_F), y < \alpha_F - \varepsilon_F \\ 0, \qquad \alpha_F - \varepsilon_F \le y \le \alpha_F + \varepsilon_F \\ d(y, \alpha_F + \varepsilon_F)/d(\alpha_T - \varepsilon_T, \alpha_F + \varepsilon_F), \alpha_F + \varepsilon_F < y < \alpha_T - \varepsilon_T \\ 1, \qquad \alpha_T - \varepsilon_T \le y \le \alpha_T + \varepsilon_T \\ d(y, \alpha_F + \varepsilon_F)/d(\alpha_T + \varepsilon_T, \alpha_F + \varepsilon_F), y > \alpha_T + \varepsilon_T \end{cases}$$

The quality evaluation process of mobile emergency big data studied in this paper is shown in the following Figure 3:

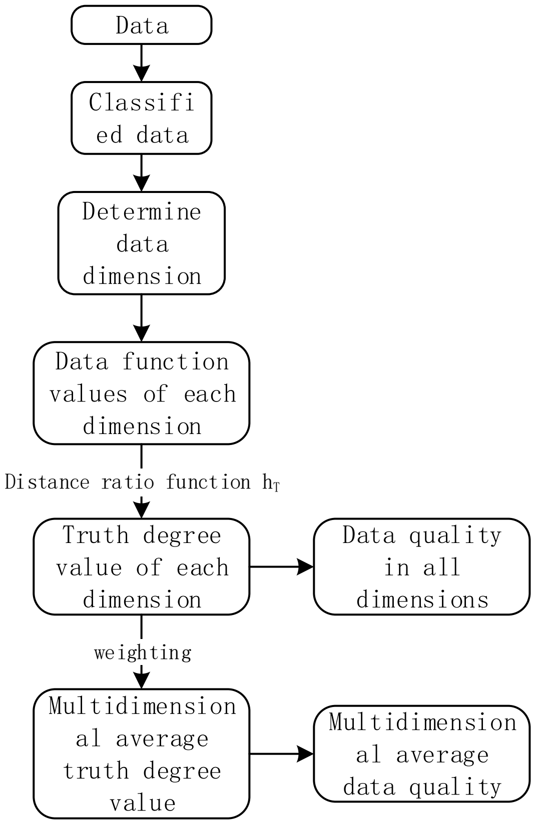

Figure 3. Mobile emergency big data quality evaluation flow chart.

4. Mobile Emergency Big Data Evaluation Model

According to the "Information Technology Data Quality Evaluation Index (GB/T 36344-2018)", data quality usually includes normality, completeness, accuracy, consistency, accessibility, and timeliness. For mobile emergency big data, with its strong proliferation, high variability, weak integrity, high process volume, and high correlation, the consistency of data is often incorporated into normality to be solved by designing a standardized data expression scheme, while accessibility is because mobile emergency big data will reach interoperability after the establishment of an information exchange mechanism is completed to support mutual access operations between each other. Therefore, with the support of the mediated truth degree measure MMTD, this paper is based on the description and design of the dimensions of data accuracy and precision according to Zhao et al. [14]. Considering the multi-source heterogeneity of the data and the main dimensions involved, the following four dimensions are set as the quality judgment criteria, and the four dimensions are defined and designed in more detail in terms of structured, semi-structured, and unstructured, respectively.

4.1. Mobile Big Data Quality Dimension Setting

According to the "Information Technology Data Quality Evaluation Index (GB/T 36344-2018)", data quality usually includes normality, completeness, accuracy, consistency, accessibility, and timeliness. For mobile emergency big data, with its strong proliferation, high variability, weak integrity, high process volume, and high correlation, the consistency of data is often incorporated into normality to be solved by designing a standardized data expression scheme, while accessibility is due to the fact that mobile emergency big data will reach interoperability after the establishment of an information exchange mechanism is completed to support mutual access operations between each other. Therefore, the following four dimensions are set as quality criteria with the support of the mediated truth degree measure, MMTD.

(1) Normative dimension. If structured data resources are considered data entities with multiple attributes, the merit of each data entity can be measured by the distance ratio of its attribute value criterion according to MMTD. Therefore, let the data have n attributes. For the jth attribute R_{ij} of the ith data, its attribute value can be written as $T[R_{ij}]$. Using $G(R_{ij})$ to denote the normality function of the R_{ij} attribute, which is expressed as the degree of the R_{ij} attribute satisfying the jth norm, the $G(R_{ij})$ default value is 0. When $T[R_{ij}]$ is structured data (i.e., $\Im(T[R_{ij}])$ holds), $T[R_{ij}]$ is detected as conforming to template P_j by the $match(\cdot) \cdot$ operator, then $G(R_{ij}) = 1$. When $T[R_{ij}]$ is unstructured or semi-structured data, it is 1 if the specification is satisfied after preprocessing. In this regard, given the jth attribute with weight r_j^T, there is a data normality function $B_1(R_i)$:

$$B_1(R_i) = iff(\Im(T[R_{ij}]), \sum_{j=1}^{n} r_j^T G(R_{ij}) = match(T[R_{ij}], P_j), iff(G(R_{ij}) = null, 1, 0)) \quad (1)$$

(2) Integrity dimension. The degree of completeness of the attribute value $T[R_{ij}]$ for the jth attribute R_{ij} is reflected in two ways: When $\Im(T[R_{ij}])$ holds, completeness is expressed as the inverse of the missing rate of the structured data, and the missing rate is the number of attribute entries with missing values as a percentage of the total data volume; and when $T[R_{ij}]$ is unstructured or semi-structured data, the data is preprocessed so that completeness is expressed as the inverse of the mean of the ratio of the missing feature data in bytes to the total number of features of the unstructured or semi-structured data. Where the feature data are inscribed by the feature target ρ_o, feature prerequisites ρ_p, feature sentences/patterns ρ_s, feature constraints ρ_c, and feature content ρ_t that embody key summary information. Given that $\alpha \mapsto (\rho_1, \rho_2, \ldots, \rho_\tau)$ denotes the count of the front α not satisfying the back τ characteristics ρ_τ, then there is a data completeness function $B_2(R_i)$ is as follows:

$$B_2(R_i) = iff(\Im(T[R_{ij}]), 1 - \sum_{j=1}^{n} (T[R_{ij}] = null)/n, 1 - \sum_{j=1}^{n} (T[R_{ij}] \mapsto (\rho_o, \rho_p, \rho_s, \rho_c, \rho_t)/|\rho_\tau|)/n) \quad (2)$$

(3) Accuracy dimension. The degree of accuracy of the attribute value $T[R_{ij}]$ for the jth attribute R_{ij} is reflected as two aspects, when $\Im(T[R_{ij}])$ holds, let $T^*[R_{ij}]$ denote the true value, and the accuracy is expressed as the inverse of the maximum relative error $|T[R_{ij}] - T^*[R_{ij}]|/T^*[R_{ij}]$ of multiple attribute values, and this error satisfies the error transfer under mathematical operations; when $T[R_{ij}]$ is unstructured or semi-structured data, the data are preprocessed, and the accuracy is expressed as the product of the size of the data resource framework construct satisfying $rdf(T[R_{ij}])$ and the similarity of the data content $Z(R_{ij})$. Where $rdf(T[R_{ij}])$ is calculated as the compatibility of unstructured data with the schema of a particular RDF framework, the content similarity is then used in a bytewise manner to calculate the cosine similarity of the angle between the summary $\Omega(T[R_{ij}])$ and the summary truth value. Thus, there is a data accuracy function $B_3(R_i)$:

$$\begin{gathered} B_3(R_i) = iff(\Im(T[R_{ij}]), 1 - \max(|T[R_{ij}] - T^*[R_{ij}]|/T^*[R_{ij}]), Z(R_{ij})) \\ Z(R_{ij}) = rdf(T[R_{ij}])[\Omega(T[R_{ij}]) \cdot \Omega^*(T[R_{ij}])]/(||\Omega(T[R_{ij}])|| \cdot ||\Omega^*(T[R_{ij}]||)) \end{gathered} \quad (3)$$

(4) Timeliness dimension. The timeliness for the ith data [25] is the difference between the ratio of the data transmission time to the effective time and one. Where D_{ST} is the data sending time, D_{RT} is the data receive time, D_{ET} is the data cutoff time, $D_{RT} - D_{ST}$ is the data transmission time duration, and $D_{ET} - D_{RT}$ is the data validity time duration. The data transfer time duration can be expressed as the file size FS and network speed NS which is the ratio of $D_{RT} - D_{ST} = FS/NS$. The data validity time can be determined according to the time constraint specified in the relevant regulations, while the value of the data timeliness function is the value between zero and the timeliness value, or the

maximum value between zero and the timeliness value. Then, there is the data timeliness function $B_4(R_i)$, as follows:

$$B_4(R_i) = max\{0, 1 - (D_{RT} - D_{ST})/(D_{ET} - D_{RT})\} \quad (4)$$

4.2. Single-Dimensional Truth Degree Measurement Model

The evaluation result of a single dimension of mobile emergency big data is a continuous value, and there is a transition interval that cannot be simply expressed in a way that is easy to understand. Therefore, after setting the quality dimension, it is necessary to calculate the degree of truth value of the data according to the correspondence between value and predicate and combine the dimension function and distance ratio function so as to determine the degree of data quality. Form a single-dimensional truth degree measurement model.

4.2.1. Mobile Emergency Big Data Quality True Value Degree

For any of the dimensions of normality, completeness, accuracy, and timeliness, with the help of MMTD formal logic, let the set $X = \{x_1, x_2, x_3, \cdots, x_l\}$ be the set of mobile emergency big data, and f be some function of data and quality degree. Its quality predicate is W, and the high or low degree of W can measure the quality of mobile emergency big data. If the quality predicate $\neg\,^{+}W$ for particularly low degree, $\neg\, W$ for low degree, W for high degree, ^{+}W for a particularly high degree, and $\sim W$ for the transition between a high and low degree is noted. Then, there are standard degrees α_T and α_F, corresponding to W and $\neg\, W$ in the "true value region" T, and the "false value region" F. Figure 4 shows the correspondence between the values, and Table 1 shows the correspondence between predicates and quality levels.

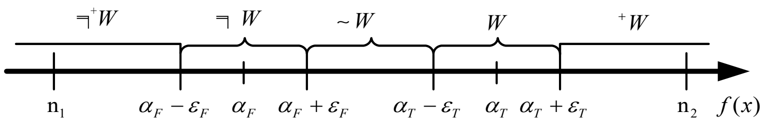

Figure 4. Correspondence between values and qualitative predicates.

Table 1. Correspondence between predicates and quality levels.

Predicate	Quality Levels	Predicate	Quality Levels
particularly high	Level 1	relatively low	Level 4
high	Level 2	low	Level 5
lower than higher	Level 3	particularly low	Level 6

4.2.2. Big Data Quality Measurement Model

The distance ratio function $h_{\mathrm{T}} : f(X) \to R$ relative to W, when $B_k(R_i) = f(x) \in f(X)$ is taken is as follows:

$$h_{\mathrm{T}}(B_k(R_i)) = \begin{cases} -d(B_k(R_i), \alpha_F - \varepsilon_F)/d(\alpha_T - \varepsilon_T, \alpha_F - \varepsilon_F), B_k(R_i) < \alpha_F - \varepsilon_F \\ 0, \qquad \alpha_F - \varepsilon_F \le B_k(R_i) \le \alpha_F + \varepsilon_F \\ d(B_k(R_i), \alpha_F + \varepsilon_F)/d(\alpha_T - \varepsilon_T, \alpha_F + \varepsilon_F), \alpha_F + \varepsilon_F < B_k(R_i) < \alpha_T - \varepsilon_T \\ 1, \qquad \alpha_T - \varepsilon_T \le B_k(R_i) \le \alpha_T + \varepsilon_T \\ d(B_k(R_i), \alpha_F + \varepsilon_F)/d(\alpha_T + \varepsilon_T, \alpha_F + \varepsilon_F), B_k(R_i) > \alpha_T + \varepsilon_T \end{cases} \quad (5)$$

$h_{\mathrm{T}}(B_k(R_i))$ is the distance ratio function [17], and the truth degree value can be obtained from Equation (5), where $d(a,b) = \left[\sum_{k=1}^{n}(a_k - b_k)^2\right]^{1/2}$ is the Euclidean distance ($d(a,b) = |a - b|$ in a one-dimensional case). Taking normalization as an example, according to the truth degree value and Figure 2, it can be seen that when $B_1(R_i) < \alpha_F - \varepsilon_F$

and $f(x)$ are in the $╕^{+}W$ region, the truth degree value is very small, and the farther away from the $╕W$ region, the lower the normalization degree of data. When $\alpha_F - \varepsilon_F \leq B_1(R_i) \leq \alpha_F + \varepsilon_F$ is in the ww region, $f(x)$ is in the $╕W$ region, and the truth degree value of the data is small, indicating that the normalization degree of the data is low. When $\alpha_F + \varepsilon_F < B_1(R_i) < \alpha_T - \varepsilon_T$ is in the ww region, $f(x)$ is in the $\sim W$ region, and the farther it is from the $╕W$ region, the greater the truth degree value, indicating the higher the normalization degree of data. $0 < h_{\mathrm{T}}(B_k(R_i)) \leq 0.5$ indicates that the normative degree of data is relatively low; $0.5 < h_{\mathrm{T}}(B_k(R_i)) < 1$ indicates that the normative degree of data is lower than higher. When $\alpha_T - \varepsilon_T \leq B_1(R_i) \leq \alpha_T + \varepsilon_T$ is in the ww region, $f(x)$ is in the W region, the degree of truth value of data is large, and the degree of normalization of the data is high. When $B_1(R_i) > \alpha_T + \varepsilon_T$ is in the ^{+}W region, $f(x)$ has a very large degree of truth value and a particularly high degree of normalization of the data. Moreover, the farther away from the $╕W$ region, the larger the degree of truth value and the higher the degree of normalization of the data.

In addition, for the integrity, accuracy, and timeliness of mobile emergency big data, $B_1(R_i)$ in the above model for normality can be replaced by $B_2(R_i)$, $B_3(R_i)$, and $B_4(R_i)$, respectively, which means that the corresponding integrity measurement model, accuracy measurement model, and timeliness measurement model can be obtained.

4.3. Multidimensional Truth Degree Measurement Model

For a comprehensive and complete evaluation of the data, simple integration of four dimensions such as normalization, completeness, accuracy, and timeliness can be carried out; that is, weights are assigned to the truth degree values of each single-dimensional measurement model. Then, the comprehensive results of multidimensional truth degree measurement are obtained by weighting, and then the truth degree measurement of batch data is obtained by averaging. Set a batch of mobile emergency data with a total of l data items, and weight the i-th data in four dimensions. If the weight of each dimension is C_1, C_2, C_3, C_4 and the sum of all dimensions is one, the measurement of the quality multidimensional truth degree of the i-th mobile emergency big data can be obtained, as shown in Equation (6). If the l multidimensional measurement models are averaged, $U_M = \sum_{i \in l} U_i / l$ then the multi-dimensional truth degree value of the quality of the whole batch of mobile emergency big data can be obtained.

$$U_i = C_1 \times h_T(B_1(R_i)) + C_2 \times h_T(B_2(R_i)) + C_3 \times h_T(B_3(R_i)) + C_4 \times h_T(B_4(R_i)) \quad (6)$$

5. Case Analysis

To test the effectiveness of the mobile emergency big data model, the Australian mountain fire data from the NASA website "https://www.kaggle.com/datasets/carlosparadis/fires-from-space-australia-and-new-zeland (accessed on 26 April 2023)" and the Chinese fire text dataset from the Critical Incident Corpus "https://github.com/shijiebei2009/CEC-Corpus (accessed on 26 April 2023)" were used as research objects. Among them, the Australian mountain fire dataset records mountain fire information up to 183,593 data points, and 135 structured data points from January 2020 are selected as the research object for quick calculation; the fire text dataset contains 75 unstructured data points. The quality function values of the selected data were obtained according to the evaluation methods of each dimension, and then the function values were put into the distance ratio function to obtain the single-dimension truth degree value. $\alpha_F - \varepsilon_F = 0.2$, $\alpha_F = 0.4$, $\alpha_F + \varepsilon_F = 0.6$, $\alpha_T - \varepsilon_T = 0.85$, $\alpha_T = 0.9$, and $\alpha_T + \varepsilon_T = 0.95$ were set. The multi-dimensional truth degree value of each piece of data was obtained by weighting the truth degree value of the single dimension, and then the average value was calculated to evaluate the whole data quality.

5.1. Normative Evaluation

The data template P_j was established, as shown in Table 2. The data were compared with the template, respectively, to obtain the data normative function values. The distance ratio function was used to obtain the truth value of the data normative value, and the normative evaluation of the data quality was carried out.

Table 2. Data template P_j.

P_j	Attribute Name	Description
P_1	latitude	Decimal latitude, accurate to four decimal places
P_2	longitude	Decimal latitude, accurate to four decimal places
P_3	brightness	Luminance temperature 21 (Kelvin): The luminance temperature of the channel 21/22 flame pixel, in Kelvin
P_4	scan	Scan along pixel size: This algorithm produces approximately 375 m pixels at the lowest point. Scanning and tracking reflect the actual pixel size
P_5	track	Pixel size along the track: This algorithm produces approximately 375 m pixels at the lowest point. Scanning and tracking reflect the actual pixel size
P_6	acq_date	Obtain the date, for example, 2021-1-1
P_7	acq_time	Capture time (UTC time)
P_8	instrument	VIIRS or MODIS: visible Infrared Imaging Radiometer or Moderate Resolution Imaging Spectrometer
P_9	confidence	Confidence estimates range from 0 to 100% and are designated as one of three fire types (low confidence fire, nominal confidence fire, or high confidence fire).
P_{10}	version	The device version represents the data acquisition source
P_{11}	frp	Fire Radiative Power, which expresses the intensity of fire, accurate to one decimal place
P_{12}	type	Data type: 0, 1, 2, 3, 4

It can be seen from Table 1 that the first normative function of a data attribute is as follows: $G(R_{11}) = 1$, $G(R_{12}) = 1$, $G(R_{13}) = 1$, $G(R_{14}) = 0$, $G(R_{15}) = 1$, $G(R_{16}) = 1$, $G(R_{17}) = 1$, $G(R_{18}) = 1$, $G(R_{19}) = 1$, $G(R_{110}) = 1$, $G(R_{1\ 11}) = 1$, and $G(R_{1\ 12})= 1$. Using fuzzy hierarchical analysis to find the weights of the attributes, the weights of each attribute can be obtained as follows: $r_1^T = 0.093$, $r_2^T = 0.093$, $r_3^T = 0.074$, $r_4^T = 0.074$, $r_5^T = 0.074$, $r_6^T = 0.093$, $r_7^T = 0.093$, $r_8^T = 0.074$, $r_9^T = 0.083$, $r_{10}^T = 0.074$, $r_{11}^T = 0.092$, and $r_{12}^T = 0.083$. The normality function of the data is calculated as $B_1(R_1) = \sum_{j=1}^{n} r_j^T G(R_{1j}) = 0.926$, which is substituted into Equation (5), to obtain the normative truth degree value $h_T(B_1(R_1))= 1$ of the data. It means that the degree of normality of the data is high, and the quality is evaluated as “Level 2”.

In addition, for unstructured and semi-structured data, the data is first pre-processed and converted into XML format, and the syntax validator can be used to verify the data normalization according to the XML syntax specification by verifying that the first unstructured data has no syntax error. Then the normality function value $B_1(R_1) = 1$, substituted into Equation (5) to obtain the normative truth degree value $h_T(B_1(R_1)) = 1.14$. It means that the data normality degree is particularly high, and the quality evaluation is “Level 1”.

5.2. Integrity Evaluation

Similar to the norm, according to Table 1, the data obtained were respectively compared with the data template P_j to obtain the data integrity function value, the distance ratio function was used to obtain the true value of the data integrity value, and the data quality integrity evaluation was carried out. According to the data template, the first data integrity attribute value is as follows: $T[R_{11}] = 1$, $T[R_{12}] = 1$, $T[R_{13}] = 1$, $T[R_{14}] = 0$, $T[R_{15}] = 1$, $T[R_{16}] = 1$, $T[R_{17}] = 1$, $T[R_{18}] = 1$, $T[R_{19}] = 1$, $T[R_{1\ 10}] = 1$, $T[R_{1\ 11}] = 1$, and $T[R_{1\ 12}] = 1$. Since the total missing number is 1 and the total number of attributes is 12, according to the integrity definition, the integrity function value of this data is $B_2(R_1) = 1 - \sum_{j=1}^{n} (T[R_{ij}] = null)/n = 1 - (1/12) = 0.9167$, which is substituted into Equation (5) to obtain the truth value of data integrity degree, $h_T(B_2(R_1))= 1$. It means that the data integrity degree is high, and the quality evaluation is “Level 2”.

In addition, for the unstructured data, pre-processing is performed first to extract the characteristic data in the data, and then comparative analysis is performed. The characteristic goal of the first data is to propagate and record the forest fire in health. The characteristic premise is to conform to a characteristic sentence pattern and characteristic constraint. The characteristic sentence pattern includes five parts: title, lead, subject, background, and conclusion. The feature constraint is to record the time, place, person, cause, process, and result of the event. The characteristic content is villagers burning paper and high-voltage wire collisions resulting in fire. By comparison, it is found that the characteristic data is not missing, and the data integrity function $B_2(R_1) = 1$ is obtained, which is substituted into Equation (5) to obtain the truth value of the data integrity degree $h_{\mathrm{T}}(B_1(R_1)) = 1.14$. It means that the data integrity degree is particularly high; the quality evaluation is "Level 1".

5.3. Accuracy Evaluation

Similar to the norm, the accuracy of the data is judged. For example, if the first data is selected and all attribute values are as follows: $T[R_{11}] = 1$, $T[R_{12}] = 1$, $T[R_{13}] = 1$, $T[R_{14}]= 0.6$, $T[R_{15}] = 1$, $T[R_{16}] = 1$, $T[R_{17}] = 1$, $T[R_{18}] = 1$, $T[R_{19}] = 1$, $T[R_{1\ 10}] = 1$, $T[R_{1\ 11}] = 1$, and $T[R_{1\ 12}] = 1$. Then the accuracy function value $B_3(R_1) = 0.6$ is obtained, which is substituted into Equation (5) to obtain the truth degree of the accuracy of the data, $h_{\mathrm{T}}(B_3(R_1))= 0$. It means that the degree of accuracy of the data is particularly high, and the quality evaluation is "Level 1".

In addition, for unstructured or semi-structured data, the national standard "Chinese News Information Content Part 2: News Metadata" is used to establish a specific RDF framework, as shown in Table 3. The data preprocessing to obtain the corresponding feature data, and compare it with the resulting data, can be obtained, $rdf(T[R_{ij}]) = 0.8$. The content of the abstract is the time, place, person, cause, process, and result of the event. By calculating the cosine similarity between $\Omega(T[R_{ij}])= (1,1,1,1,1,1)$ of the abstract and the truth value of the abstract, the accuracy function value $B_3(R_1) = Z(R_{ij})= 0.8\cdot[(1,1,1,1,1,1)\cdot(1,1,1,1,1,1)/ ||(1,1,1,1,1,1)||\cdot||(1,1,1,1,1,1)||] = 0.8$ is obtained, which is substituted into Equation (5) to obtain the truth degree of data accuracy value $h_{\mathrm{T}}(B_3(R_1))= 0.8$. It means that the degree of accuracy of the data is lower than higher, and the quality evaluation is "Level 3".

Table 3. RDF framework.

Description Item	Subproject	Definition
Title		Clear and striking words that reveal the content
Founder		An individual or group that creates a manuscript
Time range information	Start time	Event time
	End time	Event end time
	Reporting time	Event reporting time
Abstract		An extract or brief description of the main content
Source		Manuscript source information
Location		Location of the incident
Main character		participant
Main mechanism		Participating institution

5.4. Timeliness Evaluation

If the file size of the first batch of structured data is about 17 kb and the average transmission speed of the 4G network adopted by mobile emergency equipment is 10–100 Mbps. The data transmission duration is the ratio of file size FS and network speed NS, that is, $D_{RT} - D_{ST} = FS/NS$ is 0.00017∼0.0017 s. If the longest time is taken, the total duration of this data is determined to be 3 h according to the fire duration. When the data validity time is $D_{ET} - D_{RT} = 3\ \mathrm{h} - 0.0017\ \mathrm{s}$, the timeliness function value $B_4(R)$ = 1 of the first batch of data can be obtained, which is substituted into Equation (5) to obtain the timeliness truth degree value $h_{\mathrm{T}}(B_4(R))= 1.14$. It means that the degree of timeliness of the data is particularly high, and the quality evaluation is "Level 1".

In the same way, if the total size of unstructured data is 8 kb, then the data transmission time duration is $D_{RT} - D_{ST}$ = 0.000078∼0.00078 s, taking its maximum value. Data effective time duration $D_{ET} - D_{RT} = 3$ h $- 0.00078$ s, can be obtained from the timeliness function value $B_4(R)$ = 1 of the first batch of unstructured data, which can be substituted into Equation (5) to obtain the timeliness truth degree value $h_T(B_4(R))$= 1.14. It means that the degree of timeliness of the data is particularly high, and the quality evaluation is "Level 1".

5.5. Multidimensional Evaluation

First, function values and truth degree values of 135 structured and 75 unstructured data are calculated according to the above four-dimensional evaluation. Then, the multidimensional evaluation was carried out. The weights of these four dimensions were determined as $C_1 = 0.2, C_2 = 0.3, C_3 = 0.3, C_4 = 0.2$ based on the Delphi method and analytic Hierarchy process [26], and the multidimensional evaluation results of structured and unstructured data quality were calculated, as shown in Tables 4 and 5. The complete data are presented in Appendix A.

Table 4. Multi-dimensional evaluation results of the structured data.

Data Serial Number / **Dimension**	**1**	**2**	**3**	…	**24**	…	**76**	…	**135**
Normative function value	0.926	0.834	1	…	0.76	…	0.666	…	1
Integrity function value	0.916	0.833	1	…	0.583	…	0.667	…	1
Accuracy function value	1	0.6	1	…	0.6	…	0.6	…	1
Time function value	1	1	1	…	1	…	1	…	1
The truth degree value of the *i*-th data dimension	1.07	0.6948	1.14	…	0.356	…	0.3612	…	1.14
Quality evaluation	Level 1	Level 3	Level 1	…	Level 4	…	Level 4	…	Level 1
Average multidimensional truth degree value of the whole batch data	0.878								

Table 5. Multi-dimensional evaluation results of the unstructured data.

Data Serial Number / **Dimension**	**1**	**2**	…	**39**	…	**61**	**62**	**63**	…	**75**
Normative function value	1	1	…	1	…	1	1	1	…	1
Integrity function value	1	0.8	…	0.6	…	0.6	0.6	0.6	…	0.8
Accuracy function value	0.8	0.7	…	0.571	…	0.571	0.490	0.408	…	0.545
Time function value	1	1	…	1	…	1	1	1	…	1
The truth degree value of the *i*-th data dimension	1.038	0.816	…	0.456	…	0.456	0.456	0.408	…	0.696
Quality evaluation	Level 1	Level 3	…	Level 4	…	Level 4	Level 4	Level 4	…	Level 3
Average multidimensional truth degree value of the whole batch data	0.847									

By comparing Figures 5 and 6, it can be found that the function values of the structured data without using the MMTD method are closer to each other, the range of fluctuation is relatively small, and there are obvious ambiguities between some data. For example, the 23rd and 24th data are very close to the same data quality evaluation of "Level 3" in Figure 6, while Figure 5 clearly distinguishes the quality of the 23rd and 24th data as "Level 3" and "Level 4", respectively; similarly, it can be seen that the quality of structured data without using the MMTD method is relatively close, the range of fluctuation is relatively small, and there are obvious ambiguities between some data. "Similarly, Figure 7 has a smaller range of fluctuation and cannot clearly deal with the ambiguity of the data. For example, the 37th and 39th data quality evaluations in Figure 7 are "Level 3", while Figure 8 is "Level 3" and "Level 4", respectively. This shows the effectiveness of this paper's method in dealing with data ambiguity.

As can be seen in Table 4 and Figure 5, the multidimensional truth value of the 24th structured data is 0.356, with a quality rating of "Level 4". This is mainly because the attributes "longitude", "brightness", "scan", "track", and "frp" are incomplete and not accurate to one decimal place, resulting in low normality, completeness, and accuracy of the data. In the process of disaster relief, such data should be discarded to avoid influencing decision-making. At the same time, it also reminds the staff to keep the data complete enough for the next disaster relief. The same is true for the 76th structured data. In addition, the 32nd, 47th, 51st, 56th, 64th, 69th, 93rd, 127th, and 134th data also have a low degree of truth value, and the quality evaluation is "Level 3". This is mainly due to the fact that some attribute values are partially missing, which lowers the overall data quality. This kind of data should be utilized later, and high-quality data should be used first. At the same time, staff members are reminded that it is very important to record and preserve each attribute of mobile emergency data in strict accordance with the specifications.

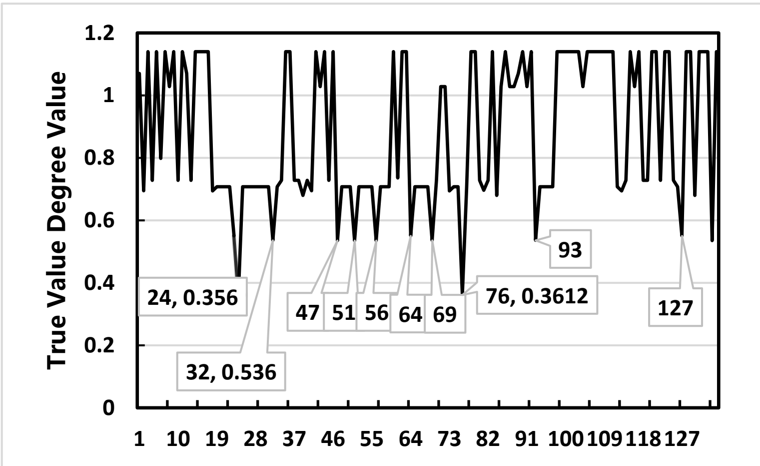

Figure 5. Multidimensional truth degree values for structured data.

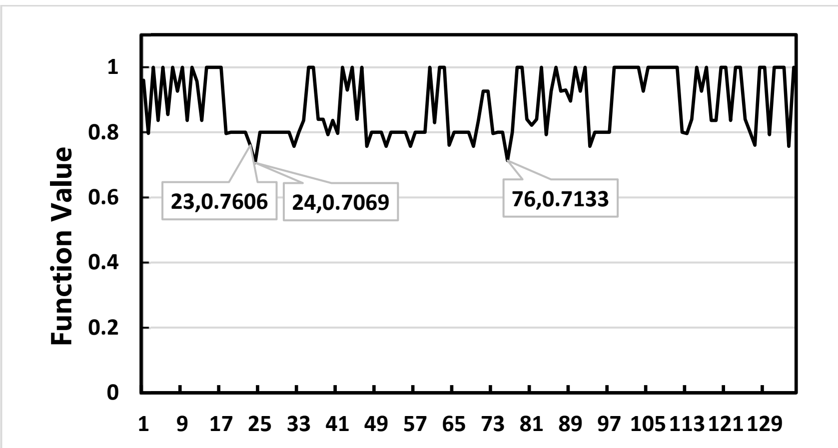

Figure 6. Multidimensional function values for structured data.

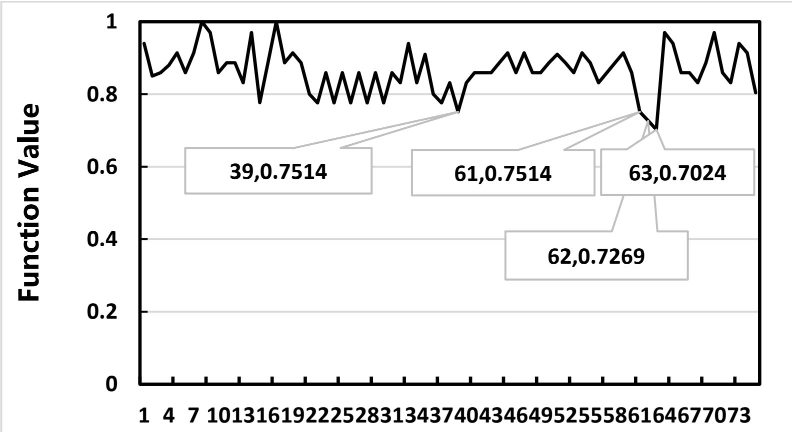

Figure 7. Multidimensional function values for unstructured data.

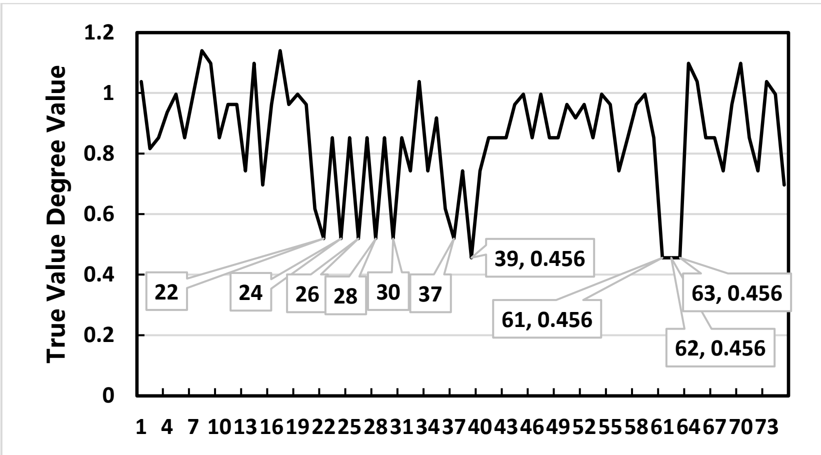

Figure 8. Multidimensional true value degree values for unstructured data.

As can be seen from Table 5 and Figure 8, the multidimensional degree of truth of the 39th, 61st, 62nd, and 63rd unstructured data is 0.456, 0.456, 0.456, and 0.408 with a quality evaluation of "Level 4", and this kind of data is discarded. The main reason is that the data are missing parts of the eigenvalues, which leads to incomplete data and an inaccurate description of the emergency disaster, resulting in a decline in the quality of data completeness and accuracy. Similarly, the 22nd, 24th, 26th, 28th, 30th, and 37th data also have a low degree of truth, and the quality is evaluated as "Level 3", so this kind of data will be used later. Staff members are also reminded to accurately describe emergency disasters and keep complete records.

From Figure 9, it can be clearly seen that the degree of truth value of accuracy has the highest volatility and the lowest average value among the structured dimensions, and even many of the degree of truth values are zero. Next is the lowest value of integrity, which indicates that the accuracy and integrity of this data are difficult to meet the requirements. At this point, the staff should be based on the problem to find the source, determine which step of the data collection, transmission, recording, and preservation process is involved in the problem, and make the corresponding improvements. For example, if the data collected by the collection equipment is incomplete, the equipment should be improved, and the staff should record the missing, duplicated, and omitted data. And the value of timeliness and standardization is kept very high and stable, which indicates that these data are very much in line with the data normality and timeliness requirements. It may be because it has a complete set of normative implementation plans, and with the development of the 5G network, the data transmission speed is fast enough to fully meet the timeliness requirements within the relief time frame. Similarly, it can be clearly seen from Figure 10 that the truth degree values of accuracy and completeness in each dimension of unstructured data fluctuate greatly and the average value is relatively low, while normality and timeliness are very stable and the truth degree values are very high.

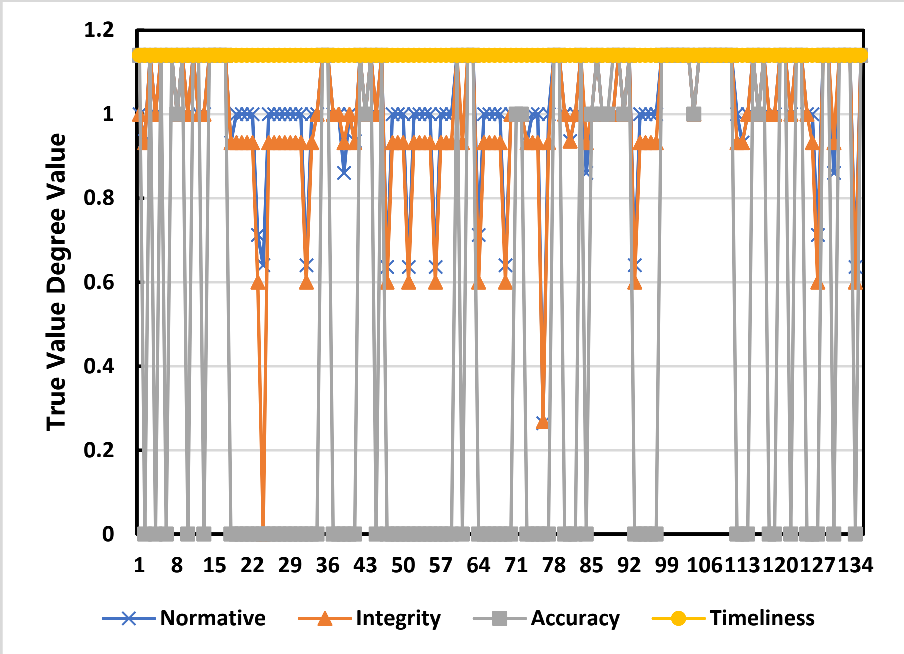

Figure 9. Comparison table of truth degree values for each dimension of the structured data.

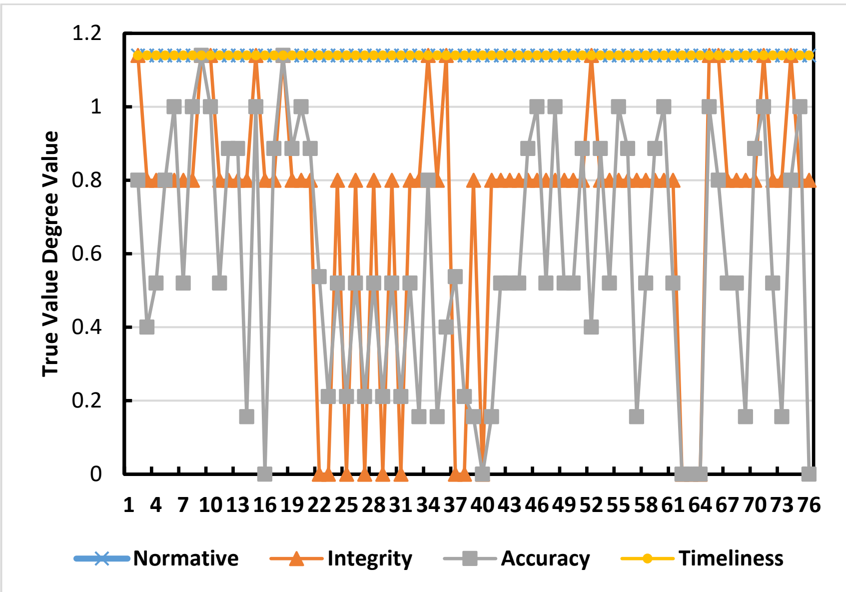

Figure 10. Comparison table of the degree of truth values for each dimension of unstructured data.

In summary, this method can effectively calculate the function values of the four dimensions of the data, the truth degree values of each data point and the whole batch of data, and finally evaluate the data quality more accurately and carefully. The first batch of structured data has a truth value of 0.878, and the unstructured data has a truth value of 0.847, which means that the quality of both data is "Level 3" and both data are of high value. In the actual data use process, the data quality can be ranked from high to low, and high-quality data can be used first and low-quality data can be discarded. In addition, through the above fuzzy processing and quantitative evaluation of the quality of mobile emergency data, it can be found that the MMTD method can clearly obtain high and low degrees of data quality. It improves the speed and accuracy of data analysis, which in turn can reduce the interference of low-quality data and improve the utilization of high-quality data. It is also beneficial to explore the causes of low-quality data, improve data collection methods and data pre-processing methods, etc., and support the realization of accurate and intelligent mobile emergency services with high-quality data.

6. Summary

Mobile emergency big data quality is low, and there is ambiguity about how to scientifically and reasonably evaluate the mobile emergency big data problem. The article adopts a combination of qualitative and quantitative ideas. Through the analysis of mobile emergency big data, it is summarized that it has the characteristics of a strong surge, large change, weak integrity, a large amount of processing, and high correlation. And, from the four dimensions of standardization, completeness, accuracy, and timeliness, combined with the attribute weights obtained from the fuzzy hierarchical analysis method, a definition of data quality dimensions is given. Considering the ambiguity of the data, the MMTD method is introduced, and the distance ratio function is used to establish single-dimension and multi-dimension mobile emergency big data truth degree measurement models based on the theory of mediation logic. The model is analyzed by using the Australian mountain fire data from the NASA website and the fire text dataset from the Chinese Emergency Incident Corpus as example algorithms. The obtained results of the first batch of the dimensional evaluation of data quality and the multidimensional assessment results show that the MMTD-based mobile emergency big data quality evaluation method can effectively respond to the degree of data standardization, completeness, accuracy, and timeliness in a quantitative way. The comparison between this method and the direct use of the function value evaluation method shows that this method can effectively deal with data quality ambiguity. It has a positive effect on improving emergency response capability and the construction of intelligent mobile emergency service systems.

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Appendix A

Table A1. Structured data multidimensional evaluation results.

Serial Number	Normative Function Values	Integrity Function Value	Accuracy Function Value	Time-Sensitive Function Values	Normative Truth Degree Value	Integrity Truth Degree Value	Accuracy True Value Degree Value	Time-Sensitive True Value Degree Value	The Truth Degree Value of the *i*-th Data Dimension	Quality Evaluation	Average Multidimensional Truth Degree Value of the Whole Batch Data
1	0.926	0.916	1	1	1	1	1.14	1.14	1.07	Level 1	**0.878**
2	0.834	0.833	0.6	1	0.936	0.932	0	1.14	0.6948	Level 3	
3	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
4	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
5	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
6	1	0.916	0.6	1	1.14	1.14	0	1.14	0.798	Level 3	
7	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
8	0.907	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
9	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
10	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
11	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
12	0.908	0.916	1	1	1	1	1.14	1.14	1.07	Level 1	
13	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
14	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
15	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
16	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
17	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
18	0.833	0.833	0.6	1	0.932	0.932	0	1.14	0.694	Level 3	
19	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
20	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
21	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
22	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
23	0.778	0.75	0.6	1	0.712	0.6	0	1.14	0.5504	Level 3	
24	**0.76**	**0.583**	**0.6**	**1**	**0.64**	**0**	**0**	**1.14**	**0.356**	**Level 4**	
25	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
26	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
27	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
28	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
29	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
30	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
31	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
32	0.76	0.75	0.6	1	0.64	0.6	0	1.14	0.536	Level 3	
33	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
34	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
35	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
36	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
37	0.926	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
38	0.926	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
39	0.815	0.833	0.6	1	0.86	0.932	0	1.14	0.6796	Level 3	
40	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
41	0.834	0.833	0.6	1	0.936	0.932	0	1.14	0.6948	Level 3	
42	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
43	0.926	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
44	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
45	0.926	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
46	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
47	0.759	0.75	0.6	1	0.636	0.6	0	1.14	0.5352	Level 3	
48	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
49	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
50	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
51	0.759	0.75	0.6	1	0.636	0.6	0	1.14	0.5352	Level 3	
52	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	

Table A1. *Cont.*

Serial Number	Normative Function Values	Integrity Function Value	Accuracy Function Value	Time-Sensitive Function Values	Normative Truth Degree Value	Integrity Truth Degree Value	Accuracy True Value Degree Value	Time-Sensitive True Value Degree Value	The Truth Degree Value of the *i*-th Data Dimension	Quality Evaluation	Average Multidimensional Truth Degree Value of the Whole Batch Data
53	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	**0.878**
54	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
55	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
56	0.759	0.75	0.6	1	0.636	0.6	0	1.14	0.5352	Level 3	
57	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
58	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
59	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
60	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
61	1	0.833	0.6	1	1.14	0.932	0	1.14	0.7356	Level 3	
62	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
63	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
64	0.778	0.75	0.6	1	0.712	0.6	0	1.14	0.5504	Level 3	
65	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
66	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
67	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
68	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
69	0.76	0.75	0.6	1	0.64	0.6	0	1.14	0.536	Level 3	
70	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
71	0.907	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
72	0.907	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
73	0.833	0.833	0.6	1	0.932	0.932	0	1.14	0.694	Level 3	
74	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
75	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
76	**0.666**	**0.667**	**0.6**	**1**	**0.264**	**0.268**	**0**	**1.14**	**0.3612**	**Level 4**	
77	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
78	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
79	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
80	0.926	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
81	0.834	0.916	0.6	1	0.936	0.936	0	1.14	0.696	Level 3	
82	0.926	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
83	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
84	0.815	0.833	0.6	1	0.86	0.932	0	1.14	0.6796	Level 3	
85	0.907	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
86	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
87	0.907	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
88	0.926	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
89	0.907	0.916	0.8	1	1	1	1.14	1.14	1.07	Level 1	
90	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
91	0.907	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
92	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
93	0.76	0.75	0.6	1	0.64	0.6	0	1.14	0.536	Level 3	
94	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
95	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
96	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
97	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
98	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
99	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
100	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
101	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
102	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
103	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
104	0.907	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
105	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
106	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	

Table A1. *Cont.*

Serial Number	Normative Function Values	Integrity Function Value	Accuracy Function Value	Time-Sensitive Function Values	Normative Truth Degree Value	Integrity Truth Degree Value	Accuracy True Value Degree Value	Time-Sensitive True Value Degree Value	The Truth Degree Value of the *i*-th Data Dimension	Quality Evaluation	Average Multidimensional Truth Degree Value of the Whole Batch Data
107	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
108	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
109	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
110	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
111	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
112	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
113	0.833	0.833	0.6	1	0.932	0.932	0	1.14	0.694	Level 3	
114	0.926	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
115	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
116	0.907	0.916	0.9	1	1	1	1	1.14	1.028	Level 1	
117	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
118	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
119	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
120	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
121	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	**0.878**
122	0.908	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
123	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
124	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
125	0.926	0.916	0.6	1	1	1	0	1.14	0.728	Level 3	
126	0.852	0.833	0.6	1	1	0.932	0	1.14	0.7076	Level 3	
127	0.778	0.75	0.6	1	0.712	0.6	0	1.14	0.5504	Level 3	
128	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
129	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
130	0.815	0.833	0.6	1	0.86	0.932	0	1.14	0.6796	Level 3	
131	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
132	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
133	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	
134	0.759	0.75	0.6	1	0.636	0.6	0	1.14	0.5352	Level 3	
135	1	1	1	1	1.14	1.14	1.14	1.14	1.14	Level 1	

Table A2. Multidimensional evaluation results of the unstructured data.

Serial Number	Normative Function Values	Integrity Function Value	Accuracy Function Value	Time-Sensitive Function Values	Normative Truth Degree Value	Integrity Truth Degree Value	Accuracy True Value Degree Value	Time-Sensitive True Value Degree Value	The Truth Degree Value of the *i*-th Data Dimension	Quality Evaluation	Average Multidimensional Truth Degree Value of the Whole Batch Data
1	1	1	0.800	1	1.14	1.14	0.8	1.14	1.038	Level 1	
2	1	0.8	0.700	1	1.14	0.8	0.4	1.14	0.816	Level 3	
3	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
4	1	0.8	0.800	1	1.14	0.8	0.8	1.14	0.936	Level 3	
5	1	0.8	0.913	1	1.14	0.8	1	1.14	0.996	Level 3	
6	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
7	1	0.8	0.913	1	1.14	0.8	1	1.14	0.996	Level 3	
8	1	1	1.000	1	1.14	1.14	1.14	1.14	1.14	Level 1	
9	1	1	0.900	1	1.14	1.14	1	1.14	1.098	Level 1	**0.847**
10	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
11	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
12	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
13	1	0.8	0.639	1	1.14	0.8	0.1561	1.14	0.74283	Level 3	
14	1	1	0.900	1	1.14	1.14	1	1.14	1.098	Level 1	
15	1	0.8	0.456	1	1.14	0.8	0	1.14	0.696	Level 3	
16	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
17	1	1	1.000	1	1.14	1.14	1.14	1.14	1.14	Level 1	

Table A2. *Cont.*

Serial Number	Normative Function Values	Integrity Function Value	Accuracy Function Value	Time-Sensitive Function Values	Normative Truth Degree Value	Integrity Truth Degree Value	Accuracy True Value Degree Value	Time-Sensitive True Value Degree Value	The Truth Degree Value of the *i*-th Data Dimension	Quality Evaluation	Average Multidimensional Truth Degree Value of the Whole Batch Data
18	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
19	1	0.8	0.913	1	1.14	0.8	1	1.14	0.996	Level 3	
20	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
21	1	0.6	0.734	1	1.14	0	0.5376	1.14	0.61728	Level 3	
22	1	0.6	0.653	1	1.14	0	0.2112	1.14	0.51936	Level 3	
23	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
24	1	0.6	0.653	1	1.14	0	0.2112	1.14	0.51936	Level 3	
25	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
26	1	0.6	0.653	1	1.14	0	0.2112	1.14	0.51936	Level 3	
27	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
28	1	0.6	0.653	1	1.14	0	0.2112	1.14	0.51936	Level 3	
29	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
30	1	0.6	0.653	1	1.14	0	0.2112	1.14	0.51936	Level 3	
31	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
32	1	0.8	0.639	1	1.14	0.8	0.1561	1.14	0.74283	Level 3	
33	1	1	0.800	1	1.14	1.14	0.8	1.14	1.038	Level 1	
34	1	0.8	0.639	1	1.14	0.8	0.1561	1.14	0.74283	Level 3	
35	1	1	0.700	1	1.14	1.14	0.4	1.14	0.918	Level 3	
36	1	0.6	0.734	1	1.14	0	0.5376	1.14	0.61728	Level 3	
37	1	0.6	0.653	1	1.14	0	0.2112	1.14	0.51936	Level 3	
38	1	0.8	0.639	1	1.14	0.8	0.1561	1.14	0.74283	Level 3	
39	**1**	**0.6**	**0.571**	**1**	**1.14**	**0**	**0**	**1.14**	**0.456**	**Level 4**	
40	1	0.8	0.639	1	1.14	0.8	0.1561	1.14	0.74283	Level 3	
41	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
42	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
43	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	**0.847**
44	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
45	1	0.8	0.913	1	1.14	0.8	1	1.14	0.996	Level 3	
46	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
47	1	0.8	0.913	1	1.14	0.8	1	1.14	0.996	Level 3	
48	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
49	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
50	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
51	1	1	0.700	1	1.14	1.14	0.4	1.14	0.918	Level 3	
52	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
53	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
54	1	0.8	0.913	1	1.14	0.8	1	1.14	0.996	Level 3	
55	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
56	1	0.8	0.639	1	1.14	0.8	0.1561	1.14	0.74283	Level 3	
57	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
58	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
59	1	0.8	0.913	1	1.14	0.8	1	1.14	0.996	Level 3	
60	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
61	**1**	**0.6**	**0.571**	**1**	**1.14**	**0**	**0**	**1.14**	**0.456**	**Level 4**	
62	**1**	**0.6**	**0.490**	**1**	**1.14**	**0**	**0**	**1.14**	**0.456**	**Level 4**	
63	**1**	**0.6**	**0.408**	**1**	**1.14**	**0**	**0**	**1.14**	**0.456**	**Level 4**	
64	1	1	0.900	1	1.14	1.14	1	1.14	1.098	Level 1	
65	1	1	0.800	1	1.14	1.14	0.8	1.14	1.038	Level 1	
66	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
67	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
68	1	0.8	0.639	1	1.14	0.8	0.1561	1.14	0.74283	Level 3	
69	1	0.8	0.822	1	1.14	0.8	0.8864	1.14	0.96192	Level 3	
70	1	1	0.900	1	1.14	1.14	1	1.14	1.098	Level 1	

Table A2. *Cont.*

Serial Number	Normative Function Values	Integrity Function Value	Accuracy Function Value	Time-Sensitive Function Values	Normative Truth Degree Value	Integrity Truth Degree Value	Accuracy True Value Degree Value	Time-Sensitive True Value Degree Value	The Truth Degree Value of the *i*-th Data Dimension	Quality Evaluation	Average Multidimensional Truth Degree Value of the Whole Batch Data
71	1	0.8	0.730	1	1.14	0.8	0.52	1.14	0.852	Level 3	
72	1	0.8	0.639	1	1.14	0.8	0.1561	1.14	0.74283	Level 3	
73	1	1	0.800	1	1.14	1.14	0.8	1.14	1.038	Level 1	**0.847**
74	1	0.8	0.913	1	1.14	0.8	1	1.14	0.996	Level 3	
75	1	0.8	0.548	1	1.14	0.8	0	1.14	0.696	Level 3	

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