Research on the framework of full-process condition monitoring and evaluation method for express logistics based on multi-information fusion and intelligent identification

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Abstract: This paper describes the background and significance of the whole process state monitoring of express logistics in the three aspects of environment, society and economy, then introduces the current status of the tracking and monitoring of logistics process at home and abroad, and proposes the method of full-process condition monitoring and evaluation method for express logistics based on multi-information fusion and intelligent identification. The content of the method mainly includes: collecting data based on various information collection methods such as sensors, extracting and identifying the characteristics of expressive behavior through the algorithm and quantitative evaluation of the whole process express logistics status. Finally, the paper summarizes the whole system-based method of multi-information fusion and intelligent identification of the whole logistics process monitoring and evaluation, and explains the follow-up work direction and content.

1. Introduction
In recent years, China's express logistics is in a period of rapid growth. In 2018, the national express delivery service business volume totaled 50.71 billion pieces, a year-on-year increase of 26.6% [1]. Express logistics has exposed more and more environmental and social issues while people's lives are becoming more and more convenient.

According to statistics, in 2015, China's express industry consumed about 9.92 billion boxes, 8.27 billion plastic bags, 3.1 billion woven bags and 16.69 billion meters of tape packaging materials [2], and have been increasing in the four years, the question has brought tremendous pressure to environment. The large amount of packaging materials is mainly used for two reasons. On the one hand, the express delivery industry has caused the damage of the goods in order to improve the sorting efficiency. The operators used a large amount of buffer packaging materials to avoid the damage of the express delivery, resulting in a large amount of express garbage. On the other hand, due to the unreasonable design of the package modulus, "large boxes of small objects" caused a waste of resources. On the basis of the state monitoring of the whole process of logistics, it is possible to co-ordinate various types of shipments. By optimizing the theory and method, the packaging modulus, buffer structure, etc. can be quantitatively designed, and a large number of packaging materials can be saved while ensuring that the mailings are not damaged, while reducing environmental pressure, greatly reducing the cost of express logistics.

Express logistics not only has a negative impact on the environment, but also triggers social problems such as “violent sorting”. Since the relevant regulatory authorities do not have perfect standards to make the responsibility clear to people, the phenomenon of violent sorting is becoming more and more serious.
This phenomenon directly leads to express delivery damaged and related enterprises are complained by the masses, not only caused huge economic losses for the merchants, but also severely restricted the development of China's express service industry. Therefore, the real-time monitoring and quantitative evaluation of the whole process of express mail logistics can not only solve the pollution and waste caused by over-packaging, but also help to improve the industry supervision system, and at the same time help enterprises complete service upgrades, enhance the industry image and reduce economic losses. Achieve both social and economic benefits.

At present, most of the real-time monitoring of express mail logistics processes in China's industry uses GPS (Global Positioning System) geographical location identification technology to track the transportation situation of freight vehicles and vehicles, or use RFID (Radio Frequency Identification) technology to collect dynamic information such as goods entering and leaving the warehouse. However, the prior art can only complete the geographical location of the goods, the monitoring of the surrounding basic environment and the management of the equipment, and it is impossible to supervise the human operation and the state of the expressive behavior of certain links. In recent years, although domestic and foreign studies have gradually begun to pay attention to the study of express delivery behavior, the research results in this area are not very rich. For detailed analysis, please see Chapter 2 of this article.

Therefore, we propose a method for monitoring and evaluating the whole process status of express logistics based on multi-information fusion and intelligent identification. This paper first introduces the background and significance of the whole process status monitoring of express logistics, then introduces the techniques and methods of tracking and monitoring in the current domestic and international logistics process, and introducing the content of the method. Finally, the paper systematically summarizes the whole systemized method and explains the follow-up work direction and content.

2. Research status and analysis at home and abroad
The following is mainly aimed at analyzing the research status of logistics condition monitoring technology and system, logistics process vibration and shock analysis, express movement and behavior recognition at home and abroad.

2.1. Logistics state monitoring technology research.
In the tracking and monitoring technology of the logistics process, as described in the first chapter, the existing research mainly uses RFID, GPS, WSN (Microsoft Service Network) and other technologies to collect and transmit the logistics process information [3-4], and more concentrated in the in-transit monitoring of special industry logistics such as cold chain [5], hazardous chemicals [6], some scholars have specially studied the collection and compression technology of logistics state information. For the storage and transportation environment of valuables, Liu Lei designed a smart tag with micro-volume to collect environmental information and alarm the unexpected situation [7]. Using the sparseness of the storage and transportation signals, Xu Fujing proposed random node design and random event sampling to reconstruct and restore the signal of the whole storage and transportation process [8].

It can be seen from the above that the research of domestic and foreign scholars mostly deals with the storage and transportation environment status of special goods such as cold chain products, weapons and equipment, and the general express condition monitoring technology for express logistics is still relatively shallow [9], and the existing express delivery state recognition is still dominated by direct observation methods [10], and research results on the state of the expressive behavior based on real-time logistics status information are still rare.

2.2. Detection and analysis of vibration and shock in logistics process
At present, this aspect of research is mainly for random vibration response detection and feature analysis of transport packaging and container cargo. The research methods adopted are mostly based on dynamic analysis or fatigue life. Xu Huan analyzed the vibration characteristics of container logistics transportation through five-point smoothing and the combination of digital filtering and FFT transformation, and applied the method to the measured vibration characteristic signal [11]. Sun Jun
experienced on the random vibration response of beer bottle turnover box under different acceleration excitation patterns. It was found that the acceleration peak distribution of beer bottles and turnover boxes under random vibration is closer to Weibull distribution [12]. Jiang Chundong studied the damage mechanism of products under random vibration, and used the linear cumulative damage theory to calculate the vibration fatigue of the product [13]. Zhou selected a car to measure and analyze the vibration level, and found that the vertical axis of the vibration level decreased with the increase of the payload, and increased with the increase of the speed [14].

It can be seen from the above that by analyzing the random vibration and impact detection in the process of logistics and transportation, it provides an effective means for the analysis and design of product packaging, but it is used for the real-time status identification of the whole process. Its reference role is limited.

2.3. Cargo movement and behavior recognition technology

In the past three years, there have been some scholars' attention and research on the identification of cargo movements, behaviors and postures. Wu proposed an inertial measurement unit (IMUs) packaging condition monitoring system that is easy to install and can correctly detect the packaging status. The system adopts a decision tree method and a clustering method to divide the steady state into a normal state, and divides the states of flipping, moving, etc. into abnormal states. Experimental results show that the system can distinguish different states of different weight packages [15]. Chuang used a simple and low-cost piezo-paste force sensor for logistics applications to ensure package security. The sensor is connected to a prototype system that can read data and record data wirelessly via a Bluetooth module [16]. Wang Shaodan proposed an RFID-based attitude detection method for cargo behavior, the method is used to determine the abnormal behavior of the goods [17], and a six-axis acceleration sensor based on the behavioral attitude detection method of dangerous goods in transit is proposed. The feature vector and decision classifier are analyzed and designed to realize the behavioral attitude classification of dangerous goods in transit [18].

The above research uses the piezoelectric sensor or the inertial sensor to identify whether the cargo has been tipped or rolled. However, it does not quantify the extent of abnormal actions, nor does it achieve real-time monitoring of the entire process.

In summary, the research objects of real-time condition monitoring of express logistics at home and abroad are mostly directed to the monitoring of special items and logistics environment, and the problem of general expressive behavior is not analyzed. The research on random vibration characteristics and impact monitoring is mainly based on the analyses of vibration characteristics by data, and there are not many related researches on indirect identification of expressive behavior state through feature analysis. Indirect recognition of express mail behavior based on other methods such as inertial sensors is rare. Therefore, we propose a systematic approach from monitoring to identifying expressive behavior.
3. Methodology framework for full-process condition monitoring and evaluation of express logistics based on multi-information fusion and intelligent identification

![Diagram of methodology framework]

**Figure 1.** A framework for full-process condition monitoring and evaluation of express logistics based on multi-information fusion and intelligent identification

The method of condition monitoring and evaluation of express logistics based on multi-information fusion and intelligent identification proposed in this paper is hardware development and design - data acquisition and preprocessing - feature extraction - behavior recognition - quantification. The overall thinking of the evaluation gradually carried out research work. The technical route of the method is shown in Figure 1.

3.1. Hardware development and design
Combine logistics environment information determine the data such as vibration acceleration, temperature and humidity, light intensity and geographical location. According to the requirements, the selection of sensors such as acceleration sensor and angular velocity sensor is completed, and the design and integration of key function modules such as data storage, data transmission and power supply are completed, and the design and manufacture of the special packaging shell of the sensor acquisition device are completed, and finally the hardware acquisition is completed. The device is tested for fixation.

3.2. Full process data acquisition and processing
Through the whole process of tracking and recording the actual express condition of the collecting device, the data recorded by the collecting device is matched with the basic information such as the time and place obtained by the tracking, and the typical data and the corresponding special situation (high temperature, transportation road bump, etc.) or human operation are extracted. Behavior (throwing, throwing, kicking, etc.), while designing experiments to simulate typical behaviors and conducting
multiple experiments. Since the collected raw data is affected by environmental interference, etc. the data needs to be preprocessed by filtering, overlapping, intercepting, and denoising.

3.3. Extraction and expression of state features
Firstly, according to the environmental information collection of each link of the logistics, the time and space characteristics of the artificial operation behavior and the information of the abnormal state of the express mail are analyzed. Secondly, according to a large number of experimental simulations of raw data and data collected by the acquisition device, the time domain features are calculated based on classical statistical theory and multivariate statistical algorithms; using classical frequency domain analysis, signal decomposition and recombination, energy/moment/entropy statistical calculation, etc. The corresponding state features are extracted in the frequency domain. Then, the extracted features are generated into a three-dimensional time series curve, and the state features are effectively expressed, and an expression matrix of the state features is obtained.

3.4. Logistics status intelligent identification and optimization
On the basis of state feature extraction and expression, a fast normal/abnormal two-state identification is first performed. Then, multi-state identification of different anomaly types and multi-state identification of different degrees of the same type are performed for the abnormal state. On the basis of abnormal recognition, the convolutional neuron network is used to identify various abnormal conditions such as illegal throwing of express mail, abnormal transportation bumps, improper transportation temperature and humidity, and improper lighting treatment. On the basis of completing different types of abnormal situation identification, for the same type of frequent violation operation, BP neuron and decision tree are used to complete the damage degree of the same type of action on the goods.

3.5. Quantitative evaluation of logistics state
On the basis of familiarity with China's current logistics industry safety and operational specifications, comprehensive aspects of express delivery logistics environment covering the entire process of express delivery logistics are established. Based on the evaluation index system, the frequency, location and severity of the illegal operation behaviors in the whole process of logistics are studied. The multi-dimensional statistical analysis of the whole process or key links is carried out by means of analytic hierarchy process and fuzzy comprehensive evaluation, and the corresponding index values are calculated., the results of the quantitative evaluation of the synthetic output. Finally, for consumers and enterprises, the results of the assessment will be diversified and vividly visualized.

4. Summary
In order to provide relevant departments with scientific basis for logistics process supervision and logistics packaging planning, this paper proposes a multi-information fusion and intelligent identification of the whole process state monitoring method of express logistics. This method is mainly based on the multi-information monitoring method to collect the real-time information such as light intensity and GPS coordinates, indirectly analyzing and identifying expressive behavior. The most critical issues are feature extraction and behavior recognition. The further expansion and deepening research that needs to be done mainly includes the following aspects:
1) Deeply mine and extract the expressive behavior features from high-dimensional raw data.
2) Further subdividing the quantification of different expressive behavior states, and accurately identifying abnormal behavior and abnormality.
3) On the basis of completing the method and technical research, it is necessary to carry out the supporting application service system development and product design and development.
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