Aviation Freight Safety Inspection System Based on RFID

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Abstract
In order to meet the needs of aviation freight safety, a new type of aviation freight safety inspection system based on RFID technology is proposed. The system combines radio frequency identification, global positioning satellite, embedded systems technology, and to intelligently manage the regular aviation freight personnel traveling and temporary road conditions, while taking advantage of the system management platform built for all levels of maintenance and management personnel to provide intelligent aviation freight information services. In addition, the system is optimized by wavelet transform and neural network learning. System through simple improvements can be further extended to railway inspection, pipeline inspection, intelligent community patrol inspection and other key targets which has broad application prospects.

Key words: Aviation Freight, Inspection System, RFID, Internet of Things

1. INTRODUCTION
With the development of aviation logistics and the rapid development of e-commerce, aviation freight has become an important means for e-commerce to transport goods, especially for transporting valuable, urgent and chilled goods. In order to ensure the safe and rapid delivery of goods under the premise of continuously improve the aviation freight transport volume, air cargo safety inspection issues has become the focus of attention. Due to the relatively high value and vulnerability of aviation freight, it is particularly vulnerable to damage caused by illegal operation, and cause greater economic losses, and even lead to serious security incidents. So the Internet of Things technology as the representative of the high-tech is constantly to address and improve the safety of aviation freight inspection and start the design and application (Christian and Daniel, 2016; Yang and Yu, 2016).

2. AVIATION FREIGHT SAFETY INSPECT SYSTEM AND SPACE FEATURE EXTRACTION
2.1. Radio Frequency Identification Technology
Radio frequency identification technology (RFID) is an important part of the Internet of Things technology. The use of RFID is a radio frequency signal through space coupling (alternating magnetic field or electromagnetic field) to achieve non-contact transmission of information through the message to identify the purpose of technology. The simplest RFID system is composed of electronic identification tags, readers and antenna consists of three parts. It will write a special message encoded tag, label pasted on the need to identify the information. When the electronic tag to enter the magnetic fields, the reader receives the signal, with the induced current obtained by sending out the energy stored in the chip product information (Passive Tag, also known as non-power passive RFID tag), or take the initiative to send a frequency signal (Active Tag, also known as a power active RFID tag); reader to read and decode the information, sent to the central information system for the processing, practical applications often require additional hardware and software support (Dietmar and Hamid, 2014; Li and Liu, 2014).

2.2. Research of AVIATION FREIGHT SAFETY INSPECT SYSTEM
The safety and smooth flow of aviation freight or not, in a certain sense, depending on the daily to maintain the level of management and prevention of barriers, rules of order transmission line maintenance staff should adhere to the aviation freight regularly tour. Safety Inspection widely used traditional manual inspection, the use of paper-based manual records of work, the way there are many human factors, low efficiency, and cannot supervise staff working conditions and other road defects, the apparent lack of timeliness of inspection, management, lack of expertise. Often result in delays in processing time, is difficult to clear up and down the responsibilities, relationships, conflict, inefficiency, and line obstacles and losses may increase. Therefore, we have before us a very pressing issue is how to use scientific and effective management methods, and promote
the implementation of inspection system, the timely detection of problems in the inspection, the prevention of various types of security risks (Leung and Choy, 2015).

The traditional inspection system is the inspection personnel in accordance with the provisions of air cargo inspection, in accordance with the provisions of the time schedule for inspection, but they only by artificial and some electronic equipment to check the packaging and transport of goods. Freight intelligent inspect system is introduced to quantify the aviation freight inspection and dynamic management of modern methods, a new form of aviation freight safety inspection method is proposed which is an important step for promote the implementation of scientific management. Intelligent data logging system to maintain the daily management of the main line departments to achieve the daily management of the maintenance department of computer dynamic management strengthen the maintenance department management, scientific, institutionalized and improve the overall management of the maintenance department.

2.3. Extraction of Space Feature

The wavelet decomposition can only decompose further the low-frequency information and cannot decompose the high-frequency information, which make the high-frequency information cannot be use and information extracting cannot get enough. So the information decomposition is completed by wavelet packet in high-frequency bands. The differentia between wavelet packet decomposition and wavelet decomposition is that wavelet packet decomposition equal to use a low-pass filter and a high-pass filter at the same time.

The wavelet packet analysis can provide a more refined analysis method, which can multi-level partition the frequency bands and analyze the high-frequency part further which don’t been subdivided by multi-resolution analysis, and choose the interrelated frequency bands to make it suited with signal spectrum. The time-frequency resolution is rising. Thus, discussing to this experiment, we can decompose the signal subtly by wavelet packet, and realize the recognition of the scratches. This paper use the pattern recognition method based on energy-defect.

Aviation cargo inspection signals in wavelet packet express with the distinct energy distributing changing in wavelet subspace. The signal j order wavelet packet transform can get wavelet packet coefficients \( \text{coeff}_{j,k}^m \), \( m = 1, 2, \ldots, 2^j \) is the number of the wavelet tree nodes which getting after decomposing, and k is the location parameter under the wavelet packet subspace of \( 2^j \) scale. After decomposing the wavelet coefficients of N frequency bands constitute N subspaces, denoted as \( A_{j,m} \), and the signal energy of each subspaces is

\[
E_{j,m} = \sum_k (\text{coeff}_{j,k}^m)^2
\]  

Constructing feature vector by using energy as element

\[
F(m) = [E_{j,0}, E_{j,1}, E_{j,2}, \ldots, E_{j,m}]
\] 

Normalizing the eigenvector \( E = \sum_m E_{j,m} \) is

\[
F(m)' = [E_{j,0} / E, E_{j,1} / E, E_{j,2} / E, \ldots, E_{j,m} / E]
\] 

\( F(m)' \) is feature space being extended after normalizing the eigenvector.

Researching from frequency-domain, if regard the highest frequency composition within original signal as 1, the wavelet packet decomposition is decomposing signal with different frequency bands evenly into several windows, and each decomposed results corresponds signal information in the frequency bands. Table1 express frequency bands partition of the 3 layers wavelet packet decomposition in the experiment. Because sample frequency of ultrasonic signal is 100 MHz, the scope of frequency band is 0–50 MHz in wavelet packet decomposition.

<table>
<thead>
<tr>
<th>Wavelet packet subspace</th>
<th>Frequency bands (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S(3,0)</td>
<td>0.000 ~ 6.250</td>
</tr>
<tr>
<td>S(3,1)</td>
<td>6.250 ~ 12.500</td>
</tr>
<tr>
<td>S(3,2)</td>
<td>12.500 ~ 18.750</td>
</tr>
<tr>
<td>S(3,3)</td>
<td>18.750 ~ 25.000</td>
</tr>
<tr>
<td>S(3,4)</td>
<td>25.000 ~ 31.250</td>
</tr>
<tr>
<td>S(3,5)</td>
<td>31.250 ~ 37.500</td>
</tr>
<tr>
<td>S(3,6)</td>
<td>37.500 ~ 43.750</td>
</tr>
<tr>
<td>S(3,7)</td>
<td>43.750 ~ 50.000</td>
</tr>
</tbody>
</table>
2.4. Pattern Recognition

Wavelet neural network is a kind of neural network based on wavelet analysis, which make use of the good local localized character of the wavelet transform and combine the self-learning function of neural network. So wavelet neural network has more powerful abilities of approximate and fault-tolerant and the realized process is simpler. In this experiment we choose the discrete orthogonal wavelet network which is evolved from radial basis function, and its construction according to discrete wavelet transform theory as: select basis wavelet function \( \phi(x) = \hat{L}(R) \cdot \phi(\omega) \) is \( \phi(x) \) Fourier transform, and suffice admissible condition:

\[
\int_{\mathbb{R}} \omega^{-1} |\phi(\omega)|^2 d\omega < \infty
\]  

(4)

The wavelet function system \( \{\varphi_{a,b}(x)\} \) can be achieved after using scale transformation and translation transform to \( \phi(x) \).

\[
\psi_{a,b}(x) = a^{-1/2} \varphi\left(\frac{x-b}{a}\right) \quad (a,b) \in \mathbb{Z}^2
\]  

(5)

In the formula, \( a \) is scale parameter, \( b \) is translation transform. To arbitrary function \( f(x) \), its definition of continuous wavelet transform is

\[
W_f(a,b) = \int_{\mathbb{R}} \psi_{a,b}(x)f(x)dx
\]  

(6)

Ordering \( a = 2^j, \ b = 2^j \cdot k \cdot j, k \in \mathbb{Z} \), so binary discrete wavelet function is

\[
\psi_{j,k} = 2^{-j/2} \varphi(2^{-j} x - k)
\]  

(7)

The function \( f(x) \) fits with coefficient \( C_{i,j} \) as

\[
f(x) = \sum_{j \in \mathbb{Z}} \sum_{k \in \mathbb{Z}} C_{i,j} \psi_{j,k}(x)
\]  

(8)

According to feature of aviation cargo inspection signals, select Morlet decompose wavelet which used to detect the signal singularity at first, as

\[
\varphi(x) = \exp(-x^2/2) \cos(1.75x)
\]  

(9)

For constructing the orthogonal basis of Hilbert space, the scale coefficient sequence \( \{h_i\} \) and wavelet coefficient sequence \( \{g_s\} \) are confirmed by the construction condition of compactly supported wavelet. Knowing from wavelet theory, when scale coefficient \( j \) is large enough, the feed-forward network, which includes one hidden layer can approximate a nonlinear mapping with arbitrary function. So we make use of three layers wavelet network in this experiment.

3. INTELLIGENT AVIATION FREIGHT SAFETY INSPECT SYSTEM

For routine inspection tasks cable line, designed based on RFID technology, integrated GPS technology and the current advanced ARM technology in one of the intelligent aviation freight safety inspection system. The intelligent data logging system consists of data logging devices, inspection points and inspection management platform shown as figure 1.

The working principle is the implementation of inspection tasks, inspection personnel handheld data logging devices or vehicle inspection path detection apparatus according to the road, to reach inspection point, inspection point to read RFID tags on the information in the monuments, logging devices will read information and GPS data marked stones together, to create a record of inspection into the CF card. In turn checked all the inspection points, all inspection records have been recorded in the CF card, the task execution after the inspection with a CF card reader to transfer records to the management platform, the management system software analysis and processing, as required to generate Tour inspection reports for management staff to examine (Seth, 2015).
3.1. Inspecting Point

Any inspection tasks should be pre-set inspection route, and strive to do the work of state inspection personnel managers well known, while increasing inspection personnel managers and transparency between. The inspection area is composed by a number of inspection points, and each point has a unique number. Inspection by the patrol route point number sequence is determined. The main role is to inspection point data logging devices with wireless communication, data logging devices to record the inspection point is the address, time and line status signal, indicating that this point has been inspection too.

Inspecting point circuit is mainly in depended on the RFID tag circuit. RFID tag information stored monuments installed in the standard rock, stone marked patrol officers arrived after the RFID tag read information, data logging devices in the CF card will record the number of the monuments, inspection location, inspection time and other information (Simon and Sebastian, 2014).

3.2. Inspection Instrument

Inspection instrument is the key to the inspection system. It is not only with the Inspection Management Workbench wired communications, but also with each inspection point for wireless communications, storage capacity required to ensure that the data does not overflow. Data logging devices overall structure of the ARM processor, memory, power, reset, system JTAG interface, network interface, man-machine interface, RFID reader modules, GPS signal receiver module circuit. The overall structure of the hardware is shown in figure 2.

- Complete system reset circuit at power-on reset and the user when the system reset button.
- Power supply circuit is provided to LPC2210 I/O port operation 3.3V power supply and on-chip peripherals and core 1.8V power supply required.
- FLASH memory to store user application has been debugged, embedded operating system or other systems the user needs to be saved after power-down data.
• SDRAM memory system is running as the main area, system and user data, the stack are located in SDRAM memory.
• 10M Ethernet interface for the system to provide Ethernet access to the physical channel, through the interface, the system can 10Mb/s Ethernet access rates.
• Chip JTAG interface can access all the parts, through the interface of the system debugging, and programming;
• LCD display and keyboard scanning the main provider of human-machine interface so that the system has good man-machine interface.
• Complete RFID reader and RFID tag identification data read.
• Completion of the GPS signals receiver module GPS signal reception.

The design uses a CF card as storage units, which mechanical properties and stability, small size, large capacity. In the inspection process, the processor to external data memory inspection point inspection data and inspection data to the file path stored in the CF card. In order to facilitate computer processing inspection instrument data management software, using the FAT16 file system to receive the data files stored on the CF card, CF card reader, or through the Ethernet port on the computer to read. Data logging devices in the boot after a software program running always in circulation, due to the operation of reading the RFID tag information is intermittent, so the reader with a button to control the operation.

3.3. Inspection Management Platform

Inspection Management Workbench mainly equipped with inspection by the management terminal management software components. Inspection management software to complete the main features include: data communications, data query, system settings and data maintenance. Data communications, including: reading records, clear history, set patrol routes and other functions; data queries, including: query, statistics, printing and other functions; system settings, including: Patrol locale, set the data logging devices, set-up and inspection personnel inspection settings; data maintenance, including data backup and data recovery. System management software is modular in design shown as figure 3.

![Software structure of the system management](image)

**Figure 3. Software structure of the system management**

By the master interface to control the entire system operation to achieve the switching module, the module functions as follows:
• Management system inspection personnel information management module, signal equipment, RFID tags, data logging devices and other information.
• Tag to set the module configuration information stored in RFID tags, RFID tags to set passwords and other operations.
• Inspection before the task, the task management module input inspection tasks, such as inspection personnel, inspection paths.
• Check printing module queries inspection personnel, signal equipment, RFID tag information, and inspection of an officer, a patrol point inspection and so on, need to print out the information by category.
• Inspection instrument data processing module under the module is divided into the following four modules: (1) data import module, import inspection points CF card recording inspection data and path data, and separate the back of the software for processing; (2) inspection of data processing module, the data generated table of inspection points; (3) inspection path data processing module, according to the recorded GPS data, the electronic map showing the path inspection; (4) generate inspection reports, comprehensive analysis of the data processing results to produce inspection the report.
4. SYSTEM OPTIMIZATION DESIGN

4.1. Algorithm optimization

The aviation freight safety inspection method based on the boundary, its essence is to find the minimum sphere containing all positive class samples, outside the spheres are aviation freight area. For the sample set $\mathcal{X} = \{x_1, x_2, \cdots, x_N\}$, wherein the samples are positive class (Singh and Ranade, 2016).

When the radius which surrounded whole sample completely by the minimum sphere is R, the center of the sphere is a, the optimizing equation is:

$$ \min L(R) = R^2 $$ (10)

$$ s.t. R^2 - (x_i - a) \cdot (x_i - a)^T \geq 0 $$ (11)

By equation (1) and (2) Lagrange function can be defined:

$$ L(R, a, \Lambda) = R^2 - \sum_{i=1}^{N} \alpha_i \left[ R^2 - (x_i \cdot x_i - 2a \cdot x_i + a \cdot a) \right] $$ (12)

In Equation (3), $\Lambda = \{\alpha_i\}, i = 1, 2, \cdots, N$; $\alpha_i$ is Lagrange coefficient, $\alpha_i \geq 0$.

By Equation (3) to solve can get the optimization equation:

$$ \max L = \sum_{i=1}^{N} \alpha_i x_i \cdot x_i - \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j x_i \cdot x_j $$ (13)

Constraints are $\sum_{i=1}^{N} \alpha_i = 1$ and $\alpha_i \geq 0$. According to the most optimal condition of KKT, most of the elements in $\Lambda$ are 0, only a small part $\alpha_i > 0$. This corresponds to the boundaries of the sample point determination, namely support vector. From the known $\Lambda$ can calculate the center of the sphere $a = \sum_{i=1}^{N} \alpha_i x_i$.

Optionally a support vector can be calculated and it is from the center of the sphere radius $R$.

Let pending state data point $z$, determine whether it is wild point is based on:

$$ \begin{cases} f(z1) > R^2 \\ f(z2) \leq R^2 \end{cases} $$ (14)

Wherein, z1 are outliers, z2 are not outliers, R is radius. The optimization equation for outlier detection is

$$ f(z) = K(z, z) - 2 \sum_{i=1}^{N} \alpha_i K(z, x_i) - \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j K(x_i, x_j) $$ (15)

$$ E = \frac{1}{2N} \sum_{k=1}^{N} E_k $$ (16)

$$ E_k = \frac{1}{2} \left( f(x_1, \cdots, x_N) - y_k \right)^2 $$ (17)

4.2. Learning rate

In the learning process of fuzzy neural network, the variety of the learning rate will have great influence on the network training. The training inspection samples and subsequent verification inspection samples in this paper are all calculated according to the following formula. The influence of network training convergence circumstance with the different was listed in the table 2.

\begin{table}[h]
\centering
\caption{Training times for expected precision}
\begin{tabular}{|c|c|c|c|c|}
\hline
Learning rate & Sample quantity & Training quantity & Expected value & Final value \\
\hline
0.01 & 27 & 214 & 0.005 & 0.00494 \\
0.02 & 27 & 111 & 0.005 & 0.00493 \\
0.03 & 27 & 114 & 0.005 & 0.00490 \\
\hline
\end{tabular}
\end{table}

From table 2 can get, with different learning rate, the training times of network is also different when it attains same scratches. The mainly reason is the revising range of network parameter will get smaller when $\eta$.
value is small. As a result attained the certain precision will increase the training times. When the $\eta$ value is big, the revising ranges of the network parameter will also getting bigger along with the reducing of the training times. The curve of net training rate in figure 4 also explains same result. Certainly, if value demand can be satisfied, we should choose the bigger learning rate as far as possible to improve the network training speeds. If $\eta$ value is so big, the network will appear shakes and the scratches curve will become not smooth, therefore confirm the learning rate is 0.02 based on this cause.

\[\text{Figure 4. The curve of net training}\]

5. CONCLUSIONS

This design of intelligent aviation freight safety inspection system consists of hand-held line inspection device, inspection points and inspection management software system. The system combines radio frequency identification (RFID), global positioning satellite (GPS), embedded systems technology, and to intelligently manage the regular cable line maintenance personnel traveling and temporary road conditions, while taking advantage of the system management platform built for all levels of maintenance and management personnel to provide intelligent information services.

System through simple improvements can be further extended to railway inspection, pipeline inspection, intelligent community patrol inspection and other key targets. This system not only can be used for line management, but also in the maintenance of special equipment, industrial pipelines, roads, railways, airways, urban transport, water conservancy fields and many have broad application prospects.

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