Intelligent Elevator Safety Detection System Based on Cloud Service Big Data

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Abstract: Elevator safety accidents often occur in people's daily lives. It is very important to perform 24-hour real-time testing of elevators in daily operation. This paper proposes a smart elevator security detection system based on cloud server distributed architecture and big data algorithm technology to solve the problem of elevator security detection. The C4.5 algorithm can process incomplete data with high accuracy, and can quickly analyze the operation of the elevator, which is convenient for maintenance personnel to quickly repair and protect people's safety.

1 INTRODUCTION

As a special equipment for mechatronics, elevators are inextricably linked with people's daily lives. For high-rise buildings, the use of elevators as a means of transportation greatly facilitates people's travel, saving time and improving the efficiency of office and life. While the elevator brings convenience to people's work and life, like other special equipments, its safe and reliable operation and hidden dangers also attract people's attention. In the event of an accident, it is easy to cause casualties and affect public safety (Park and Yang,2010) (Hang and Guo-jun, 2012) (Xu and Zhao, 2014).

At present, the following treatment process is often used for the troubleshooting of elevators: when the elevator fails or an accident occurs, the elevator owner or the property department makes a request to the elevator maintenance department, and then the maintenance personnel arrive at the scene to troubleshoot, and the handling of the accident lags behind.With the development of the Internet of Things technology, the remote monitoring and diagnosis system of the elevator will provide guidance and support for the maintenance personnel to eliminate the fault in the first time(Niu,Lee and Yang,2018)(Ertuğrul Durak and Yurtseven,2016). Remote Elevator Monitoring System (REMS) refers to the remote monitoring, data management, maintenance, statistics, analysis, fault alarm and rescue of multiple elevators installed in a building in a certain area(Lu ,Wang and Liu,2018)(Pisani and Zucco,2018)(Katakura and Kuroda,2015)(Jin, Zhao and Ji,2018). However, today's elevator remote monitoring systems have more or less defects, such as: the failure analysis of the elevator is not in place, the maintenance is inconvenient, the test results are not stored, and it is not convenient for personnel to check.

This paper proposes a new type of elevator detection scheme, which is improved on the basis of the elevator remote monitoring system. Large-capacity data storage, cloud servers and smart interconnects enable the system to analyze elevator operation problems from large amounts of data while processing big data, so that maintenance personnel can prescribe the right medicine. The rapid analysis and processing of the information enables rapid response when the elevator fails, and timely feedback to the computer, so that the maintenance personnel can repair the elevator in the shortest time. The detection system consists of front-end sensor detection terminals, cloud servers, big data recognition and analysis algorithms. Once the elevator runs out of problems, the server or maintenance enterprise manager will feedback the results to the elevator maintenance engineer for the first time, which will help the elevator repair to quickly reflect and repair (Yi and Zhang,2018)(Crespo, Kaczmarczyk and Picton,2018)(Sun,2017).

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2 SYSTEM IMPLEMENTATION PRINCIPLE

2.1 Program Function Block Diagram

Figure 1 is a schematic diagram of the structure of the intelligent remote elevator monitoring system.

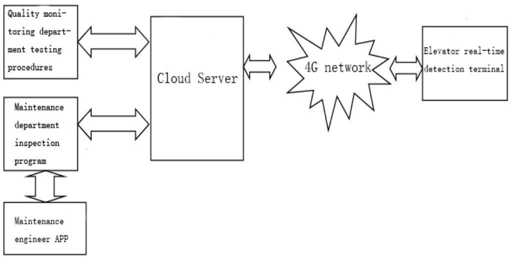

Figure 1: Schematic diagram of structure.

The system uses a speed sensor,a sound sensor,a frequency sensor,a light level layer sensor, and a current sensor as terminal data acquisition devices. Use Arduino to process the collected data and send the data to the cloud via arduino's wifi module. The C4.5 algorithm is used to analyze the data transmitted to the cloud, predict whether the elevator is faulty and the cause of the failure, and transmit the elevator to the maintenance department and the elevator manufacturer.

The following figure is a big data algorithm topology of the big data detection system:

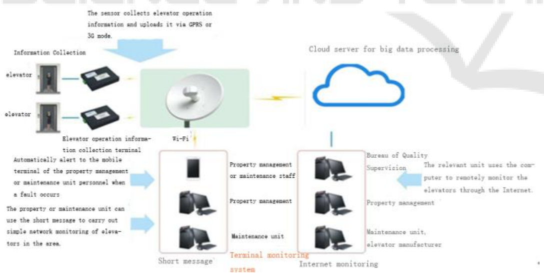

Figure 2: Big data algorithm topology.

2.2 Algorithm Principle

The specific calculation process of the algorithm is as follows:

Below we set:

(1) Acceleration(Ac)(m/s2): Ac > 1.5 is high, 0.9 < Ac < 1.5 is medium, Ac < 0.9 is low.

(2) LevelingAccuracy(LA)(mm): |LA| > 15 is high, 10 < |LA| < 15 is medium, |LA| < 10 is low.

(3) UpstreamCurrent(UC)(A): UC > 11 is high, 9 < UC < 11 is medium, UC < 9 is low.

(4) VibrationFrequency(VF)(Hz) VF>10k is high,1000<VF<10k is medium,VF<1000 is low.

(5) RunningNoise(RN)(dB) RN > 50 is high, 20 < RN < 50 is medium, RN < 20 is low.

(6) Classification(Cla): 1. circuit failure; 2. chain failure; 3. engine failure; 4. runner failure; 5. no fault;

We did a series of experiments, the experimental data shows the fault category statistics when different variables are used. And the data table is placed in the appendix. And we'll use C4.5 algorithm to calculate the data and draw the decision tree.

1. Computing the Information Entropy:

S1(circuit failure) = 446,
S2(chain failure) = 331,
S3(engine failure) = 2977,
S4(runner failure) = 1363,
S5(no fault) = 1087,
S = S1 + S2 + S3 + S4 + S5 = 6204

$$\mathrm{Info}(D) = \sum_{i=1}^{5}\left(P(Si/S) * \log_2 \frac{1}{P(Si/S)}\right) = 1.9251$$

2. Computing the Information Entropy of Each Attribute:

Info(UpstreamCurrent-high) = 1.6223
Info(UpstreamCurrent-medium) = 1.8478
Info(UpstreamCurrent-low) = 1.5399
Info(UpstreamCurrent)
= 2145/6204 * Info(UpstreamCurrent-high) + 1663/6204 * Info(UpstreamCurrent-medium) + 2396/6204 * Info(UpstreamCurrent-low)
= 1.6510

3. Computing the Information Gain:

Gain(UpstreamCurrent)
= Info(D) – Info(UpstreamCurrent) = 0.2755

4. Computing the Attribute Splitting Information Measure:

H(UpstreamCurrent) = 1.5690

5. Computing the Information Gain Ratio:

IGR(UpstreamCurrent)
=Gain(UpstreamCurrent) / H(UpstreamCurrent)
= 0.2755 / 1.5690
= 0.1756

Similarly, we can compute the IGR of other attributes:

IGR(Acceleration) = 0.1635
IGR(VibrationFrequency) = 0.1534
IGR(RunningNoise) = 0.1265
IGR(UpstreamCurrent) = 0.1383

Based on the above calculation results, we can set "UpstreamCurrent" as the root node of the decision tree. Similarly, we can calculate and get all the leaf nodes. And the final decision tree is as follows:

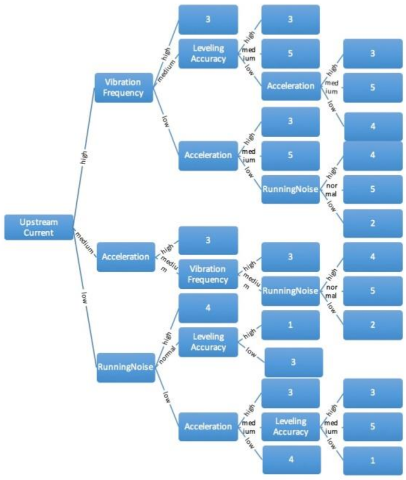

Figure 3: Decision tree.

1. By taking the measured data of the sensor into the tree for analysis and comparison, it is possible to predict the cause of the elevator failure.

3 ANALYSIS OF RESULTS

The system establishes the simulation environment through MATLAB, and uses C4.5 algorithm and ID3 algorithm to test in the elevator load range. In the simulation test, the actual load of the elevator is no load, load 50%, load 70%, load 100%, and the remaining variables are controlled to obtain the following data:

Table 1: Data from simulation experiments.

Load	Testing frequency	C4.5 forecast situation (number of times, classification)	ID3 forecast situation (number of times, classification)	The actual situation (number of times, classification)	Relative error (C5.4)	Relative error （ID3）
0%	50	(5,1)	(5,1)	(5,1)	2%	14%
		(17,2)	(17,2)	(16,2)		
		(11,3)	(9,3)	(11,3)		
		(8,4)	(7,4)	(8,4)		
		(9,5)	(12,5)	(9,5)		
				1 other failure		
50%	50	(3,1)	(1,1)	(3,1)	0%	12%
		(21,2)	(20,2)	(21,2)		
		(7,3)	(7,3)	(7,3)		
		(5,4)	(8,4)	(5,4)		
		(14,5)	(14,5)	(14,5)		
				0 other failures		
70%	50	(11,1)	(13,1)	(11,1)	6%	8%
		(3,2)	(3,2)	(2,2)		
		(3,3)	(1,3)	(4,3)		
		(19,4)	(19,4)	(18,4)		
		(14,5)	(14,5)	(14,5)		
				1 other failures		
100%	50	(5,1)	(5,1)	(5,1)	2%	14%
		(9,2)	(10,2)	(9,2)		
		(18,3)	(18,3)	(17,3)		
		(3,4)	(0,4)	(3,4)		
		(15,5)	(17,5)	(15,5)		
				1 other failures		

It can be seen from the test data that within the load range, the prediction of the C4.5 algorithm has little error with the actual situation, and the error rate is lower than that predicted by the ID3 algorithm, which also indicates that the system is very good in practical application. Performance. The following figure shows the MATLAB simulation speed, uplink current, and leveling accuracy.

Figure 4: Speed simulation diagram.

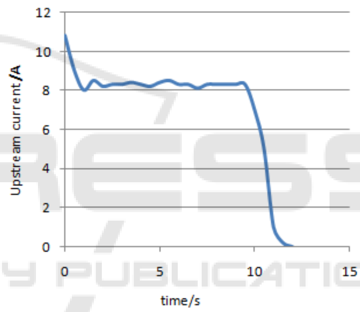

Figure 5: Uplink current simulation diagram.

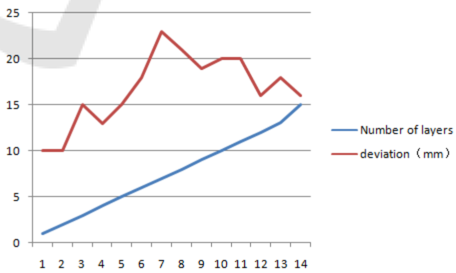

Figure 6: Naughty precision simulation.

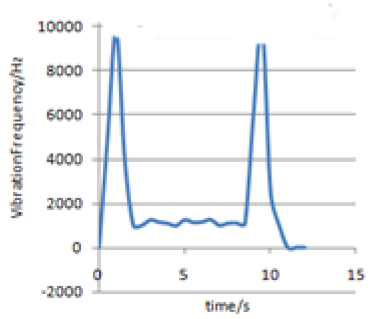

Figure 7: Vibration frequency simulation diagram.

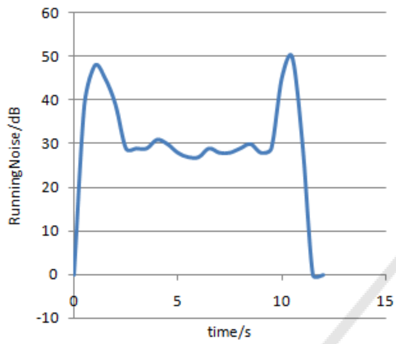

Figure 8: Running noise simulation diagram.

It can be concluded from the simulation diagram that the average acceleration of the elevator is 1.25m/s2, the upstream current is 8.3A, the leveling accuracy is 16.7mm, the vibration frequency is 9900Hz, and the running noise is 51dB. It can be obtained from data analysis, and the elevator has runner failure.

4 CONCLUSIONS

With the wide application of elevators, elevator use units should continuously strengthen the detection of elevators in accordance with the actual situation, eliminate various problems and hidden dangers in the operation of elevators, avoid more safety accidents, and ensure the personal safety of passengers. The system detects whether there is a fault in the elevator from the acceleration of the elevator running, the displacement of the car and the current when the elevator is running, and reflects the situation of the elevator to the terminal of the maintenance department in real time, reducing the detection of manpower, and the safety of the elevator is improved.

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APPENDIX

Cnt	UC	LA	Ac	VF	RN	Cla
45	high	high	high	high	high	3
56	high	high	medium	high	high	3
76	high	high	medium	high	medium	3
34	high	medium	medium	high	medium	3
45	high	medium	low	high	medium	3
67	high	medium	low	high	low	3
45	high	high	high	medium	medium	3
76	high	high	medium	medium	medium	3
56	high	high	low	medium	low	3
42	high	medium	high	medium	high	5
82	high	medium	high	medium	medium	5
45	high	medium	medium	medium	medium	5
76	high	medium	low	medium	medium	5
27	high	medium	low	medium	low	5
65	high	low	high	medium	high	3
47	high	low	high	medium	medium	3
27	high	low	high	medium	low	3
85	high	low	medium	medium	medium	5
45	high	low	medium	medium	low	5
37	high	low	low	medium	medium	4
52	high	low	low	medium	low	4
72	high	high	high	low	high	3
37	high	high	high	low	medium	3
42	high	high	high	low	low	3
87	high	medium	high	low	medium	3
65	high	medium	high	low	low	3
60	high	low	high	low	low	3
21	high	high	medium	low	high	5
36	high	high	medium	low	medium	5
59	high	high	medium	low	low	5
33	high	medium	medium	low	medium	5
49	high	medium	medium	low	low	5
62	high	low	medium	low	low	5
35	high	high	low	low	high	4
63	high	medium	low	low	high	4
25	high	low	low	low	high	4
45	high	high	low	low	medium	5
64	high	medium	low	low	medium	5
27	high	low	low	low	medium	5
45	high	high	low	low	low	2
65	high	medium	low	low	low	2
23	high	low	low	low	low	2
45	medium	high	high	high	high	3
64	medium	high	high	high	medium	3
53	medium	high	high	high	low	3
35	medium	high	high	medium	medium	3
45	medium	high	high	medium	low	3
63	medium	high	high	low	medium	3
47	medium	medium	high	high	high	3
42	medium	medium	high	high	medium	3
68	medium	medium	high	high	low	3
49	medium	medium	high	medium	medium	3
30	medium	medium	high	medium	low	3
53	medium	medium	high	low	medium	3
48	medium	medium	high	low	low	3
31	medium	low	high	medium	medium	3
57	medium	low	high	medium	low	3
43	medium	low	high	low	medium	3
53	medium	low	high	low	low	3
67	medium	high	medium	high	medium	3
64	medium	high	medium	high	low	3
43	medium	medium	medium	high	medium	3
53	medium	medium	medium	high	low	3
64	medium	low	medium	high	low	3
64	medium	high	medium	medium	high	4
65	medium	medium	medium	medium	high	4
45	medium	low	medium	medium	high	4
64	medium	high	medium	medium	medium	5
65	medium	medium	medium	medium	medium	5
45	medium	low	medium	medium	medium	5
75	medium	high	medium	medium	low	2
67	medium	medium	medium	medium	low	2
56	medium	low	medium	medium	low	2
48	low	high	high	high	high	4
42	low	high	normal	normal	high	4
56	low	high	normal	low	high	4
53	low	high	low	normal	high	4
35	low	high	low	low	high	4
45	low	medium	high	high	high	4
63	low	medium	high	normal	high	4
23	low	medium	normal	normal	high	4
41	low	medium	normal	low	high	4
53	low	medium	low	normal	high	4
61	low	medium	low	low	high	4
40	low	low	high	high	high	4
35	low	low	high	normal	high	4
39	low	low	normal	normal	high	4
50	low	low	normal	low	high	4
61	low	low	low	normal	high	4
34	low	low	low	low	high	4
45	low	high	high	high	medium	1
63	low	high	high	normal	medium	1
26	low	high	medium	high	medium	1
84	low	high	medium	normal	medium	1

53	low	high	medium	low	medium	1
64	low	high	low	normal	medium	1
24	low	high	low	low	medium	1
53	low	low	high	high	medium	3
24	low	low	high	normal	medium	3
56	low	low	medium	high	medium	3
60	low	low	medium	normal	medium	3
50	low	low	medium	low	medium	3
42	low	low	low	normal	medium	3
56	low	low	low	low	medium	3
42	low	high	high	high	low	3
23	low	high	high	medium	low	3
75	low	high	high	low	low	3
42	low	medium	high	high	low	3
50	low	medium	high	medium	low	3
61	low	medium	high	low	low	3
42	low	low	high	medium	low	3
29	low	low	high	low	low	3
49	low	high	medium	high	low	3
52	low	high	medium	medium	low	3
52	low	high	medium	low	low	3
39	low	medium	medium	high	low	5
46	low	medium	medium	medium	low	5
30	low	medium	medium	low	low	5
63	low	low	medium	high	low	1
24	low	low	medium	medium	low	1
63	low	high	low	high	low	4
23	low	high	low	medium	low	4
41	low	medium	low	high	low	4
42	low	medium	low	medium	low	4
29	low	low	low	medium	low	4