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A System with Minimal Redundancy for Intelligent Prediction Management

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Abstract. This paper proposes a predictive redundancy method for management, which is used for intelligent prediction management, which can effectively improve the real-time online reliability of agents. This method changes the multi-redundant post-processing scheme of traditional system and adopts single-redundant real-time pre-switching. Through a large number of experiments, the feasibility of the system is verified, and the system can be built as a redundant fault-tolerant system. The redundant fault-tolerant system has good generalization and can be implemented in the scene. A redundant module that is about to fail is used, including: the proposed redundant module that continues to decline in health, a redundant module that rapidly decreases in health at a certain time, and a redundant module that is always in a sub-healthy state. After the health assessment, you can enter the early warning model and observe whether the early warning model can issue a health warning, which can verify the effectiveness of the early warning model.

Keywords. AI, neural networks, health prediction, aircraft

1. Introduction

Most of the traditional redundant fault tolerance technologies [1-3] are fault-tolerant control [4-8] through the advance design of the expert knowledge base [9], which can successfully identify fault errors after they occur, but it is difficult to achieve prophetic prediction of fault errors and find unknown errors [10]. In the redundant system, the slight accidents of each redundant module are perceived and recorded through intelligence technology [11-14], and early warning based on these minor accidents [15] can avoid the occurrence of serious accidents with a high probability.

This article addresses the above problems and introduces the latest methods of neural network technology into redundant fault-tolerant systems. By calculating the health of each redundant module, using the active redundancy fault tolerance method to prejudge in advance, select a better redundant module to perform operations, and improve the redundancy fault tolerance performance.

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2. System Composition

Through the analysis of the health of the module's historical state and current state, the early warning model realizes the prediction of faults and improves the reliability of the system. The specific steps are as follows:

(1) Build a sensor waveform transformation system;

(2) In the health state, record the input and output of the minimum system, and build the health state data set;

(3) Investigate and analyze the common faults of the system, artificially create faults, and construct different degrees of fault data sets;

(4) Use the constructed data set to train and fine-tune the redundant fault-tolerant system;

(5) Use data of different health levels to test whether the health assessment model can give appropriate health degrees;

(6) Enter a set of health data and fault data at the same time to verify whether the decision model can give the correct output;

(7) A set of data on the sharp decline in health, a set of data on the continuous decline in health and a set of long-term sub-health data are given to test whether the early warning model can give early warning.

3. Model Implementation

The function of the waveform transformation system is to transform one waveform into another waveform, as shown in figure 1 to transform a sine wave into another sine wave, and figure 2 converts the square wave into a triangular wave.

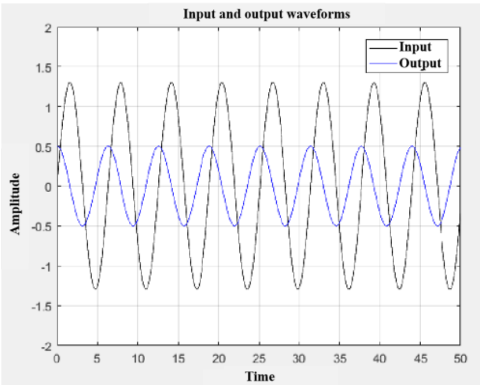
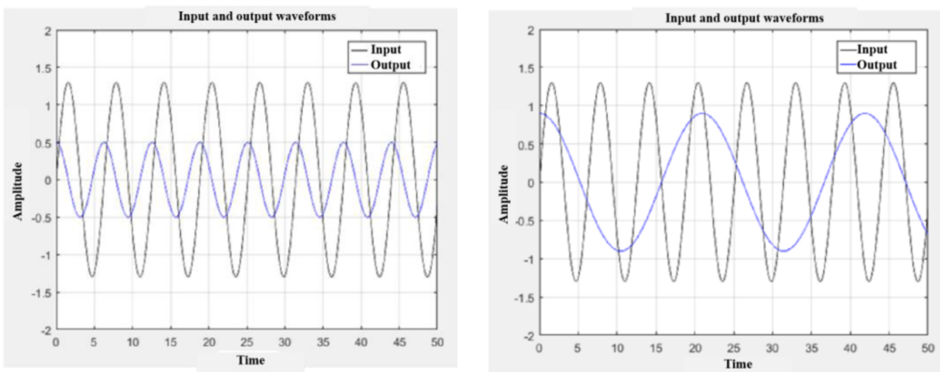


Figure 1. Sine wave input and output waveform diagram.

The advantages of JFET input amplifiers over bipolar devices are their very high input impedance and low noise performance, making them ideal for the accurate acquisition of data from this solution. The selection basis for the resistance of this system is as follows. In this solution, the appropriate resistor should be selected because the frequency, amplitude, and gain value of the signal conversion circuit of the input signal need to be constantly changed. In terms of resistor selection, the permissible error, rated power, maximum operating voltage, temperature coefficient and noise of the resistor need to be considered. Among them, the allowable error of the general metal film resistance is 5%, and the allowable error of the precision resistance can reach 0.001%. The rated power of common resistors is 0.125W, 0.25W, 0.5W, 5W, 10W and other specifications, in the application, the resistor rating value should be higher than the actual value in the circuit 1.5 to 2 times more. The temperature coefficient of a resistor is the percentage of the relative change in resistance value caused by every 1°C change in temperature. Resistance noise fluctuates due to the resistance value caused by irregular voltage and current in the resistor. In this design, a carbon film resistor (CFR/CCR) is proposed, which has stable performance, a resistance range of $0\,\Omega$ to $22\,\mathrm{M}\Omega$, a small size, and an operating temperature of -55°C to 125°C and limit voltage are higher. And its pulse load adaptability is strong, high frequency characteristics are good.

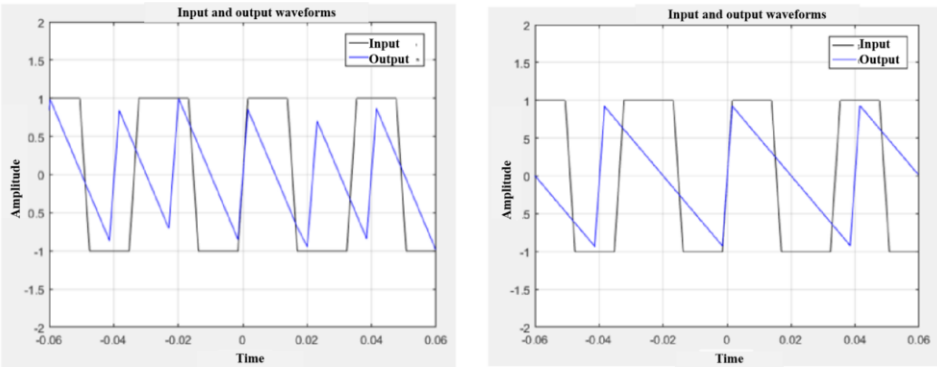
Commonly used capacitors are fixed capacitors, which are divided into inorganic dielectric capacitors and organic film capacitors. The former mainly includes mica capacitors, porcelain dielectric capacitors and monolithic capacitors; the latter mainly includes paper dielectric capacitors, metalized paper dielectric capacitors and polystyrene capacitors. Among them, the porcelain dielectric capacitor has the advantages of small temperature coefficient, high stability, low loss and high withstand voltage, and the maximum capacity does not exceed 1000 pF, which is suitable for high-frequency circuits; polystyrene capacitor insulation resistance is large, the dielectric loss is small, the capacity is stable, and the accuracy is high, which is suitable for medium and high frequency circuits. Therefore, in this scheme, it is possible to switch between a ceramic dielectric capacitor with different resistance values and a polystyrene capacitor, which are shown as in figures 2 and 3.



(a) The resistance capacitance is normal

(b) Resistance capacitance offset

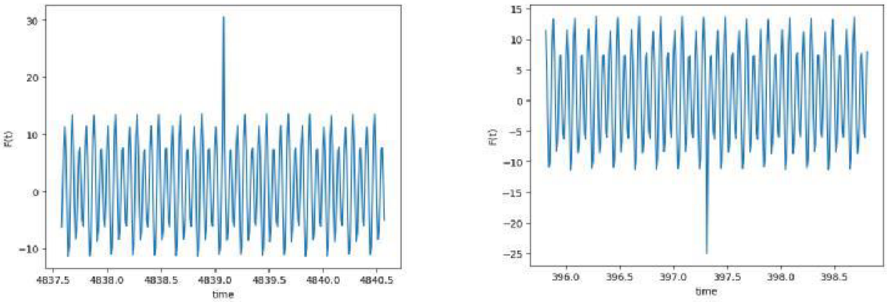
Figure 2. Sine wave input and output waveform diagram.



(a)The resistance capacitance is normal (b) Resistance capacitance offset

Figure 3. Triangle wave input and output waveform diagram.

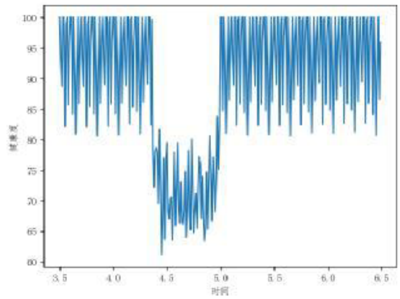
Some of the fragments of the generated data are shown in the figure 4:



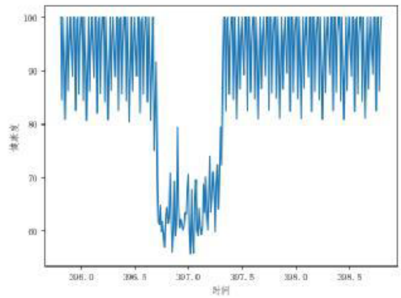
(a) Positive fragments (b) Negative fragments

Figure 4. Fragment of data with singularity.

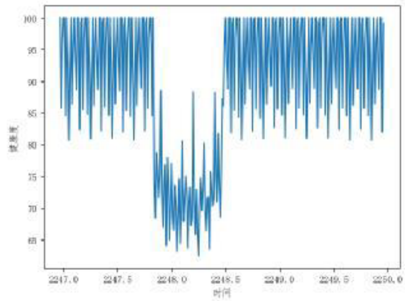
As shown in the figure, the data contain singularities, or "spike peaks," and are present for a very short time. Enter the data into the health assessment model to see if the model can capture the presence of singularities, and the experimental results are as follows:



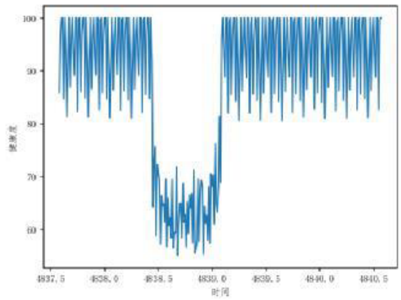
(a) 5s singularity and its vicinity health curve



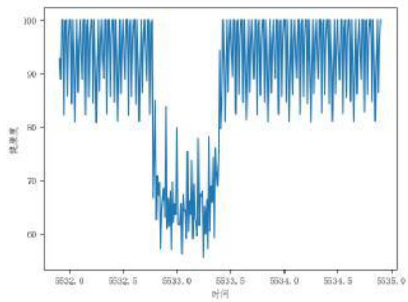
(b) 397s singularity and its vicinity health curve



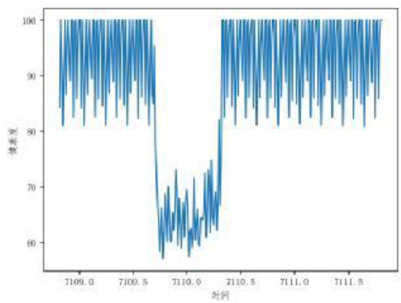
(c) 2248s singularity and its vicinity health curve



(d) 4839s singularity and its vicinity health curve



(e) 5533s singularity and its vicinity health curve



(f) 7110s singularity and its vicinity health curve

Figure 5. Singularity and its vicinity health curve.

It can be seen from the figure 5 that in and around the 6 singularities, the health curve has decreased significantly, that is, the health assessment model can effectively sense the above 6 singularities. Among them, the degree of decline of the health curve is proportional to the amplitude of the impulse function, that is, the larger the amplitude, the more prominent the spike, and the greater the impact on the health curve. In summary, for singular signals with a very short action time, the health assessment model will not ignore them and can be effectively identified.

4. Summary

Typical symptoms of traditional system failures are abnormal vibration, increased noise, and abnormal heat generation. For the smallest system with a simple structure such as a waveform transformation system, the failure of the system may not cause too many changes in vibration, noise and heat generation, and this external sensing parameter contains less fault information. Although parametric faults do not lead to a complete loss of circuit functionality, they can cause changes in circuit output characteristics and deviations in the overall or partial performance of the system, resulting in the system not being able to complete the specified functions as required. For the smallest system with clear functions such as the waveform transformation system, once the function and performance of the system are changed, the impact on the output of the system is very obvious, and it is easy to observe and extract. As shown in the paper, after the resistance or capacitance in the integrating circuit changes, the signal frequency and amplitude at the output of the integrating circuit also change.

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