Abstract

Aiming at the complex characteristics of aircraft structural strength test environment, the research on the extraction method of abnormal sound source signal of aircraft structure is carried out. The empirical mode decomposition method is used to reduce the noise of the sound source. The end point detection of the noisy signal is carried out by the Teager energy operator plus the two-parameter double threshold method of short-time zero-crossing rate, which forms an abnormal sound source for aircraft structural strength test. Signal extraction method. The method was verified by extracting the abnormal sound source signal of the actual structure of the aircraft such as the fracture of the composite board and the rivet fracture. The results show that the proposed method can accurately extract the abnormal sound source signal of aircraft structure in the signal with background noise, and is suitable for the extraction of abnormal sound source signals in the complex environment of aircraft structural strength test. At the same time, it lays a technical foundation for the rapid positioning of aircraft acoustic source and the identification of sound source characteristics. Key words abnormal sound source signal extraction aircraft structural strength test Chinese map method classification number V216 Chang 5; document identification code B   During the structural strength test of the aircraft, abnormal sounds may occur in the structure of the aircraft. These sounds indicate that the aircraft structure is damaged or a precursor to damage. It is very important to quickly locate the sound source location and identify the sound source type according to the sound source characteristics in providing test decision support and timely detecting test risks. Aircraft structural strength test site environment is more complex, including the aircraft structure itself and numerous test devices. At the same time as the aircraft structure is abnormally sounded, it is usually accompanied by background noise generated by equipment, personnel, etc. in the test environment. In addition, the time domain signal of the aircraft structure sound is usually in the order of milliseconds. Therefore, how to accurately extract structural anomalous sound source signals in a mixed noise environment has become a key technical problem for realizing rapid positioning of sound sources and identification of sound source types. The key to effective extraction of short-term pulse signals in a mixed-noise environment is signal noise reduction and signal endpoint detection. A lot of researches have been done on signal noise reduction researchers. Various signal denoising methods such as fixed target filtering, adaptive filtering and singular value decomposition have been successfully applied in various fields such as aviation, shipbuilding and automobiles [1–3]. For the detection method of signal endpoints, the research and application of short-time energy method are mainly concentrated. Zhang Yahui et al. used short-time energy and short-time amplitude methods to detect the endpoints of unexploded ordnance audio signals [4]. Zhou Zhengxian et al. used the short-time energy method to realize the endpoint detection of distributed fiber sensor vibration signals [5]. Yin Ming Received funding from the Aviation Fund (20150981006) on August 11, 2016 Introduction to the first author: He Qian (1980—), male, senior engineer. Research direction: full scale Inch aircraft structure static / fatigue test technology. E-mail: heqianrun@163 com. Reference format: He Qian, Feng Jianmin, Han Kai. Aircraft structural strength test abnormal sound source letter Research on extraction method [J]. Science Technology and Engineering, 2017, 17(5): 312-315 He Qian, Feng Jianmin, Han Kai. Exceptional sound sources signal ex-traction in aircraft structural strength test [J] . Science Technology and Engineering, Wan 20 Party 17, Number 17 Data (5): 312-315   The et al. used the short-time energy and zero-crossing rate method to detect the endpoint of the speech signal [6]. However, the short-term energy method is suitable for the case where the target audio signal energy and noise energy are very different [7]. For the aircraft structural strength test, the signal energy of the aircraft structure sound is equivalent to the background noise energy generated by the test equipment, personnel, and the like. In the previous research, it was also found that the short-time energy method could not accurately intercept the signal of the abnormal sound of the aircraft structure. Therefore, the short-term energy method is not suitable for the endpoint detection of abnormal sound source signals in aircraft structural strength tests. In this paper, based on the characteristics of the aircraft structure test environment, the audio signal denoising is performed by the empirical mode decomposition method, and the Teager energy operator is used. The two-parameter and double-threshold method of short-time zero-crossing rate is used to detect the end point of the signal, and a set of abnormal sound source signal extraction method suitable for aircraft structural strength test is formed, which lays a technical foundation for realizing abnormal sound source localization and sound source feature identification. . 1 Sound source signal extraction method In the aircraft structural strength test, the abnormal sound of the aircraft structure is usually accompanied by background noise in the test environment. Therefore, the effective extraction of the structural abnormal sound source signal is realized, including the noise reduction and endpoint detection of the sound source signal. 1.1 EMD-based noise reduction method Empirical mode decomposition (EMD) method [8] based on the local feature time scale of the signal, the letter The number is decomposed into several intrinsic mode functions (IMFs) with certain physical meanings, including high frequency to low frequency. The signal frequency component, the bandwidth is determined by the characteristics of the signal itself. Since each IMF contains a range of feature scales, Can be used to filter or denoise the signal [9,10]. Specific steps based on EMD noise reduction include:   (5) Calculate the zero-crossing rate, in order to 5 He Qi, et al. Study on the method of extracting abnormal sound source signals from aircraft structural strength test 313   Let the signal x(t) = s(t) + n(t), where s(t) represents the useful signal and n(t) represents the noise signal. (1) Perform EMD decomposition on the noisy signal x(t) to obtain the k-order IMF component and residual component. (2) Calculate the energy density En of each order IMF and the corresponding average period Tn. - - - (3) Find the IMF component of ln E +ln T /ln T≥α (α When the signal is from 0 to 25 to 0, the filtering effect is stable. (4) The above IMF component is threshold threshold processed. (5) The demodulated signal is obtained by recombining the IMF component and the residual component. 2 2 sound source signal endpoint detection method Double with Teager energy operator and short-term zero-crossing rate as parameters The parameter double threshold method performs end point detection of the sound source signal. The Teager energy operator is a nonlinear operator proposed by Kaiser [11], which can Effectively extract the "energy" of the signal. The abnormal sound of the aircraft structure is a stable or semi-stable signal. The Teager energy operator can strengthen the stable or semi-stable signal, attenuate the unstable signal, and have the characteristics of the nonlinear energy tracking signal, which can obtain a reasonable signal energy change. The amplitude envelope of the signal and the change in the instantaneous frequency of the FM signal are very sensitive. For the Teager energy operator definition for discrete time systems [12]: T[xi (m)] = [xi (m)] 2 -xi ( m +1) xi ( m -1); m =1,2, ,N (1) In equation (1), it is assumed that the time sequence of the sound signal is x(n), and the ith frame sound signal obtained by windowing and frame processing is xi (m) and the frame length is N. The short-time zero-crossing rate is also an important indicator of the sound signal. It refers to the number of times a frame of a sound signal crosses the horizontal axis (zero level), that is, the number of times the sample is sampled to change the symbol. The short-term zero-crossing rate can be defined as [13] : N -1 Zn = 1 ∑ sgn[xn (m)] -sgn[xn (m -1)] 2 m =0 (2) In equation (2), N is the frame length; sgn is a function for finding the value of the point Number, ie Sgn( x ) = 1, x ≥ 0 (3) -1, x <0   1.3 effective sound source extraction method According to the characteristics of the aircraft structural strength test environment, the EMD method is used for noise source noise reduction. The endpoint detection of the sound source signal is carried out by the two-parameter double threshold method, and the accurate extraction of the abnormal sound source signal of the aircraft structure is finally realized. Figure 1 is a flow chart of the method for extracting effective sound source signals. Specific steps are as follows. (1) Perform EMD decomposition on the noisy tone signal x(t) to obtain a series of IMFs, analyze the current environmental noise effects, remove the spurious patterns in the IMF, and then perform combined reconstruction on the IMF of the sound. (2) Framing the reconstructed signal x珓(t) x珓i(m) for each frame Then perform EMD decomposition to get a new set of IMFij (m). Where the superscript i is represented as the i-th frame, and the subscript j is represented as the jth after the EMD decomposition Order mode; m is the time sequence number. (3) Calculate Teager energy for each order of IMFji m components, and Calculate the average: N Eji 1 ∑ T IMFji m i [ ( 4) = N m =1 )] (4) i Add the Ej of each order IMF component to get the signal per frame TE, superscript i is expressed as the i-th frame; L TEi =∑ Eij j =1 (5) For the original noisy signal x n Ensure that the zero-crossing rate calculation is stable, and the excluded signal may have some slight drift, so when inputting the windowed framed speech signal When x i m, do the center clipping processing, ie Xi (m), xi m >δ Xi m = xi m (6) 0, <δ In the formula (6), δ is a small value. (6) After determining the zero-crossing rate, the TEi of each frame signal is combined, and the endpoint detection is performed by using the two-parameter double threshold method. The threshold value is not set to a constant value, and the adaptive threshold is adjusted dynamically as the preamble has no abnormal sound segment noise. 2 Sound source signal extraction method verification In the laboratory environment without obvious background noise, two kinds of pure aircraft structural abnormal sounds were collected, which were the sound signals of composite board fracture and rivet fracture. In this environment, conventional endpoint detection technology was used.   Figure 1 Flow source signal extraction method flow The Process of sound source signal extraction

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