A Preliminary Study Application Clustering System in Acoustic Emission Monitoring

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Abstract. Acoustic Emission (AE) is a non-destructive testing known as assessment on damage detection in structural engineering. It also can be used to discriminate the different types of damage occurring in a composite materials. The main problem associated with the data analysis is the discrimination between the different AE sources and analysis of the AE signal in order to identify the most critical damage mechanism. Clustering analysis is a technique in which the set of object are assigned to a group called cluster. The objective of the cluster analysis is to separate a set of data into several classes that reflect the internal structure of data. In this paper was used *k*-means algorithm for partitioned clustering method, numerous effort have been made to improve the performance of application *k*-means clustering algorithm. This paper presents a current review on application clustering system in Acoustic Emission.

1 Introduction

The Acoustic Emission technique has been widely used in the field civil engineering for structural health monitoring (SHM) [1-6]. Structural health monitoring (SHM) refers to the process of implementation on early damage detection of incipient defects. An acoustic emission (AE) signal is an ultrasonic wave emitted from the sudden release of the strain energy when damage happens, for instance interface debonding, fibre breakage and matrix cracking in composite materials [7-10]. AE signals contain useful information regarding on the damage mechanisms. A major challenge of AE analysis is how to discriminate the AE signals due to the different damage mechanisms [10-13]

Generally accepted ways of discriminating AE signals is cluster analysis. Cluster analysis can be define as generic name for variety of mathematical method, classification numbering in hundreds and that can be used to find out the similarity[14]. The three important things in cluster analysis which are, the selection of AE parameters will be used, choosing the clustering algorithm and validation of the define cluster [15-17].

Many researchers have developed techniques to find out the damage classification by means of AE signal parameters [18-21]. The AE parameters are using to distinguish the type and stage of failure and the integrity of the materials [22-24]. Therefore based on the

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literature, detail definition about clustering method is partition data object such as patterns, entities and unit in some category and it also the analysis of some object into cluster based on the similarity characterization as shown in Fig. 1[9].

Fig. 1. Cluster based on the similarity.

2 Previous research on AE clustering system

This review paper based on the combining information from available literature journal paper since 2010 till 2016. Table 1a, b and c was shown the previous research focusing on the application of clustering system in Acoustic Emission (AE) and review on AE. The Applications on AE clustering systems are currently well known in term of damage classification. The methods are Neural Network, Artificial Neural Network (ANN), Supervised Clustering and Unsupervised clustering [17, 18, 24]

Table 1. Summary of previous research based on application of clustering in AE.

Year	Ref	Country	Title	Findings
2010	Calabrese et al. [13]	Italy	Use of cluster analysis of acoustic emission signals in evaluating damage severity in concrete structures	Two kinds of unsupervised clustering method was used such as principal component analysis (PCA) and self-organized map (Kahonen map). Combining both method it has been possible to quantify the damage severity and to identify the development of damage itself.
2011	Ono [1]	Los Angeles	Acoustic Emission in material research	Review the progress in method of signal analysis used in Acoustic Emission (AE) as applied to materilas research. The achievment and inadequacy regarding AE from materials during deformation, fracture and other processes are examined systematically.

Year	Ref	Country	Title	Findings
2013	Pomponi and Vinogradov [14]	Russia	A real-time approach to acoustic emission clustering	New evolutionary clustering algorithm which is adaptive sequential k-means (ASK) has been proposed and prove effective to classify the AE signal with different emitting sources.
	Yadav and Sharma [15]	India	A review of K-means Algorithm	K-Means firstly proposed by Macqueen in 1967. Three dissimilar modified k-means algorithm are discuss. 1 st algorithm remove the limitation of specifying the value of k in advance, 2 nd algorithm reduce the computational complexity and also remove dead unit problem. In 3 rd algorithm use simple data structure that can be used to store information in each iteration.
	S. Shahidan, et al. [9]	Malaysia	Damage classification in reinforced concrete beam by acoustic emission signal analysis.	The acoustic emission analysis was successfully used to determine the mode of crack and classify the damage level accordance the AE parameters
2014	Li et al. [5]	China	Cluster analysis of acoustic emission signal for 2D and 3D woven glass/epoxy composites.	Peak amplitude and peak frequency were selected as the best cluster definition features from AE parameters by k-means algorithm. This features represent adequately and reproducible way the AE event clustering.
2015	Yang et al. [15]	China	Frequency is the key parameter in discriminating the failure types of thermal barrier coatings: Cluster analysis of acoustic emission signals.	Using the k-means cluster analysis of acoustic emission (AE) signal is the key parameter in discriminate the failure. The findings indicate that the frequency can be applied to identify the AE sources mechanisms.

Year	Ref	Country	Title	Findings
2016	Fallahi et al. [16]	Italy	Supervised and non-supervised AE data classification of nanomodified CFRP during DCB tests.	Detect the damage mechanisms using supervised and non-supervised clustering method. Non-supervised such as k-means and supervised using Neural Network (NN). Result showed, that cluster AE signal are reliable tool to detect damage mechanisms, neural network show 99% of accuracy.
	Farbaniec, Couque, and Dirras [17]	France	Probabilistic improvement of crack propagation monitoring by using acousting emission.	K-means++ algorithm, was used fro clustering with two AE parameters such as peak frequency and number of counts. The AE result indicates is corrected by repetitive tests are useful for monitoring crack ppropagation.
	Assarar et al. [6]	France	Acoustic emission characterization of damage in short Hemp-fiber Reinforced Poklymer (HFRP) composites.	The AE technique combined with scanning electron microscopy was used to identify the microstructurall damage event in overall failure in HFRP composites. The identifiication was made with unsupervised method, k-means. Based on the AE signal induced by interface failure and amplitude range, shown the fibre-matrix interface has a major damage process of HFRP composites.

3 Conclusion

In this review paper, has been made a literature on application clustering in Acoustic emission. AE events can be discriminated in four cluster based on peak amplitude, peak frequency, frequency of centroid and RA value. However, this review have revealed that Peak amplitude (PA) and peak frequency (PF) are the most important parameters in this discrimination. Other than that, this review also found the most favorable to classify the damage mechanisms is used the clustering approach by k-means clustering. The k-means

application showed the good results for the clustering of AE signal. Using the k-means cluster analysis of acoustic emission (AE) signal is the key parameter in discriminate the failure. The findings indicate that the frequency can be applied to identify the AE sources mechanisms. The analysis technique proved effective and can be used for the classification of AE data from future tests. It is observed that a lot improvement has been made to the working of k-means algorithm in the past year.

This work was supported by the Faculty of Civil and Environmental Engineering, University Tun Hussein Onn Malaysia, Center for Graduate Studies, UTHM and the Research Grant Contacrt Vot U523.

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