Fault Detection in Motorbike using Wavelet Denoising and Svm

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ABSTRACT
At present, there are many faults conditioning system for electrical or mechanical machines. In most of the cases, these are easily built as data for training can be collected from one machine and data for any other similar machine can be tested. For e.g. Data can be collected from one three phase induction motor for training and testing data can be from other motor, only constraint is both motors should be of same power. But in case of automobiles, data for training has to be collected from many automobiles as fault signals will vary in its characteristics with usage and distance traveled with that automobile. In recent years, automatic identification of motorbike engine faults has become a very complex and critical task. The acoustic signal produced by a motorbike engine is important information of fault diagnosis in any automobile. In this paper, an approach to identify the faults in motorbike using wavelet denoising and Support vector classification by fitting a radial based kernel is used. Preprocessing with level 4 db6 decomposition has produced optimum results. SNR for wavelets used for preprocessing is noted

Keywords
SVM, radial basis function, wavelet denoising

1. INTRODUCTION
In field of automotive electronics, identifying the faults is an uphill task. Such automated fault conditioning systems can reduce the damages which can occur in automobiles in near future. Thus automobile manufacturers will get fewer complaints. Aim is to build an intelligent system which can test and identify the faults by its own. Importance of such an expert system is very much explicit. This intelligent system is beneficial only if data for training is collected in highly noisy environments. Sound quality is an important term that describes an objective measure of the radiated sound.

There are two methods to solve it. One is to get a transducer without an inbuilt noise filter, denoise the signals and then extract features and built a classifier. Other approach is to get a good transducer with an inbuilt noise filter and build the system directly.

In this paper, the first approach is followed. On briefly comparing two approaches, both have its own advantages and disadvantages. First approach i.e. one shown in this paper has an advantage that the system will be cost effective and disadvantage that random preprocessing has to be done, thus processing time will increase. In second approach, though cost to build system is high, processing time is less. Major disadvantage of second approach is there is no guarantee that no processing is required. This can be verified only after building the entire system.

As signatures to the faults, only the basic features are extracted from the faulty signals. Features extracted are statistical and frequency domain features. Spectrum analysis helps us to capture minute variation in signals. In preprocessing, noise is filtered out using wavelet denoising, after which feature extraction and feature classification are carried out.

Artificial neural network (ANNs) has been used very extensively in recent years (1). Artificial Neural Network (ANNs) provides alternative form of computing that attempts to mimic the functionality of the brain. ANN is commonly used in engineering applications for dealing non-linear or complex systems. In various researches carried on online incipient fault analysis in motorbikes, ANN is used as classifier. In this paper, SVM is used as a classifier to build the system as it is shown to have better generalization properties than traditional classifiers and accuracy of SVM does not depend on the number of features of classified entities. The presented approach guarantees good accuracy as well as less computational time when compared to other approach.

2. DIGITAL VOICE RECORDER
All material on each page should fit within a rectangle of 18 x 23.5 c A digital voice recorder is a tape recorder that uses digital technology instead of tapes. Digital voice recorders are slim, compact in size, and portable. Digital voice recorders offer a low-cost solution for those seeking to produce high quality. It is used to record sound signals in high quality and is used to record voice memos to a memory chip and play the memos back. Files are saved in a numbering scheme with a time-and-date stamp. After recording sound signals the recorder can be plugged into computer and some permanent storage can be arranged for files. Here cenix w600 digital voice recorder is used

Features of Cenix digital voice recorder:-

- Display –digital seven segment
- Format Supported -MP3, WMA
- Battery Type-DC 3V*2 (AAA Battery)
- Operating System -WINDOWS XP/200/98/ME

- Recording Time -More than 12 hrs
- Encoding -MP3

3. FAULTS DEALT

Three types of fault are classified: All the faults are ones which occur due to long usage of vehicle or lack of maintenance of the vehicle.

1) Drive chain fault-The drive chain is the link between the transmission gear box and the rear wheel. Due to continuous run of the engine this chain gets loosened leading to wobbling in the chain producing noise in the motor bike.

2) Valve gap fault-Valve faults occur due to the wear and tear. Due to continuous opening and closing of the valves, the valves get rubbed against its surface continuously leading to these faults.

3) Cam chain fault-The cam chain is the link between the crank and the camshaft. loosening of this chain can be found in bikes which have run more than 50,000 kilometers. This fault creates a noise in the engine.

TIMING CHAIN FAULT

VALVE GAP FAULT

DRIVE CHAIN FAULT

Fig 1: Positions in bike for various faults

4. PREPROCESSING

Following steps are followed:

1) Collected signals are in mp3 format. They are converted in wav format.

2) Denoise the signals using different wavelets and different levels of decomposition (8) (9) (10)

3) Extract the features for each of type of denoised signals and send the features for classification

5. WAVELET DENOISING

Steps in wavelet denoising are:-

1) Decomposition-Wavelets used are db4, db6 and symlet 12. Levels of decomposition used for db4 is six, db6 is four and six and for symlet12 is six.

2) To discard detail coefficients, select a threshold in each level from 1 to level selected and applies either soft or hard thresholding. Her soft thresholding is used.

3) Reconstruction-Compute the signal with orginal approximation coefficients and modified detailed coefficients obtained after thresholding.

6. FEATURE EXTRACTION

Feature extraction of the signal is a critical initial step in any monitoring and fault diagnosis system. In this paper, the features of the signals are extracted from the time domain, frequency domain.

SPACE	NO OF FEATURES
Time domain	11
Frequency domain	5

Features extracted in:

Time domain: Mean, Standard deviation, covariance, Skewness, Kurtosis, minimum, maximum, range, entropy, variance, root mean square and mean square.(2)

Frequency domain: Center frequency, Root mean square frequency, standard deviation frequency and mean frequency. Features are obtained from FFT spectrum

7. FEATURE CLASSIFIER

Support vector machine is used to build a classifier. A Support Vector Machine (SVM) performs classification by constructing N-dimensional hyper planes that optimally separates the data into many categories (3) (4) (6). SVM finds the hyper plane placing the largest possible number of points of the same class on same side, while maximizing the distance of either class from the hyper plane. When SVM cannot draw a linear separating line between classes, rather than fitting nonlinear curves to the data, SVM handles this by using a *kernel function* to map the data into a different space where a hyper plane can be used to do the separation.

Using a Radial Basis Function as kernel

The output of the kernel is dependent on the Euclidean distance of the support vector and the testing data point. The support vector will be the centre of the RBF and c will determine the area of influence this support vector has over the data space.

$$K(a, b) = \exp((-\|a-b\|^2)/(2*(c^2)))$$

A larger value of c will give a smoother decision surface and more regular decision boundary. This is because an RBF with large c will allow a support vector to have a strong influence

over a larger area. The RBF is by far the most popular choice of kernel types used in Support Vector Machines. This is mainly because of their localized and finite responses across the entire range of the real x-axis.

.8. EXPERIMENTAL GRAPHS

Graphs of denoised faulty signals are given below SNR of signals is also found which proves the results

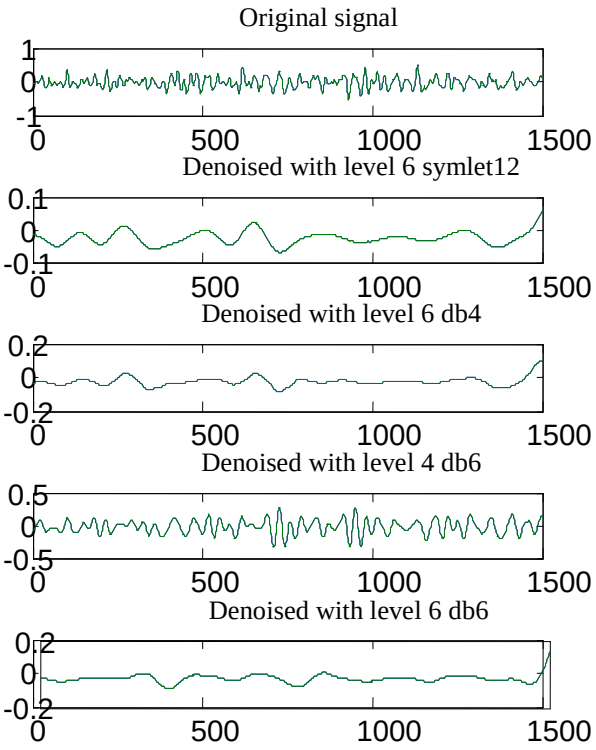

Fig 2: DRIVE CHAIN FAULT

Table1. SNR values

Wavelet(level)	SNR (db.)
db4 (level 6)	-2.24
Symlet12 (level 6)	-0.69
db6 (level 4)	-2.48
db6 (level 6)	-0.80

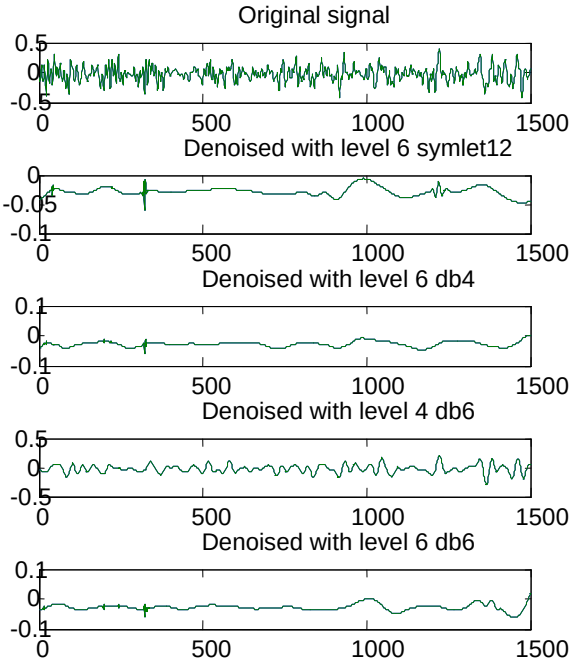

Fig 3: TIMING CHAIN FAULT

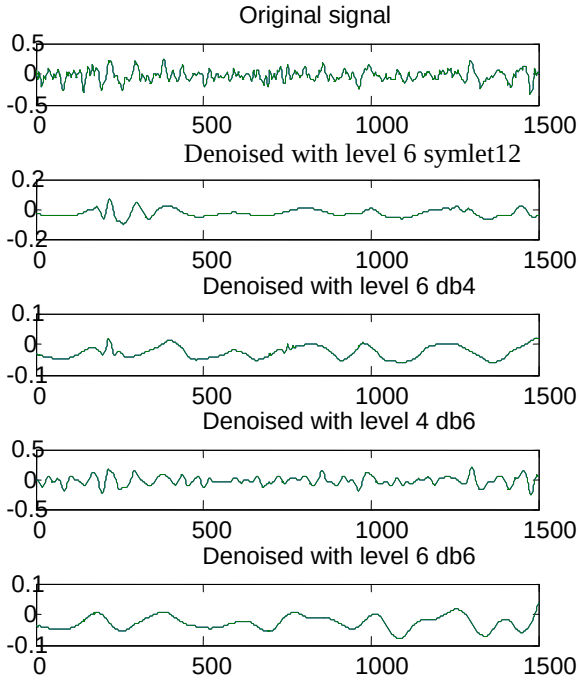

Fig 4: VALVE GAP FAULT

9. TABLES SHOWING ACCURACY

Table2. db4 (level 6)

Fault	Accuracy
Drive chain	49.5
Valve gap	86
Timing chain	90

Table 3.Symlet12 (level 6)

Fault	Accuracy
Drive chain	44.5
Valve gap	82.5
Timing chain	92

Table4. db6 (level 4)

Fault	Accuracy
Drive chain	78.5
	95.5
Valve gap	79.5
Timing chain	

Table5. db6 (level 6)

Fault	Accuracy
Drive chain	90
Valve gap	83.5
Timing chain	51.5

10. CONCLUSION

In this paper, machine fault diagnosis of a bike engine using acoustics signals is discussed. Drive chain fault, timing chain fault, Valve fault are the three faults dealt. Fault signal is denoised using wavelet and statistical and frequency domain features are extracted and faults using support vector machine by fitting RBF kernel .Results obtained show that the combination of wavelet denoising and SVM of acoustic signal (4)used to detect faults in bike engine. Advantage is that faulty signals are taken in highly noise conditions and still an optimum accuracy is obtained when wavelet db6 level 4 decomposition is used

11. FURTHER WORKS

Other type of classifiers such as neural network and fuzzy logic can be used and tested for accuracy. Number of faults can be increased. Piston faults can be included. Fault inducement for such faults is costly. These faults were excluded to make the system cost effective

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