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INVESTIGATION ON THE USE OF JOINT TIME FREQUENCY ANALYSIS TECHNIQUES ON PERODUA SOUND SIGNATURES

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The Thesis was submitted as a partial fulfillment of the requirement for the Barchelor Degree Of electronic Engineering

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April 2006

DECLARATION

"I, hereby declare that this thesis entitled, Perodua engine Sound Signature Analysis by Joint- Time Frequency Distribution is a result of my own research idea except works that have been cited clearly in the references."

Signature :
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Date : 29/MAY/2006.

Special dedication to my loving parents Puan Che Zaharah Bte Ismail and Mohd Zin Bin Mat Diah , all my siblings, my kind hearted supervisor Cik Norhashimah binti Mohd Saad and my dearest friends.

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Abstract

This investigation proposes the used of Joint Time Frequency techniques to analyze Perodua Engine Sound Signatures. All engines emit sounds that have a unique signature that can be used for classification and diagnostic purposes. A computerized interpretation of engine sound signatures is needed to make the diagnosing more effective. Spectrum analysis is now firmly involved in the areas of telecommunications, acoustic and others, including with the engine sound processing. In this work a new approach of engine sound processing has been developed by using Joint-Time-Frequency-Analysis. The spectrogram technique has been tested on six Perodua engine vehicles to analyze the new criteria of engine sound signature in the form of jointly time and frequency domain. The purpose of this study was to determine whether spectrogram techniques can be differentiating between good and bad engine condition. The analysis is done by using MATLAB 7.0 interfaces. Six engines are classified; Kancil EZ660, Kancil EX850 , Kelissa, Kembara, Rusa and Kenari . The advantage of the Joint Time Frequency analysis is its computational simplicity, so it cab be used to construct computer analysis system for Perodua Engine signature. Thus, all automobile industry can be benefit from this research because it provides solution in diagnosing vehicles engines

Abstrak

Penyelesaian ini adalah mengenai pengunaan *Joint-Time-Frequency-Analysis* didalam menganalisa bunyi enjin kereta yang dihasilkan oleh Perodua. Kesemua enjin menghasilkan bunyi yang unik dimana bunyi ini boleh digunakan untuk tujuan menganalisa dan pengelasan. Penggunaan komputer untuk menganalisa bunyi ini menyebabkan analisa ini menjadi lebih berkesan dan efektif. Kaedah penganggaran spectrum ini banyak digunakan didalam bidang-bidang telekomunikasi, akoustik dan lain-lain bidang termasuklah didalam memproses bunyi kenderaan. Didalam projek ini satu kaeadah baru untuk menganalisa bunyi kenderaan dibangunkan dengan menggunakan kaedah *Joint-Time-Frequency-Analysis.* Kaedah menganalisa menggunakan spektrum ini telah diaplikasikan keatas enjin kereta Perodua untuk menganalisa kriteria-kriteria baru yang boleh digunakan untuk menganalisa enjin termasuklah penggunaan *Joint-Time* dan *Frequency domain.* Keutamaan projek ini adalah untuk membuktikan samada *spectogram techniques* boleh digunakan untuk tujuan membezakan diantara keadaan enjin samada baik atau tidak baik. penganggaran spectrum unutk menganalisa bunyi enjin dari kenderaan yang dihasilkan oleh Perodua. Cara ini mudah dan berkos rendah kerana ia tidak memerlukan sensor yang jitu. Analisis yang digunakan ialah menggunakan kaedah *Joint Time Frequency Analaysis.* Analisa ini dijalankan menggunakan atntaramuka MATLAB 7.0. Terdapat enam jenis enjin kereta Perodua yang tellah diuji: Kancil EZ660, Kancil EX850 , Kelissa, Kembara, Rusa and Kenari. Klebihan utama menggunakan kaedah ini ialah ianya dilakukan memalui komputer oleh itu ianya boleh digunakan untuk dibangunkan satu sistem analisa enjin untuk Perodua. Oleh itu semua yang terlibat dialam industri automotif ini akan mendapat kelebihan kerana sistem ini memberikan penyelesaian terhadap kaedah menganalisa enjin yang murah dan mempunyai kejituan yang tinggi.

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

All engines emit sounds that have a unique signature thate can be used as a classification and diagnostic purposes. So in this project we will able to design, do an analysis and simulate signal sound signatures for Perodua Engine Vehicle. This approach is convenient and low cost method in diagnosing engine because it is non-intrusive and does not require high precision sensors. So we can predict the situation of engine earlier and faster. Its only needs a quality audio recorder to take data. Then the data are converted into .wav format to analyze in the MATLAB 7.0 interfaces

The interest of this project is to evaluate the used of Joint-Time-Frequency-Analysis to detect any variance on Perodua engine sound signatures. The spectrogram techniques is used to analyze the condition of the engine and reveal a unique harmonic content for classification purposes

1.2 OBJECTIVE

The main objective of this project is:

1. To analyze and investigate the used of Joint-Time-Frequency-Analysis for Perodua engine sound signatures.
2. To detect new parameter in engine sound signatures in the form of joining time and frequency domain by using spectrogram techniques.

1.3 SCOPE OF WORK

1. Study Of Engine
    i. Characteristic Of engine
    ii. Part of engine

2. Type of vehicle
    i. Kancil EZ660
    ii. Kancil Ex850
    iii. Kelissa
    iv. Kenari
    v. Kembara

3. MATLAB
    i. Periodogram Source Code
    ii. GUI

1.4 PROBLEM STATEMENT

As a human we can easily differentiate several of sounds. To automate the analysis and classification process, several designs and implement issues has to be resolved. In this project the issues is in two parts which is in vehicle sound samples recorded and signal analysis method.

For the first issues on the sound vehicle samples recorded, to take a data we must use a same quality audio recorded equipment. As we know various equipment gives several quality audio so the best one should be selected. For that purposed I has selected Creative Zen Photo as a recorded equipment because Creative product has less noise and smooth sound. We also must take a samples in same engine condition that's means we used the same speed and method. Otherwise the comparison criteria are not appropriate.

For the second part , there are many techniques can we use to obtain an analysis. So in this part we use spectrum techniques because their estimation gives the small variance. This is to ensure that the parameter estimation procedure produces minimum error.

1.5 RESEARCH METHODOLOGY

In order to make sure this project success the following steps are required.

1 **Reviews of literature.** Familiarize with the engines. Known the characteristic and part of Perodua engine. The existing technology or method that has been used before also review to understand to overall concept and application.

2 **Data Collection.** Perodua engines sound has been recorded using Creative Zen Photo MP3 player. This player has a less noise then other player in market so quality of product is higher.

3 **Data Convereter.** The Audio to wave converter software has been used to convert data from audio format to .wav format. MATLAB cannot recognize the audio format except its convert into .wav format.

4 **Analysis of Data.** Joint Time Frequency Analysis has been used as a method to do an analysis. Its estimation have a less variance, precise and easy to use.

5 **Computation Platform.** All analysis is done by MATLAB 7.0 software, running in personal computer using WINDOWS XP as a operating system.

6 **Thesis Writing**

1.6 ORGANIZATIONAL OF THESIS

Chapter I provides an overview of the project. This will allowed by a review of literature and recent development in technology in Chapter II. Chapter III will describes the theory that has been used in this project. With the concept of the theory on previous chapter, Chapter IV will be project development. Chapter V a result and discussion. Chapter VI will be the conclusion.

CHAPTER II

REVIEW OF LITERATURE

2.1 INTRODUCTION

For investigation success , this chapter will describe the structure and combustion system in perodua engine. This Chapter begins with the structure and combustion engine on Perodua Vehicle. Chapter II will end with literature review on current research and recent technology.

2.2 PERODUA ENGINE

They are six type of engine that will used in this investigation: Kancil EZ660, Kancil EX850 , Kelissa, Kembara, Rusa and Kenari. Perodua are wll known in Malaysia as a company that produces a subcompact car and Muti Propose Vehicle (MPV) car. Their engine has been design with a different characteristic and type depend on usage.(Refer Appendix)

Perodua has developed an engine with manual and auto submission. The total displacement for each Perodua engines is between 659 cc to 1659 cc. There are two type of engine that been used either Double Over Head Cam (DOHC) or Single Overhead Cam (SOHC) and its depend on horse power for Perodua engine.

Otherwise Perodua used a mutli type of engine it still easy to differentiate sound signatures of each engine. All engines have unique sound signatures that can be identify easily using MATLAB 7.0 interfaces.

2.3 HISTORIC OF ENGINE

While chemical and electrical engines of enormous power dominate the modern world, engines themselves are not new. Engines using human power, animal power, water power, wind power even steam power date back to antiquity. Human power was focused by the use of simple engines, such as the capstan, windlass or treadmill, and with ropes, pulleys, and block and tackle arrangements, this power was transmitted and multiplied. These were commonly used in cranes and aboard ships during Ancient Greece, and in mines, water pumps and siege engines in Ancient Rome. Early oared warships used human power augmented by the simple engine of the lever -- the oar itself. The writers of those times, including Vitruvius, Frontinus and Pliny the Elder, treat these engines as commonplace, so their invention may be far more ancient.

Automotive production down the ages has required a wide range of energy-conversion systems. These include electric, steam, solar, turbine, rotary, and different types of piston-type internal combustion engines. The gasoline internal combustion engine, operating on a four-stroke Otto cycle, has traditionally been the most successful for automobiles, while diesel engines are widely used for trucks and buses. The patent on the design by Otto had been declared void. Karl Benz led in the development of new engines. in 1878 he began to work on new patents. First, he concentrated all his efforts on creating a reliable gas two-stroke engine, based on Nikolaus Otto's design of the four-stroke engine. Karl Benz showed his real genius, however, through his successive inventions registered while designing what would become the production standard for his two-stroke engine. Benz finished his engine on New Year's Eve and was granted a patent for it in 1879. In 1896, Karl Benz was granted a patent for his design of the first boxer engine with horizontally-opposed pistons. His design created an engine in which the corresponding pistons reach top dead centre simultaneously, thus balancing each other with respect to momentum. Flat engines with four or fewer cylinders are most commonly boxer engines and are also known as, horizontally-opposed engines. This continues to be the design principle for high performance, automobile racing engines such as Porsches. Continuance of the use of the internal combustion engine for automobiles is partially due to the improvement of engine control systems (computers) and forced induction (turbos and superchargers), giving modern diesel engines the same power characteristics as gasoline engines.

The internal combustion engine was originally selected for the automobile due to its flexibility over a wide range of speeds. Also, the power developed for a given weight engine was reasonable; it could be produced by economical mass-production methods; and it used a readily available, moderately priced fuel--gasoline.

In today's world, there has been a growing emphasis on the pollution producing features of automotive power systems. This has created new interest in alternate power sources and internal-combustion engine refinements that were not economically feasible in prior years. Although a few limited-production battery-powered electric vehicles have appeared from time to time, they have not proved to be competitive owing to costs and operating characteristics. In the twenty-first century the diesel engine has been increasing in popularity with automobile owners.

However, the gasoline engine, with its new emission-control devices to improve emission performance, has not yet been challenged significantly.

Smaller cars brought about a return a to smaller engines, the four- and six-cylinder designs rated as low as 80 horsepower (60 kW), compared with the standard-size V-8 of large cylinder bore and relatively short piston stroke with power ratings in the range from 250 to 350 hp (190 to 260 kW).

The automobile motor had a bigger range, varying from 1-12 cylinders with corresponding differences in overall size, weight, piston displacement, and cylinder bores. Four cylinders and power ratings from 19 to 120 hp (14 to 90 kW) were followed in a majority of the models. Several three-cylinder, two-stroke-cycle models were built while most engines had straight or in-line cylinders. There were several V-type models and horizontally opposed two- and four-cylinder makes too. Overhead camshafts were frequently employed. The smaller engines were commonly air-cooled and located at the rear of the vehicle; compression ratios were relatively low. The 1970s and '80s saw an increased interest in improved fuel economy which brought in a return to smaller V-6 and four-cylinder layouts, with as many as five valves per cylinder to improve efficiency.

2.4 STRUCTURE

The structural features of the engines are complimentary to the number and arrangement of its cylinder where the displacement is generally deciding factor required for the performances characteristic. As for the cylinder arrangement, the main requirement is those of compact dimension and low weight, consistent with adequate rigidity for smooth operation.

2.4.1 Internal Combustion Engine

The internal combustion engine is a heat engine in which the burning of a fuel occurs in a confined space called a combustion chamber. This exothermic reaction of a fuel with an oxidizer creates gases of high temperature and pressure, which are permitted to expand. The defining feature of an internal combustion engine is that useful work is performed by the expanding hot gases acting directly to cause movement, for example by acting on pistons, rotors, or even by pressing on and moving the entire engine itself.

This contrasts with external combustion engines such as steam engines which use the combustion process to heat a separate working fluid, typically water or steam, which then in turn does work, for example by pressing on a steam actuated piston. The term *Internal Combustion Engine* (ICE) is almost always used to refer specifically to reciprocating engines, Wankel engines and similar designs in which combustion is intermittent. However, continuous combustion engines, such as Jet engines, most rockets and many gas turbines are also very definitely internal combustion engines.

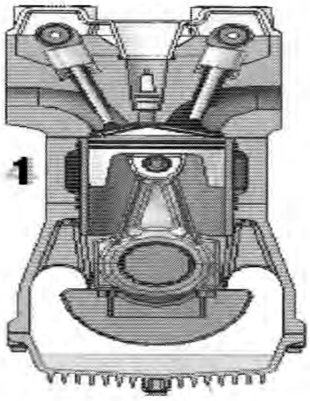

FIGURE 2.1:Internal Combustion System

Internal combustion engines are most commonly used for mobile propulsion systems. In mobile scenarios internal combustion is advantageous, since it can provide high power to weight ratios together with excellent fuel energy-density. These engines have appeared in almost all automobiles, motorbikes, many boats, and in a wide variety of aircraft and locomotives. Where very high power is required, such as jet aircraft, helicopters and large ships, they appear mostly in the form of gas turbines. They are also used for electric generators and by industry.

The potato cannon uses the basic principle behind any reciprocating internal combustion engine: If you put a tiny amount of high-energy fuel (like gasoline) in a small, enclosed space and ignite it, an incredible amount of energy is released in the form of expanding gas. You can use that energy to propel a potato 500 feet. In this case, the energy is translated into potato motion. You can also use it for more interesting purposes. For example, if you can create a cycle that allows you to set off explosions like this hundreds of times per minute, and if you can harness that energy in a useful way, what you have is the core of a car engine

Almost all cars currently use what is called a four-stroke combustion cycle to convert gasoline into motion. The four-stroke approach is also known as the Otto cycle, in honor of Nikolaus Otto, who invented it in 1867. The four strokes are illustrated in Figure 1. They are:

1. Intake stroke
2. Compression stroke
3. Combustion stroke
4. Exhaust stroke

All internal combustion engines depend on the exothermic chemical process of combustion: the reaction of a fuel, typically with air, although other oxidisers such as nitrous oxide may be employed. Also see stoichiometry.

The most common fuels in use today are made up of hydrocarbons and are derived from petroleum. These include the fuels known as diesel, gasoline and liquified petroleum gas. Most internal combustion engines designed for gasoline can run on natural gas or liquified petroleum gases without modifications except for the fuel delivery components. Liquid and gaseous biofuels, such as Ethanol can also be used. Some can run on Hydrogen, however this can be dangerous. Hydrogen burns with a colorless flame, and modifications to the cylinder block, cylinder head, and head gasket are required to seal in the flame front.All internal combustion engines must have a means of ignition to promote combustion.

Most engines use either an electrical or a compression heating ignition system. Electrical ignition systems generally rely on a lead-acid battery and an induction coil to provide a high voltage electrical spark to ignite the air-fuel mix in the engine's cylinders. This battery can be recharged during operation using an alternator driven by the engine. Compression heating ignition systems, such as diesel engines and HCCI engines, rely on the heat created in the air by compression in the engine's cylinders to ignite the fuel.

Once successfully ignited and burnt, the combustion products, hot gases, have more available energy than the original compressed fuel/air mixture (which had higher chemical energy). The available energy is manifested as high temperature and pressure which can be translated into work by the engine. In a reciprocating engine, the high pressure product gases inside the cylinders drive the engine's pistons.

Once the available energy has been removed the remaining hot gases are vented (often by opening a valve or exposing the exhaust outlet) and this allows the