



## Sound marketing on engine sound design

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### ABSTRACT

Cultural differences in favorable engine sound are investigated. Two characteristic physical parameters are chosen from five main parameters of active engine sound design in previous studies. By mapping the two parameters; we can learn the engine sound preferred in German and Italian markets. Considering this difference, engine sound design is experimented by using Gabor transform. Thus, this finding suggests that global markets car should use different engine sounds for each market.

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### 1. INTRODUCTION

Car engine sound plays an important role in brand image. It is not only that engine sound is quieter but also the engine sound is better. Moreover, it improves value of the car in the market. Engine sounds are usually recognized as a sporty and luxurious sound. Especially, the obvious sporty vehicles should have a distinctive engine sound which allows us to have an images of high performance.

Also, such engine sound is played in advertisements; which means that engine sound has marketing value and people are proud to have that product. As marketing, automobiles are classified often by engine size or sporty and luxurious axes. However, it is not usually discussed regarding difference in markets, especially cultural differences. This paper will be focused on such cultural differences.

Active sound design system (ASD) is recognized as the best tool to modify engine sound easily and practically. Disadvantage of ASD is that it requires engine revolution data from CAN-BUS, which sometimes is hidden and not released to the public. To solve this problem, I would like to introduce the sound design by Gabor transform.

### 2. Sound design recipes to Sound marketing

#### 2.1 2 axes in Marketing

The 2 axes in marketing analysis is often used to indicate values of product. It is useful to figure out the position of products visually. So, what kind of parameters are best fitted for sporty vehicles?

#### 2.2 5 parameters in sound design recipes

As a starting point, 5 parameters in sound design recipes used in active sound design (1) are useful because they cover the whole parameters in engine sound design. These parameters are;

- Frequency dynamic
- Harmonic balance 1 – Half orders
- Harmonic balance 2 – music harmonic balance, especially octave
- Amplitude dynamic – Resonance
- “Spaceship” effect

#### 2.3 2 parameters are chosen for sound marketing

Looking into these 5 parameters, both frequency dynamic and “spaceship” effect are easily emitted for this purpose. Frequency dynamic differs in numbers of cylinders so that it effects on sporty impression directly. For this sound marketing, it is not required to measure values of sportiness but

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also type or character of sporty sound. Also, “Spaceship” effect reveals artificial sound and it is not commonly used for engine sound design.

Moreover, harmonic balance 1 and 2 can be merged as 1 axe. They are just opposite in terms of representing amplitudes of engine orders. Amplitude dynamic should be re-named as linearity for mapping marketing value because car manufactures evaluate these sound as non-linearity or linearity during the acceleration conditions.

Therefore, 2 axes, namely, harmonic/inharmonic and linearity/non-linearity are selected and would be considered with real engine sound measurement inside vehicle.

**2.4 German engine sounds vs Italian engine sounds**

7 engine sounds were examined for the 2 chosen axes as sound marketing mapping. Sporty cars from German and Italian manufactures were evaluated, which is shown in Table 1

Table 1 – Engine sounds

Manufactures	Models	Numbers of cylinders
Volkswagen	Golf R32	6
Volkswagen	GTI	4
Porsche	Boxster	6
BMW	335i Cabriolet	6
Ferrari	F430	8
Ferrari	F12	12
Lamborghini	Aventador	12

Amplitude dynamic and amplitude of engine orders in all 7 candidate cars are examined and plotted in the two axes as shown in Figure 2.

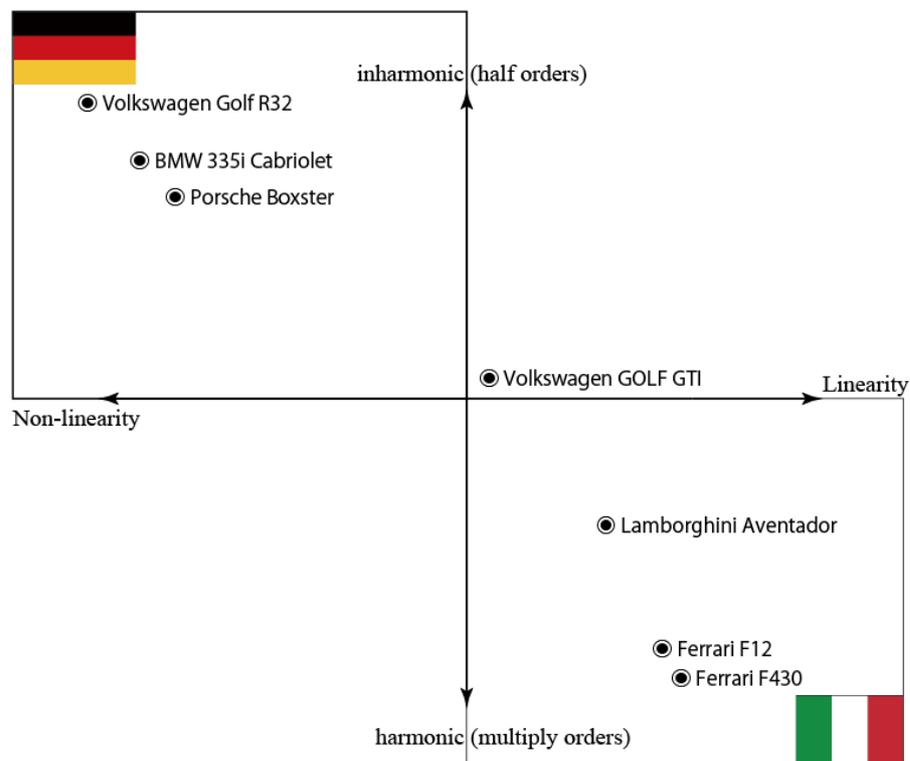


Figure 2. Marketing chart on engine sounds

Results of 7 engine sounds shows a clear difference between German and Italian manufactures. German manufactures prefer to have inharmonic; half orders and non-linearity. On the other hand, Italian manufactures prefer to have harmonics and linearity. They are completely opposite. It means people in different countries have different preference of sounds even with having the same sporty impressions. In other words, if the car is exported ~~in~~ worldwide, engine sound of that car may be modified in each market.

### **3. Algorithms of engine sound design**

#### **3.1 Sinusoidal waves summation in active sound design**

What kind of system will be useful if engine sound of each car can be changed in different markets? Considering the current technology, active sound design systems should be a possible candidate, which can obviously change engine sound with some set-ups. Although the system is proved enough to modify engine sound, two difficulties regarding user-friendly point of view are brought up. One is that the system sums sinusoidal waves, which requires a bit complicated set-up. Another is that since engine revolution data is necessary, the system should connect with CAN-BUS. Especially in the case if the developer wants to install its independent system from the car itself, such inflexible tool causes limitation of sound design.

#### **3.2 Gabor transform**

In order to overcome such disadvantages, Gabor transform is suggested in this paper. The method of the time-frequency transform is often used for pitch-shifting of musical instrumental and vocal sounds (2). Of course, these sound becomes higher or lower in frequency with the same length as the original, which differs from resampling method. Although this method is not common being used for engine sound design, it has clear advantages over higher engine orders without engine revolution data and also without changes of time lengths.

### **4. Engine sound design by Gabor transform**

#### **4.1 Engine sound design by Gabor transform**

By active sound design, users should set amplitude of all engine orders over whole revolutions. Additionally, if a sound of 4-cylinder engine is changed to that of 6 cylinder, 3<sup>rd</sup> order should be amplified more than 2<sup>nd</sup> order, which means "frequency dynamic shift" (1). The same approach to change engine sound with Gabor transform is impossible. Simply, the higher order the engine has, the higher all orders become which means all frequency contents of engine orders double when it is manipulated with doubling frequency.

It is suggested to mix several modified sounds by Gabor transform with original engine sound for designing more natural tones and better variations.

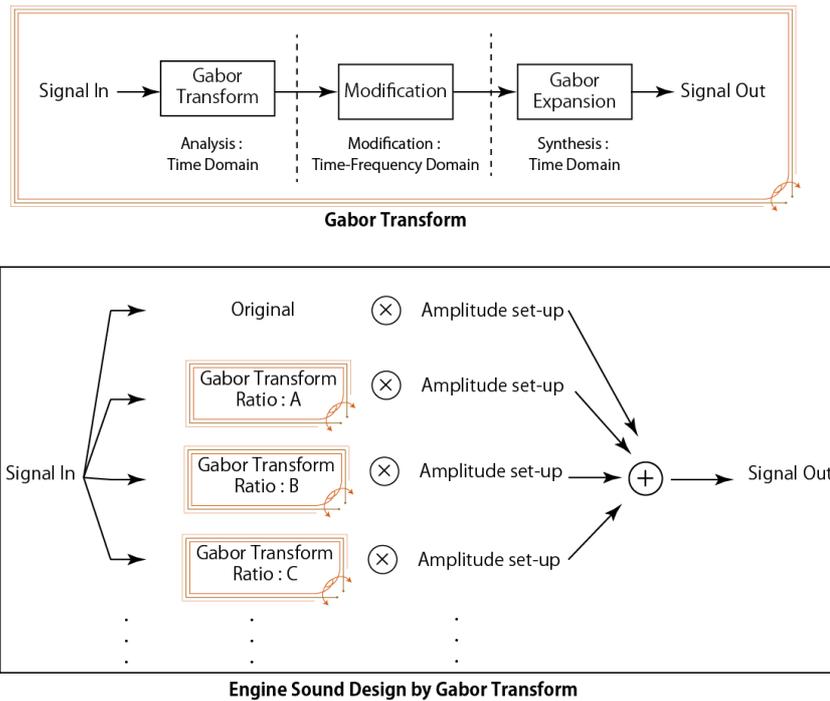


Figure 3. Suggested engine sound design by Gabor transform and mixings

### 4.2 German taste engine sound

As discussed in section 2.4, German manufactures prefer to have inharmonic and non-linearity. In order to have inharmonic tones, mixed engine sounds by Gabor transform are mainly focused on sound modified as 1.25 times higher and 0.75 times lower frequency. Figure 4 shows the comparison of original engine sound (Volkswagen Golf) with modified German taste engine sound.

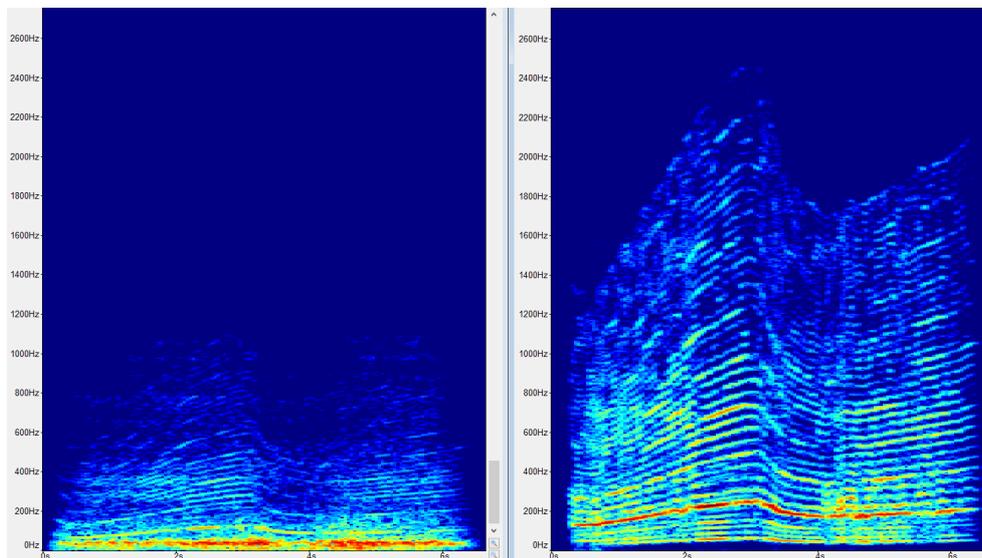


Figure 4. Original engine sound (Volkswagen Golf) vs German taste engine sound

### 4.3 Italian taste engine sound

As stated in previous section, Italian car manufactures tend to have harmonic sounds. In order to have harmonic tones, 2 times higher and 4 times higher frequency tones are mixed with original engine sounds. Modified German taste engine sound is compared with original engine sound as shown in Figure 5.

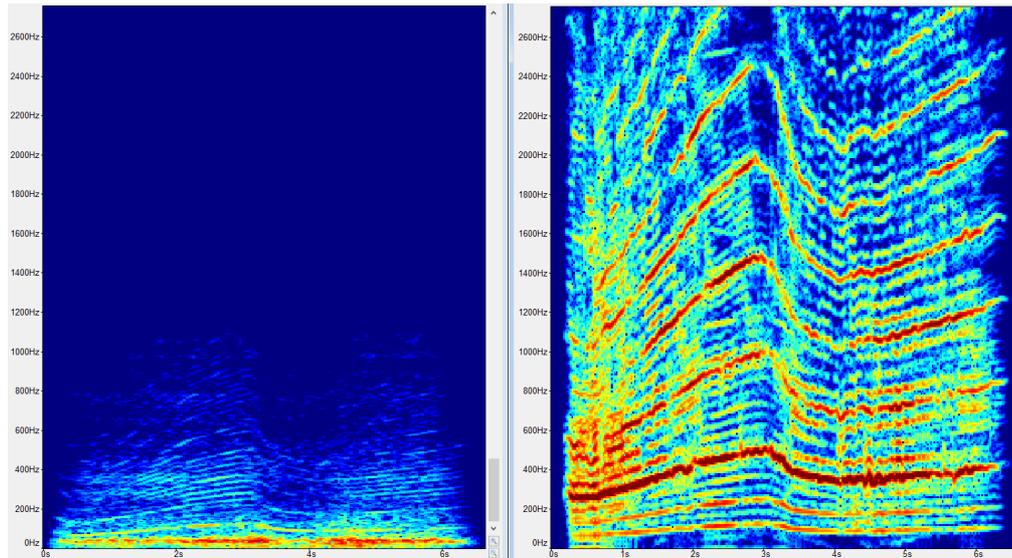


Figure 5. Original engine sound (Volkswagen Golf) vs Italian taste engine sound.

## 5. CONCLUSIONS

In order to find parameters to differentiate characteristics of sporty engine sounds, 2 parameters are chosen, namely harmonic and linearity. These two values clarify cultural sound differences between German and Italian car industries.

For the purpose of easy-to-use and independent device from car system, engine sound design by Gabor transform are trialed and examined. It is proved that the time-frequency modification enables to create engine sounds with different characteristics which are discussed as German and Italian taste.

In the future, this sound modification method without engine revolution may bring a tool to provide wide variations of engine sound in small device at real time.

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