Ideal sound for AVAS (Approaching Vehicle Audible Systems)

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YAMAHA CORPORATION

Semiconductor Div.



Introduction of Yamaha #1

- Product (consumer)
 - Musical Instrument (Acoustic & Electric), Audio Products
- Product (B to B)
 - Semi-conductor Div., PA equipment, Acoustic Consultant





Introduction of Yamaha #2

Semi-Conductor Division

- Sound LSIs for cellular phones & TVs in global market
- Graphic & Sound LSIs for automotive market
- R &D activity for suitable sound for AVAS



What is an ideal sound for AVAS?

Requirement for sound of AVAS?

Noticeable & Acceptable Sound associating motor vehicles



What are important factors for sound of AVAS?

- Associative
 - Associated with Vehicle running condition
 - Needs to vary according to drive information
 - Sounds like running vehicles
 - Associated with engine or motor behavior
- Noticeable
 - Noticeable in City Noise
 - Hard to be masked by background noise
 - Audible for wide age range
 - Sound rich in low \sim mid frequency
- Acceptable
 - Immune to frequency / repetition
 - Familiar sound
 - Immune to time length
 - Non-melodic nor non-tonality



Sound associating vehicles #1

- Vehicle's running condition shall be expressed by sound variation
 - Vehicle's running condition is judged from real time variation of sound according to the condition of acceleration, brake pedal and gear
 - Real time response enables pedestrians to notice

distance from vehicles
speed of vehicles
vehicle's running condition (approaching/in halt/departing)

Sound reflecting engine condition make pedestrians feel it associated with vehicles



Sound shall change according to vehicles speed



Sound associating Vehicles #2

Volume as well as Frequency need to vary (should not be constant)









With variation similar to engine sound, even Synth sounds like a vehicle

- Quick response is required
 - Pedestrians & drivers feel uncomfortable in failing to respond to speed variation in a real time manner
- Smooth fade out in reaching an upper limit speed is desirable
 - Fade out with break makes an undesirable effect on comfort & quality
 - Smooth cross-fade with Road noise is preferable



Sound Generation Equipment

- Characteristics needs to cover from low frequency to high frequency
 - Should not be the one only to generate single frequency such as a buzzer
 - Wide range frequency enables to create noticeable and acceptable sound
 - Low frequency sound with less directionality and less distance decay
 - High frequency sound with unidirectionality and human ears are sensitive to it
- Balance between durability (cf. waterproof) and quality (playability of low frequency range) needed
 - Quality Criteria for waterproof and dustproof needed
 - Playability of Frequency range on speakers to be discussed



Noticeable vs. Acceptable

Important to have wide frequency range

- Wide frequency range is recognizable because it is hard to be masked by background noise
- Low frequency is audible even in the presence of obstacles due to its diffraction effect
 - Easy to reach areas hardly seen from drivers such as an intersection with walls
 - However, it needs more power and sound isolation is difficult



Characteristic of Human Ears

- High frequency sound (3~5kHz) is more noticeable due to human ears characteristics
 - Audible effectively with small power
 - Transferred locally due to unidirectionality
 - But sound of this frequency range only is uncomfortable & abrasive



Figure 4 : Normal equal-loudness-level contours





Hearing Loss caused by aging

Audible for elder people with hearing loss caused by aging

- High frequency is less audible for aging people
 - Refer to Figure 5 below
- Sound of low & mid. frequency (~1kHz) is audible for elder people



Figure 5 : Statistical distribution of Hearing Thresholds as a function of age (ISO7029:2000)

Sound to combine low & mid. Frequency is necessary

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Fluctuation

- Fluctuation is important for Sound
- What is fluctuation ?
 - Periodical variation of Amplitude & Frequency
- Helpful for perception
 - Sound without fluctuation is easy to be masked by background noise
 - More noticeable by variation of sound
 - More sensitive to variation due to human ears' characteristics
 - Too much fluctuation leads to discomfort
- Sound with fluctuation can be associated with vehicles as conventional engine sound has fluctuation
 - Fluctuation can also express engine rotation



Effect of Fluctuation

Without Fluctuation



With Fluctuation

Which is more recognizable?





Comfortable

- Needs to be Immune to (frequent & long) hearing
 - Sound strong in pitch is noticeable but is vulnerable to (frequent & long) hearing
 - Horn/Alarm sound is noticeable but likely to stick in the ears or to scare pedestrians
- Non-melodic, natural & noticeable
 - Melodic sound is noticeable but vulnerable to frequent hearing (air conditioner sound is not distinguished but immune to frequent hearing)
 - Mixing noise is also effective



Sound Content

- Needs to consider situation where multiple sound is being played simultaneously
 - not uncomfortable nor abnormal even in a situation (ex. intersection or trafficy area) where multiple sound can be being played simultaneously
 - Weak in pitch so as not to be dissonant when multiple sound being played simultaneously
 - Pitch without dissonance
 - Non-tonality (neither major nor minor)



Summarize

- What is the points for ideal sound for AVAS?
 - Sound that varies according speed and other driving information to notify pedestrians driving conditions & drivers intension
 - Sound to combine low and mid. frequency for better perception



 Not melodic sound but sound with appropriate noise mixed for better acceptability



Action Required

- To balance reception and acceptance, which are trade-off to each other, social valuation on actual vehicles could be important.
- This discussion is still in process, not determined yet.
- As installation rate of ASAS increases, the validation data of actual vehicles in a real world would be collected.

Continuous Discussion Needed

