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Motor2Synth: Leveraging DDSP for Generating ASD-Compatible Combustion Engine Sounds

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Abstract:

In Active Sound Design (ASD) applications for electric vehicles, many manufacturers want to have at least some sounds that emulate aspects of combustion engine noise, while being different enough to show their own identity. Consequently, combustion engine sounds frequently serve as the foundation for creative sound design. Traditional artificial sound generation methods, however, struggle to replicate the distinct acoustic properties and dynamics of combustion engines, leading to unrealistic results. Although real vehicle recordings are available, their chaotic nature and significant RPM fluctuations make them challenging to process for sample-based synthesis. This paper introduces a novel approach to model arbitrary combustion engine sounds using artificial intelligence, specifically through Differentiable Digital Signal Processing (DDSP). DDSP models a sound or process with differentiable implementations of typical signal processing modules such as harmonic generator, noise filter and reverberation. The model can then generate sounds based on an estimation of a fundamental frequency and signal loudness, effectively as a synthesizer, being the reason, we call our tool Motor2Synth. For motor sounds, however, the fundamental frequency should be the rotational speed (rpm), and pre-trained models for music such as CREPE fail to provide good results. To address this, we developed a self-supervised pitch estimator based on the PESTO model to estimate rotational speed, integrating it into a DDSP framework to generate sounds. We show that our model can correctly estimate the rpm of combustion engine noise while also producing realistic outputs that can be used as base for ASD applications. Finally, we demonstrate a designed sound using a DDSP version of a high performance V8 engine as a component to create a sound variant for the cars Xiaomi SU7 and SU7 Ultra.

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