Sound module for a radio-controlled model car
„The Car Scaling Project“

The basic idea of this project is to properly scale a modelcar in every aspect. When I was young and played with R/C model cars, I already had developed the vision of a much more accuralty scaled car. I remember that I was not interested in absolute speed and performance at all. For me the sound of a model is the major aspect for a realistic apearance beside the driving dynamics. For the proper simulation of the engine sound it is necessary to measure the throttle signal, which gives the engine load, and the resulting revolution at some point of the drivetrain, which is proportional to the rotational speed of the engine, both with sufficient temporal resolution.
Just for realizing this project I entered the hobby again. As a basis in principle any hobby grade electrical driven model can be used. For me the choice for the 1/10 scale respresents the best compromise between available space, the availability of different model chassis and body shells, and last but not least moderate costs. Fig. 1 shows some early versions of the sound module and model chassis. The sound module consists of several components, an Arduino Nano microcontroller, which is measuring and preprocessing the PWM signal of the radio channel controlling the throttle, a fast Teensy 3.6 microcontroller, which is measuring the revolution of the main gear with an optical encoder, and as a core element the Raspberry Pi 3B with a Hifiberry DAC+ as an audio interface, which is doing all calculations for modelling the sound based on the measured data. The main program running on the Raspi is designed in a modular way, which allows to adapt for individual characteristics of different car models (gear ratios, shifting dynamics including details like small oscillations in the revolution of the engine after loadchanges, extra sounds like wistling sound of a turbocharger, ...). Since resampling in good audio quality is a extensive computational task and a low latency of the audio signal is important, the processing of the different audio streams representing different driving conditions is done in parallel on the different cores of the processor.

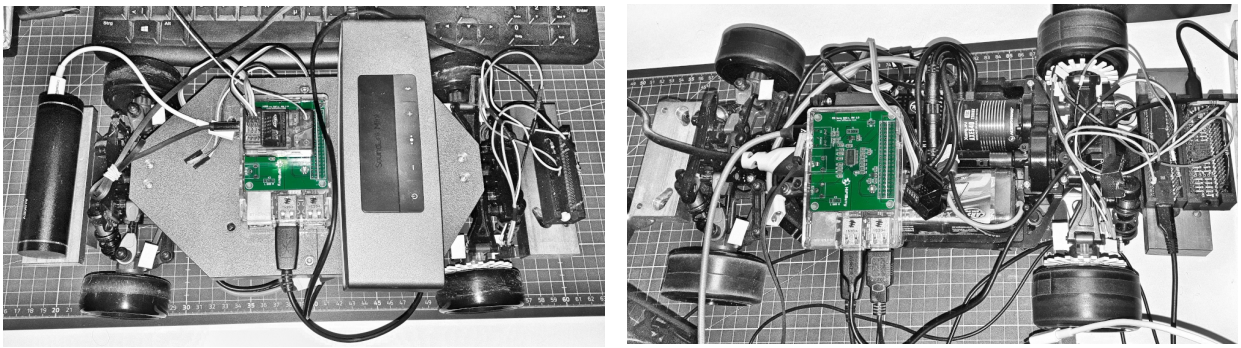

Fig.1: Early stage chassis and versions of the sound module, with the Hifiberry on top of the Raspberry Pi. Left: Finding the right speaker for the best and most powerful playback within the restricted space was quite demanding (This one was obviously too wide for mounting a body shell). Right side: Two encoder wheels on each side of rear axis were used for increasing the accuracy of the measurement.

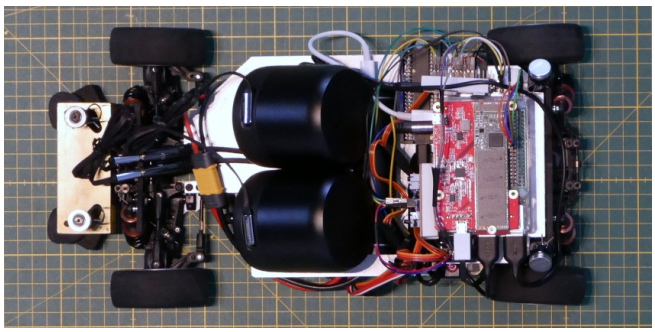
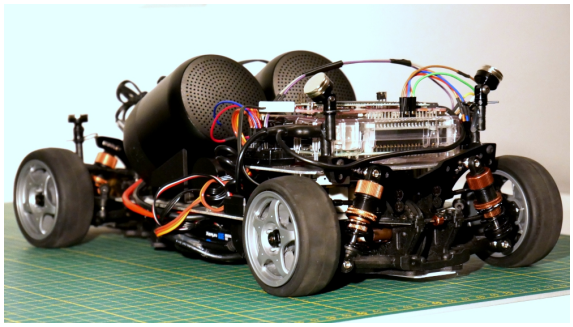

Fig.2: Final model car (3Racing - Sakura XI Sport) with finalized sound module (the Hifiberry was covered by a SATA SSD module at the time this picture was taken) mounted on the additional aluminium levels of the chassis.

The choice for the final chassis was mainly driven by the need for low inherent noise level of the model, Fig. 2. Much effort has been exerted to reduce the inherent noise of every component (drivetrain, choice of motor and power electronics). For the drivetrain of the final chasis a helical gearing was developed for achieving the maximum reduction of the gearing noise. These parts were produced by selected laser sintering (SLS) in special wear-resist plastics, see Fig. 3 left. The optical encoder wheel was laser cut from an white acryl sheet, aalso Fig. 3. The housings of the different components are either modified commercially available parts, 3D printed or scratch built with styrene sheets. For mounting all the parts of the sound module, the battery and speakers, and also for stiffening the chassis, a second and third level of the chassis made out of aluminium sheet metal has been manufactured.

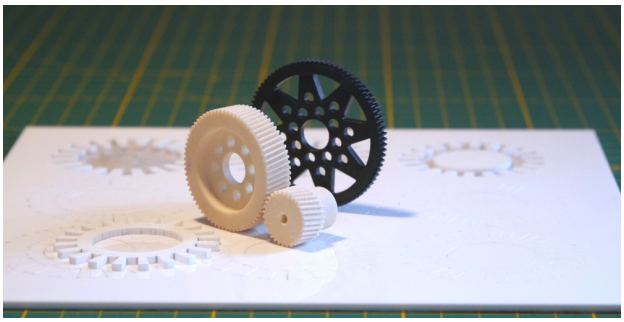


Fig. 3: Left: Laser manufactured parts: The SLS manufactured main and pinion gears replacing the original spur-toothed gears. Next to it is the laser cut optical encoder wheel, which is mounted to the main gear. Right: Final car with an Audi Quattro body shell.

For the moment the development of the sound module and the chassis are mostly finished. There are plans for implementing the scaling of more deatailed physical effects like distance-dependent (damping and refraction) and other sound effects.

- More pictures of the final car model can be found here: https://www.instagram.com/thecarscalingproject/?hl=de
- Maybe the most interesting part of the documentation can be found here: https://www.youtube.com/watch?v=lFe11E0X7Ko
  The video is maybe a bit long, nice scenes are: begining to 00:48, 02:20 to 3:05, 4:12 to end
- The STEP and SVG files for the customized main and pinion gear and the optical encoder are attached.

„Modern cars are rolling computers“. Now, rolling computers become classic cars. Cars for future! ;)