

Acoustic vehicle speed estimation from single sensor measurements

PROJECT SCRIPTS

feature_extraction.py creates HDF5 datasets with input features (log-mel spectrogram (LMS)), ground truth labels (proposed modified attenuation (MA) feature) and annotation data (speeds and train-valid split) for each vehicle. No-vehicle audio files are also included (see elements "NoCar" and "NoCarTest" in array folds). HDF5 datasets are made using audio and txt files from the **audio+annotations** folder. The created HDF5 datasets are output in the **datasets** folder.

project_tools.py contains tools required for project implementation.

MA_regression_all_vehicles.py performs regression of the proposed MA feature. We carry out 10-fold cross-validation. Of the ten folds, one fold (vehicle) is retained for testing, whereas the remaining nine folds are used for training and validating the proposed neural network (NN) model. The NN model is trained 20 times (variable runs). The script saves an HDF5 file with MA regressions corresponding to all test vehicles. NN model parameters are included in the filename.

MA_regression_one_vehicle.py does the same as **MA_regression_all_vehicles.py**, but for one test vehicle (variable `test_veh_ind` represents index of test vehicle). This script allows parallelization of MA regression (e.g., running on several Google Colab accounts simultaneously). The script saves a HDF5 file with MA regressions corresponding to the selected test vehicle. NN model parameters and test vehicle name are included in HDF5 filename.

join_vehicle_regressions.py joins MA regressions of separate vehicles (saved by script **MA_regression_one_vehicle.py**) into one HDF5 file.

speed_estimation_SVR.py carries out speed estimation based on MA regressions of all vehicles. Speed estimation is carried out using support vector regression (SVR). The script saves a HDF5 file with speed estimations per vehicle, obtained over 20 runs.

fig_MA_predicted_plots, **fig_MA_detection_histograms.py** and **fig_speed_estimation_plots.py** create Figs. 6, 7 and 8, respectively. Figs. 6 and 7 present results based on MA predictions, whereas Fig. 8 presents speed estimations.

tab_print_speed_est_results.py prints speed estimation results presented in Tables 2 and 3 in the paper.

PROJECT FOLDERS

Folder **audio+annotations** contains 12 folders with wav audio files and txt annotations. Ten folders correspond to vehicles, two (NoCar and NoCarTest) to no-vehicle scenario. When you download the Python project, this folder will be empty, so you should extract archives from **Audio + annotations** dataset into this folder.

Folder **datasets** contains HDF5 datasets with LMS features, labels and annotation data obtained using script **feature_extraction.py**. We provide the datasets (`data_CitroenC4Picasso.h5`, `data_Mazda3.h5` etc.) with parameters described in the paper (listed in the beginning of script **feature_extraction.py**).

Folder **results** contains two folders: **MA_regressions** and **speed_estimations**. Scripts **MA_regression_one_vehicle.py** and **join_vehicle_regressions.py** save MA regression files into folder **MA_regressions**. Script **speed_estimation_SVR.py** saves a HDF5 file with speed estimations obtained with the proposed method into folder **speed_estimations**.

How to use the codes

IMPORTANT! Before running the codes, ensure that archives from the Audio + annotations dataset are extracted into project folder audio+annotations. There should be 12 folders with wav audio files and txt annotations within audio+annotations:

- *vehicle folders* (CitroenC4Picasso, Mazda3, MercedesAMG550, NissanQashqai, OpelInsignia, Peugeot3008, Peugeot307, RenaultCaptur, RenaultScenic, VWPassat), and
- *no-vehicle folders* (NoCar, NoCarTest).

Step 1: Run script `feature_extraction.py` to create HDF5 datasets with input LMS features, ground truth MA values and annotation data. You can find the already created datasets (`data_CitroenC4Picasso.h5`, `data_Mazda3.h5` etc.) with parameters described in the paper (listed in the beginning of the script) in folder `datasets`. For a different parameter setup, run `feature_extraction.py` with other values of parameters.

Step 2: Run script `MA_regression_all_vehicles.py`, which carries out regression of the MA feature. The script saves an HDF5 file with MA regressions corresponding to all vehicles. Filename includes NN model parameters (e.g., `regression_NN_1000-200-50-10-1_reg1e-3_lossMSE.h5`).

Alternatively, MA regressions can be obtained with script `MA_regression_one_vehicle.py`, which carries out regression of the MA feature for one vehicle. It should be executed 10 times (possibly in parallel, e.g., on several Google Colab accounts), with variable `test_veh_ind` varying from 0 to 9. The resulting files are then joined into one file with MA regressions of all vehicles by executing script `join_vehicle_regressions.py`.

Step 3: Run `speed_estimation_SVR.py` to carry out speed estimation based on MA regressions of all vehicles. Speed estimation is carried out using support vector regression (SVR). The script saves a HDF5 file with speed estimations per vehicle, obtained over 20 runs.

Step 4: Run scripts `fig_*.py` files to create Figs. 6-8. Run `tab_print_speed_est_results.py` to print speed estimation results presented in Tables 2 and 3 in the paper.