UMR Acoustique Environnementale
(Université Gustave Eiffel-Cerema)

PHD THESIS PROPOSAL 2024

PhD thesis title

Dynamic rolling model for predicting tyre/road noise using statistical hybrid method

Recommended education

☒Master Science (M2)

Requested skills

Main specialty: Acoustics and vibrations
Other concerned specialties: Mechanics of structures, Contact mechanics

Description

Tyre/road noise, also called rolling noise, is the main source of road traffic noise in smooth driving conditions. Its understanding and physical modelling therefore constitute an important issue for reducing the impact of road traffic noise on the environment. The interaction between the tyre and the road surface during rolling generates noise sources of mechanical (vibratory excitation of the tyre) and aerodynamic (air-pumping) origin which are then amplified by the dihedral formed between the tyre and the road surface. [1].

The objective of the thesis is to develop a dynamic rolling model for predicting tyre/road contact noise using a hybrid statistical method. Hybrid statistical models use experimental databases, enriched by physical models, in order to establish statistical laws for rolling noise emission based on the parameters of the road surface and the tyre causing the noise. This type of approach has been widely used within UMRAE for rolling noise prediction [2,3,4].

The thesis program is structured into several tasks:

1. *Bibliographic study*
2. *Geometric and vibrational characterization of a reference tyre*
3. *Recalibration of a reference hybrid statistical model*
4. *Calculation of dynamic tyre/road rolling*
5. *Exploitation of dynamic rolling model data in the hybrid statistical model*

Task 1 – Bibliographic study

The bibliographic study will focus on the characterization of the road surface (noise, texture, absorption), hybrid statistical models for the prediction of rolling noise and the physical modelling of rolling noise of vibratory origin (vibration response of the tyre, model of tyre/road contact, acoustic radiation).

Task 2 - Geometric and vibrational characterization of a reference tyre

A reference tyre will be chosen as part of the thesis, probably the standard SRTT P1 tyre recommended in the ISO 11819-3 standard for the close-proximity (CPX) measurement of rolling noise. The objective here will be an experimental geometric and vibrational characterization of the tyre for use in rolling noise prediction. The mechanical parameters of the tyre (mechanical modules, damping) will be identified by comparison with the waveguide finite element high frequency (WFE-HF) vibration model anticipated for the modelling of dynamic rolling [5].

Task 3 - Recalibration of a reference hybrid statistical model

The objective of this task is to realign the UMRAE reference hybrid statistical model, called HyRoNE (Hybrid Rolling Noise Estimation), from a rolling noise measurement database for the reference tyre of the thesis. An experimental measurement campaign will be carried out on the reference test track of the Gustave Eiffel University located on the Nantes campus. It will consist of measuring the CPX rolling noise on different road surfaces of the track (between 10 and 15 surfaces), supplemented by texture measurements for the new test sections of the track and by sound absorption measurements for the porous surfaces. The HyRoNE model, based on a static 3D envelopment model, will then be calibrated from this new dataset at different reference speeds and its accuracy will be quantified.

Task 4 - Calculation of dynamic tyre/road rolling

The dynamic tyre/road rolling model will be based on the coupling between the multi-asperity contact model developed within UMRAE [2] and the recently developed WFE-HF waveguide finite element tyre vibration model [5]. The model will first be validated for simplified configurations, then applied to real road surfaces. The output data from the rolling model useful for the thesis (dynamic contact forces, resultant contact force, vibration field resulting from the forced response on the surface of the tyre) will be calculated for all the road surfaces studied in the framework of Task 3.

Task 5 - Exploitation of dynamic rolling model data in the hybrid statistical model

The objective here is to exploit the data from the dynamic rolling model in HyRoNE modelling. Correlations will be established between these different quantities of dynamic rolling and the continuous measurements of rolling noise. The different results obtained will be compared with those of the HyRoNE 3D model based on static envelopment. The purpose is to evaluate the gain obtained on the noise estimation with the dynamic rolling model.

References:

[1] Heckl M. « Tyre noise generation ». *Wear* 113, n° 1 (1986): 157-70. https://doi.org/10.1016/0043-1648(86)90065-7.
[2] Dubois G., Cesbron J., Yin H.P., Anfosso-Lédée F. and Duhamel D. « Statistical estimation of low frequency tyre/road noise from numerical contact forces ». *Applied Acoustics* 74, n° 9 (2013): 1085–1093. https://doi.org/10.1016/j.apacoust.2013.03.011.
[3] Klein P. and Cesbron J. « A 3D envelopment procedure for tyre belt radiated noise level prediction ». In *Proceedings of Inter-Noise 2016*, 2230-41. Hamburg, Germany, 2016.
[4] Klein P. and Cesbron J., « Prediction of Coast-By tyre/road noise levels at peri-urban and urban speeds », in Proc. 9th Forum Acusticum, Lyon, France, décembre 2020, p. 2517-2524.
[5] Treyssède F. and Cesbron J., « Waveguide finite element modelling for broadband vibration analysis of rotating and prestressed circular structures: Application to tyres », Journal of Sound and Vibration, vol. 543, p. 117361, janv. 2023, doi: 10.1016/j.jsv.2022.117361.

Key-words: tyre/road noise, tyre/pavement interaction, tyre vibrations, multi-asperity contact, statistical hybrid modelling, road surface, acoustical measurement

Expected skills and background

Master's degree acoustics and vibrations with skills in computational mechanics. A complementary experience in contact mechanics would be appreciated. Skills and a taste for both experimentation and modelling are expected. Writing skills in French and/or English are expected. Dissemination of the work by publication of scientific articles in peer-reviewed journals is expected, as well as a communication to at least one international conference in mechanics or acoustics.

Doctoral school

The student will be enrolled at doctoral school « Sciences de l'Ingénierie et des Systèmes » (SIS) (https://ed-sis.doctorat-paysdelaloire.fr). The registration school will be Université Gustave Eiffel.

Place of the thesis

☐ **Uni Eiffel, Campus Lyon** (25, avenue François Mitterrand, Case24, Cité des mobilités, F-69675 Bron Cedex)

☒ **Uni Eiffel, Campus Nantes** (route de Bouaye, CS4, F-44344 Bouguenais Cedex)

☐ **Cerema – Strasbourg** (11, rue Jean Mentelin, Strasbourg-Koenigshoffen, F-67035 Strasbourg)

Supervision

- PhD thesis director: Julien CESBRON Université Gustave Eiffel/UMRAE)
- PhD thesis co-director: Fabien TREYSSEDE (Université Gustave Eiffel/GERS-GeoEND)
- PhD thesis supervisor : Philippe KLEIN (Université Gustave Eiffel/UMRAE)

Funding

- Cofunding Université Gustave Eiffel - Région des Pays de La Loire

Other information

To apply please send by email to Julien Cesbron (julien.cesbron@univ-eiffel.fr) the following documents:

- a resume;
- a motivation letter;
- his (or her) Master degree scores (with rank);
- possibly one or more letter(s) of recommendation.

An incomplete application will not be considered.

Contact

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