

Title

Improving trumpet sound simulations by data-driven modelling techniques

Supervisors

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Place of internship

Laboratoire de Mécanique et d'Acoustique, LMA (UMR CNRS 7031)

4 impasse Nikola Tesla, 13013 Marseille

Online meetings with Yamaha corporation (Japan) will be organized during the internship

Duration: 6 months

Gratification: about 600 EUR/ month

Language: French and English

Contact

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Description

Sound simulation by physical modelling relies on the representation of the physics underlying the functioning of musical instrument. It constitutes an interesting tool to simulate the variety of behaviors of the instrument, and also a very useful tool for musical instrument makers in order to better understand the influence of the different design parameters on the response of the system (sound, blowing pressure, etc.). Indeed, the instrument designer can investigate numerically the consequences of changes in the conception on the response of the instrument, without having to build a physical prototype. This numerical aid is therefore very interesting to investigate various design choices.

Furthermore, one challenge in developing such physical models relies on the modelling of the players, that is to say of the lips for brass instruments. Indeed, the lips constitute a sophisticated biomechanical system that are currently modelled using simple linear or nonlinear mechanical oscillators.

Although these models provide relatively satisfactory performances, the parameters of these models (resonance frequencies, damping, mass) remain difficult to estimate precisely. Besides, measurements to identify these parameters are very difficult (or even impossible) to conduct without perturbing the player.

To try to overcome this issue, experimental systems such as artificial players have been developed at LMA and in Yamaha laboratories in order to play instruments in controlled conditions, and to monitor a number of variables (pressure, lip displacement, etc.) during the performance.

The objective of this project is to study the performance of a data-driven system identification technique to identify lip models and their parameters using experimental data collected on an artificial trumpet player developed at LMA. This approach relies on combining sparsity-promoting techniques and machine learning with nonlinear dynamical systems, to discover the governing physical equations from measurement data.

The work will consist of the following phases:

- 1- Explore different regression and machine learning algorithms for the identification of nonlinear systems using data generated numerically (simple nonlinear systems, simple models of wind instruments)
- 2- Apply the identification techniques to experimental data collected on an artificial player system at LMA
- 3- Validate the identified system by running simulations and comparisons with sounds obtained on the artificial player system

This internship is proposed in the context of the academic chair NAMI (Numerically Aided Musical Instrument Design) between Yamaha corporation, Ecole Centrale Méditerranée, and LMA.

[1] S. Brunton, J.L. Proctor, J.N. Kutz, Discovering governing equations from data: Sparse identification of nonlinear dynamical systems, *Proc. Natl. Acad. Sci. USA*, 113 (15), 2016.

[2] V. Fréour, L. Guillot, H. Masuda, S. Usa, E. Tominaga, Y. Tohgi. Numerical continuation of a physical model of brass instruments: Application to trumpet comparison, *Journal of the Acoustical Society of America*, 148 (2), 2020.