Inria recruits	**A post doctorate candidate *(M/F) – CDD 12 months*** Optimal design of wind instruments using full waveform inversion

Scientific domain

- Applied mathematics, scientific computing
- Musical acoustics

Team : Magique-3D

About the Inria team

Established in 1967, Inria is the only public research body fully dedicated to computational sciences. Combining computer sciences with mathematics, Inria's 3,500 researchers strive to invent the digital technologies of the future. Educated at leading international universities, they creatively integrate basic research with applied research and dedicate themselves to solving real problems, collaborating with the main players in public and private research in France and abroad and transferring the fruits of their work to innovative companies.

The researchers at Inria published over 4,500 articles in 2013. They are behind over 300 active patents and 120 start-ups. The 172 project teams are distributed in eight research centers located throughout France.

http://www.inria.fr/

Magique-3D project-team is specialized in numerical techniques for seismic imaging and develops a mathematical and numerical methodology for various applications in physical imaging. With a strong expertise in seismic imaging, the team has recently extended its application horizon to new fields such as helioseismology, ultrasonic imaging and musical acoustics in partnership with experimental research teams.

Mission

This project aims at adapting the tools for imaging complex media developed by Magique-3D for several years in the purpose of a proof-of-concept to design optimal wind instruments in terms of tuning and playability. We propose to use the technique of full waveform inversion (FWI) on the equations of propagation of acoustic waves in a pipe.

For centuries, instrument makers have performed adjustments (essentially geometrical) in their workshops in order to improve tuning, tone, homogeneity but also the volume, ergonomics and robustness of their instruments. Over the last decades, musical acoustics has been aiming at rationalizing the empirical knowledge established on the subject in order to understand the reasons for past changes, and to contribute, through a scientific approach, to future developments. In this project, we are interested in wind instruments, whose main design parameters are 1/ the area of the section of the pipe at any point (the function which at any point of the pipe associates the areas is called the bore) and 2/ the position of the holes and their diameter. After having defined design criteria, based on historical criteria, the objective is to find the optimal bore and holes that best meet these criteria. This is a so-called "inverse" problem because we are looking for the optimal geometry which minimizes the difference between the result of a simulation on this geometry and a predefined criterion. The aim of this study is to provide efficient and accurate inversion algorithms through an in-depth understanding of acoustic phenomena and sophisticated numerical methods.

Description

The experience gained by Magique-3D in other fields of application (ultrasound, geophysics, helioseismology) has shown the relevance of the FWI technique, which allows to directly optimize the parameters of interest. More precisely, this technique is based on a series of calculations of the waveform in media characterized by these parameters. In this project, we wish to use this technique in order to optimize the bore and in a second time the holes. We will use numerical tools based on 1D finite elements for waveform calculations. This will make it possible to get rid of simplifying geometric assumptions, and will give access to situations that are very realistic and, hopefully, sufficient for design. First, we will use the one-dimensional Helmholtz equation with variable coefficients that models a plane wave in a variable section pipe. This leads to a linear inverse problem. Then, to better represent the wind instruments, this equation will be considered in the time domain and coupled to one or more nonlinear ordinary differential equations which will model the holes, as well as the mouthpiece, the latter having a very strong impact on the accuracy instruments.

Skills and Profile

Skills / Knowledge

- Numerical analysis of PDEs
- Wave propagation modelling
- C++ / matlab or python
- Musical Acoustics

Degree and required experiment :
Doctorate in applied mathematics - numerical analysis
ou
Doctorate in musical acoustics (modeling and numerical methods)

Advantages

Business restaurant on site, transport costs….

Complementary information

Workplace :
Centre de recherche Inria Bordeaux Sud Ouest – 200 avenue de la vieille tour – 33400 Talence

Estimated starting date *: 01/06/2017*

Contract duration : 12 months

Dossier de candidature
Please send you curriculum vitae and letter to

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As part of its diversity policy, the Institute's posts are open to people with disabilities.