PhD proposal (2022-2015) within the interdisciplinary CNRS MITI project **InteracSon**

Aeroacoustic and phonetic study of sound source interactions in speech

Context and state of the art

Speech production relies on the respiratory system (anatomy, physiology) which allows an airflow (physical principles, LEGI lab) from the lungs to be guided into the upper airway, through the larynx and then the vocal tract. This flow can thus interact with itself as well as with the tissues -- dynamic or static -- of the larynx (in particular the vocal cords) and the vocal tract (containing different articulators such as the tongue, incisors, lips etc.). The different speech sounds (phonetic, LPP Lab) are generated when this airflow from the lungs passes through the upper airway. The **dynamics and interaction of the voiced and/or unvoiced sound sources** under consideration depend on the dynamics of the respiratory airflow as well as the dynamics of the vocal tract, which are mainly determined by their geometry and tissue properties. These physical characteristics are, in turn, determined by the phonetic context as well as by the phonetic embodiment. The embodiment is related to biology (morphology, age) as well as posture, movement, etc., which can be influenced by conditions such as Parkinson's disease, which is known to interfere with speech production.

The state of the art of existing phonetic and physical studies shows that the characterisation, modelling and thus the understanding of the dynamics and interaction of sound sources is an open research topic. Indeed, in speech production studies, most research efforts focus on sustained vowels (voicing source) or sustained unvoiced fricatives (aeroacoustic source), **neglecting voiced fricatives, plosives as well as the dynamics of the different sources** determining their generation, maintenance, cessation and coexistence. A better understanding under normal conditions is of fundamental interest. In pathological conditions, related to the different stages of Parkinson's disease, a better understanding could eventually contribute to applications related to the diagnosis, evaluation or management of these disorders.

Objectives

The thesis focuses on the *dynamics and interaction between the sound sources* (of different natures) behind the production of speech sounds. As such, the proposed thesis aims to contribute to the *characterisation, modelling and validation of the aerodynamic mechanisms* associated with the generation, maintenance, cessation and interaction of the sound sources underlying speech phonemes, fricatives (voiced and unvoiced) and plosives (consonantal occluders) and their transitions. The originality therefore concerns the dynamics of the sources and their interaction, which includes voiced plosives and fricatives.

A first objective is to focus on the *dynamics of individual phonemes* (dynamics of different individual sound sources). Then, the second objective is to focus on the d*ynamics of concatenated phonemes* (dynamics of interactions between different sound sources).

Methodology

In order to describe the dynamics of the sound source, the time-varying airflow and the interaction with the time-varying upper airway walls are **modelled** (LEGI) for physical conditions (airflow, geometry, wall properties) relevant to those encountered in normal human speech and in the case of speakers affected by Parkinson's disease. If this approach, which we propose to call **phonetic-physics**, is important for the study of normal speech production, it is crucial for the study of pathological speech. The generation, maintenance, cessation and interaction of different sound sources are **quantified** and the acoustic modelling is evaluated. Typical conditions relevant to multiple phoneme utterances for normal and pathological speakers are identified and characterised on human speakers (LPP). Then, in order to study these conditions in a controlled and repeatable way, the typical conditions are reproduced using **mechanical replicas** (LEGI) so that the modelling can be validated quantitatively and its advantages and limitations identified, first for normal and then for pathological conditions. Finally, the developed model is applied to data obtained from human speakers in order to quantitatively compare the modelled and measured data.

Expected results

The expected results are multiple and related to the fundamental objectives concerning the characterisation and modelling of the dynamics and interaction of sound sources involved in normal (including voiced plosives and fricatives) and pathological (Parkinson's, first model study) human speech production. The results will be published in relevant journals, presented at conferences and developed in the thesis manuscript. It is important to stress that the impact of the results will benefit from the proposed phonetic-physics approach in terms of generality (relevance and validation). Thus, as a result of this study, the results in terms of automatic modelling and characterisation can contribute to applications (diagnosis, monitoring, rehabilitation or compensation strategy, treatment, rehabilitation technology, etc.) related to speech disorders such as Parkinson's disease.

Co-supervision, location and contact

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The PhD will be carried out at LEGI (Grenoble Campus, France) with regular visits to LPP (Paris, France).

Application

Highly motivated students with a degree (5-year master or engineering degree obtained or to be obtained in the academic year 2021-2022) in fluid mechanics, (aero)acoustics, physics or applied mathematics can apply by sending a CV, academic results and a motivation letter by email (see contact).

Websites

https://lpp.in2p3.fr/didier-demolin/
http://www.legi.grenoble-inp.fr/people/annemie.van-hirtum/