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INHARMONICITY OF A TRUMPET WITH A VARIABLE DEPTH **MOUTHPIECE**

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DIFFERENT TRUMPETS: with a variable depth mouthpiece Characterization Variable Trumpet by the Input mouthpiece Impedance Zin x: depth of the cup (cylinder) nuous variation of the depth of the cup (screw) $0 \le x \le 3$ mm

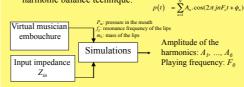
3 INVESTIGATION METHODS

Resonance frequencies of the **INPUT IMPEDANCE**

- Measurement of the input impedance Z_{in} for one given depth (x=0).
- Extrapolation of the input impedance for different depths by impedance calculation (addition of a cylinder of length x with the transmission line formalism)
- Extraction of the resonances frequencies of the impedance, for different mouthpiece depths

Playing frequencies of SIMULATED SOUNDS

· Simulation in the frequency domain with the harmonic balance technique:



- 4 Fingerings: $D_0 D_1 D_2 D_{23}$
- 5 Regimes: R2 to R6
- 30 Mouthpiece positions (discretization of x)
- · 300 virtual "embouchures"

Playing frequency of a note averaged on the different embouchures

Playing frequencies of RECORDED SOUNDS

- Trumpet with the variable mouthpiece played by a musician
- Extraction of the playing frequencies of the sounds
- 4 Fingerings: D₀ D₁ D₂ D₂₃
 5 Regimes: R2 to R6
- · 3 Mouthpiece positions: x=0mm, 1.5mm and
- · 3 repetitions

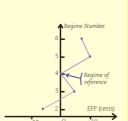
Playing frequency of a note averaged on the 3

OBJECTIVE

Study of the agreement between the playing frequencies of the recorded sounds, the playing frequencies of the simulated sounds, the resonance frequencies of the impedance

=> Toward a prediction of the intonation

ESTIMATION OF THE INHARMONICITY: The Equivalent Fundamental Pitch (EFP)



- Choice of a reference *f(ref)*: 4th regime of the fingering D₀ (tuning note)
- EFP of each note (cent):

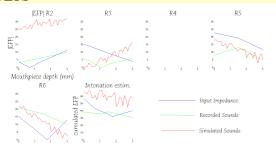
$$EFP(i) = 1200log_2\left(\frac{f(i)/i}{f(ref)/ref}\right)$$

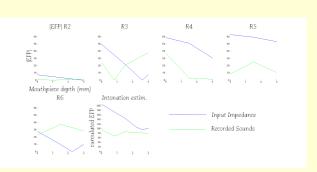
Proposition of an estimator of the global intonation for the whole trumpet

$$Intonation_{estim} = \sum_{j \in \{fingerings\}} \sum_{i \in \{regimes\}} |EFP_{ij}|$$

RESULTS

CONCLUSIONS





Evolution of the EFPs and the Intonation according to the mouthpiece depth x for different regimes (R2 to R6), for fingering D0 only (left) and fingerings D0, D1, D2, D23 (right)

- For Fingering D₀: noticeable similarities in the global behaviour for the 3 methods:
- The general evolution trends of the EFPs for the different regimes are consistent (except for regime 3 for the impedance)
- The absolute values of the EFPs are consistent (except for regime 2 and the simulations)
- Influence of the virtual embouchure on the simulated sounds. Necessity of a method to select the embouchures
- For all the fingerings
 - The precision of the intonation predictions remains low with the impedance. Results in progress for the simulations...