Model-based Effects Screening of Stringed Instruments

Numerical prototyping art and craft domains

R. Viala[1] V. Placet[2] S. Cogan[3]

Department of applied mechanics, FEMTO-ST institute, University of Bourgogne Franche-Comté, Besançon, France

[1]PhD Student, UFC
[2]Research engineer, UFC
[3]Researcher, CNRS

34^t h edition of IMAC, Dynamics of Multiphysical Systems: From Active Materials to Vibroacoustics
the Rosen Plaza, Orlando, Florida USA
January 26th 2016

Table of Contents

Context
Context

- Stringed instruments making requires selecting woods,traditiona linstruments shapes and craftmanship acquired throughout extensive practice
- Repairs and preset operations rather than building new instruments for the instrument makers
- Modeling approaches in transport, aerospatial, aeronautics, automobile,etc. . .
- Use computing power of personal computers to simulate thebehavior ofcomplex systems

1. Transpose numerical methods from the industryt to arts and craft domain
2. Provide instrument makers decision support software to design and build stringed instruments

FEMTO-ST DMA
Besançon

FEMTO-ST DMA

Romain VIALA, PhD student

PhD subject

Numerical prototyping of stringed musical instruments

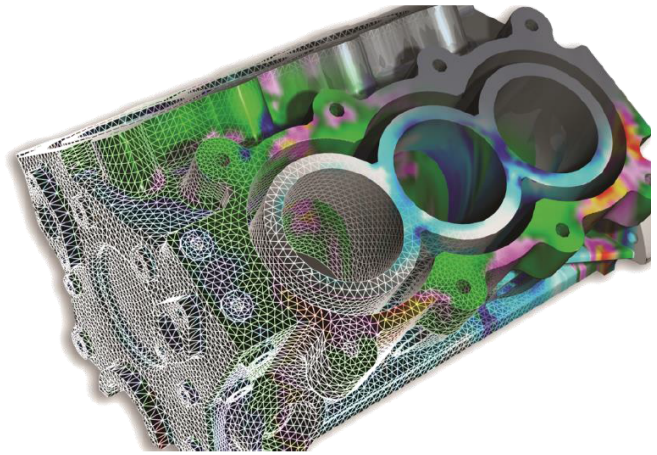
Supervisors

- Vincent PLACET for the material modelisation and characterization part
- Scott COGAN for virtual prototyping and model validation

Foundings

- Public foundings
- Former industrial contracts
- Action COST WoodMusick

Context
Luthier problematic



- Traditionnal musical instruments making
- Variability of the material
- Competition due to cheap instruments on the market
- availability of the wood

$\Rightarrow$ Numerical models as a decision tool?

Context
Subject

1. Vibroacoustic studies of musical instruments at low frequency **basse fréquence**
2. Characterization of elastic and damping properties of the material $\rightarrow$ essential datas for numerical modeling
3. Experimental validation of models on assemblies and subassemblies $\rightarrow$ Credibility of simulations
4. Complex phenomenons analysis
5. Exploratory virtual prototyping with experimental validation

$\Rightarrow$ Develop decision tool software for instrument makers

Variability
Variability




- Hardwoods versus softwoods variability
- Inter specific variability
- Intra specific variability
- Intra individual variability

Density
Density

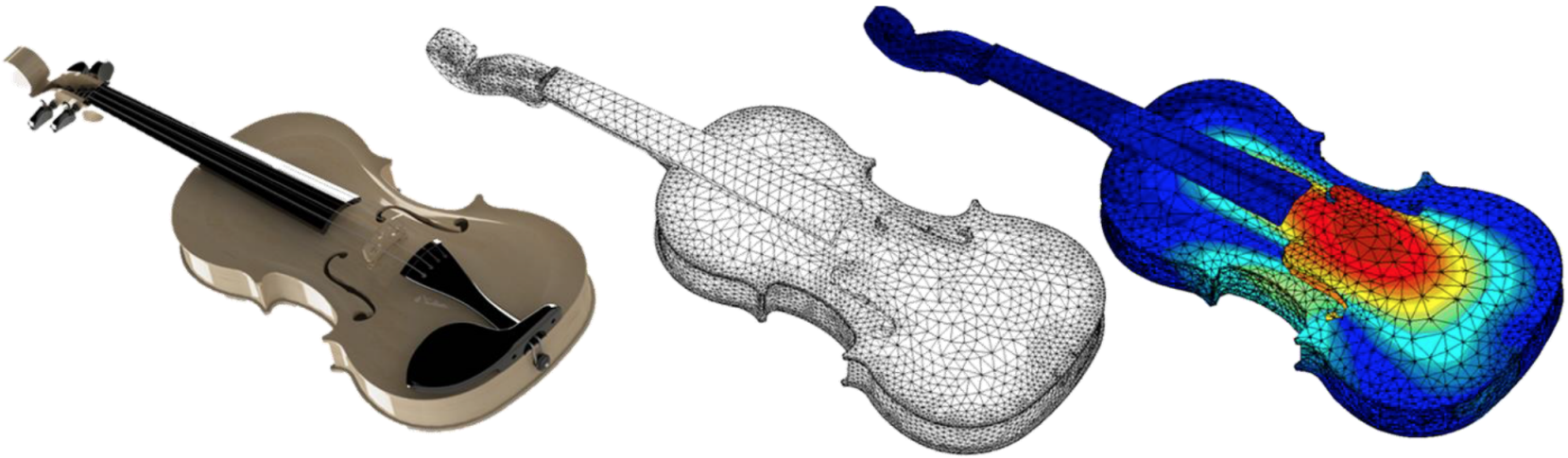
- Density linked to cell wall proportion in the wood
- Density is non homogeneous (annual rings variations)
- Relation between stiffness parameters and density

Hygroscopicity
Hygroscopocity

- Effects of relative humidity on moisture content of the wood
- Moisture content affects both density and stiffness parameters in different ways

Virtual protyping

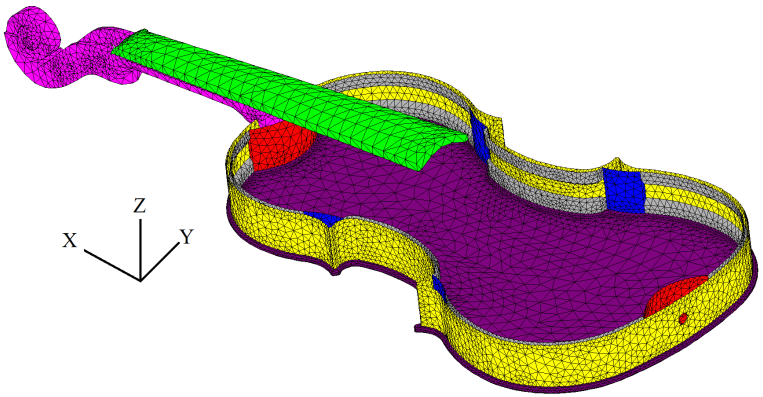
Step

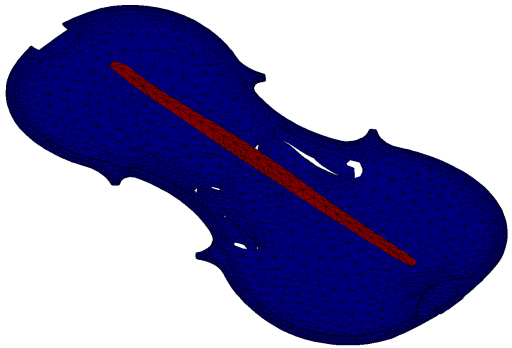


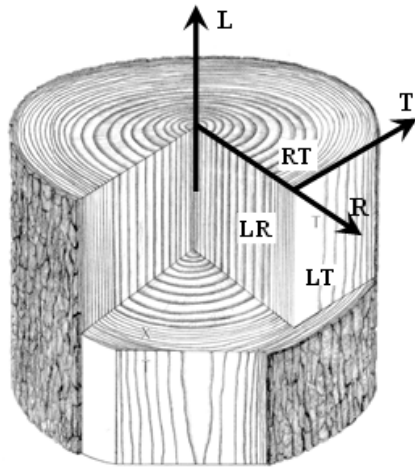
- Detailed numerical models based on physical laws
- Virtual studies
- Virtual modifications

$\Rightarrow$ Propose conception and construction protocols, and model modifications

Sensitivity analysis
Unmounted, assembled violin

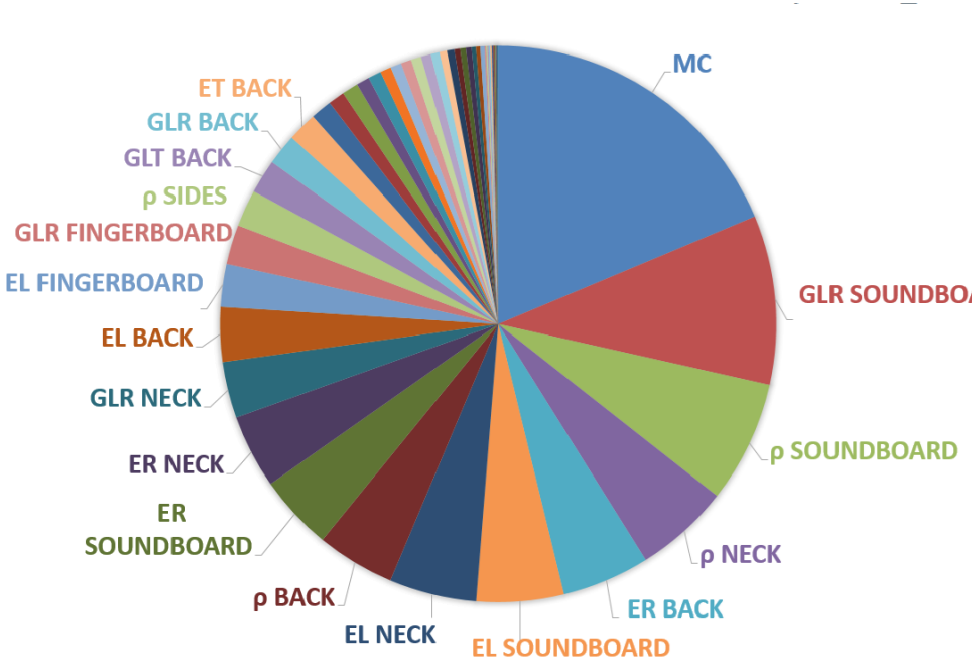


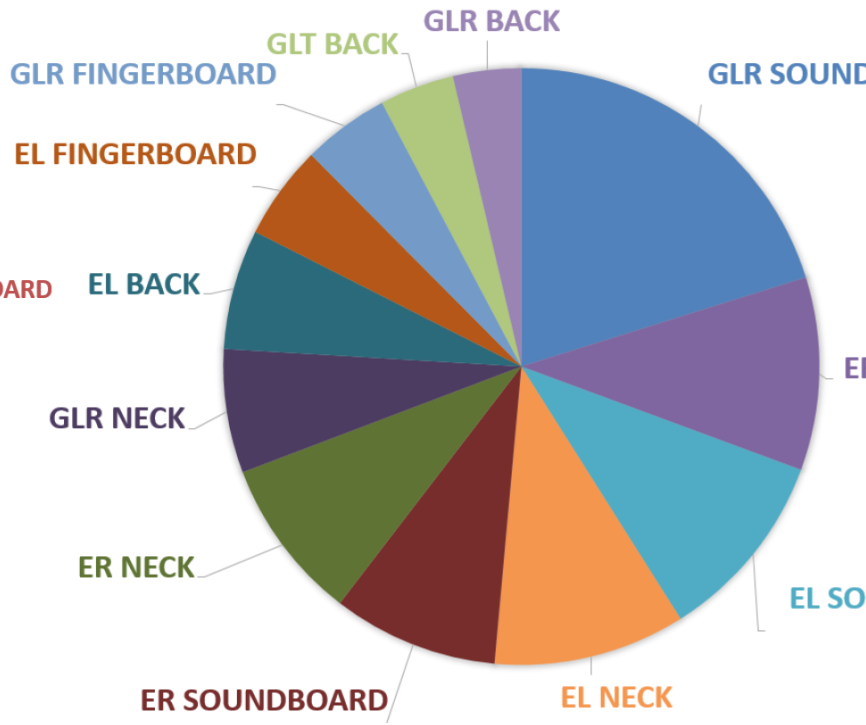




- 3 longitudinal stiffnesses (EL,ER, ET)
- 3 Coupling coefficients
- 3 shear stiffnesses (GLR, GRT, GTL)
- Density (homogeneized)
- Moisture content

Sensitivity analysis
Unmounted, assembled violin





- Ranking of most influent material properties on the vibrationnal behavior from 0 to 3500 Hz
- Study on the effect of the moisture content (linked to the relative humidity)

Advantages

- Study of complex geometries and material behaviors
- Main topic in industrial domain $\rightarrow$ Potential benefits for other domains

Limits

- Nedd detailed infomrations on geometry and materials
- Sensitivity to geometrical properties
- Exwpensive soling codes

Conclusion

- Combination between traditionnal craftmaship, experiments and numerical models
- Better understanding of complex behaviors
- time saving
- raw material economy

Perspectives
Colaboration possibilities

- Discussion

$\Rightarrow$ Which experimental measurements and model validation are possible