A method for a acoustical comparison of the Hammered Dulcimer

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INTRODUCTION

Often musical instrument makers need to compare instruments in terms of sound quality. In addition to the sound spectrum of the produced tone, the decay time of the excited note is also a main quality parameter for the hammered dulcimer [1]. To provide a reproducible excitation, an artificial drum mechanism is used.

Fig. 1: Typical Styrian Dulcimer (diatonic)

EXCITING A DULCIMER

In general, the Styrian Dulcimer (see Fig. 1) is played using a special set of drumstick. Mostly the heads of the wooden hammers have one side covered with leather to soften the surface. This gives the musician the possibility to change the characteristic of the produced sound [1, 2].

Parameters of variety

For comparing the sound and decay rate of the initiated note, the excitation has to be as reproducible as possible.[3] Fig. 2 illustrates the main parameters of variation in excitation, where:

- φ is the angle of strike,
- α describes a possible tilt in the rotation of the hammer,
- β is the variance of the hammer angle different from 90 degrees in relation to the strings,
- XPos defines the variation in the distance measured between beater and bridge,
- YPos is the strike position in relation to the center of the set of strings,
- F is the striking force, and
- v the striking velocity.

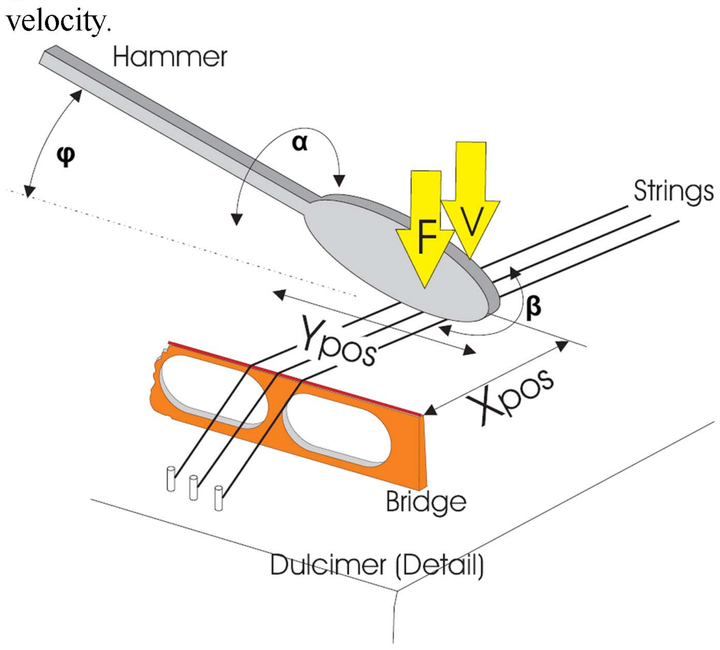

Fig. 2: Parameters of variety

Artificial excitation mechanism

According to the aforementioned possible variations of striking parameters, an electro mechanical system to provide reproducibility has been designed (Fig. 3).

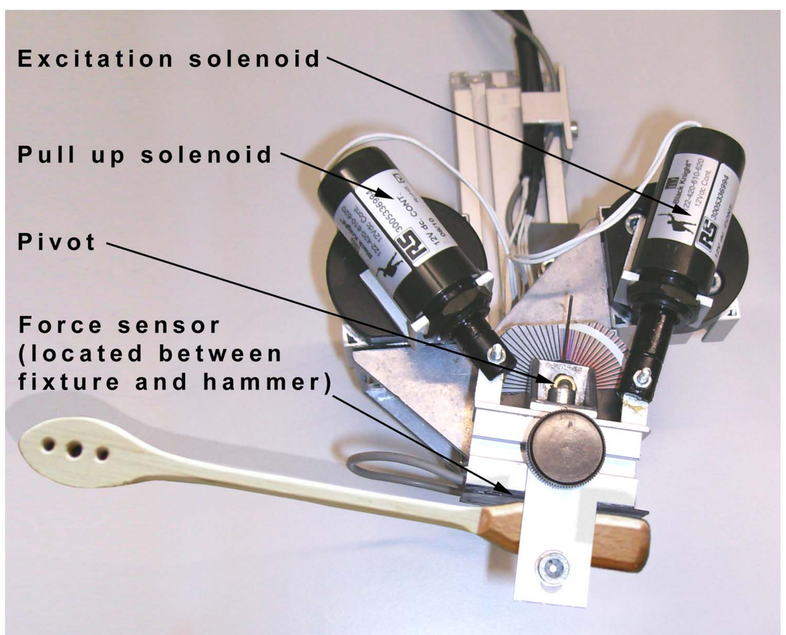

Fig. 3: The mechanical excitation mechanism

To provide a free vibration of the string after a strike, as well as a non chattering excitation, the hammer has to be pulled up immediately after the first string-to-hammer contact.

SOUND DATA ANALYSIS

To provide comparable sound data for analyzing, all recordings where done inside an anechoic chamber. The instrument sits on an optical table where also a heavy yet movable stand for carrying the AEM is also mounted.

Segmentation of sound data

For a consistent decay rate processing, the time domain signal has to be trimmed at a specific level of amplitude (red lines in Fig. 4). The total length of the trimmed sound data becomes dependant on the decay rate, but will be independent of the total recording time and position of attack after recording start (see blue colored signal in Fig. 4).

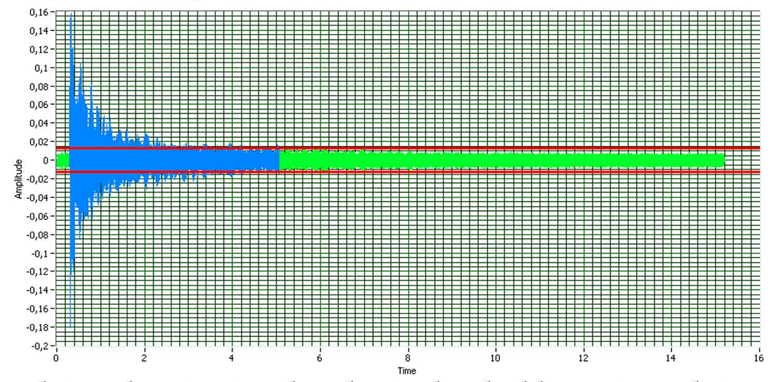

Fig. 4: Captured time domain signal, red: trim levels, blue: trimmed signal, green: cut signal

Calculation of decay rate

After calculating the envelope of the time signal (see red curve in Fig. 5) the method of least squares is used to fit the decay rate curve (black line in Fig. 5). The gradient value can now be used to compare the decay rates of different notes of one instrument and also for a comparison of different models of dulcimers.

Fig. 5: Decay graph, red: RMS amplitude, black: least square fitted linier approximation

CONCLUSIONS

The artificial excitation mechanism proved to excite the instrument more consistently (therefore more reproducibly) than a musician. The standard deviation of the measured decay rates of 5 human excitations (1,23) in comparison to 5 computer controlled excitations (0,12) showed a factor of about 10 in difference (see Fig. 6).

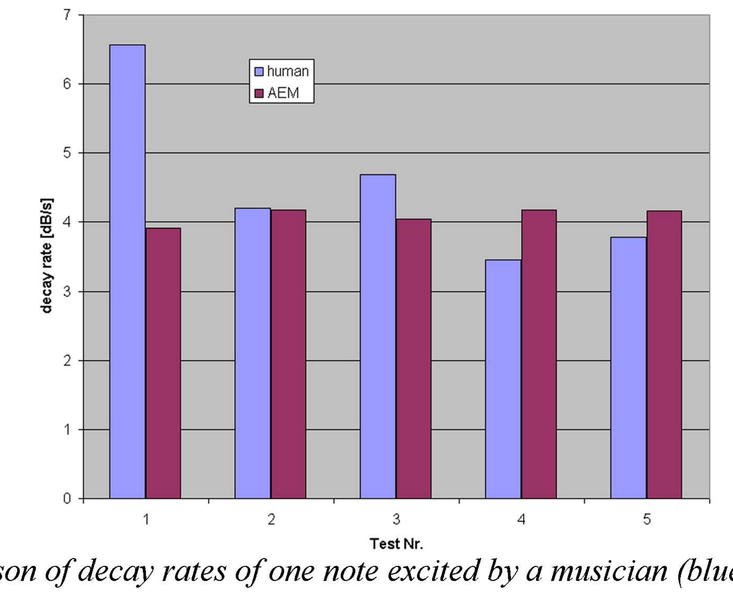

Fig. 6: Comparison of decay rates of one note excited by a musician (blue) and the artificial excitation mechanism (red), 5 times each

Due to thermal effects inside the solenoids and electronics, some variances in the striking force are not negligible. The accuracy of the AEM could be improved by using the force sensor not only as a trigger, but also to normalize the recorded sound signal by the measured striking force.

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