STSM Report

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The primary goal of this STSM was to investigate how changes in the mechanical design of the kantele affect its tonal, dynamical, and radiational behavior and how to apply this knowledge for sound synthesis purposes. In other words, the aim is to help the process to create physically motivated control parameters of a plucked string instrument for computer controlled sound synthesis. The collaboration between the Laboratory of Acoustics and Audio Signal Processing at Helsinki University of Technology (TKK) and the Luleå University of Technology (LUT) aimed at 1) making sound field and vibrational mode measurements on a traditional and new modified design of the musical instrument kantele, 2) developing the measurement equipment involved in this kind of a measurement, 3) analysing changes due to the modified construction, 4) evaluating the need for modeling the possible changes, and 5) publishing the results in a respected journal of the field.

During both visits the instruments at hand were measured with a scanning laser system (Polytec) and the air radiation was captured with a measurement microphone (B&K), placed about a meter from the instrument near the laser head. Prof. Mikael Sjödahl was the supervisor of the visit, Emeritus Prof. Nils-Erik Molin provided valuable insight through discussions. The measurements were conducted with Licen. Kourosh Tatar and MSc. Per Gren.

Previously the loudness of the modified kantele was proved trough listening tests which were supported via acoustical measurements and calculations [1,2]. The research team at LUT have experience in making vibrational mode measurements with musical instruments [3,4] and have the required equipment. This setting between TKK and LUT provided a good starting point for a scientific collaboration. Vibration mode measurements with a scanning laser can provide information of eigenmode shapes and frequencies. This way the behavior of the instrument can be understood more completely. This knowledge can be translated to information that can be used at the modeling stage of the kantele. In addition, possibilities and ranges about the expressiveness of the instrument can be obtained this way. In away, the information can be used to design both synthesis models and mechanical designs that are more expressive.

The staring point of the research is the traditional design of the kantele and a modified design. The traditional design is quieter, i.e., has a smaller dynamic range, than the modified design. In addition, the strings in the traditional design are on average in a tension that is 11% smaller than in the modified design. This means that a pitch glide that disturbs the clarity of notes is more vague in the traditional than in the modified design. The measurements target also to parametrize these aspects of both instruments.

While writing this STSM report an article on the vibrational modes of the modifed kantele has begun to take shape. The plans are to submit this article to the Journal of the Acoustical Society of America during spring 2007.

Visit 1 at Luleå University of Technology – Nov. 13-17, 2006

Monday 13th - Tuesday 14th

The measurement setup was setup. The traditional kantele was mounted its varras (bottom) end and the tip of the top-plate. In traditional instrument vibrational measurements the instrument is excited with a sinusoidal signal, at a point frequency or a sweep. This was also the first excitation method tested in this setup. To be able to know the locations in the frequency domain of the eigenmodes of the kantele it was excited with an impulse hammer at different locations. It was difficult to obtain reliable results with the sinusoidal excitation method with a shaker. Hence, it was decided to build a repeatable impulse hammer setup. For this a pendulum with an accelerometer was built. The excitation point was scanned so that the main eigenmodes were visible in the measured magnitude responses. The repeatability of the setup proved to be reliable.

A rotating disc apparatus previously used for a violin was also used. The rotating disc simulates a bow with an infinite length. The angle and speed of the disc could be accurately controlled. The rotating disc sets the string to a harmonic motion and hence sets the kantele to forced oscillations at the harmonic frequencies of the string. The eigenmodes measured with the pendulum are natural modes of the kantele. In contrast, the harmonic frequencies produced with the rotating disc lie at mode frequencies of the string. Even if the kantele is a plucked string instrument the rotating disc simulates the vibrational behaviour during playing of the instruments.

Wednesday 15th - Thursday 16th

After two days of testing and setting up the traditional kantele was replaced with the modified version. The same measurements done for the traditional one were repeated for the modified. During the week Emeritus professor Nils-Erik Molin visited the measurement laboratory daily, for about a half an hour. These visits proved to be very useful due to his three decades of experience in acoustical measurements of musical instruments.

On Thursday Henri Penttinen presented the past and present activities of Laboratory of Acoustics and Audio Signal Processing, Helsinki University of Technology (TKK).

Visit 2 at Luleå University of Technology – Jan. 8-13, 2007

Monday 8th – Wednesday 10th

During the second visit the measurement setup was altered so that the kantele was higher from the ground and the concrete wall. This gave better resolution for the air radiation measurements. However, the rotating disc setup changed it behavior during Wednesday which prevented systematic comparison. In addition, it was understood that anechoic conditions are essential for the radiation measurements.

Instrument builder Jyrki Pölkki was present and the kantele was modified during the measurements by him. We started with a closed box with fixed edges and ended up with a kantele with a removed wing and no back plate. The intermediate steps were measured to enable us to follow the changes occurring. In addition, the fixing of the instrument was changed so that instead of the left edge at the end of the instrument the attachment was applied to the tuning pin. This improved the free edge behaviour of the instruments to be closer to the natural playing situation. The eigenmodes and body vibrations were measured as previously.

Thursday 11th - Friday 12th

On Thursday two new measurement techniques were applied and tested. The vibrations of the sides were measured and plucking was used as an excitation mechanism. At least for one measurement set of comparable results for the rotating disc and the manual plucking were obtained. This indicates that the rotating disc can be used to excite the kantele and that relatively repeatable results can be obtained by manual plucking. On Friday a special kantele was measured that is larger in size and has four additional strings to the typical eleven. Prof. Nils-Erik Molin visited the measurement site on Thursday and Friday and again provided valuable comments and discussions.

During both visits the arrival to Luleå was set to be on a Sunday, so that the work could be started aptly on Monday morning. This is not visible in the visit period. The return date is included in the displayed visit period.

Main Results

This STSM has provided TKK and LUT a fruitful cooperation possibility that has provided at least the following results. The rotating disc system can be used to excite the kantele even if it has steel strings. This suggests that for example guitars can be excited with the exact same system. Additionally, manual plucking seems to be one viable option to excite the instrument while examining the body bodes of the plates. The analysis of air radiation implies that the result is temporarily negative, i.e., the air radiation of low frequency modes cannot and should not be investigated in anechoic conditions. The participants of the measurements during the visit have already come up with a viable solution for an alternative measurement setup, which would solve the problems confronted in the current setup. Regarding the excitation mechanism of the body the impulse hammer method prevailed over the sweep method. Traditionally, since the 1970's the sweep method has been typically been used in these kind of holographic measurements. The lack in the success of the sweep method most probably lies in the fact that the impulse hammer was able to create a stronger force to the object which was under investigation. In addition, modern laser techniques provide to scan the surface which enables the usage of the impulse hammer.

The more exact analysis of modal behaviour is underway and will be reported in the planned journal article. The results obtain so far are very measurement orientated they will provide a great basis for future analysis and collaborations. Moreover, the preliminary results indicate significant differences in the kantele types, which means that the alterations made to the structure have to be considered in the modeling of the instrument. All the goals have, at least partly, already been met, hence, the visit can be considered to be a successful one.