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Towards a Computer Assisted Violin Teaching Aid

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This paper presents a possible approach for developing a violin teaching aid based on violin pedagogy, sound analysis and comparison of beginner and good player recordings. This teaching aid is targeted at students who have difficulty listening attentively to the sounds they produce. It aims to draw their attention to the sound of a fault, offer correction and to train the user's ear to actively listen.

INTRODUCTION

Many methods have been used to try and understand the complex interactions between the various components of stringed instruments [7]. Much of the research has been carried out to gain insight and understanding about the making of some of the top sound quality stringed instruments. An even greater body of research exists for speech recognition and has influenced the musical instrument recognition, transcription [1] and retrieval domains. Many algorithms and approaches initially used and others, which are still used in the music domain, originated from more general signal processing techniques and from those used in speech. The analysis and synthesis of the singing voice has been possible for some time. However, not a great deal has been done on researching the effect of the player or playing technique on an instrument sound from an analysis perspective. A variety of texts exist on violin pedagogy and playing styles [6], but this knowledge, as far as the authors are aware, has not yet been in any way implemented into a sound analysis device. No studies on poor instrumental playing seem to have been carried out. However, some research into bad singing, within a query-by-humming context, has been published in the music retrieval domain [2]. A computer game developed as a singing aid was presented recently at DAFx 2004 [4]. Presently, it seems that no such violin learning aid or tool exists and an opportunity exists for the development of such home learning aids. This paper puts forward the concept of a computer based violin teaching aid, called ViTool.

EXISTING APPROACHES

There is nothing new in developing music learning aids, but with the advances in signal processing and interactive computing, much more sophisticated systems are now being developed. Hämäläinen *et al.* developed a successful real-time singing aid in [4], which describes the use of pitch-based, i.e. intonation, control of a game character by the user's voice. However a direct transfer of this approach into a violin, or another instrument aid wouldn't be as successful. A singer is physically 'free' to concentrate on a screen and able to react to it. Instrumentalists, especially beginners, need to be looking at what they are doing and looking elsewhere, i.e. at a screen, will disturb their position. For this reason, a system which offers feedback after the user has played their short piece would be much more effective. This differs greatly in approach to the Music Minus One [5] CDs which offer a variety of recordings to which the user plays the solo part.

VITOOL OUTLINE

The ViTool can be thought of as a type of 'box' which records a beginner, analyses it and returns a critique of their technique. The 'box' has a priori knowledge of the piece and is also based on the standard tuning of A440. The ViTool will involve tuning the violin and the selection of the piece of music by the player. Then the recording will be made, analyzed and feedback will be offered to the player. The ViTool can be thought of as several task specific tools. These are a tuning tool, a tone tool, an intonation tool, and a timing tool. This way, the needs of a beginner are better fulfilled. The ViTool could also be expanded and developed for higher level players who may need to work on a specific bow stroke or vibrato speeds. The approach could also be modified and applied to other stringed instruments.

GOOD VIOLIN TECHNIQUE

The highly subjective topic of timbre and how it relates to violin technique cannot be avoided. No two people hear a sound exactly the same and so this research is biased in favour of what professional standard violinists seek in a violin sound. A good sound is produced through a combination of a naturally good sounding instrument plus an essentially flawless or highly efficient playing technique. The poorer the quality of the instrument, the greater the need for stronger or better playing technique. A higher quality instrument allows the player to push their technique further. Possible methods or approaches for measuring these characteristics will be considered.

Good vs. Beginner Timbre

Through investigations into violin timbre, the relationship between timbre and technique was explored. This involved making recordings of beginner and professional standard players, using the same violins and recording setup. The outcome of these sessions was that typical beginner errors can be broadly grouped into five main fault categories. These include what are often referred to, in player parlance, as squeaks, crunches, skating and nervousness. Through visual inspection of the recorded waveforms, these descriptions can be associated with certain features in the waveforms. These tone faults have been identified and can be seen in the figures shown below. They are: onsets, offsets, amplitude, unevenness or nervousness, and non-symmetry about the x-axis. Onset refers to the initial attack or the section of the waveform during which the note is established. The offset section contains information on how the note is finished. Both of these sections are susceptible to 'crunches' in the beginner player examples. This is due to poor bow string contact which effects the clarity of the sound. The amplitude is associated with a sound's loudness. The unevenness or lack of smoothness which may be present in a waveform are often linked with a skating or nervousness in the sound. These are due to bow pressure and contact position problems. The non-symmetry about the x-axis is the most difficult as it is not consistently linked with a clearly audible effect unlike the previous faults. As these effects are visible on the waveforms, standard signal processing algorithms theoretically could be applied and modified for automatic fault identification or detection. The main faults described above are illustrated in the following figures. Figure 1 shows examples of crunching during the onset and offset. A good player sound has been included for comparison. A closer look at the crunch regions, indicated by arrows in figure 1, is shown in figure 2. The spectrograms for figure 1 can be seen in the figure below. In this figure, the regions in the time-frequency domain where the sound quality is not maintained is visible in the lack of clarity of the horizontal lines which represent the harmonics present.
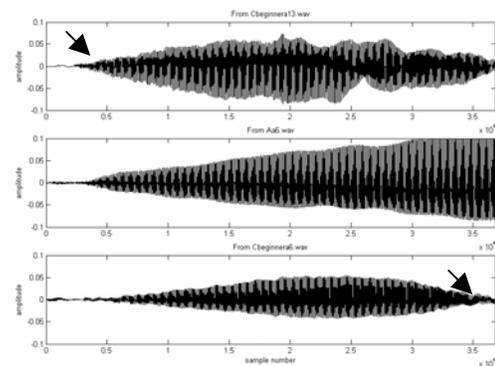

FIGURE 1 Arrows indicate crunch sections. Top: beginner crunching during onset; Middle: Good sound; Bottom: beginner crunching towards end.
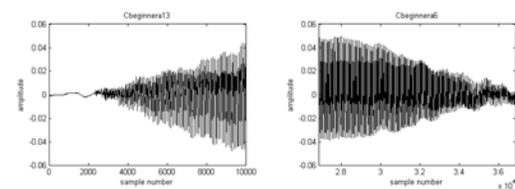

FIGURE 2 Close up of crunch regions at onset and offset as indicated by arrows in previous figure.
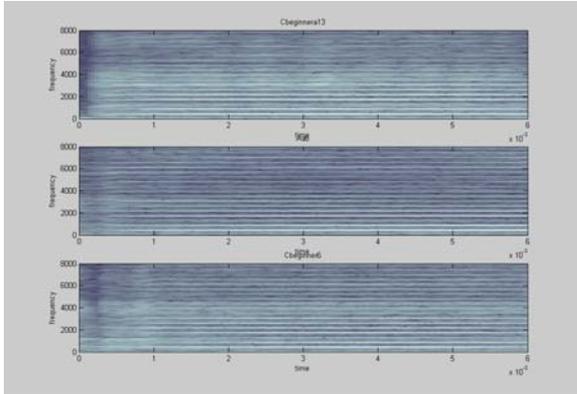
FIGURE 3 Spectrograms of waveforms shown in figure 1.

The amplitude of a waveform is associated with a sound's loudness. Significant variation in amplitude level can be seen between a beginner waveform compared to that of a good player (see figure3). The better sound has a much smoother overall shape than the beginner waveform which has ripples. The plots have been put on the same scale to highlight these differences. The rippling present in the beginner waveform is not enough of a disturbance to become noticeable in the spectrogram but is audible. This is in contrast to deliberate amplitude modulation, caused by the player creating a tremolo.
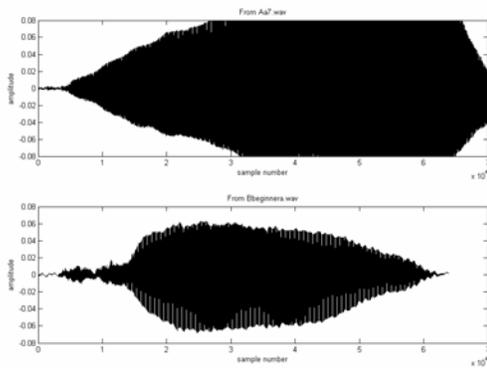

FIGURE 4 Good player (top) vs. beginner (bottom) waveform amplitudes.

Nervousness or skating refers to a wobbling bow which stutters and slips at an angle across the string, adding a nervous quality to the sound. The bow should be kept parallel to the bridge, inline with the tops of the *f*-holes when being pulled across the string to get the cleanest sound possible. To keep this effect clearly visible, the

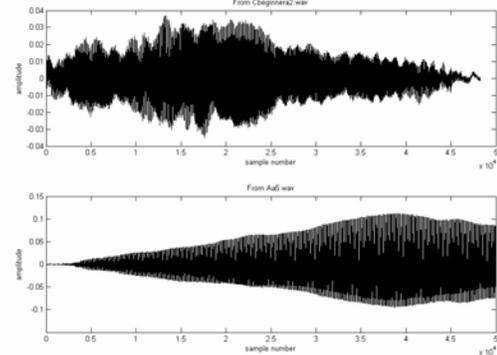two waveforms have been put on the same time scale, but not amplitude.

FIGURE 5 Nervous, skating beginner sound (top) vs. good legato sound (bottom).

The spectrograms show much clearer harmonics for the better sound than for the beginner ones. The beginner sound is a much noisier signal which is evident in both the waveform and in the spectrogram.
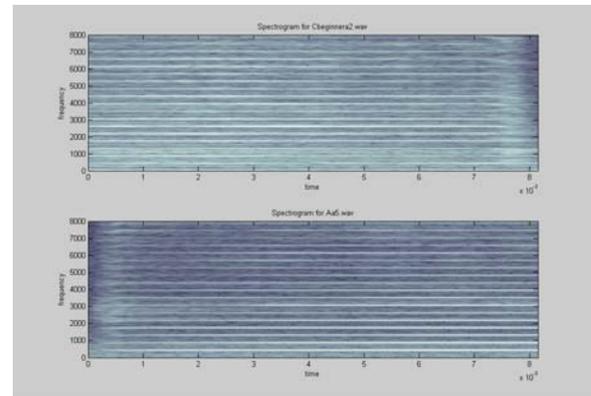

FIGURE 6 Spectrograms of waveforms shown in figure 5.

Most real violin sounds are not perfectly symmetric. Good sounds though tend to be more symmetric than some of the beginner examples. Figure 7 is one such example. Only the fact that there is no clear sound shows up in the spectrogram (see fig. 8).
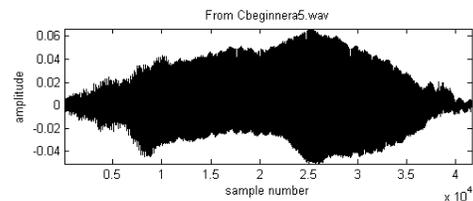

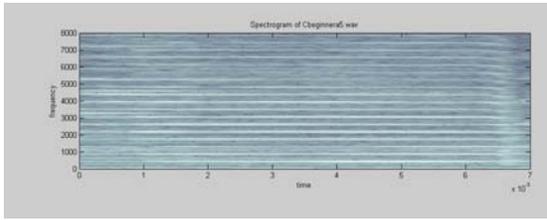**FIGURE 7** An example of asymmetry about the x-axis.

FIGURE 8 Spectrogram of waveform in fig. 6.

PROPOSED METHOD

Five main beginner violinist faults have been identified as being present in the waveforms and in the spectrograms. However, the difficulty arises in differentiating between certain acceptable effects and variations, such as vibrato or tremolo, and from the faults which need to be corrected. Further research needs to be carried out in order to be able to develop a reasonably robust automatic fault detector. Before this becomes possible, a quantitative evaluation as opposed to a qualitative sense of good violin timbre must be achieved. This can be achieved by means of extracting features from violin recordings. Much research has been carried out towards finding representative features for music. However, the multidimensionality of timbre makes it difficult to define. Many features are useful in instrument identification tasks [8]. The number of possible features is reduced though when it comes to contrasting good and poor quality sounds on the same instrument.

 Features can be considered as descriptors and standard features include pitch, its variance, spectral centroid, zero-crossing rates, mean acoustic energy, onset, offset times to name but a few. In [9], many features have been determined. Many of these features may be of use in this timbre task. One possible feature which could help in determining a better sound quality is the spectral centroid, which is often used as a measure of 'brightness' in comparing sounds. Another particularly useful feature could be a note's harmonicity or noisiness. Features which are best suited for detecting the beginner playing faults will be determined and from this, an automatic fault detection system can be developed and subsequent computer assisted violin teaching aid.

CONCLUSION

The research to date has shown that the development of ViTool is viable as the beginner's faults are visible, and several potential quantitative features have been identified. Future work involves implementing a fault detection system as part of the ViTool.

ACKNOWLEDGEMENTS

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