MIDIATOR: A TOOL FOR ANALYSING STUDENTS' PIANO PERFORMANCE*

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Abstract

The *MIDIator* is a software tool that has been developed to analyze a piano student's performance. The program takes MIDI data that has been generated by an electronic instrument like a Disklavier or electronic keyboard and compares it to the data generated by previous performances of the same score or to the nominal score to study variations in tempo, note volume and duration as well as the articulation, producing graphs that are visual representations of what has occurred at the keyboard. Teachers and students have an objective measurement of the student's performance that can be used as a basis for analyzing the performance, correcting mistakes, and following progress over time.

INTRODUCTION

Piano pedagogy is the study of the interactions between an instructor, a student and a piano. The interactions in this scenario are quite diverse and involve verbal communication, auditory perception, visual demonstration, physical interaction and the instructor's feedback, which is based on aural and visual inspection and verification of the student's performance. The objective is to teach the student how to properly play the instrument, and to achieve this, the instructor needs to evaluate the player's performance. This measurement takes into account many factors, such as correct reading of the musical score (tempo, duration, dynamics, articulation) and proper interpretation of a composer's intention, as well as the piano player's physical movements and body posture.

Traditionally, professional piano teachers have relied extensively on subjective visual and acoustic observation of students to improve their performance. This approach has been successful when highly qualified teachers are working with gifted and dedicated students.

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However, the results are not as conclusive with less experienced teachers and/or students with less motivation. Recently, piano pedagogy specialists have recognized the benefit of using audio-visual technologies to monitor piano students during live performances (Baker-Jordan, 2003; Comeau, Brooks and Spence, 2004; Toy, 2003). Such monitoring assists piano teachers and students in evaluating piano playing more efficiently (Canazza, Friberg, Rodà and Zanon, 2003; Riley, Coons and Marcarian, 2005). In this computer age, numerous technologies are available to push this investigation a step ahead. Our interest is in applying these technologies to provide a simple tool with which piano teachers and piano pedagogy researchers can measure and analyze a player's performance, both for live and offline processing.

NEW TECHNOLOGY

Recently, we have seen the emergence of a number of music-related software programs that evaluate musical performance and can be applied to music teaching and learning. *IMUTUS*, for example, provides an interactive multimedia music tuition system for training users on traditional instruments. The system is based on audio/optical recognition, multimedia, and virtual reality technologies (Fober et al., 2004). *Feel-ME* is another tool that focuses on the communication of emotion in the performance of music. It attempts to develop new methods for teaching expressivity based on recent advances in music science, psychology, technology, and music acoustics (Juslin, 2004).

Many artificial intelligence methods that can measure tempo and dynamics in a musical performance are also being developed. Dixon, Goebl and Widmer (2002) have created a system that attempts to quantify and characterize musical performance by tracking specified parameters and displaying them in an animated graphical format called the Performance Worm. *Classic RUBATO* is a software tool for computer-aided analysis and performance of musical material. This program can perform musical gestures and has been used in an audio-visual environment to model the performance of virtual artists (Müller, 2002).

Director Musices (Bresin and Friberg, 2000; Canazza, et al., 2003; Friberg, Colombo, Fryden and Sundberg, 2000) provides a way for researchers to understand what makes a good musical performance. The program transforms scores into musical performances, which are created using predetermined rules (parameters) that are not only geared to determining the rules corresponding to fundamental performance principles used by musicians, but also to assess these rules and their importance. Although these tools provide useful features for analyzing musical performances, they have not been specifically designed to measure and compare the performances of a young music student in a teaching/learning situation, where a teacher in the piano studio or the student in the home environment can visualize, on simple graphs, the quality of the student's playing, both in

real-time and off-line, and compare current performances with his or her previous ones, to see progress and/or evolution.

PROPOSED APPROACH

It is well known that there are two types of score performances. One is the *nominal* performance, which is how the music would sound if it were to be played exactly according to the notes and without any attempt at personal expression. The other type is the *expressive* performance which is the personal rendition of a piece by a musician. There is usually a difference between a nominal score and its expressive counterpart, due to artistic interpretation. With our tool, called the *MIDIator*, we can capture the expressive performance of a piano student and easily compare it to the nominal score, or to the expressive score of a professional pianist. To accomplish this, we use the MIDI (Musical Instrument Digital Interface) format. MIDI is a standard specification that enables electronic instruments such as the Disklavier, electronic keyboards, synthesizers or samplers to communicate with a computer. MIDI data contains precise information such as tempo, volume of the individual note, and start and finish times (duration and articulation). The *MIDIator* uses both nominal and expressive scores to compare the performance between various renditions, in order to see the differences in tempo, as well as differences in volume, duration and articulation of the notes in the score. The system also displays a quantitative summary of the differences between the two scores, including the least and best matched note in terms of timing, and average timing deviation between the expressive and the nominal scores.

THE *MIDIATOR*

Architecture

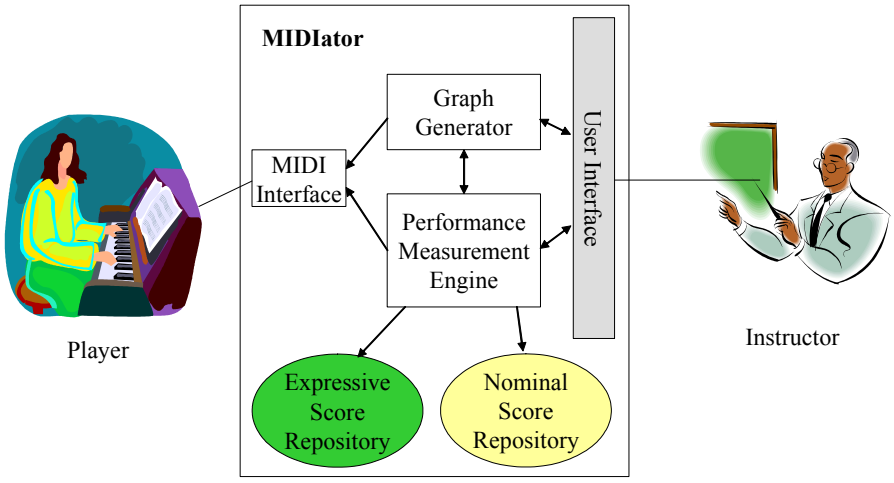


FIGURE 1. The *MIDIator* architecture

The architecture of our system, implemented in Microsoft's .Net platform using C#, is clearly shown in figure 1. In this system, a Yamaha Disklavier equipped with a MIDI port sends the pianist's musical performance to a computer running the *MIDIator* system. The system can read the MIDI information and allow the instructor to monitor the player's performance with the graphs produced by the software. The instructor can then pinpoint the places that errors occur in the pianist's interpretation, as well as their magnitude, in comparison with either the nominal score or a selected expressive score that is deemed to be a good performance. The player can also measure his or her own performance by comparing it to specific nominal and expressive scores, or to his or her own previous performances. A repository of nominal scores as well as a repository of the selected expressive scores is available, and implemented in Extensible Markup Language (XML). Because these repositories are in XML, it is possible to add more performances to the system.

Features

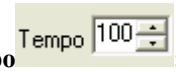
Figure 2 shows some of the *MIDIator*'s most commonly used tools. Let us have a quick look at some of these features.

Zoom  **:** By first clicking this button, the user is able to zoom into the graph simply by clicking over the graph with the mouse and then drawing a zooming box.

Undo/Redo  **:** These buttons undo or redo the last zooming or panning operation.

Bars 

: The user is able to choose the number of musical bars displayed on one screen.

Tempo 

: This button allows the user to specify the tempo at which the music was performed.

Performance Comparison 

: This allows the user to choose the nominal (or expressive) score to compare to the current score.

Display Nominal 

: The user clicks this button to view the nominal score in the score panel.

Display Performance 

: The user clicks this button to view the expressive score in the score panel.

FIGURE 2. The *MIDIator* toolbar

The next figures illustrate some of the graphs displayed by the *MIDIator* for various components of the musical performance.

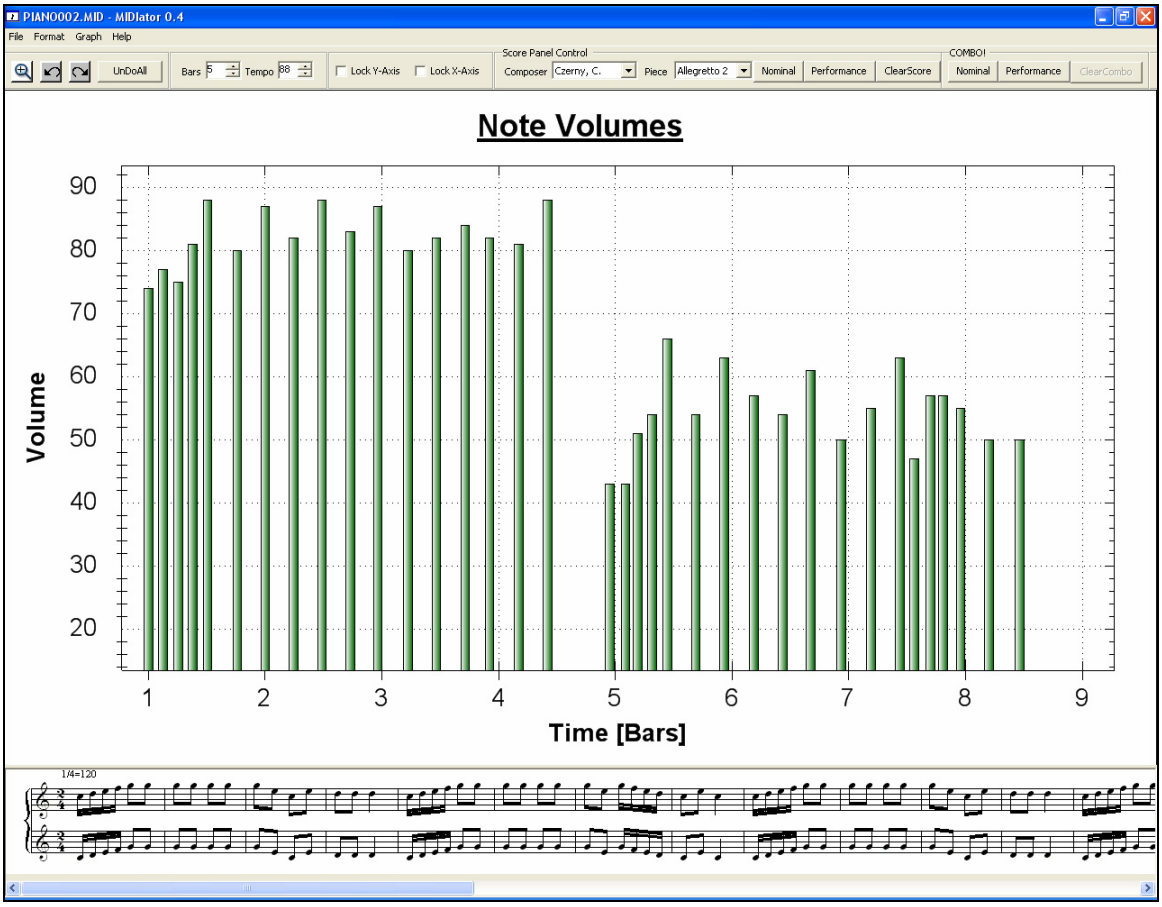


FIGURE 3. Right-hand note volumes displayed as a bar graph

In figure 3, each bar indicates the absolute volume level of each note in the right hand. By looking attentively at the overall level of different sections, the instructor or the student can see the changes in dynamics and the amount of variation (i.e. a lot of changes in the dynamics or very few) as well as the intensity of each variation (i.e. a huge difference between the loud and the soft sections, or subtle changes between two). In the above graph, there is an obvious contrast between the first section, which is played *forte* and the second, which is *piano*. We can also see the change in dynamics within each section if we look at the individual note volumes.

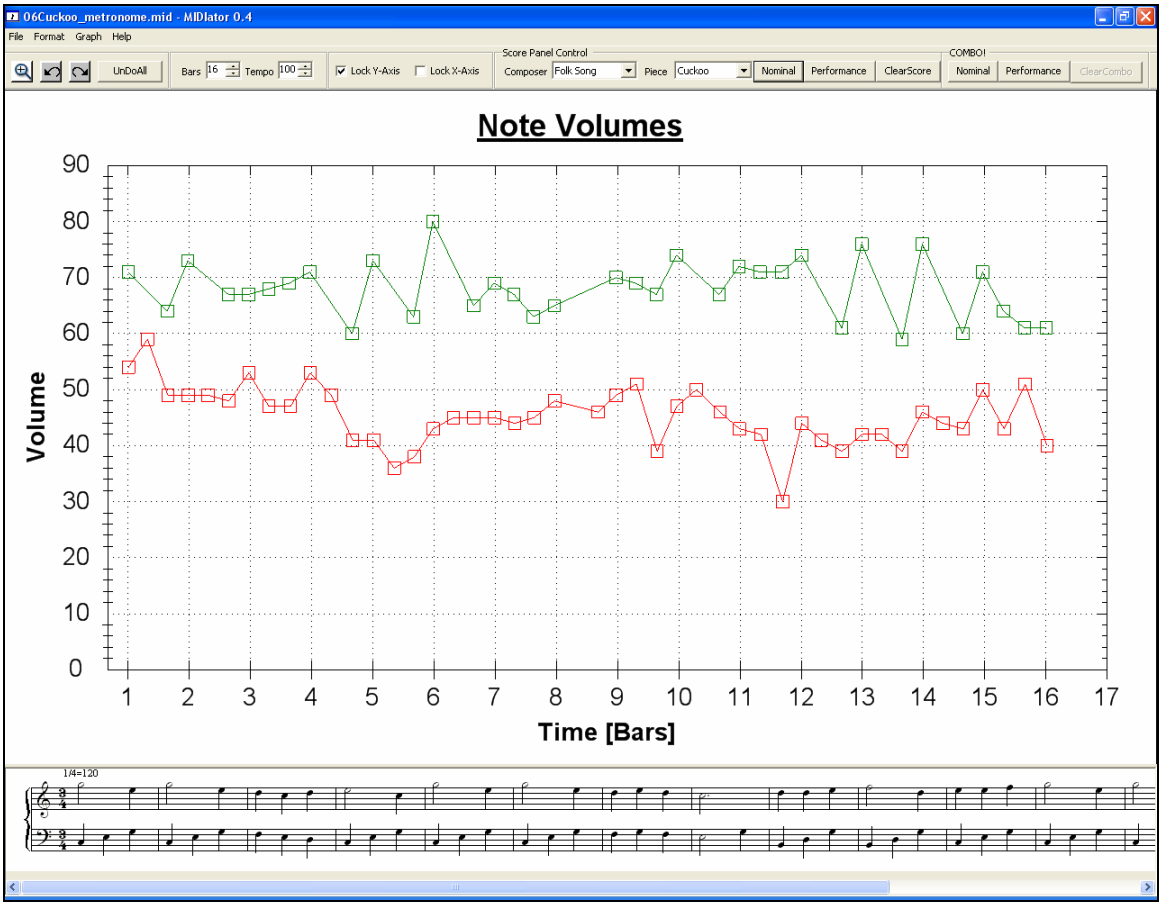


FIGURE 4. Note volumes displayed as a line graph

Figure 4 also represents note volume, but the data is presented as a line graph; again the green lines indicate the right hand while the red lines indicate the left hand. This provides the instructor or the student with a good visual representation of the way each musical phrase is shaped. The subtlety of musical expression can be analyzed by looking at the way the note volumes make patterns or follow certain shapes. By looking at the relationship between the two lines, the balance between the volume in the right hand and the left can also be studied.

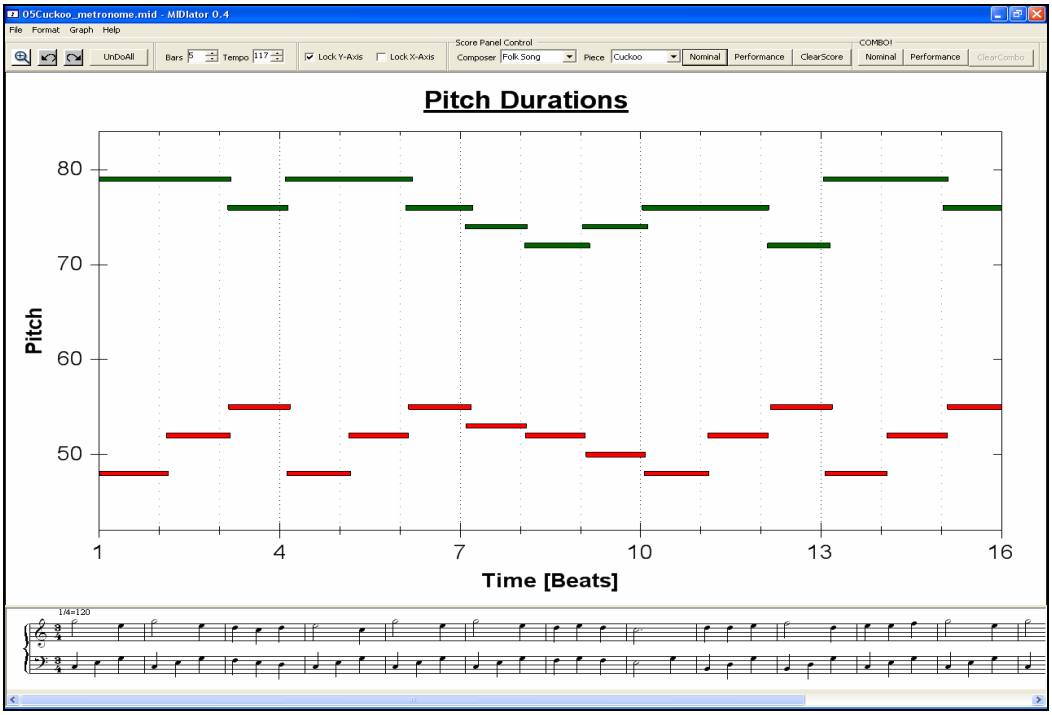


FIGURE 5. Pitch durations (Example 1)

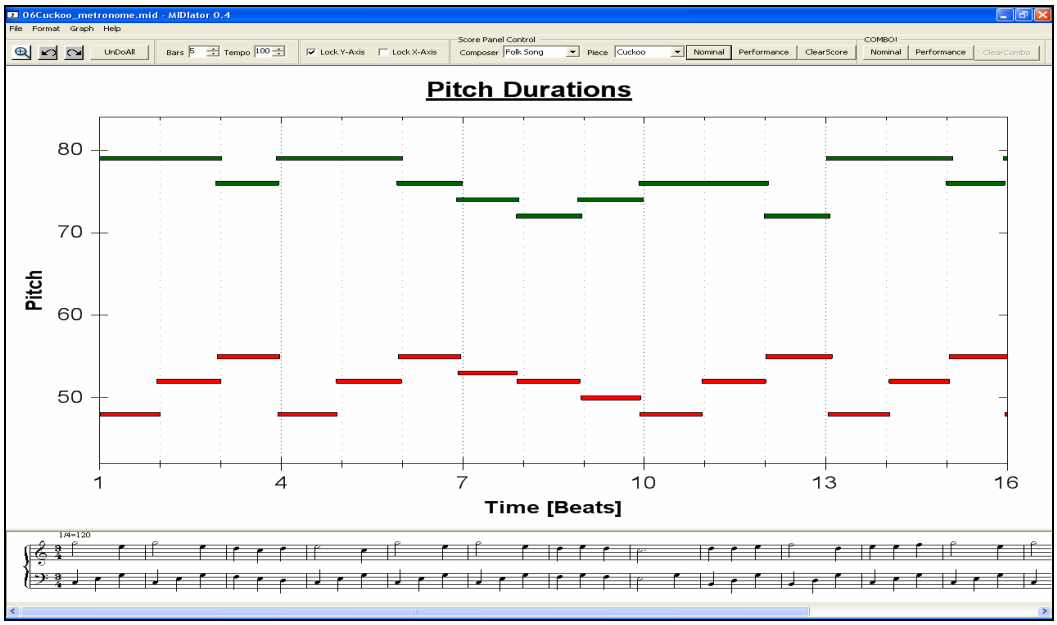


FIGURE 6. Pitch durations (Example 2)

Figures 5 and 6 show the durations of each note. The dotted vertical lines on the graph indicate the beats, which are organized according to the time signature. In expressive performances, the duration of each note is often stretched or shortened slightly to provide certain nuances and accentuate certain directions. These graphs clearly indicate how note durations are modified to suit the performer's intention. In figure 5, the performer prolongs each note slightly, while in figure 6, he or she plays just a bit ahead. Both performances sound in time, but when we analyze them, we see the slight modifications that show how the student is expressing the timing or duration.

The same graphs can also be studied for an analysis of each note's articulation, a slight overlapping indicating a strong *legato* while a space between durations indicating various kinds of detached notes (from a *portato* to a very short *staccato*). In terms of students' performances, this kind of graph can also show rhythm errors, such as long notes not being held, Alberti bass where fingers are not removed on time, notes in the R.H. and L.H. that are not struck together, etc. It can also illustrate improper articulation, such as forgotten staccato, legato with a slight gap between the notes, or legato where the overlapping is too pronounced, etc.

PRACTICAL USES

A prototype of the *MIDIator* has been completed and is now ready to be used in the Piano Pedagogy Research Laboratory at the University of Ottawa. From a pedagogical perspective, the performance data measured and analyzed by *MIDIator* have many applications. They provide a quantitative basis for comparing, reproducing, and improving a pianist's performance.

Figures 7 and 8 show some of the experimentation that has already been done in a studio environment.

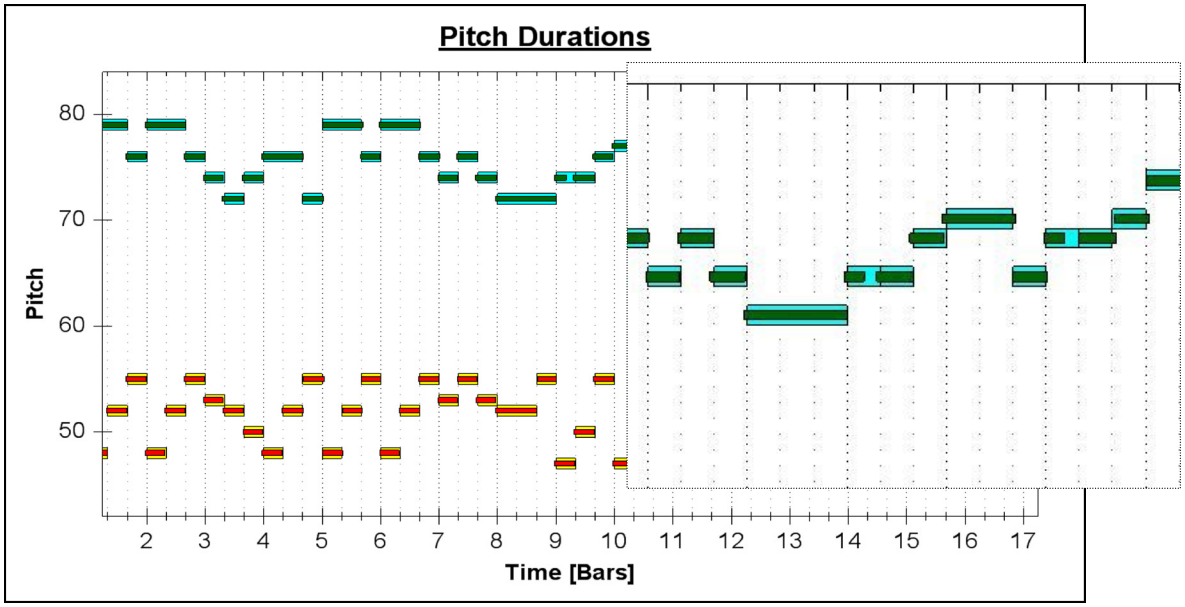


FIGURE 7. Pitch durations. Nominal right hand, turquoise, nominal left hand, yellow. Superimposed on these are the bars representing the student's performance: the right hand is green, the left hand is red.

In figure 7, the turquoise bars represent the absolute mathematical durations of the notes in the nominal score. The superimposed green bars represent the student's performance. Looking at the zoomed-in area in the graph, it is possible to see how the performer plays the notes in the earlier bars slightly ahead of time giving a sense of moving forward in the music toward a climax. The later bars show the opposite tendency, a slight elongation of the notes, which gives an impression of a subtle delay in the forward motion of the music. Thus we have a graphical representation of the performer's expressivity.

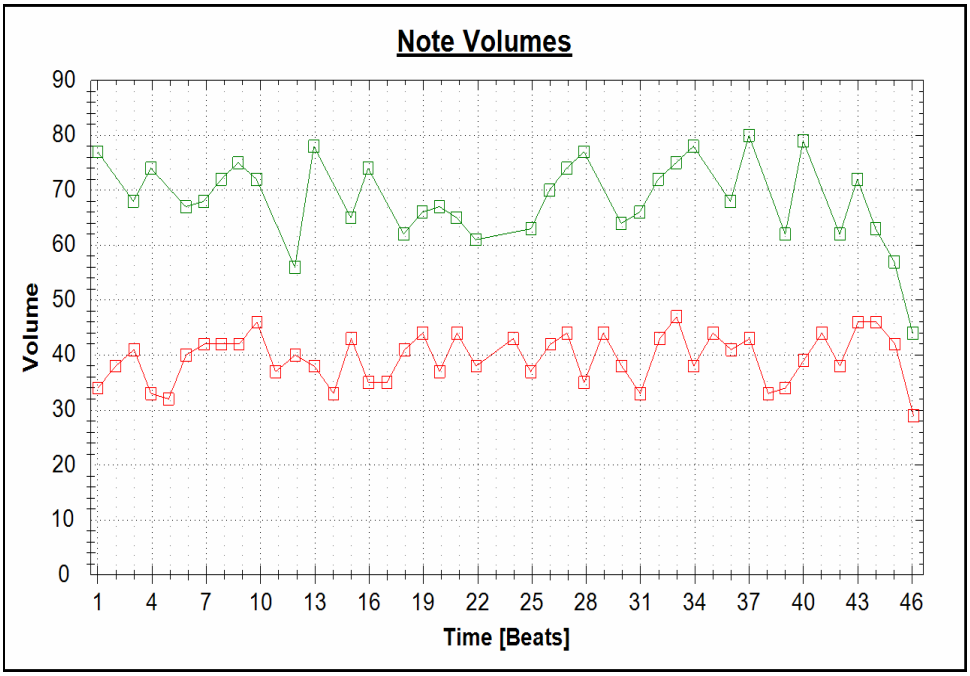


FIGURE 8. Note volumes from the performance of a more advanced student

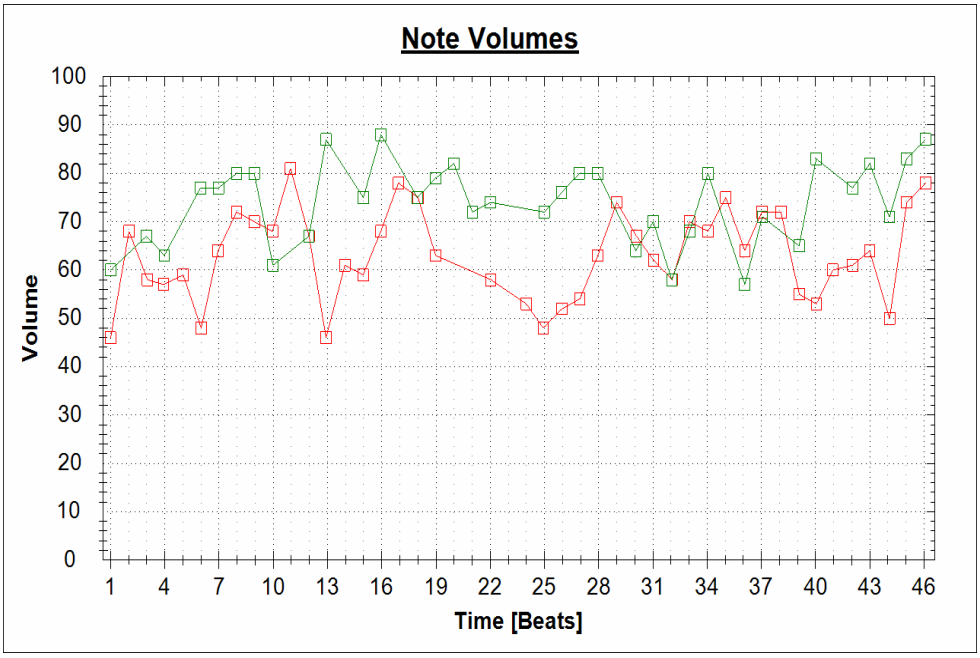


FIGURE 9. Note volumes from a beginner student's performance

Figures 8 and 9 compare the performances of two students at different levels. In figure 8, showing the performance of the more advanced student, we can clearly see the difference in level of sound between the right and left hands (red vs. green), indicating an appropriate balance between the two hands, where the melody in the right hand comes out nicely over a softer accompaniment. This is a skill which is hard to acquire in the early stages of music learning. Figure 9 shows the note volumes from a performance by a beginner student, and we can see that the student is still unable to play with the appropriate balance between the hands. This skill will be developed over a number of weeks and/or months. The visual representation, however, helps the student understand the difference, and develop an idea of where he or she is going. More important, by redoing the same graph periodically, the student can see the progress that is being made and the teacher can monitor how the skill is developing.

CONCLUSION

We have demonstrated a software tool that can be used to analyze a pianist's performance and compare it to other performances or the nominal score. In addition to refining its application to the individual teaching situation, other directions will be explored. First, the *MIDIator* will be developed into a more user-friendly system for use in the home studio. Second, building on our experience in web-based collaboration (Oliviera et al., 2003) and e-learning (Comeau et al., 2004), the *MIDIator* will be expanded for use as a distance-learning tool that allows collaboration between geographically-distributed players and instructors.

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