

Unobtrusive practice tools for pianists

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ABSTRACT

This paper proposes novel computer-based interfaces for piano practicing. They are designed to display in real time certain well-defined sub-aspects of piano playing. They are intelligent and unobtrusive in that they adjust automatically to the needs of the practitioner so that no other interaction is needed than moving the piano keys. They include 1) a pattern display, finding recurring pitch patterns and displaying expressive timing and dynamics thereof, 2) a chord display, showing timing asynchronies and tone intensity variations of chords tones, and 3) an acoustic piano roll display that visually models the acoustic piano tone from MIDI data.

Keywords

Piano Practice, Performance Visualization, Music Education

INTRODUCTION

There is an increasing interest in the possible roles and uses of computers in music education (Webster, 2002), and the technical facilities needed are easily available to virtually everyone. However, there are still only few approaches for developing computer-based tools that are successfully used in every-day music performance practice. As an example, we mention refined spectrogram representations with fundamental frequency trackers that are used in singing lessons (see e.g., the VOXed system Welch, Himonides, Howard, & Brereton, 2004).

In piano performance, visual feedback from conventional piano roll displays has proved to be a helpful means in piano instruction (Riley-Butler, 2001, 2002). A compu-

tational implementation of a MIDI-based performance visualization system has been presented by Smoliar, Waterworth, & Kellock (1995). The displayed performance parameter include onset and offset timing, dynamics, articulation (referring to tone length), and tone onset asynchronies. However, the paper lacks a technical description of how these parameters were computed and implemented, but it becomes evident that this system works in an offline manner (computing the displayed parameters after recording).

The elaborated MIDI-based visualization system “comp-i” (Hiraga, Mizaki, & Fujishiro, 2002) depicts performance information (onset and offset timing, dynamics, pitch) in a 3-dimensional space. Another approach aimed to explicitly exemplify higher-level performance information was provided by Hiraga & Matsuda (2004). They calculate and display local tempo change, local articulation, and local dynamics change. Both of the just mentioned systems work offline (Hiraga, Mizaki, & Fujishiro, 2002, Hiraga & Matsuda, 2004). More recent developments aim at developing computer software that allows relatively fast access to performance information, such as tone intensity or timing (MIDIator software from the Piano Pedagogy Research Lab in Ottawa¹).

High-level approaches aim to impose specific models of emotions and emotional playing on music students via feedback about the goodness of fit of the human performance to the model (Juslin, Friberg, Schoonderwaldt, & Karlsson, 2004). However, such an approach seems problematic because it makes an aesthetic judgment by pre-defining a target performance on the basis of an artificial cognitive model.

AIMS

In this paper, we propose piano practice interfaces that support the pianist in enhancing the effectiveness of his or her daily practice load. They are not meant to be THE solution to all practice problems; instead, they focus deliberately on certain sub-tasks of piano playing. They provide in real time immediate visual feedback via the computer screen to the performer and require a MIDI-compatible piano. They are intelligent in that they “listen” to the pianist’s playing and decide themselves what to display.

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¹ <http://www.piano.uottawa.ca>, seen in May 2006

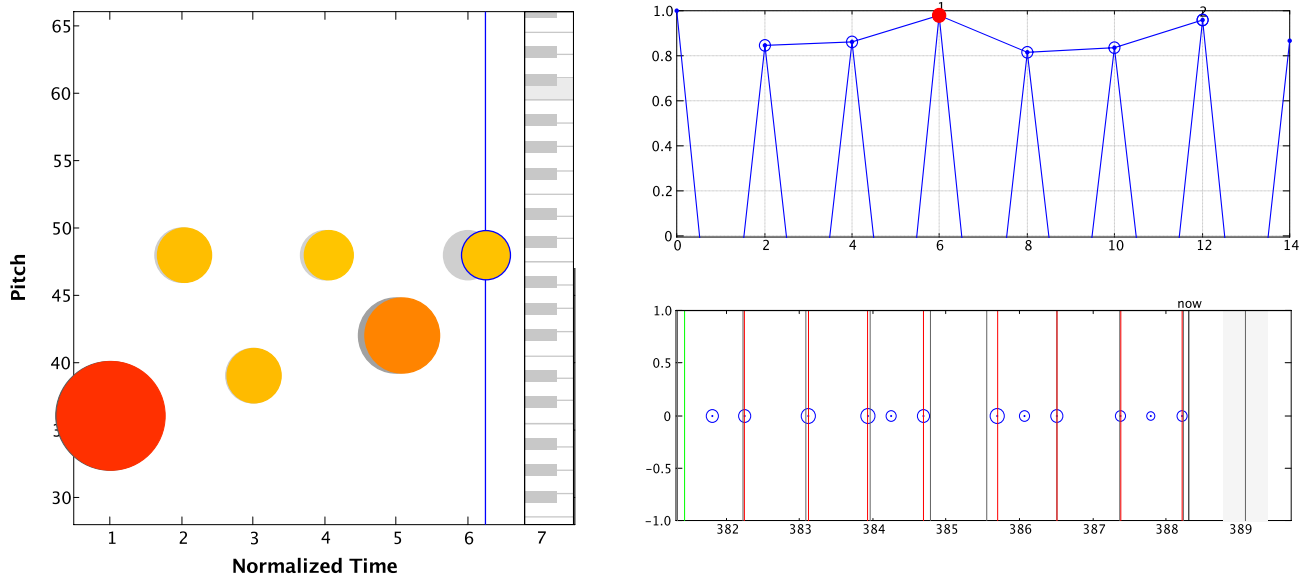


Figure 1 Pattern Display. The left panel shows a 6-tone pattern in a pitch–time space just after its last tone has been played. Circle size and color indicate dynamics (MIDI velocity), horizontal placement the timing deviation relative to the timing of the corresponding pattern tone of the previous pattern cycle (displayed as shaded disks). On the top-right, the auto-correlation pattern is shown (correlation coefficients against shift amount). The bottom-right panel depicts a screen-shot of the frugal beattracker (against time in s), with the present moment marked by “now.” Circles denote played tones, (red) lines tracked beats, and shaded lines expected beat onsets. On the right, the future expected beat is outlined.

They are unobtrusive in that they do not require any direct interaction of the user (the pianist) via computer keyboard or mouse. We argue that any change of haptic modality (from piano keyboard to computer touch pad) would disrupt the flow of practice considerably. The proposed practice interfaces could run permanently in a practice session, getting sometimes the pianist’s attention (e.g., when she is deliberately scrutinizing her own chord play), and sometimes none at all.

The proposed practice interfaces currently consist of three parts which we will describe in the following:

1. A pattern display that identifies recurring pitch sequences and shows timing and dynamics deviations of the found pattern;
2. A chord display that displays timing asynchrony and tone intensity balance of chords (sequences of tones within a certain time window); and
3. An acoustic piano roll representation that visually models properties of the piano sound including decay and pedal interaction.

The current version is implemented in JAVA 1.5 programming language and therefore runs on multiple computer platforms.

PATTERN DISPLAY

Let’s assume the following practice situation: a piano student wants to improve his or her technical ability in per-

forming fast accompaniment passages, such as Alberti bass figures frequently found in the Classical piano literature. For example, take a bass tone followed by two medium-pitched tones, all three alternated by a higher-pitched tone – therefore a six-tone pattern. It repeats several times with slightly varying pitches, but with the same pitch contour. The student wants to know what it is that makes these figures sound irregular, dull, or the opposite – swinging and vibrant.

Our interface automatically identifies the above pattern after typically 2 or 3 repetitions and displays the timing and dynamics of its six tones in real time while the student is practicing. The student can therefore react on his or her irregularities and shape the performance of that pattern according to her taste. We describe in the following the three processing levels of this pattern interface.

Pattern Finding Algorithm

The pattern finding algorithm uses autocorrelation to detect a pattern. Sequences of relative pitch (pitch differences) are correlated to each other repeatedly, each time shifted one element further apart.² The smallest shift at which the correlation coefficient has a peak and is beyond a certain threshold is taken to be the cycle length of the

² In case of a chord (more than one tone within 70 ms), the most prominent tone (in terms of MIDI velocity) is considered for calculation.

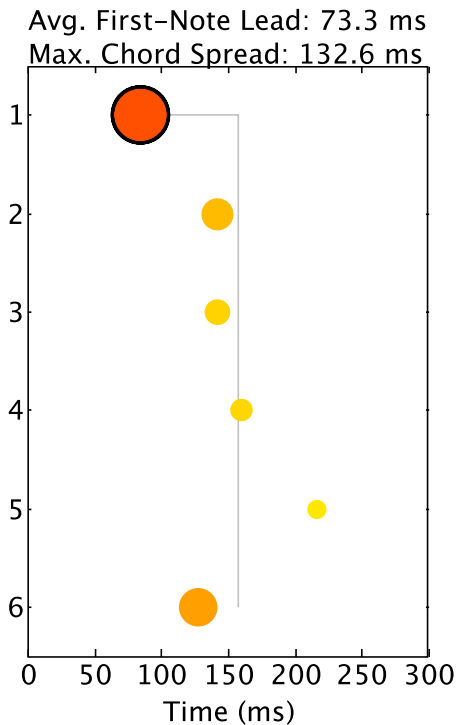


Figure 2 The **Chord Display** (voice number against time in ms) shows onset asynchronies of chords and the dynamics of each tone. Mean first-note lead and maximum chord spread are printed on top of the panel.

pattern. In order to provide a more stable behavior of the pattern finding algorithm, cycle length is kept in a buffer of which the most frequent value (mode) is considered. The phase of the pattern is determined by the relative tone intensity within the pattern, the loudest tone being the first. Through this definition, the performer can re-adjust the pattern start as desired simply by emphasizing the first note of a pattern.

Frugal Beat Tracking

Parallel to the pattern finding algorithm, a simple (frugal) beattracker determines a fundamental tempo, from which estimates for future beats can be inferred. For programming efficiency, a very simple approach was followed (Pardo, 2004), although we assume that more elaborate beat tracking algorithms (such as Dixon, 2001) are more apt for this purpose. They will be integrated into the present system in the near future.

Display

As soon as a pattern has been established, its constituent tones are shown in a pitch–time space. Individual tones are displayed as colored disks varying in size and intensity of color (reddishness) with tone intensity. The higher the MIDI velocity value, the more the yellow of soft tones turns into red and the larger the disk gets. Timing devia-

tions are displayed against the beat estimate from the beat-tracker.

A tone occurring too early is displaced leftwards with the corresponding previous tone of the pattern shown grey in the background. A more common way to display timing would be to show inter-onset interval (IOI) timing. However, we strongly prefer the present display over plotting IOIs because every IOI value stems from two tone onsets, so it would be hard for the performer to disentangle these two pieces of information. A screenshot of the components of the pattern display is shown in Figure 1. The left panel shows a 6-tone pattern just after its last tone has been played with pitch on the y axis (the middle-C key is marked grey) and time on the x axis. Circle size and color correspond to dynamics (MIDI velocity), horizontal placement to timing deviation relative to the timing of the corresponding pattern tone of the previous pattern cycle (displayed as shaded disks).

On the top-right, the auto-correlation pattern is shown (correlation coefficients against shift amount), indicating a pattern period of six tones. The bottom-right panel depicts a screen-shot of the frugal beattracker (against time in s), with the present moment marked by “now.” Circles denote played tones, red (in case of black and white print: dark) lines successfully tracked beats, grey lines expected beat onsets. On the right, the future expected beat is outlined.

Chord Display

The second aspect of piano performance visualized by the proposed system concerns timing asynchronies and tone intensity balance of chords. Pianists almost never play nominally synchronous score notes entirely simultaneously. Studies on expressive piano performance report systematic trends in these asynchronies (Palmer, 1996). In particular, when melody tones are emphasized (played louder), their onsets typically occur around 30 ms ahead of the other chord tones (Goebel, 2001). Apart from that, the timbral color of a chord may be shaped deliberately by the performer by altering the intensity balance of the chord tones (Neuhaus, 1973).

The proposed chord display detects potential chords in the MIDI data stream, calculates the first-tone lead and the chord spread, and displays the tones of the chords according to their pitch order (vertical axis) and time (horizontal axis). The intensity of the tones are reflected in size and color of the displayed disks (the louder, the larger and the more red on the same scale as in the pattern display). The leading tone is indicated by a black margin. A screenshot of a chord display example is shown in Figure 2.

A chord is defined by a simple heuristic: tones belong to a chord when each individual chord tone is no more than 70 ms apart and the total spread does not exceed 300 ms. These figures were approximated from experience with a large corpus of piano performance data.

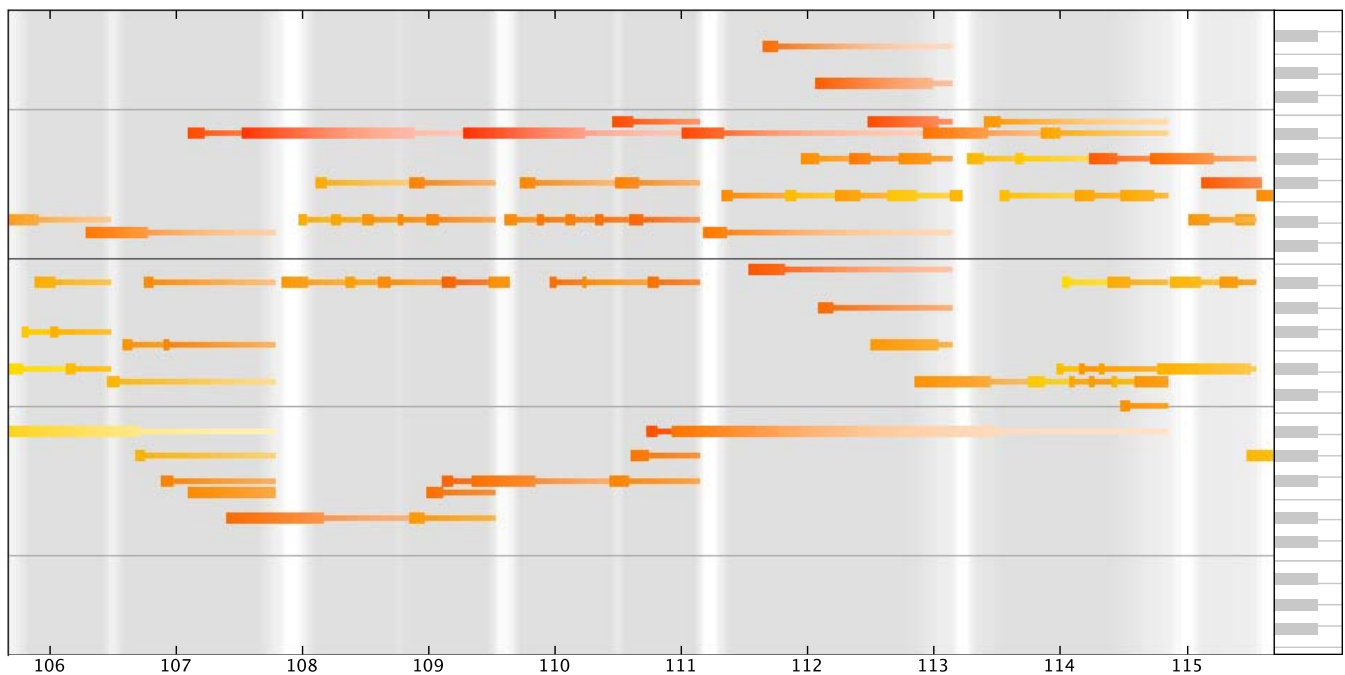


Figure 3 Acoustic Piano Roll. An excerpt of a performance of Schubert’s G-flat Major Impromptu is shown (pitch against time in ms). Background shading of the panel corresponds to pedal press; color saturation of the tone bars depicts acoustic decay of the piano tones; thinner decay bars indicate tones that are still sounding after note off due to pedal press.

Whenever a tone is played (i.e. when MIDI data is received), the display is updated and displays the last chord played. It works therefore in real time. As simple as this tool is, as explicit is its statement to the performer: It immediately exemplifies the relation of vertical dynamics differentiation to voice anticipation or lag.

ACOUSTIC PIANO ROLL DISPLAY

Piano roll displays are very common and can be found in every sequencer software package nowadays. They usually represent onset and duration of played tones through the position and extent of bars in a pitch–time space. By displaying this, they provide important note information; however, essential data of piano performance is left out, that is e.g., pedal information (especially from the right pedal), dynamics of each tone, and the interaction between pedals and the sounding tones (These data are usually shown in separate channels or on demand; e.g., by clicking on a note bar, its velocity is shown.) Here, we decided to include all performance data derived from a piano into a single comprehensive piano roll representation. A screenshot of this interface is shown in Figure 3, displaying an excerpt of a performance of Schubert’s G-flat Major Impromptu.

In the pitch–time space, we integrated a visual approximation of what is sounding at a given time on the basis of MIDI-like data from a piano performance. This includes – beyond displaying the onset and offset of tones with bars – the dynamics of each tone, represented by color

intensity (on a color map between yellow and red), the decay of the piano tones (represented by color saturation), and the interaction of the right pedal and the tones that sound during pedal press (represented by prolonging the decaying tones with slightly thinner bars). The right pedal itself is shown as grey shading of the background.

To model the tone decay of a piano, a set of piano samples recorded from a computer-controlled grand piano (Bösendorfer SE290) was analyzed in terms of their loudness decay over time. 25 different pitches distributed over the whole keyboard were played back on the computer-controlled piano in 5 different dynamic levels (MIDI velocity units from 30 to 110 in steps of 20), each tone sounding for a minimum of 5 seconds (for the low tones 10~s). Loudness representations of these 125 samples were measured in sone according to the Zwicker model (Zwicker & Fastl, 1999) (implemented by Pampalk, Rauber, & Merkl, 2002) and used to interpolate decay functions for all pitches and dynamic levels (MIDI velocities). Essentially, lower tones decay later than higher pitches; softer tones decay faster than loud ones. These data were linearly matched to saturation of an HSV color space; thus, a decaying tone is losing color with time and turning more and more into white.

As the other parts of the proposed system, the acoustic piano roll works in real time. To avoid showing always the full range of possible tones of the piano (usually 88 keys from A0 to C8), the interface takes care of dynamically

adjusting the displayed pitch range on the vertical axis to the present performance.

FINAL REMARKS

This paper has presented visualization tools to be used in a pianist's every-day life at practicing piano. They have not yet been extensively tested by pianists in practice. In future work, usability studies will show advantages and drawbacks of the present tools which we will use for further improvements. Foreseen extensions of these interfaces will include other performance parameters (such as tone length), improvement of pattern finding and beat-tracking algorithms, and the identification of other pianistic sub-tasks. Furthermore, immediate display of touch characteristics could be realized with new computer-monitored instruments as, e.g., found in the latest version of Bösendorfer's computer-controlled piano ("CEUS") that provides continuous key position data.

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