Transferring Piano Performance Control Across Environments

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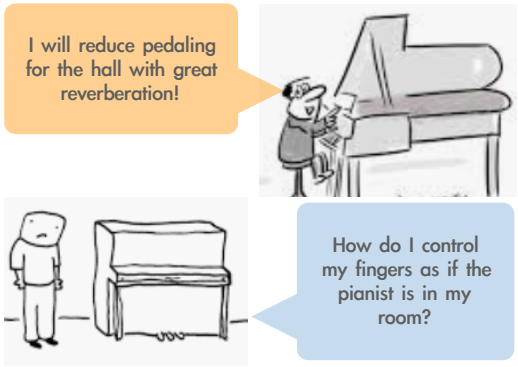


Motivation:

- **Physical Measurements:** Sound effect varies across environments (including room effects and piano devices).
- **Psychoacoustic studies:** Pianists adjust their performance control (force, duration and pedaling) in different environments.
- **MIDI Representations** of performance controls enable replications of music through Player Pianos.

Aim:

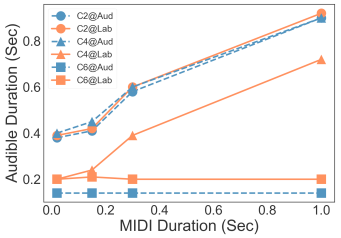
- Given Environment **A** and piano performance control parameters under **A**, find an optimal control in Environment **B** so that performance **B** sounds like **A**.

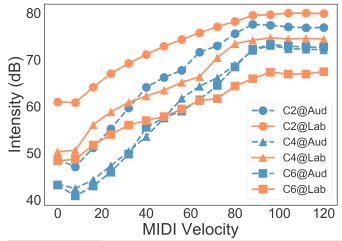
Contributions:

- First method to transfer controls on player pianos to cope with the deviation of environments.
- Provide measurements of performance under different environments and conduct listening test upon them.

Measurement of Performance:

- Measured velocity-intensity effect and note duration-audible duration effect.
- Room acoustics influence both curves.
- The two factors are interactive with each other.
- The pedals of two pianos mostly varies on the effective ranges.





Fact:

- The tone of a fixed piano is only related to (a) the pitch being played, (b) the endmost velocity of the key, (c) the duration of the note, and (d) the use of sustain pedal.

Representing Performance Controls

Name	Pitch	Velocity	Onset	Duration	Sustain Pedal
Notation	p	v	o	d	S
Value	0, 1, …, 88	0, 1, …, 127	Sec	Sec	0, 1, …, 127

Transfer Method (PETA):

- **Define environmental effect functions**

$$E_i(v_i, d_i) = \big(f_i(v_i, d_i), g_i(v_i, d_i)\big) = (I_i, D_i), \text{ for } i = 1, 2.$$

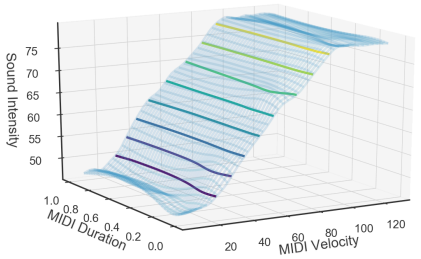
- **The optimal transferred control is a minimizer as**

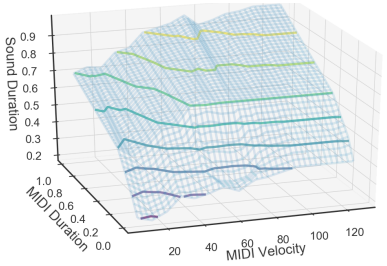
$$(v_2^*, d_2^*) = \arg\min_{v,d} \big\| E_2(v, d) - (I, D) \big\| = \arg\min_{v,d} \big\| \big(f_2(v, d) - I, g_2(v, d) - D\big) \big\|.$$

- **Conduct the iterative coordinate-search algorithm until convergence.**

Algorithm 1 Calculate v_2^* and d_2^* when v_1 and d_1 is played on the source piano with pitch p and onset o, without sustain pedal ($s = 0$).

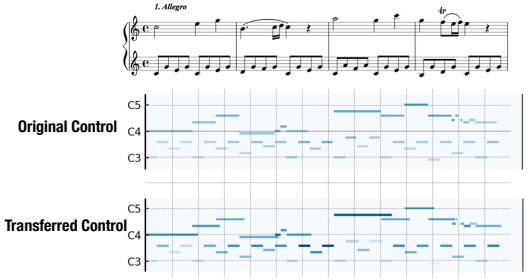
$I \leftarrow f_1(v_1, d_1), D \leftarrow g_1(v_1, d_1)$
$v_2^{(0)} \leftarrow v_1$
$d_2^{(0)} \leftarrow d_1$
do:
  $v_2^{(k+1)} \leftarrow \arg\min_v |f_2(v, d_2^{(k)}) - I|$
  $d_2^{(k+1)} \leftarrow \arg\min_d |g_2(v_2^{(k+1)}, d) - D|$
while $v_2^{(k+1)} - v_2^{(k)} > \delta_v$ **and** $d_2^{(k+1)} - d_2^{(k)} > \delta_d$
$(v_2^*, d_2^*) \leftarrow (v_2^{(k+1)}, d_2^{(k+1)})$





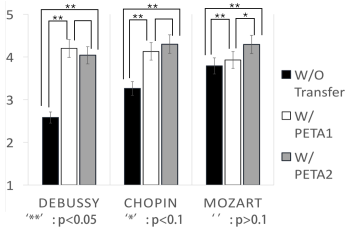
Experiments:

- Implemented PETA on Mozart's sonata, Debussy's etudes and Chopin's etudes.
- Conducted a listening test with 20 music players.



Results:

- Transferring velocity and duration has significant listening enhancement.
- Listeners could not quite tell the difference between the effect of a sustain pedal and a hold-on note.



Future Works:

- We are currently moving on to explore the pedal transfer methods.
- Online learning can be applied to this algorithm and embedded in MIDI softwares connected to player pianos.

Download **Poster:**

Listen to **Demos:**

The experiment was conducted at NYUSHANGHAI with two Yamaha Disclavier player pianos.

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