Harmonic Intonation Trainer: An Open Implementation in Pure Data

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ABSTRACT
Pedagogical research demonstrates theories and practices of perception or production of melodic or harmonic "intonation", i.e. the realization of pitch accuracy. There are software and hardware to help students improve intonation. Those tools have various functions. Nevertheless, they still miss something which could benefit users very much. Even worse, they are not easy to be revised. Most importantly, there should be more amusing and engaging interaction between a tuning trainer and a user which is able to exchange roles of tuner and player. In this research, we implement an open-source program named "Harmonic Intonation Trainer" in Pure Data. It includes most of essential elements of a smart tuner. A user can tune his pitch while optionally hearing (through earphones) the target pitch and other harmonic intervals in respective octaves. Moreover, in its interactive accompanist mode, a user's input pitch serves as the reference frequency; the program follows his intonation to generate corresponding harmonic intervals. Additionally, user can straightforwardly edit all parameters and patches by Pure Data. Any adoption or revision is absolutely welcome. Finally, we will initiate another research to test and to inspect experimental results from student orchestras so that its future version is expected to be more sophisticated.

Author Keywords
intonation, tuner, temperament, open-source

1. INTRODUCTION

1.1 Intonation
Perception and production of intonation are very fundamental abilities to perform music in tune. Some instructors employ software or hardware to assist students. The most common one is a traditional tuner. Tuning is, however, merely the initial step. Rawlins claimed that "although most students tune their instrument at the beginning of each rehearsal, very few of them will adjust the intonation as they play." [4] Students have to learn melodic and harmonic intonation through other courses. Scherber explained that "performing in-tune is an ongoing process and not merely a ritual to be performed at the outset of rehearsal." [5] To support students become self-corrective, people have proposed and have experimented diverse methods, e.g. beat eliminations, vocalization, and singing intervals. [3]

1.2 Training
An instructor may assign separate training for a student to discriminate and to produce intonation better. Powell concluded that "no consistent relationship between the ability to hear and identify intonation problems (perception) and the ability to perform in-tune on a wind instrument." [3] Also, Vurma found that "the musical interval perception ability of the singers is more finely honed for production than it is for perception." [6] Furthermore, the changes of tuning system can bring distinct results because Karrick discovered that "deviation was greatest when compared to just tuning and least when compared to equal tempered tuning." [1]

1.3 Demand
Research showed that instruction and student attributes are the most crucial aspects which affect wind-band's intonation. [7] While instructors' pedagogies may vary, students need more available and accessible tools for self-training. Scherber summarized that "most directors described asking students to work with a tuner as they practiced in order to increase sensitization to pitch discrepancies ... only 23% of directors indicated they required students to own a tuner, and a small subset of these indicated they owned classroom sets of tuners available to students for checkout." [5]

1.4 Comparison
Companies have been promoting prominent products for both teaching and learning. First, Korg Cortosia is sufficient to monitor a player's pitch stability and timbre. [8] Nonetheless, it addresses not much in terms of harmonic intonation. Second, Yamaha Harmony Director HD-200 provides customizable temperaments. [9] The physical keyboard makes users painless to play chord (inversions) in close or open position and to change each volume of individual pitch. It, however, lacks an elementary tuner to let users learn playing in tune through a visual feedback in addition to existing aural indications. Third, unlike HD-200, TonalEnergy's [10] and Tunable's [11] interfaces somewhat restrict the freedom of each chord pitch volume and octave. Even if they basically fulfill requirements of satisfactory smart tuners, they cannot build a precise chord upon a user's playing pitch frequency. We suppose that the function could be very helpful to develop the user's perception of harmonic intonation.

1.5 Motivation
All above three tools are neither open-source nor free. It decreases the accessibility and extendibility. Questionnaire results revealed that much fewer directors ask students to use software or apps for personal exercise outside class. [5] Therefore, we implement Harmonic Intonation Trainer, an open-source and easy-editing program. We will not only distribute this program but also deploy it in student orchestras for upcoming experiment.

2. IMPLEMENTATION

2.1 Design
To keep this program open and effortless to alter, we choose to implement in authentic Pure Data (PD) without any external patch. It also enables us to quickly assemble the prototype so that we can faster conduct a pilot research to observe its effect. We design seven harmonic intervals with controls of octave and volume. Thus users can easily manipulate voicing position, chord inversion, and respective volumes. In pursuit of timbre

richness, we include both simple oscillators and MIDI as sound sources. To realize microtones in MIDI, we employ "bendout" PD patches. Thereby, the MIDI has the capability to generate pitches outside twelve-tone equal temperament. Most important of all, users can activate an auxiliary oscillator for the purpose of listening to the last input (i.e. detected or selected) pitch. He can hear the beat, the interference between the input frequency and the target frequency, if they are slightly different.

2.2 Roles

We invent an operation which switches the role of this program between a tuner and an accompanist. In tuner mode, it works just like a smart tuner which allows a user to select the temperament and the reference frequency, listen to pitches in respective octaves, change each of their volumes, sing or play a pitch, and monitor the deviation. In interactive accompanist mode, the reference frequency always equals the user's input pitch. Consequently, the program generates corresponding harmonic intervals. The user can experience and enjoy a perfect accompanist who has the best harmonic intonation.

2.3 Interface

The vertical radio buttons control and display each octave of harmonic intervals (see Figure 1). To change the window size of for pitch tracking in PD, we put another set of vertical radio buttons in the left-hand side of main screen. Thereupon, users can switch varied sizes according to the pitch he playing.

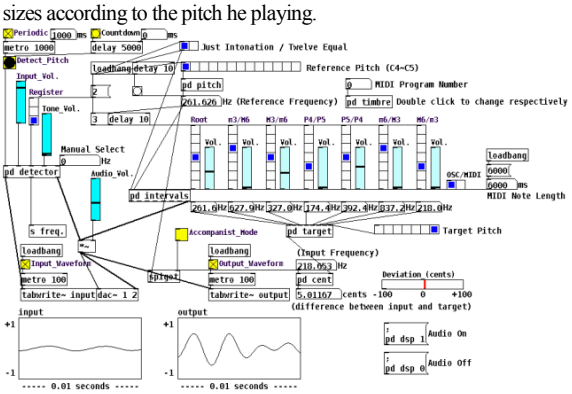

Figure 1. Screenshot

3. DICUSSION

3.1 Application

Harmonic Intonation Trainer (HIT) is a versatile program. First of all, a user can set the target pitch and simply use HIT as a basic tuner. With the intention of listening to the target pitch, he can turn on the volume. At the same time, he can activate the auxiliary oscillator on purpose to examine or to magnify the beat effect. Next, a user can turn on more or less harmonic intervals to constitute a chord (inversion) in open or close position. He can listen to the chord through earphones, mute the target pitch, and try to play it in-tune by himself. Last but not least, after switching to interactive accompanist mode, the user's input pitch will also be the reference frequency, which commands HIT to follow his intonation to generate corresponding harmonic intervals. Those practices could facilitate the user's both perception and production of harmonic intonation.

3.2 Expansion

Thanks to the innate convenience from PD, users can customize all parameters and adapt all patches with ease. Several sub-patches are highly reusable, e.g. cent calculator and MIDI microtone; others are ready to expand or duplicate, e.g. more harmonic intervals and more target pitches.

3.3 Limitation

Even with an appropriate window size, the pitch tracking sometimes retrieves an obviously wrong frequency. We create three ways to trigger the pitch detection: periodic, manual, and countdown. A singer should have no problem to use the manual one while an instrumentalist must rely on the periodic or the countdown. On the other hand, Kopiez outlined that "intonation ... is the result of an interaction among compositional features, the acoustics of the particular musical instrument, and deviation patterns in specific intervals." [2] Although HIT may act as a tutor or an assistant, users should incorporate other knowledge and skills to pursue exceptional melodic and harmonic intonation proficiency.

3.4 Expectation

This program is an alternative but not a replacement for any other specific tool. We are going to release and to keep updating the source code online. People are welcome to download, test, and modify it. We will be glad to see people adopt any approach from it and apply to other products as well. Besides, we plan to experiment on student symphonic or wind orchestras to measure its effectiveness. The results should be valuable to future improvement and research.

3.5 Conclusion

We reviewed literature on the training in intonation and compared current famous products. In answer to requests for a more accessible, versatile, and flexible tool, we implemented Harmonic Intonation Trainer, an open program in Pure Data. It has numerous functions and a novel role beyond tuner. Our next step is to experiment on students and further revise it.

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