Easy Piano Tuner

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Background and Motivation

Anthony started tuning by ear. The cost of devices were high, and there were a few annoying issues. One was that they were all Apple apps. Although these were professional tools, it was difficult to justify $900 when starting out. He also had trouble finding things on the layout. The VErituner required too many taps. The Cybertuner lost him so much he had to read the instruction manual, and did not understand the Chameleon button. TuneLab, as an out-of the box, involved too much.

- Annoyances with existing programs:
  - Apple only, with the exception of TuneLab
  - High cost ($300 TuneLab, $600 Verituner, $1000 Reyburn Cybertuner)
  - Steep learning curve (Verituner is easiest_
    - TL layout seems unintuitive to me. Need to tweak settings
    - Verituner switching notes
    - RCT Chemeleon button?
    - TuneLab, need to tweak settings for a satisfactory tuning

Opening in Existing Market

- Lacked a simple, low-cost option for hobbyists and backup option for piano tuners. TuneLab's trial version somewhat filled the void, but the 2-minute pauses are annoying.
- Opportunities for improvement: integration with calendar, device location, load default tuning files from the cloud when a piano's information is added, etc.
- Anthony['s program is the only piano tuning app on Android besides Entropy. We can access an Android emulator called BlueStack.

Added Features in Easy Piano Tuner

- Tuning curve display
  - To get a snapshot of what the piano is doing, play each note of the piano into the program. You can see the graph of where the piano should be and where it is.
    - If you don't like the tuning curve moving and changing the target, you can lock the curve in one spot if you want to tune a set way.
- Inharmonicity display
  - Scroll to the right and you can see the inharmonicity pattern. The blue dots are the measures, and with these the program evens out a graph line with the averages of the dots.
  - A grand piano curve will be lower, especially in the bass, whereas a spinet inharmonicity line will be much higher.
- Spectrum display
  - Go another to the right and you can see the power for each frequency. Play one note and watch the harmonic peaks. On some you get a shock effect before it moves to the fundamental.

        - There are a couple ways to change the notes: chromatic or sporadic
        - You can also lock one note.
        - You can tap on the mouse on the arrows to change by note or by octave.
        - You can drag the red bar up and down the keyboard.
- One-tap note switching
- Ability to lock the tuning curve
- Multiple data fields for tuning files
    - To save a tuning file, go to the menu and open the tuning file
        - You can enter the piano & serial number, the customer name, and more.
        - There is a space for notes.
        - You can sort by name, manufacturer, or date.

Tuning Theory:

- 3 ways to measure pitch
    - FFT: Fast Fourier Transform
        - Pros: Easy to implement, measure many pitches at the same time
        - Cons" Slow (there's as delay) and not very precise. It is possible to make it more precise, but this requires even more of a delay.
    - Filter and count zero crossings:
        - Pros: Fast, easy to code
        - Cons: Lots of noise unless you measure over long periods. For the filters you have to know exactly what frequencies you're looking for.
    - Look at phase: (e.g. Strobe Tuner)
        - Wagon wheel effect (in a movie, it looks as though the wheels are turning backward).
            - There is a clock that generates the viewing time, as a strobe light would flash every time the next wave is at the top
            - In calibration mode, generate a 440 Herz wave, then move the sound closer and farther to watch the Doppler effect, even though the note stays in tune. By watching this we can actually measure the le3ngth of the wave in the air by moving the sound source back to each wave peak.

Calculating a Tuning

- Measure the inharmonicity, and approximate the notes that haven't been measured. When you know the inharmonicity, you will know where all the harmonics will be.
    - 440 (A2) – 440 – 660 – 880 – 1760 – 3520
    - Tune A4 to A2 so the harmonics line up, etc.
    - Now add A5 and align the harmonics with A4 and with each other
    - For fun, add E4, or E3
    - Look at all these octaves at the same time
    - Do slow-beating intervals

- Calculate the frequencies of all the harmonics for all the notes, using the inharmonicity
- Shift the fundamental and harmonics for each note so that the difference between coincident harmonics is minimized.
- Only look at the coincident harmonics of certain intervals, and assign a "weight" to each one according to its beat rate. (Octaves, 5th, 4th, 12th, double octave, triple octave, etc.) Some intervals are more important than others.
- Tuning is recalculated as more data is measured.

Pitch-Raising

- In Verituner, when you're doing a pitch raise, you have to pause at the beginning of each note change for the program to measuyre the pitch and calculate an over-pull. Additionally, if the note is more than fifty cents flat, the program detects the note below and, thinking it is sharp, calculates a negative over-pull. For example, if the piano is 70 cents flat, it will calculate a negative target, which is useless. Another problem is that if the initial pitch varies widely between notes, the calculated over-pulls will also be rough. So for years I ended up just calculating a rough over-pull in my mind and then tuned to a consistent +15, +20, or +25 cents.
- In EPT we take a different approach. Rather than measuring the initial pitch of every note, we measure only 1-3 sample notes per octave, and then interpolate (or take the average) between the samples. Having widely spaced samples makes it so we can measure notes that are over 150 cents flat. It also results in more of a smooth over-pull profile.
    - Anthony demonstrated with his program. He went to the menu, clicked on pitch raise, and chose three particular notes that he wanted it to listen to, and measured these sample notes for each octave. The thin green line above the black line is the over-pull target.
- Anthony demonstrated a muteless pitch-raise with his over-pull setting. The computer will sense the closest string to the target. The dial turns, the numbers give the actual cent values, and the rings stop spinning when the over-pull target is reached. The art is tuning the other two strings to this first string by ear. This feature eliminates about 110 mute-moves per piano, which is minutes of time reduced. Anthony first realized this can be done when tuning a birdcage that was 150 cents flat.
    - Anthony set a timer and pitch-raised an upright in fifteen minutes with no mutes.
    - To check, he played a fifth, with a fourth on top, and a third above that. Check fifths and major tenths.

Testing and Results

- Took a Yamaha U1 and tuned the center strings only of the entire piano four times with the strings strip-muted, using TuneLab, RCT, EPT, and Veritune. When he got each note as close as he could, he recorded that note.
- Used default settings for each program.

    - Used default settings for each program (OTS 4 for RCT) except on Cybertuner I used fine tuning mode instead of the smart mode. Verituner and EPT got to listen to the whole piano, together, and then turned off the inharmonicity measurement and locked the tuning curve. For RCT and TuneLab I measured the recommended notes.
- Recorded each note immediately after tuning to avoid the effects of changing the tension of other strings. Tune, pause 2 seconds, record, etc.
- Analyzed each recording to extract the harmonics of each note.
- Constructed a tuning curve from the lowest harmonic of each note.
- He ran each note through a program that extracted each harmonic. From this frequency date he reconstructed a tuning curve for each of the programs.
    - The curves were surprisingly close.
    - The most stretch was Easy Piano Tuner
    - The biggest discrepancy was with TuneLab.
- Charts and diagrams
    - Tuning curve diagrams
    - Import frequency raw data to Excel: chart
        - The 3rd harmonic of the bottom note and the nineteenth harmonic of the top should be the same.
    - Plot of actual beat rates of the 12ths (3:1)
        - They were pretty similar in the bass and tenor,and went all over the place in the treble. Chart of all programs super-imposed
    - Individual chartgs for each program
        - Cybertuner is pretty close to zero, goes all over
        - Easy: starts wide, at zero, then goes narrow
        - Verituner a little wide, bounces around in the treble
        - TuneLab starts narrow, fairly close to zero, then all over the place in the treble.
    - Kent Walker wants Anthony to do a pure false tuning. He used TuneIt
        - Anthony did the same analysis
        - OnlyPure jumped up quite a bit in the treble. You can also see the transition between the single, double, and triple strings
        - The calculate EPT was smooth, but also goes up.
        - The 12th beat rate (3:1) Only Pure, the treble goes really wide in the treble – lots of stretch
- Anthony pre-tuned a Baldwin grand with the Easy Piano Tuner program for us to play and listen to.

Pricing

The free version tunes the center two octaves.

The next version will be the Hobbyist version that will just tune a piano, but will have no additional features, for $20.

The professional version will do pitch-raising and much more, for maybe around $100.

Anthony launched in May, and his graph is steadily rising. At this moment 4739 people own his program.

Anthony developed a code, but hired someone to translate it into Java & more.

Review

“This app helped me in an emergency. My Peterson Strobe failed to work at a client’s home. Unfortunately, I had a major pitch raise to perform and I did not want to do it by ear. It would have been better to practice a pitch raise on my own piano before doing a client’s, but I had no other choice. I found this app to be more accurate and easier to understand than my Peterson. Furthermore, there are no moving parts to make noise, and it is small enough to fit on a spinette, and the piano sounded so much better when I finished. I think I will leave the Peterson at home today.”

- Philip Royd, 10/12/2017