THE SONIC TILT COMPETITION

Tim Ziemer

University of Hamburg
Institute of Systematic Musicology
Hamburg, Germany
tim.ziemer@uni-hamburg.de

ABSTRACT

The International Community for Auditory Display (ICAD) is well-known for research and development in the field of sonification. As a community event and a means to boost young and established researchers' creativity, we organized the *Sonic Tilt Competition*. To win this competition, participants conceptualized, developed and implemented their own sonification design in a spirit level app. The first price is the inclusion of the sonification in a worldwide app release. But the overall objective is in accordance with this year's ICAD conference theme *Sonification for the Masses*: Making sonification better known and usable by the majority of people. This manuscript presents the Sonic Tilt Competition, the jury, and all participating apps.

1. INTRODUCTION

The ICAD2023 theme was *Sonification for the Masses*, expressing the objective of the sonification community to increase visibility and public awareness of sonification. In that spirit, we carried out a sonification design competition. The task was to conceptualize, design, and implement a sonification for a bullseye spirit level app.

In 2019, my students and I released Tiltification [1], a bullseye spirit level app that leverages sonification. The app utilized the psychoacoustic sonification that was not designed for a spirit level app, but for navigation tasks [2, 3]. The app has been released in the Google Play Store, the Apple App Store, and on our website. With over 30,000 downloads, the app already reached very many people. It was received well, got high ratings and many positive reviews by users and journalists. But two negative criticisms have been raised repeatedly, namely the sound being unpleasant, and the sound being uninterpretable [4].

Even though experiments have already proven that the sound is indeed interpretable with a very high precision [5, 6, 7], the critique highlights that this was not a sonification for the masses, as it excluded those people who have little acoustic education and experience using sound. However, instead of designing a more appropriate sonification ourselves, we decided to make the Tiltification source code freely available and benefit from the creativity of the auditory display community. With the name *Sonic Tilt* [8], we shared the Tiltification source code under an MIT license, so everybody can use and modify our app. Sonic Tilt can be compiled using Android Studio, Flutter and Pure Data, producing an APK file that can be installed on Android smartphones. Lecturers can use Sonic Tilt as a demonstrator for sonification applications and use cases, to let student explore sonification interactively, as well as a framework to teach sonification design. It is certainly very motivating for students when they can implement their sound design in a useful app that they can install on their phone and share with their fellow students, friends and family. Sonic Tilt can also serve as a framework for sonification researchers to test their latest sonification designs interactively. And of course, Sonic Tilt serves as a framework for the Sonic Tilt Competition. Here, participants implement their own sonification design that they think is ready for the masses. The Sonic Tilt Competition was announced in 2022. This gave researchers and students more than half a year to develop, implement, and tune their sonification design. We prepared a written manual and a video tutorial on how to install and run Sonic Tilt, and gave a hands-on workshop at the Interactive Sonification Workshop (ISon2022) to ensure that people could participate in the competition. In a hybrid workshop at the ICAD2023 conference, the submitted apps were presented to the ICAD community before the winner was announced by the jury. The price is a release of the submitted app.

2. THE CHALLENGE

Sonifying the information provided by a bullseye spirit level is not straightforward. In fact, this task can expose you to five common and yet not universally solved problems [9, 10]:

1. Two orthogonal dimensions, each with a
2. high resolution and
3. two polarities (positive/negative) and an
4. absolute 0 that need need to be sonified with
5. preferably little annoyance to the user and the people around them.

Perfect orthogonality does not seem to exist in psychology [11], so the sonification designer has to come up with a solution to present the x- and the y-dimension without interference. At the same time, users need to be able to integrate both dimensions. An additional challenge is that these dimensions are continuous and should exhibit a high resolution. For a useful real-life application, sonification designers need to ensure that users can level with a precision of 1° or so.

Another difficulty is the existence of two polarities: A smartphone can be tilted 5° to the left or right. However, to guide the

user towards 0°, these two polarities should sound different. The same is true for, say, 5° towards or away from you.

The target position for a bullseye spirit level is $(0^\circ, 0^\circ)$. Guiding a user towards an absolute position is not straight-forward. Imagine that one axis is represented by the frequency of a pure tone, and the other one by its amplitude. When the sound becomes quiet, does this mean that the amplitude inaudibly low, or that the frequency is inaudibly low? Or both? You cannot know. Sonification designers need to find a strategy ensuring that users always know the magnitude of both dimensions.

Last but not least, the sound needs not only to be interpretable, but also more or less pleasant. In fact, only two aspects have been criticized repeatedly in the Tiltification app: The sound being uninterpretable and the sound being annoying [4]. Many audio enthusiasts, like music producers, mixing engineers, and sound designers are familiar to all kinds of sounds, noises, and audio effects. This audio experience raises their acceptance for yet unheard sounds and also enables them to listen analytically and, therefore, understand all kinds of sounds. But the majority of smartphone users are no audio enthusiasts, but inexperienced listeners. Many people only know three types of sound: music, speech, and all the rest, which is unwanted noise that they try to avoid whenever possible. A sonification for the masses needs to get this type of listeners on board. Solutions may be musical sonifications, sonifications that utilize speech, or sonifications that are entertaining, fun or that have such an ambient character that users could well ignore them.

3. THE JURY

To run a fair and democratic Sonic Tilt Competition, I invited much-valued colleagues to form a jury that is divers in terms of cultural and professional background. The jury included

- Areti Andreopoulou, National and Kapodistrian University of Athens, Greece
- Matti Gröhn, Glue, Finland
- Mike Winters, Microsoft, USA
- Rajiv Ratn Shah, IIIT Delhi, India
- Takanori Komatsu, Meiji University, Japan.

They volunteered to install, test and evaluate the submitted apps and read their corresponding documentations, identify and, finally, call the winning app. The jury combines expertise in music technology, audio signal processing, app development, human-computer interaction, multimedia programming and other aspects of auditory display.

4. THE SUBMITTED SONIFICATIONS

Eleven apps have been submitted to the Sonic Tilt Competition. They sound amazingly diverse and even though they exhibit unique ideas and follow different philosophies, they can be assigned to four different types of sonification. Most of the submissions to the Sonic Tilt Competition were added as branches to the Sonic Tilt Github project. [8]

4.1. Abstract Sound

Four submitted apps use abstract sound, just like the original Tiltification app. *Niveau à Bruit* [12] by Alexandre D'Hooge uses two pure tones. When tilted in any direction, the amplitude of the lower tone is modulated sinusoidally, producing loudness fluctuations. The larger the tilt angle, the faster the fluctuation. When almost leveled, the higher tone has about twice the frequency of the lower tone. When tilted away from you, its frequency rises. When tilted towards you, its frequency falls. When leveled perfectly, the higher tone is muted. This sonification is amazingly simple and effective.

Level Assistant [13] by Justin Niestroj is geared to the parking assistant sonification in cars. This is a brilliant choice to reach the masses, as parking assistant sounds are probably the best-known sonification. As many people are familiar with it, this approach may find a high acceptance and be readily interpretable by many people. The x-axis uses a cowbell sound. The angle size is mapped to the inter-onset-interval of four samples. A high pitch indicates a rotation to the right, a low pitch a rotation to the left. Below $\pm 3^\circ$, a medium pitch is heard. The y-axes works accordingly, using a woodblock sound. The two take turns once per second. When the target $(0^\circ, 0^\circ)$ is reached, a confirmation sound is triggered.

Soniclevel Tuning App [14] by Stephen Barrass is inspired by the process of tuning a musical instrument. This ingenious approach combines musical and psychoacoustical considerations. The sonification uses a reference tone with a steady frequency. The tilt angle alters the frequency of a second tone. When the smartphone is tilted a lot, you can clearly hear two pitches. When tilted less, the two tones produce a rough timbre. When approaching perfect leveling, the two tones produce beats. The slower the beats, the closer to $(0^\circ, 0^\circ)$ the smartphone tilt. Only when leveled perfectly, you hear one tone with a steady frequency. Users have to derive the necessary tilt direction interactively: if the beats get faster, you have to turn around and tilt in the other direction.

Tripod sound level [15] by Rainer Bollhorst is designed for a smartphone that is attached to a tripod. A bass guitar represents the tripod leg on the right-hand side, a cowbell represents the leg on the upper left, and a hi-hat sound represents the leg on the lower left. The rest works just like the level assistant app: the amount by which the leg has to be raised in mapped to the inter-onset-interval, sounding more urgent, the more the leg length has to be adjusted. Near the x- and y-axes, the sound pressure level is reduced, contributing to calming down the auditory scene. When leveled, a confirmation sound is triggered, and the app remains quiet as long as the smartphone stays leveled. When you actually attach your smartphone to a tripod, this sonification is very effective.

4.2. Animal Sounds

Two apps use animal sounds to raise acceptance. *Soniclevel Crickets app* [16] by Stephen Barrass reduces the leveling task to two questions: 1) did my last motion get me closer to perfect leveling? 2) Is it leveled now? The first question is answered by a cricket sound that only appears when the tilt angle increases. Just as in nature, the cricket gets quiet when you approach it. The second question is answered by another cricket sound that is only triggered near perfect $(0^\circ, 0^\circ)$. This sonification allows you to level things with very little acoustic information, which seems perfect for beginners.

Soniclevel Pobblebonk App by Stephen Barrass relies on the van Noorden galloping rhythm — a well-known auditory scene analysis phenomenon. It consists of three quarter notes, followed by silence with a duration of one quarter note. When being similar in pitch, the auditory system integrates the three notes into a single auditory stream. As a consequence, this sounds like a gal-

loping rhythm. When either of the pitches is too deviant, it will segregate from the others, making their pitch- and time-relations ambiguous. In the app, the x-angle is mapped to the frequency of the first quarter note, the y-angle is mapped to the frequency of the third quarter note. The second note is a steady reference. When the x-angle is close to 0°, the first note and the second get integrated and produce a rhythm. When the y-angle is close to 0°, the second and the third note get integrated and produce a rhythm. Only when almost leveled, all three notes produce a common rhythm. From this rhythm, users can clearly hear out the pitch relationships of the three notes. This allows for fine adjustments. Furthermore, the pattern speeds up when approaching the target $(0^\circ, 0^\circ)$, making the rhythm more pronounced. Frog-like sounds are being used, making the sonification sound a bit like a frog concert. This is both entertaining and a tribute to PobbleBonk frogs, who are domestic in Stephens home area. The ingenuity of this sonification is that even though understanding the sonification principle is demanding, it even works for inexperienced and uneducated listeners, as auditory stream integration and segregation happen automatically in humans.

4.3. Speech

Two apps relied on the human voice as angle display and guidance tool. This is a natural choice, as people are used to follow instructions given through human voice. *A-E-I-O-U* [17] by Katharina Groß-Vogt & Carmen Jenny Rieder uses speech synthesis to produce vowel sounds of two separate voices. A satisfied [a] sound represents the $(0^\circ, 0^\circ)$ target, and large angles along the different axes sound like disapproving "oh o!", "eh e!", etc. Amazingly, this accentuation works in many languages and cultures. The rhythm and the amplitude guide the user.

The app *Voice Balance* [18] by Piet Kuchenbecker uses very short speech snippets. Consonants [l] and [r] represent the x-axis, vowels [o] and [u] represent the y-axis. Listeners can always decide to concentrate on either the vowel or the consonant. The larger the tilt angle, the louder the corresponding vowel and/or consonant. Below a first threshold, pink noise is triggered to inform the user that the phone is almost leveled. Below a second threshold, the pink noise becomes audibly louder, masking the voice sounds when the phone is leveled. This trick inhibits a wild fluctuation of vowels and consonants whenever the 0° target is surpassed in either dimension. This app won the Sonic Tilt competition, as it is easy to learns and understand, has a high acceptance potential and a brilliant solution to avoid fluctuations near $(0^\circ, 0^\circ)$. It will be fine-tuned and then released as a new spirit level app version.

4.4. Musical Sonifications

Three apps count on musical sonification. This is a brilliant idea: Music can lead to a high acceptance as people are familiar with music, enjoy listening to music, and like to play around, move to, and interact with, music.

Melodification [19] by Andrea Strata, uses a simple drum pattern accompanying a bell-like sounding step sequencer. When tilted to the right, the bells play a rising melody. The larger the tilt angle, the longer the sequence of rising notes, and the higher the highest note. When tilted to the left, the melody has decreasing pitches. The further you tilt the phone away from you, the more distorted the melody instrument will sound, implemented through a bit crushing effect. When tilted towards you, the bit crushing effect will affect the drum sequence. The principle is amazingly simple, and searching for the right angle is a lovely, musical experience.

Tilt to the Beat [20] by Jatin Agarwala & Pratyaksh Gautam also uses a step-sequencer. When tilted to the right, three out of four notes produce a sequence of rising pitches. The larger the angle, the larger the pitch interval between the notes. When tilted to the left, a sequence with descending pitches can be heard. Only at 0°, the pitch is steady. The approach is related to Melodification, but sounds rather different. When tilted away or towards you, the decay time of the notes becomes shorter. This modifies the portamento-like melody to a pizzicato-like sound. When leveled, the notes have no decay, fusing to a continuous tone. Described in the documentation but not implemented by the time of the submission was an encouraging "ding" whenever the user goes below the next threshold, a monishing "woop" whenever the user surpasses the next threshold, and a "victory tune" when perfectly leveled. These additional elements give the sonification a game-like character, which can be very motivating and engaging, as discussed in [21].

The app *Chord Level* [22] by Julien Bohnsack lays a rectangular grid over the two-dimensional space. The grid density decreases with increasing distance from the target $(0^\circ, 0^\circ)$ position. Whenever a grid line is surpassed, a four-note arpeggio is triggered. This makes this the only-model-based sonification [23] in this competition, making the app comparably peaceful and quiet, when moving slowly: When tilted to the right, the first three notes are c-e-g. When tilted to the left, the first three notes are g-e-c. The tempo of the sequence is a function of the tilt angle. At 0°, all notes are played simultaneously. The pitch of the fourth note is controlled by the other tilt angle. At 0°, it is a g. When tilted away from you, the pitch is increased up to almost one octave. When tilted towards you, the pitch is decreased by up to almost one octave. Only at the target $(0^\circ, 0^\circ)$ you hear a consonant triad.

A twelfth contribution is my own sonification design called *Mixing Levels* [24]. Here, the tilt angles of the smartphone level 4 different tracks from a music loop. Only when leveled at $(0^\circ, 0^\circ)$, the mix is balanced and a blazing synthesizer squeaks in At all other angles, at least one of the tracks in over-emphasized at the cost of another instrument. This app and the accompanying documentation served as an example project and were an unofficial competitor, not being tested and evaluated by the jury.

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