

“Stray”: A New Multimedia Music Composition using the Andantephone

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ABSTRACT

The andantephone is an instrument that allows a performer to physically step through a piece of music by walking. Each note or chord of the piece is assigned to one footstep, so expressively varying velocity varies the tempo in turn.

A new, more flexible design of andantephone was created for use in a new composition, using an array of tiles sensitive to geophonic seismic waves from footsteps. This user-interface was combined with a real-time frequency shifterbank which shifted the geophonic vibrations of human feet to the frequencies of the musical notes and chords of the composition. Matrix multiplication in the shifterbank allowed chords from various tiles to be expressively layered together depending on the geophonic sounds coming from any number of tiles being stepped on at a time. Moreover, the new shifterbank adjusted its tuning dynamically (according to the composition) as the performer cycled around the track, creating a responsive multitouch landscape that unraveled around the track ahead of and behind the performer. The shifterbank output was also interfaced to a pipe organ, via FLUIDI, using the organ as an additional sounding device.

A new andantephone tile configuration led to advantages over previous configurations, including less off-track radial acceleration required to change tempo, and the ability to multiplex between different types of vertex turns, which was found to improve spatial orientation when performing.

Categories and Subject Descriptors

H.5.2 [User Interfaces]; H5.5 [Sound & Music Comp.]; J.5 [Computer App.]: Arts & Humanities—*Fine Arts*

General Terms

Design

Keywords

Andantephone, tangible user interfaces, footsteps, input devices, shifterbanks, FLUIDI, pinched loop, yaw, stall cusp

1. INTRODUCTION

The andantephone is a recently-invented musical instrument, played by simply walking on it [1]. A piece of music

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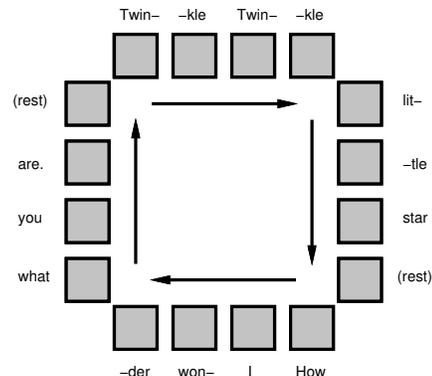


Figure 1: Simple example of a song in 4/4 time, arranged on andantephone. “*Twinkle, Twinkle, Little Star*” was previously programmed into an andantephone so 16 tiles arranged in a square corresponded to the notes of the song. The four-beat bars were assigned with one bar along each side. [1]

is played by walking along a series of tiles in sequence. A person can physically step through the notes of a song as if he or she were walking along the song’s timeline.

Video of andantephone be seen at:

<http://wearcam.org/andante.htm>

Andante, in musical terminology, refers to a tempo that is “at a walking pace”. Combining the Italian “andante” with the Greek word “phone” (meaning “sound”, a commonly used suffix for musical instruments), results in “andantephone”.

With an andantephone, the melodic line fluidly follows the rhythm paced out by the player. The musical tempo is always according to the player’s footsteps as they speed up and slow down. This differs from other recent floor-based user interfaces [3][6][5], and other similar ORGANic user interfaces [4].

The tiles are physically separate from one another, and geophonic vibrations are sensed by each tile independently. In a performance or rehearsal setting, the tiles can be arranged in a variety of patterns.

These patterns can include basic geometric shapes, for music with a regular repeating rhythm (e.g. divided in groups of four tiles for pieces in 4/4 time, such as in Fig. 1), and can also take the form of irregular patterns or more whimsical arrangements.

2. GEOPHONIC VIBRATIONS IN TILES INTERFACED TO PIPE ORGAN

The andantephone in this work was constructed with an array of flat footpad tiles which responded to pressure from



Figure 2: Organ pipes of the St. Andrew’s Lutheran church organ, controlled by the andantephone user interface through a shifterbank processor.

footsteps. The signals from each tile were fed into an embedded microcontroller.

The microcontroller served as a real-time frequency shifterbank which shifted the geophonic vibrations of human feet to the frequencies of notes and chords of the composition.

The vector of 16 seismic signals was multiplied in real-time by a matrix corresponding to notes and chords for each tile. Matrix multiplication in the shifterbank allowed chords from each tile to be expressively layered together in performance depending on the geophonic sounds coming from any number of tiles being stepped on at a time.

Moreover, the new shifterbank dynamically retuned itself in different keys and timbres (according to the composition) as the performer cycled around the track, creating a responsive multitouch landscape which continued beyond the next track corner and always appeared ahead of the performer.

The footsteps, after being mapped to the notes and chords of the composition, were also encoded into serial FLUIDI [2] data, to fluidly control the Casavant Frères pipe organ of St. Andrew’s Lutheran Church, Toronto. The geophonic footstep vibrations were translated into crescendos and diminuendos moving between different ranks of pipes. (See Fig. 2.)

3. “STRAY”: NEW MUSICAL COMPOSITION FOR ANDANTEPHONE

“Stray,” composed by author R. Janzen, premiered in Toronto on March 13, 2010 at a concert entitled “ORGANic Evolution” at St. Andrews Lutheran Church, Toronto.

The piece incorporates dance elements, as a physical performance piece. The artistic statement begins:

This new work for andantephone follows the path of a wandering traveler through an unknown landscape. In this artificial world, space is brutally linked with time, and time with space. The explorer passes tumultuously through emotional stages of development, as if his life story is being fast-forwarded unwittingly by his movement.

The composition process took place over two stages. The first stage was to create the “artificial world” – that is, the sequence of notes and chords which formed the spatio-temporal environment that the user traverses.

The sequence of notes and chords was represented not in musical notation, but in matrix algebra programmed in C.

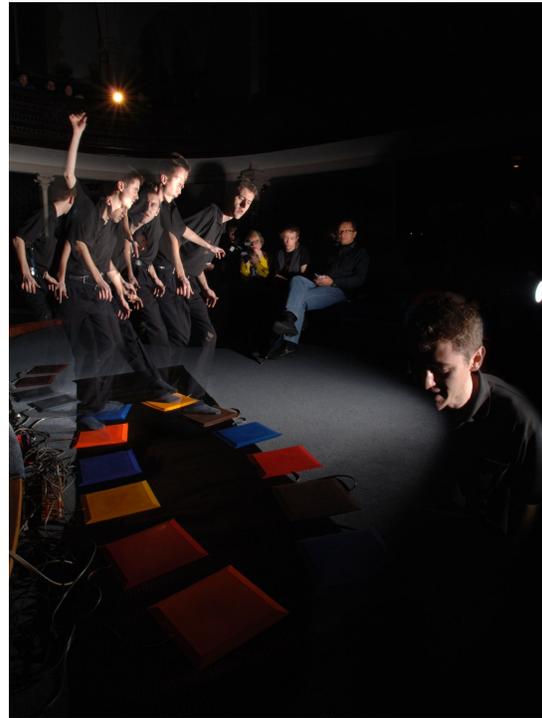


Figure 3: Time lapse multi-flash image of a public performance of “Stray” on andantephone.

The second step, which consists of the performance itself, is an act of rhythmic interpretation, and takes place on a higher artistic level, visible to the audience.

Some sections of the new composition progressed sequentially along the tiles (similar to the simple example in Fig. 1) while other sections required the performer to step in retrograde, or otherwise step in a variety of irregular patterns.

4. NEW CONFIGURATIONS TO IMPROVE FLEXIBILITY IN ROTATIONAL AND TRANSLATIONAL MOTION

New andantephone configurations were developed for “Stray” to increase flexibility in rotational and translational motion.

Previous configurations of andantephones are illustrated in Fig. 4. It was decided that a square pattern would adversely impose an unchanging regular rhythmic pattern to the performance. A circular pattern does not impose any set rhythmic pattern, but still does impose a linear, sequential playing pattern because it is difficult to jump across the no-man’s-land in the middle of the circle.

Another more subtle problem with the circular configuration is that it is difficult to do tempo variations while keeping in balance, because the body’s inward-leaning angle (to enforce centripetal acceleration) cannot be suddenly changed without stepping inside or outside the tiles (i.e. missing a beat). That is, a tempo (forward velocity) change requires not only forward acceleration, but also radial acceleration.

4.1 Quad rotation pinched loop pattern

A new pattern is proposed: a quad rotation pinched loop pattern. See Fig. 5. This pattern was tested in the “Stray” performance by making it integral to the composition itself.

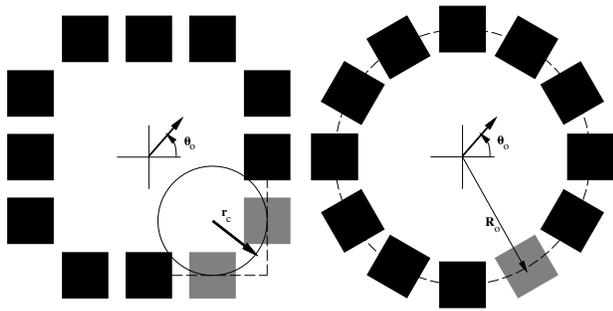


Figure 4: Square tile layout (16 tiles per phrase, divided in a 4-beat rhythm), and circular tile layout.

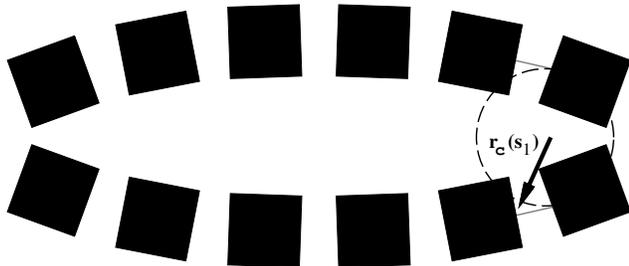


Figure 5: Pinched loop pattern used in “Stray”. Advantages over previous configurations include: Less off-track radial acceleration required to change tempo (compared to circle); Ability to multiplex between different types of vertex turns; Long durations between vertex turns (compared to the square and antephone) followed by constant gentle curvature, which was found to improve spatial orientation, and aid in smoothly accelerating around the vertices. Thus it became easier to overcome the imposition of a repetitive set rhythm. (i.e. the geometry need not impose groups of 6 beats or 3 beats)

This pattern attempted to overcome the limitations of some of the traditional loop patterns, as described in the following sections.

4.2 Translational flexibility of the new pattern

The square and circular patterns constrain the player to a somewhat one-dimensional sequential motion (can still go forward or reverse, or skip over a tile).

The new pinched pattern creates two new possibilities:

First, the player can jump across between tiles on the forward and return paths. Second, the player can treat square or rectangular regions near either end as pixels of a two dimensional playing surface.

4.3 Rotational flexibility of the new pattern

Reducing the 4 discontinuous turns of the square creates longer stretches of time making slow continuous turns.

Every time there is a sudden turn when walking in a loop, the user needs to reorient, rebalance, and accelerate in the new direction, all while multiplexing both feet onto tiles for the desired rhythm. On the other hand, a slow continuous turn lets the user remain oriented to the same visual reference points, needing less concentration to keep one’s balance. As a result, one can focus on the performance itself.

Pinched turns, approaching nearly 180 degrees, make it possible to complete the turn with little bias toward either spinning clockwise or counterclockwise to complete the turn. Therefore, it becomes possible to alternate (or create any sequence of) counterclockwise and clockwise turns, and thus reduce dizziness by delta-sigma modulating the direction of turning to create an average turning of approximately zero. See Figs. 6 and 7.

Four types of turns and rotations become possible:

Type	Location	Turn	$\frac{\omega_h}{\omega_{cc}}$	Fwd/Rev
Trackwise Arc	long span	-	0.3	continue
Direct Yaw	vertex	160°	3.2	continue
Conjugate Yaw	vertex	-200°	-4.0	continue
Stall Cusp	vertex	-20°	-0.4	toggle

The direct yaw is an ordinary right-hand or left-hand turn at a vertex, while its conjugate turn, rotating in the opposite direction, can be used to balance rotations to manage dizziness. The stall cusp is analogous to an airplane pointing upward, stalling, and falling backwards while still pointed in almost the same direction. It permits very small rotations at the vertices when the tempo is fast.

4.4 Relating tempo to rotation rate

For a circular tile pattern, the rate of rotation (vorticity) of the human body ω_h is equal to the circulation rate around the centre point, ω_o , as $\omega_h = \omega_o = v/R_o$, where R_o is the circular tile pattern radius and v is the forward speed.

However, for more general non-circular tile patterns,

$$\omega_h(t) = \frac{v(t)}{r_c(s(t))} = \frac{BPM(t)}{60sec/min} \cdot \frac{d_T}{r_c(s(t))} \quad (1)$$

where $BPM(t)$ is the beat-per-minute tempo, d_T is the tile separation and $r_c(s)$ is the local radius of curvature at position $s = s(t)$ along the track (for t.w. arc and direct yaw).

If the music requires a certain amount of rubato, represented by Δv , and abruptness of rubato, represented by $\frac{dv}{dt}$, the new long andantephone spans in Fig. 5, with a large radius of curvature, give less severe $\Delta\omega_h$ and $\frac{d\omega_h}{dt}$, to improve orientation and allow more flexible variations in tempo.

Additional flexibility in the musical phrasing came from an extension to the tile layout (Fig. 8), allowing graceful, non-sequential phrasing of the piece through movements that need not travel in one direction around a circle.

5. CONCLUSIONS

A new, more flexible design of andantephone was created for use in a new musical composition, using an array of tiles sensitive to geophonic seismic waves from footsteps. This user-interface was interfaced into a real-time frequency shifterbank which shifted the geophonic vibrations of human feet to the frequencies of musical notes and chords of the composition. The piece’s varied rhythm was played by the performer walking, running and jumping across the andantephone. The shifterbank output was interfaced to a pipe organ, using the organ as an additional sounding device.

A new andantephone tile configuration led to advantages over previous configurations, including less off-track radial acceleration required to change tempo, and the ability to multiplex between different types of vertex turns, which was found to improve spatial orientation when performing.

Video of “Stray” being performed can be seen at: <http://ryanjanzen.ca/composing/andantephone/>

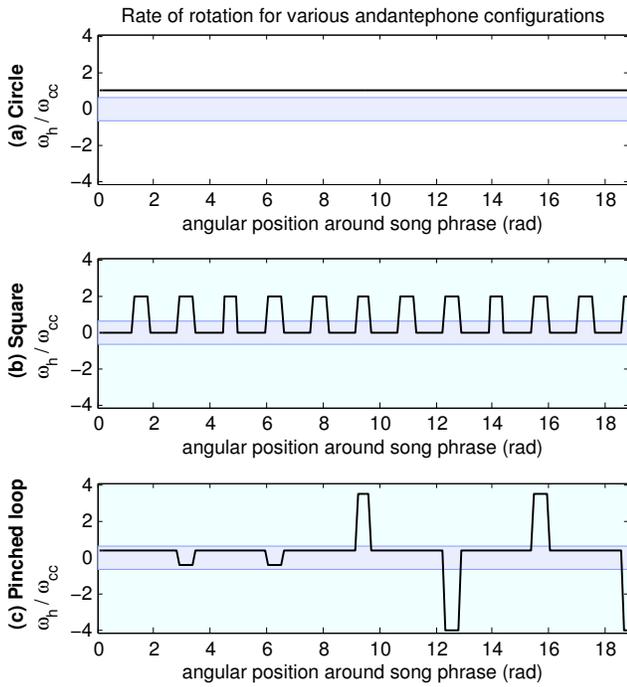


Figure 6: Angular velocity at a steady tempo. (a) A circular andantephone causes a constant rate of turning, ω_{cc} . If there are very few tiles per phrase, then the performer’s rate of self-rotation may be higher than what is comfortable to keep oriented to the stationary reference frame. (b) A square andantephone pattern requires four 90° turns every phrase. The repetitive rotations make a high average rate of rotation, which will cause problems later in Fig. 7 when the tempo varies. (c) Pinched loop pattern has half as many vertex rotations as the square pattern. There are four unique rotation rates (see table), which can be sequenced for an average rotation of approximately zero. Rotations within the shaded band were found to aid in orientation to the stationary reference frame during performance.

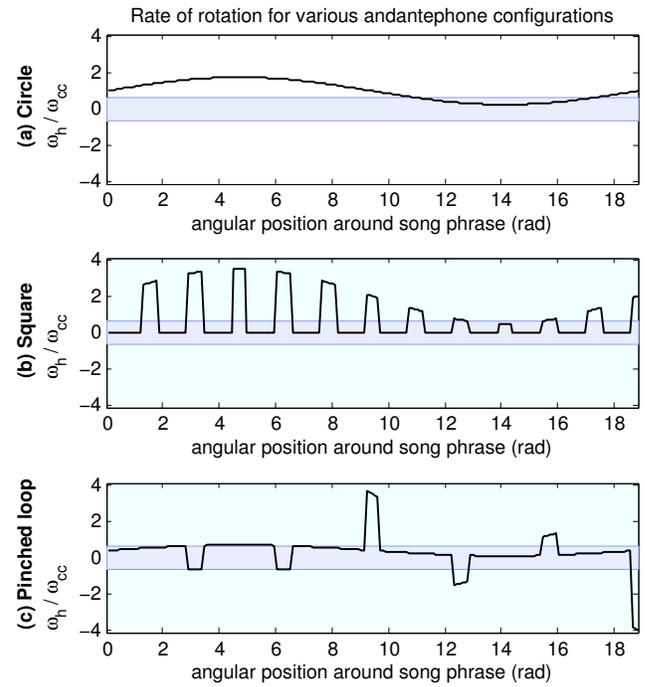


Figure 7: Angular velocity with rubato tempo. This simple example illustrates a sine-wave variation in tempo. (a) Rotation around a circular andantephone varies with the rubato tempo. (b) The original square andantephone pattern causes problems with rubato tempo because the fast turns occur in rapid succession, and each requires a different rate of rotation, which can be jarring and requires a high focus of attention to keep one’s balance. (c) On the other hand, the pinched loop pattern gives more time to reorient in between each vertex turn. The three types of vertex rotations can be sequenced intelligently, so that large-angled yaw turns can take place when the tempo is slower (i.e. when there is more time to gradually make the sharp turn).

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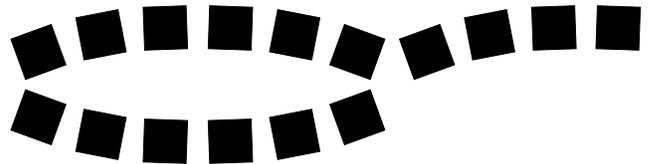


Figure 8: The final, extended tile layout used in “Stray”. The extension was added as a visual aesthetic element, and to add greater flexibility in musical phrasing. A recurring theme was exploring an unknown territory, landscape, or environment; While most of the performance took place circling around the pinched loop (as well as some periods concentrated at either the left end of the loop or the region where the loop and extension meet), occasionally the performance involved venturing out on the extension, as if it were a precarious precipice on a mountaintop or a window to a yet-unseen world.