MUSICAL APPLICATIONS AND DESIGN TECHNIQUES FOR THE GAMETRAK TETHERED SPATIAL POSITION CONTROLLER

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ABSTRACT

Novel Musical Applications and Design Techniques for the Gametrak tethered spatial positioning controller are described. Individual musical instrument controllers and large-scale musical and multimedia applications are discussed.

1. INTRODUCTION

Although hundreds of new controllers have been explored for musical applications, very few have emerged as sufficiently flexible and general to serve as platform technologies for a wide variety of musical instruments and interactions. One successful controller that is already widely used in musical applications is the digitizing tablet [15, 16]. In this paper we show by exploring representative examples how the Gametrak controller is emerging as another viable platform technology.

The Gametrak spatial position controller is an increasingly popular platform for experimental musical controllers, math and science manipulatives, large scale interactive installations and as a playful tangible gaming interface that promotes inter-generational creative play and discovery. Although largely displaced in its original market as a gaming controller by the Nintendo Wii, the Gametrak is attractive for music controller experiments and performance-quality instruments because of its unusually simple, cheap implementation and the ease with which it can be customized.

After introducing the peculiarities of the Gametrak and comparing it to related spatial position sensing systems we survey musical applications of the device and some of the basic design techniques discovered by the authors. The short paper format cannot do justice to the depth and breadth of such applications, so projects have been selected based on whether they represent unusual or surprising uses of the controller or because they represent fruitful starting points for future explorations. More detail on each project can be obtained from the web links included in the bibliography.

2. The Gametrak: a versatile tethered position sensing system

The Gametrak system was invented in 2000 by Elliot Myers [8]. He arrived at the basic concept while playing with a retractable washing line in a hotel. By placing potentiometers on a worm gear driven by the hubs of two retractable nylon tethers, the distance of the extension of the chords can be estimated. Passing the chords through the knobs of a pair of gaming joysticks supplies two orthogonal angle estimates for each.

This approach is cheap to implement but requires a careful mechanical design to achieve the desired precision, avoid tangling and to minimize the impact to the user of the pull of the tether. The first problem is solved by a series of smooth guiding tubes and by a clean path for the nylon chords. The basic ergonomic design was influenced by gaming applications involving the swinging of clubs (golf), bats (baseball) bowling or skiing. The two joysticks and tethered sensors are housed in a weighted box that is normally placed on the ground. Nylon clips are provided that can be attached to accompanying gloves. The unit also includes a plug-in footswitch.

Figure 1 Gametrak and Footswitch

The control electronics implements serial protocols for USB using HID protocols for computers, a specialized USB protocol for PS2 and there is also support for XBOX. The choice of format is made by shorting solder pads under the board making it straightforward to change a Gametrak to a different platform if required.

Perhaps the most important single factor to its recent popularity as an experimental music controller is the low cost of the device that resulted when thousands of Gametraks entered the surplus wholesale channel and became available for between US$8 and US$20 at internet retailers.

The official retail price for Gametrak games bundles is listed as US$70 but MadCatz the current owner of the technology has discontinued the device. Unlike other interesting discontinued controllers such as the P5 glove and the fingerworks iGesture, the Gametrak will be readily available for many years as over 300,000 have been sold. Note that it is easy to build comparable 3-axis position sensing from readily available string pots (from Celesco or Penny and Giles, for example) and joysticks.

3. Comparison with other Spatial Positioning Technologies

The Gametrak occupies a unique niche in the rich ecosystem of devices that can be used for 3D spatial position sensing [3]. It is by far the cheapest of any absolute position-sensing device. The Gametrak has in common with 3D time-of-flight cameras and other remote optical sensing techniques of low mass at the point(s) being sensed. Most other position sensing devices require a wand or small box with associated weight and power requirements. Most IR sensing devices such as the Wii controller or Buchla Lightning only work reliably indoors. GPS on the other hand works poorly indoors and has too low resolution for gesture sensing. The Gametrak works outside but is not weather proofed for permanent installations. The Gametrak, like the Polhemus system, is insensitive to most interference in the physical environment.

The major peculiarity of the Gametrak is of course the constant pull of the tethers. So although of low mass, each tether both constrains the position of objects to be sensed (because of tangling) and requires a source of counterbalancing force to establish a controlled position. In the following applications we will see that much of the interesting work with the Gametrak comes from strategies for embracing, tackling or defeating the tether. Note that the original Gametrak patent describes a haptic feedback component to the device where the tether's response was controlled dynamically[8].

People have little difficulty compensating for the constant pull of the tether because they already master comparable interactions, i.e., lifting constant mass limbs against the force of gravity; car accelerometer pedal; high-hat pedals; bent branches and stems; retractable dog leashes, key fobs, laptop cables, and vacuum cleaner power chords; fishing lines; sailing boat "sheets" and the bell ringers "sally," etc.

4. Gametrak Design Techniques and Applications

4.1. Direct mapping: Tethered Theremin

A straightforward musical application useful for exploring calibration, mapping and scaling of Gametrak gestures is a Tethered Theremin illustrated in Figure 2. the Gametrak gloves are used as originally intended on the hands, with one hand controlling pitch on the x-axis (and an optional wave-shaping filter on the y-axis) simulating distance from a theremin's upright antenna, and the other hand controlling volume based on z-axis extension, simulating distance from the theremin's loop antenna [10, 13].

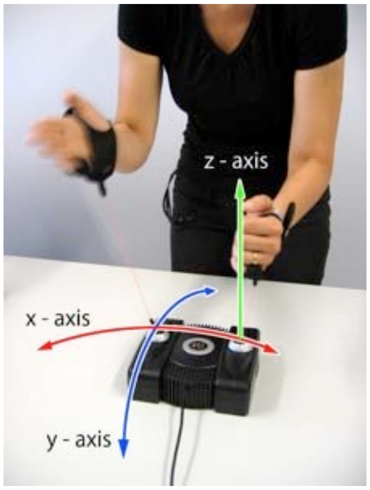

Figure 2: Tethered Theremin control axes

4.2. Counterweighting: Pendaphonics

In Pendaphonics installations Gametraks are ceiling mounted with balls or other object ("Pendaphones") attached to the tethers designed as counterweights to the spring-return force of the tether reels and to create physical dynamics that are engaging for users [5]. This effectively mimics what divers call a "neutral buoyancy" and from the users point of view (as for divers and astronauts) changes the interaction from counteracting a constant force to exercising inertial control.

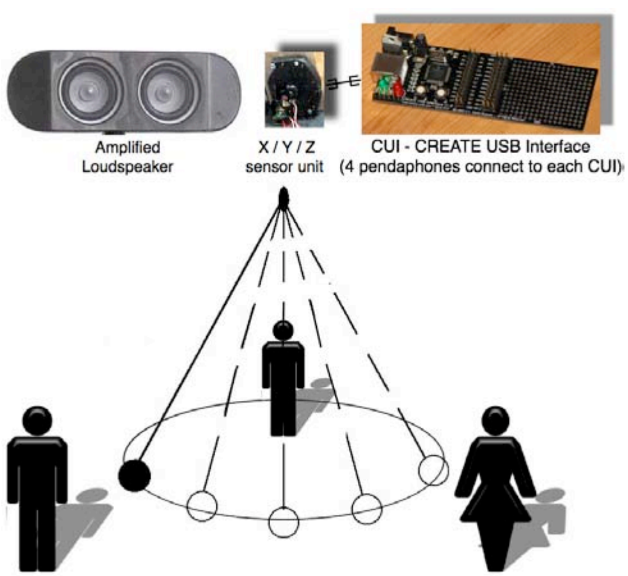

Figure 3. Pendaphone Components with Multiple Users

Each Pendaphone can be raised and lowered between 0–3 meters in height, and the trajectory of their swings directly controls the sounds emanating from a loudspeaker mounted above them. Multiple channels of loudspeakers are used to spatially distribute the sounds that are generated, enhancing the sense of physical immersion in the space. The physical setup is designed to be flexible and can be adapted to many different exhibition spaces and applications.

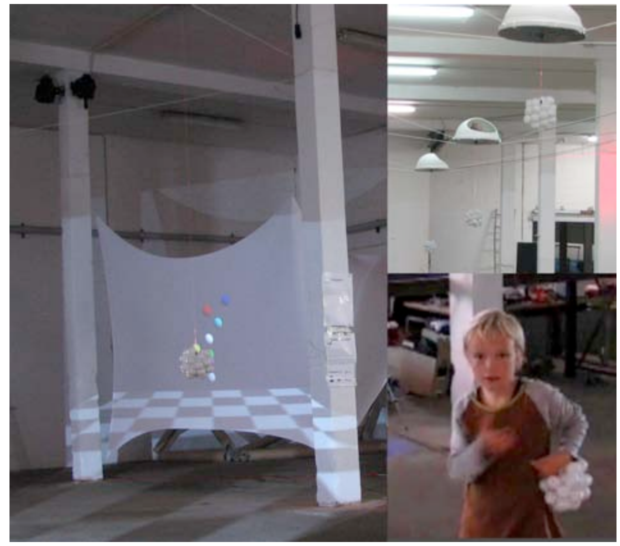
Figure 4x, y, and z. Left x), a Pendaphone bob hanging with a projected 3D environment; top right (y), three suspended Pendaphones; bottom right (z), a child plucking the string while holding the Pendaphone bob steady.

To illustrate the range of applications possible with pendaphonics we describe 3 mappings used at the Platform4 event. These were all directed towards the intuitive investigation of the interface, where exhibition visitors activate a soundscape in physical space. Familiar metaphors have been used, such as the idea of the turntable, where a rhythmical soundtrack is played back.

4.2.1. Clockwise Rotation

Clockwise rotation plays the sound forward, and counter clockwise rotation plays the soundtrack backward; the polar velocity of the swing changes the playback speed.

4.2.2. Percussion Sounds

Another sound feedback system consisted of percussion sounds that were mapped to cue points along the 360 degrees of the pendulum swing. Every thirty degrees a percussion sound was activated. The percussion sound changed pitch, depending on how high or low the pendulum was positioned in the air, and the audio frequencies percussion sound was filtered according to the amount of acceleration.

4.2.3. Musical Piece

The third sound feedback system was a musical piece composed by Mads Weitling (see http://www.kiloton.dk/). It consisted of a pre-composed soundscape, where the pendulum movement generated tones that mixed in with the soundscape and varied in texture and velocity.

Other metaphors for Pendaphonics being explored are:

- Sound ball improvisation tool [1]
- Sound transfers and sound traveling (locally and networked), incorporating hanging loudspeakers embedded in the bob, providing natural Doppler and "Leslie" effects
- Diverse ways of throwing and catching sounds through physical actions with the pendaphones
- Plucking the pendulum strings to set up future events or trigger special effects (either sounds or visuals)
- Detection of user's direct interaction with bobs while the string is motionless, e.g. w/ embedded accelerometers
- Detection of spatial interaction between two or more bobs
- Diverse game/play scenarios
- Individual instruments versus one collective instrument
- Physical vs. virtual presence, movement, and representation

4.3. Pendaphonics + Sound Directivity Control

The Pendaphonics application of Figure 5 combines a Gametrak, an inertial sensor (Wii) and a 120-channel programmable directivity loudspeaker array [4]. In one application the tether is used to steer narrow sound beams. In another striking gestures are captured for a virtual swinging gong. These gesture parameters drive sound motion and directivity models that are synthesized in real-time and rendered on the speaker array.

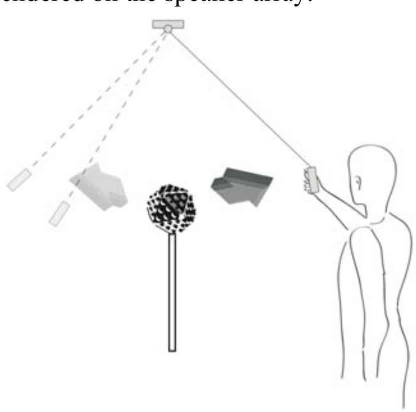

Figure 5: Spherical speaker array radiation pattern control

4.4. Combining and Duplexing Vertically

Another way of providing "neutral buoyancy" is shown in Figure 6 with two Gametraks (one floor mounted, the other ceiling mounted) tethered at the corners of a lightweight cube corresponding to the vertices of a tetrahedron. This arrangement allows for orientation and position to be computed. It also offers an interesting set of mechanical resonances to interact with as the cube twists independently around its center and this center rotates around the axis between the Gametraks.

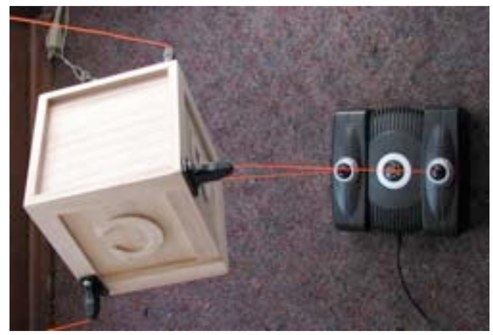

Figure 6: Tethered cube viewed from upper Gametrak

4.5. "Gearing" with the Gametrak control space

The conical bound on the Gametrak measuring region means that large spaces require a longer tether and are less precisely measured. These constraints suggest using the shortest tether that provides a large enough sensing region. It also affords mappings that let the user decide in real-time what range of motion they want to use with the radial axis being the gear factor. For example for acquiring conducting gestures the Gametrak is installed at waist height (on a robust music stand for example) and the axial parameters are mapped to the rhythmic gesture analysis. Conductors with a flamboyant use of space use long tethers, more reserved precise conductors are closer to the Gametrak. Note that the distance axis information need not be discarded for gesture analysis. It can be used to establish, for example, a direction for the conductors' leaning gestures.

4.6. Pinned Tether – The tea chest bass

In addition to the free-plucked tether of the Pendaphone stopped-string instruments can be simulated by extending a tether, pinning it down and providing an angled fingerboard. One application of this idea simulates a tea-chest or wash-tub bass.

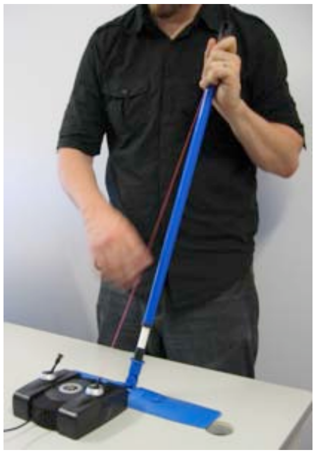

Figure 7 Gametrak Chordophone

An analysis of attack events (based on impulses on the x- and y-axes) determines whether the musician has plucked a string and to what extent the string deviated from its average position.

4.7. Specialty Tether: Tethertonium

With a conductive fingerboard and conductive thread attached to a tether the footpedal input can be used to provide accurate timing of touches on a simulated trautonium [14] as shown in Figure 7.

Figure 7: Tethertonium

4.8. Dividing + Dismantling: Kotrak and Ondestrak

In some applications the imposed distance between the two joysticks is too constraining. This can be easily addressed by adding a second Gametrak or by dismantling one and reassembling its two sensors at the desired distance. The Kotrak can be used to capture the string pressing and pulling gestures of Koto players.

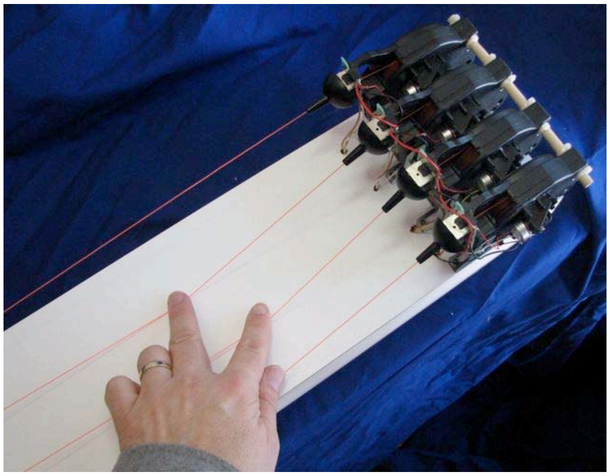

Figure 8: Kotrak

The Ondestrak [7] takes the dismantling even further as one of the two sensors is used with its spring removed. This needs to be done carefully because of the energy stored in the spring, its sharp edges and the messy lubricant.

The Ondestrak was built to explore a variant of the Ondes Martinot variable pitch interface. Instruments preceding the Ondes Martinot such as the Hellertion [6]and Trautonium [14] provided a combined amplitude and continuous pitch control for an untethered hand. The Ondestrak is a hybrid form of these instruments. A finger drags a ring attached to a loop of chord driving the Gametrak sensor without spring. The other sensor measures displacement of the board the whole system is built on as it is pressed against springs at each end. Note that the joysticks provide for a third axis of control as the ring is moved away and towards the player. This is naturally mapped to timbral parameters.

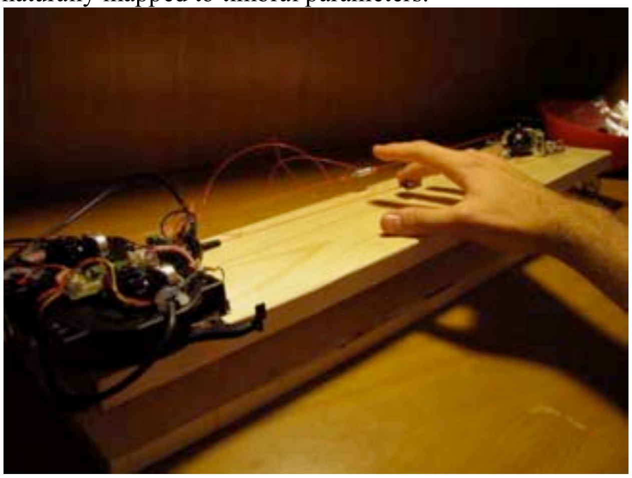

Figure 9: the Ondestrak

4.9. Controller Replacement

The HID interface using the PC USB configuration is "plug and play" using the HID objects in Max/MSP and PD and other music synthesis programs. It is common practice to rewrap the HID data as OSC messages. It is also straightforward to replace the Gametrak microcontroller with a wireless transmitting system or another interface as illustrated in Figure 10 which shows a $25 Microchip USB microcontroller board with uOSC [11] to provide a 1000Hz update rate for the data encoded directly in OSC.

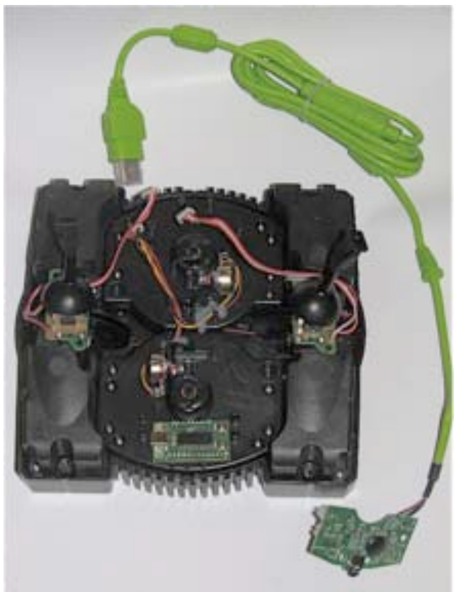

Figure 10: replacing the microcontroller

As well as providing a higher data rate and higher resolution samples the uOSC board provides control of latency and jitter to reasonable bounds for exacting performance applications [12]. Pendaphonics installations typically use CUI boards [9] to acquire the data from 2 pairs of Gametrak sensors.

5. Conclusion

Each of the applications presented invites exploration of numerous interesting mapping strategies for sound, image and motion synthesis. Ultimately development of the mappings takes longer than the physical prototyping. The Gametrak is a convenient platform to learn about mapping strategies and can facilitate rapid "sketching" of user interfaces [2] that may ultimately use untethered or inertial sensing.

An important conclusion from our explorations is that although the tethers are sometimes a nuisance they often create opportunities to more fully engage users in physical interactions beyond those originally reflected in commercial gaming applications.

6. References

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