Musical Navigatrics: New Musical Interactions with Passive Magnetic Tags

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Abstract
Passive RF Tagging can provide an attractive medium for development of free-gesture musical interfaces. This was initially explored in our *Musical Trinkets* installation, which used magnetically-coupled resonant LC circuits to identify and track the position of multiple objects in real-time. Manipulation of these objects in free space over a read coil triggered simple musical interactions. *Musical Navigatrics* builds upon this success with new more sensitive and stable sensing, multi-dimensional response, and vastly more intricate musical mappings that enable full musical exploration of free space through the dynamic use and control of arpeggiatiation and effects. The addition of basic sequencing abilities also allows for the building of complex, layered musical interactions in a uniquely easy and intuitive manner.

Keywords
passive tag, position tracking, music sequencer interface

INTRODUCTION
Free gesture interfaces provide for uniquely expressive and interesting musical controllers. They remove the restrictive physical link between the instrument and the player, allowing freedom of motion and a visually expressive interaction. However, along with being difficult to play due to lack of haptic feedback, most free-gesture implementations, such as capacitive sensing and light reflection, are limited by their inability to reliably identify more than a few modes of interaction; e.g., one hand is the same as the next. Those that do, such as the digital baton[1] or the visually based "Augmented Groove" project [2] by ATR and the University of Washington require highly complex systems or suffer from issues of visual occlution.

Our approach toward implementing an expressive and intuitive volumetric free-gesture musical controller is to use passive, resonant RF tagging techniques to implement a system capable of multi-dimensional tracking of up to 20 distinct objects in real time over an area roughly 12" above the sensing surface[3,4]. As magnetic fields can readily pass through non-ferrous material, magnetically coupled resonant tags, in the form of simple LC circuits, provide us with small, inexpensive, and easily identifiable tracking tools free from overly complex hardware and problems of occlusion.

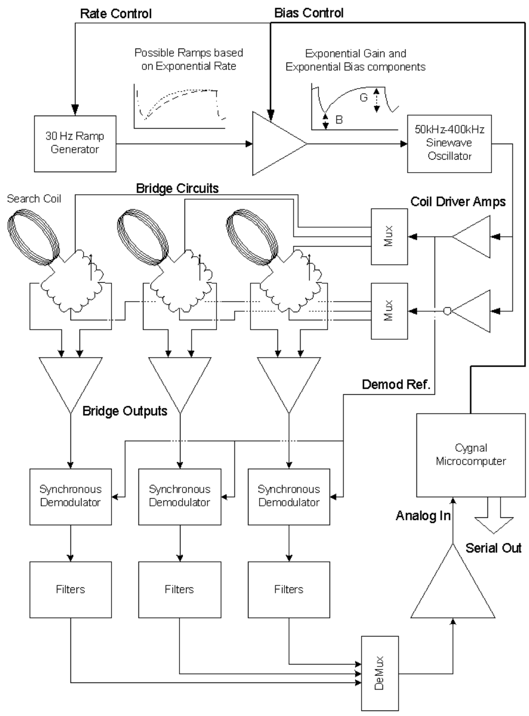

Figure 1 : Multi-Coil Swept Frequency Tag Reader

The implementation of the first major revision of the swept frequency RF tag reader is outlined in Figure 1. Both the earlier and present tag readers use a search coil to generate an AC magnetic field that sweeps 30 times a second from roughly 40 kHz to 400 kHz. An inductive bridge is used to detect the presence of a resonant tag from its load on this magnetic field. This signal is processed by a microcontroller to determine which tags appeared in the sweep and how strongly they coupled to the field (set by proximity and angle).

While the original tag reader worked well, it suffered from problems of frequency drift that, over time, can cause one tag to be confused for another or to disappear altogether off the edge of the sweep. The new reader[5] takes significant steps to alleviate this problem by continually monitoring the number of oscillator cycles across the frequency sweep and dynamically adjusting to compensate for any drift while retaining the original sweep profile. Also, as an additional check, the tag reader will periodically switch in known test tags, allow-

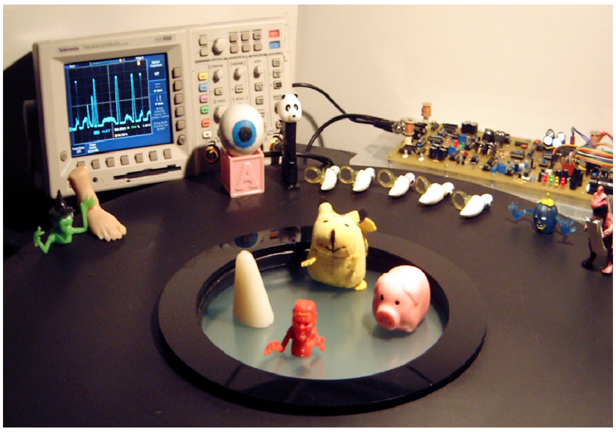

Figure 2: Tag board and *Musical Trinkets* tags

ing an external computer to monitor any drift that may still occur. The new tag reader features increased sensitivity through sampling and suppression of the baseline signal and increased bit-accuracy, along with the capability to drive up to 3 coils asynchronously on one board. This significantly eases the development of multi-coil geometries [3] by dramatically reducing the hardware otherwise required.

TRINKETS TO INSTRUMENTS

Musical Trinkets [3,4] made initial inroads at exploring the capabilities of the swept RF tagging board as a free-gesture instrument. Using 20 tags in 16 objects, *Musical Trinkets* explored a basic interaction, where bringing an object near the search coil would trigger a specific simple musical response. Moving an object into the reader's field would either introduce a musical note or drone, or alter the existing sounds with the addition of vibrato, pitch shift or limited effects. While *Musical Trinkets* made some use of the continuous nature of the tagging signal response, its highly constrained interaction made it very limited as a musical instrument. Additionally, *Musical Trinkets* is essentially one-dimensional; horizontal movement of a tag, a natural gesture attempted by many first-time users, fails to elicit any particular response.

Musical Navigatrics is an entirely new musical application of swept RF tagging. Using *MAX*[6] to implement musical mappings and sequencing and *Reason*[7] as its sound engine, *Musical Navigatrics* provides the means to physically explore sound in 3-dimentional space through the use of multi-coil geometries, multiple tangible objects, and full exploitation of the continuous nature of the tagging interaction. Tagged objects are divided into three categories: arpegiation/tonal manipulation, effects, and sequence control. The arpeggiation objects take a ready-made sequence and build neutral figuration on it. Parameters like arpeggio depth, shape and direction are determined by the objects' positions in relation to the coils. Thus, by moving an object from one side of the sense region to the other, a player can easily and quickly change arpeggiation direction. Moving the object closer to the coils, meanwhile, will increase the depth of the arpeggiation. The inclusion of a curve generating tag allows for easy free gesture production of simple musical lines without external sequencing requirements. Another tag adds and selects a drum pattern. The effects tags are split into controlling master effects, like delay and reverb, that act on all musical voices, while assignable voice effects such as volume, frequency cutoff, and resonance can be used to act on any simultaneously selected number of sequenced lines. The control objects (record, tempo, play) enable the recording, overdubbing, and playback of all non-control tag movements. This results in the ability to manifest a large degree of control over the creation of densely-layered arpeggiation and effects.

A unique advantage of the tagging interface is that due to the wide variety of trackable objects, interactions can be easily and instantly selected by the user. All it requires is picking up one object instead of another. As each object has a specific response associated with it, the interaction remains well defined. The objects and the playable space also maintain a clear physicality, enabling rewarding tactile and visual interaction. Due to the orientational nature of magnetic coupling, by mounting three orthogonal tags in an object, as demonstrated in *Musical Trinkets*, it is possible to determine the object's inclination. This enables 3-D rotational interaction, where the user can almost physically grab and twist a sound. Mechanical detuning of a resonant tag provides for additional pressure-sensing interactions, while the ability to detect multiple tags simultaneously provides for an impressive range of concurrent continuous control. For instance, a user can control several parameters of arpeggiation with an object in one hand while also adding effects on that voice by playing an effects tag in the other. Several tags may be worn as rings, enabling a different interaction on each finger. This multi-object capability also leads to the effectiveness of *Musical Navigatrics* as a multi-user instrument. Despite the complex sounds and musical interactions available, objects retain a clear musical functionality, allowing *Musical Navigatrics* to remain an intuitive and easily playable expressive musical controller.

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REFERENCES

[1] Paradiso J., Sparacini, F., "Optical tracking for music and dance performance", in *Optical 3-d Measurement Techniques IV*, A. Gruen, H. Kahmen Eds. Herbert Wichmann Verlag, Heidelberg Germany, 1997, pp.11-18.

[2] Poupyrev, I., "Augmented Groove: Collaborative Jamming in Augmented Reality," in *SIGGRAPH 200 Conf. Abstracts and Applications*, ACM Press, NY, p.77.

[3] Hsiao, K,. "Fast multi-axis tracking of magnetically resonant passive tags: methods and applications," MS Thesis,

MIT Department of EECS and MIT Media Laboratory, February 2001.

[4] Paradiso, J., *et al*, " Sensor Systems for Interactive Surfaces," *IBM Systems Journal*, Volume 39, Nos. 3 & 4, October 2000, pp. 892-914.

[5] Smith, L,. “Development of An Improved Swept RF Tagging System and its Musical Applications,” Meng. MIT Department of EECS and MIT Media Lab, Jan. 2002.

[6] See: http://www.cycling74.com/

[7] See: http://www.propellerheads.se/