Towards the T-Tree 2.0: Lessons Learned From Performance With a Novel DMI and Instrument Hub

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ABSTRACT

In this paper, the authors describe working with and on the T-Tree, a device that integrates multiple instances of a gestural controller known as the T-Stick. The T-Tree is used in two public performance contexts; the results of those performances are summarized, potential improvements to the design of the hardware and software are introduced, and issues are identified. Improvements in the T-Tree from the first version are also discussed. Finally, the authors present future design improvements for the T-Tree 2.0.

Author Keywords

gestural controller, DMI, digital musical instrument, design documentation, hub, IMS, interactive music system, t-stick, t-tree

CCS Concepts

•**Applied computing** → **Sound and music computing;** *Performing arts;* •**Human-centered computing** → Sound-based input / output;

1. INTRODUCTION

The T-Stick is a family of gestural controllers originally created in 2007 [7]. They have been the subject of research in creating community around DMIs and extending their longevity, as well as used in numerous public performances [3], [11]. In [5], Kirby et al. introduced the T-Tree, a "digital musical instrument (DMI), interactive music system (IMS) [15], hub, and docking station that embeds several t-Sticks." The T-Tree is a collaborative, multi-user interface that allows for group performance as well as installation use. In the year since its creation, it has been used in two public performances.

In this paper, we describe those performances and reflect on how the design of the T-Tree both helped and hindered our ability to use it. Improvements from the first version of the T-Tree are discussed. Finally, we document future work and goals for the T-Tree 2.0, the next major iteration of the T-Tree's original design.

2. PERFORMANCE USAGE

In the year since the creation of the T-Tree, it has been used in two public performances. One was as part of an interactive art installation, and the other was a live performance in a Western concert setting in which the audience and performers were separated. This section describes these two performance contexts and their results.

2.1 The Windy Days - Art Neuf Residency

The Windy Days is an ongoing project led by Lucy Fandel which investigates "how to weave together the discarded pieces of our habitats (plastic bags, rustling leaves, an act as complex as a slow walk) to (re)connect us to the subtle and urgent transformations of our most familiar landscapes."[1] The second author worked as the sound designer for this project alongside scenographer Darah Miah, and was tasked with building a small interactive installation in the main lobby of Art Neuf.[2] Dancers could interact with the installation and demonstrate the interactions possible within the space, which the public would also be free to explore. The T-Tree and two T-Sticks were used as the interactive hub for the installation.

Inspired by the techniques outlined in Jordan Lacey's *Sonic Rupture* [6], a small Bose SoundLink Revolve speaker was placed inside the hollow wall close to the T-Tree which hid the speaker while amplifying and colouring the sound. The sounds produced intermingled with the pre-existing soundscape of the gallery and the park outside, furthering the metaphors of transformation and shared space.

A 30-minute soundscape was created by manipulating field recordings of the Champs-des-Possibles using concatenative synthesis in Max/MSP, which was then re-granulated using Pure Data during the installation. This newly granulated material was fed through a reverberator, a series of resonant filter banks, and a series of delays, inspired by the processing proposed in [14].

The force-sensitive resistor (FSR) of one T-Stick controlled the reverb level while the FSR of the other T-Stick controlled the filter bank level. Capacitive touch sensing controlled the delay mix. The capacitive touch sensing of

[1]https://lucyfandel.com/portfolio/the-windy-days/
[2]https://artneuf.ca

NIME'23, 31 May–2 June, 2023, Mexico City, Mexico.

both T-Sticks was summed together to control the gain of the granular synthesizer and the frequency response of the filter bank. In this way, the full mapping was accessible only if both T-Sticks were used, either by one user playing with both T-Sticks or by two users. Inspired by [1], these slow control rates require the user to slow down and sustain their actions with both T-Stick "branches."

Figure 1: The T-Tree in Art Neuf.

2.2 The live@CIRMMT Performance

The *live@CIRMMT* performance series showcases artistic research by members of the Centre for Interdisciplinary Research in Music Media (CIRMMT).[3] Paul Buser, Kasey Pocius, and Linnea Kirby applied to perform with the T-Tree and were accepted as part of a concert of new electroacoustic and mixed works. For this performance, we wanted to create something that would clearly associate the gestures of each performer with a particular branch of the T-Tree.

We chose to create sounds that were complementary in timbral space: one performer controlled the bass voices, one had noise material, and one had a mixture of melodic and percussive voices.[4] The outputs were then sent to a delay, reverb, and granulator via auxiliary tracks, which helped glue the voices together while allowing for further modulation by all three T-Sticks.

The second author took the lead on the mapping design, ensuring that gestures were clear to the audience regardless of their seating position and giving the performers subtle control of their overall amplitude. All mappings used the FSR of each T-Stick to control the amplitude of each voice, while the gyroscope of each T-Stick controlled the position and rotation of each voice in Spat Revolution.[5] Many of the more prominent timbral changes in the synthesis engines—such as filter FM, waveshaping, and grain window shape—were mapped to gestures associated with the inertial measurement unit (IMU). The spatialization also acted to add additional emphasis to the movement of each T-Stick.

Although the lights on the T-Tree were mapped to the gestures of each performer individually, the sounds of each performer could be cross-modulated by the gestures of one another. We found that this led to more possibilities for improvisation and stimulated engagement amongst the performers; even if one person was not making sound themselves, they could still affect the timbre of the other players.

3. DESIGN CHOICES FROM T-TREE 1.0

The T-Tree is a multipurpose device that allows for embedding and enhancing the capabilities of the T-Stick family of gestural controllers [5]. In addition, the T-Tree was designed and built with other goals in mind: replicability, ease of use, low entry barrier for new users, and backwards compatibility.

Having performed publicly with the T-Tree twice since the publication of [5], some choices the creators of the T-Tree have made worked well, while others have caused difficulties in performance and exhibition. In this section, we reflect on some of these aspects.

3.1 Effective Aspects of the T-Tree

The choice to "use plumbing pipe and fittings because they are lightweight, sturdy, and relatively cheap" [5] has been effective at creating a movable and robust structure. In one performance (The Windy Days), the T-Tree was reinforced with gravel bags, and in the other (*live@CIRMMT*), it was not. In both cases, the structure of the T-Tree was sturdy and did not pose any problems to the performance.

The modularity of the design has also worked well. Because branches can be unscrewed and removed from the T-Tree, in both performances the T-Tree was customized according to the number of T-Sticks needed.

In terms of software, the Raspberry Pi 4 has proven to be an effective platform for our needs and is flexible and powerful enough to do both onboard signal routing and synthesis. A large ecosystem of open-source software is also available for Raspberry Pi, which allows for additional functionality to be created if the T-Tree does not currently meet the needs of its users. We will address further improvements in software in Section 4.1.

3.2 Challenging Aspects of the T-Tree

It is currently difficult to insert or remove the Raspberry Pi from the T-Tree. Because the wiring is internal, if a user needs to plug a cable into the Pi, the entire trunk of the T-Tree must be unscrewed in order to access the internals. This makes setting up the T-Tree a tedious and error-prone process.

Although the Pi supports onboard synthesis, the T-Tree was not designed for use with an internal speaker, and thus, requires external speakers and amplification. Furthermore, there are no external ports or user interface components on the T-Tree itself, which means that cables need to be inserted into holes drilled in the T-Tree, and any changes to the software need to be done via an external computer.

Although it is a primary goal of the T-Tree to support all different revisions of the T-Stick, supporting heterogenous instruments can be difficult. We realized this first-hand when, after a week of successful rehearsals, we had a catastrophic T-Stick failure onstage during our performance at *live@CIRMMT*. Fortunately, the T-Tree continued to route signals from the two remaining T-Sticks and we were able to finish our performance with some improvised adjustments. This is not a problem with the T-Tree per se, but we would not recommend using older wireless T-Sticks in a performance-critical context.

[3] https://cirmmt.org
[4] https://github.com/IDMIL/T-Tree/
[5] https://www.flux.audio/project/spat-revolution/

Figure 2: The T-Tree played by three of the authors in the *live@CIRMMT* performance.

4. IMPROVEMENTS

A number of improvements have already been made to the T-Tree since its creation. In this section, we describe these improvements, including easing wireless configuration, standardizing the software framework on which the T-Tree is built, and expanding compatibility for wired T-Sticks.

4.1 Standardization of Software

The T-Tree now uses Puara,[6] "a framework for building and deploying New Media installations and New Interfaces for Musical Expression" that powers the Media Processing Unit (MPU)[7] [9]. It is developed jointly at the Input Devices and Music Interaction Laboratory (IDMIL)[8] and Société des Arts Technologiques (SAT) Metalab.[9] By adopting Puara as its software framework, the T-Tree now has a standardized computing environment that is optimized for audio processing. Puara itself is open-source, and it also comes preconfigured with common open-source audio processing tools, including SuperCollider, Pure Data, and JackTrip.

One beneficial side effect of using the Puara framework is that the T-Tree is now compatible not only with T-Sticks, but with any instrument that uses the Puara DMI toolkit. This could allow instrument designers to more easily create DMIs that interface with the lights of the T-Tree or any future sensors/actuators.

4.2 Easier WiFi Configuration

Configuring T-Sticks with the correct WiFi and network information has become much easier since the introduction of the T-Tree. This used to be a laborious process, involving a number of steps; missing any of them would lead to an unusable T-Stick. By creating the Puara Serial Manager,[10] this process is automated and happens in a matter of seconds. Each T-Stick connected to the T-Tree will be automatically configured to send OSC messages to it, each on a different port.

We used the Puara Serial Manager in our *live@CIRMMT* performance to configure three T-Sticks, and found that it worked well to update T-Sticks as our networking environment changed.

[6] `https://github.com/Puara`

[7] The MPU was formerly known as the GuitarAMI Sound Processing Unit.

[8] `https://idmil.org`

[9] `https://sat.qc.ca/fr/metalab`

[10] `https://github.com/Puara/puara-serial-manager`

4.3 Translation Layer for Wired T-Sticks

Although the first version of the T-Tree could interface with wired T-Sticks, it did not possess the software to convert their signals into something usable. Now, the T-Tree includes a translation layer in software that allows the wired T-Sticks to send serial data that is converted into wireless OSC messages that match the namespace of newer wireless T-Sticks. This allows for older T-Sticks to work with newer patches, though the patches may need to be reconfigured slightly, as older T-Sticks do not include all sensors present in new ones.

5. FUTURE WORK

Although we've learned a great deal through performance, and many improvements have already been made to the T-Tree, there still remain a number of opportunities for further development. We document the most crucial work to be done here, including a structural redesign, optimization for use in an installation context, and tighter integration between the T-Stick and the T-Tree.

We will implement these improvements in a new T-Tree, adhering to Cook's advice to "build a (new) copy, don't trash the original" [2]. This will allow us to make direct comparisons between the two iterations of the T-Tree and chart our progress. We also will continue documenting public performances with the T-Tree, as establishing a body of work is a critical part of the ecosystem of resources that enables a DMI's longevity [8].

5.1 Structural Redesign

Unifying the power supply into a single 5-volt, 8-amp power supply (3 amps for the Raspberry Pi, 4 amps for the LEDs, and one amp for a safety margin) will reduce the number of cables necessary to run to the T-Tree, and thus, the possibility that someone might trip. It also reduces the number of potential points of failure.

The brain of the T-Tree should be expanded to include room for an internal speaker and amplification system. This will require some testing to figure out how much power is needed for the amplification system, as well as the specific resonances of the structure of the tree. This could be designed in conjunction with the aforementioned unified power supply. As an extension of this idea, including one speaker per branch would increase the creative possibilities for self-contained multichannel sound production from the T-Tree.

Including external ports on the body of the T-Tree will allow users to plug in without unscrewing the trunk, which caused particular annoyance in both performances. We suggest including at minimum one DC barrel connector for power, one Ethernet port, and two USB-A ports.

We would like to include a larger chamber in the trunk of the T-Tree to allow more room for the Raspberry Pi or other single-board computer (SBC). The Raspberry Pi fits inside the T-Tree as it is, but with barely any additional space. Including extra room will also allow a larger SBC to be used if desired, reducing lock-in to a single computing solution.

Finally, some kind of rudimentary user interface should be implemented on the body of the T-Tree, allowing for basic commands like patch changes to be done without the need for an external computer. The MPU includes a 4x20-character LED display and a four-button interface, which could be repurposed for this task.

Reducing set-up time and complexity is not just a technical concern, but one of longevity. In a 2017 survey of 70 participants in NIME conferences between 2010–2014, Morreale and McPherson found that 47.1% of DMIs created by respondents would not be able to be played in performance without at least "a few hours" of work [10]. There is a clear need to make set-up time as quick and easy as possible if the T-Tree is to be used for years to come.

5.2 Optimization of the T-Tree As Installation

The T-Tree, when configured with a sound generator and mapping layer, can function as a "composed instrument" that "carries as much the notion of an instrument as that of a score" [13]. But how does one expose a potential user to this capacity for music-making? We will need to investigate how to make people aware that the T-Tree is interactive. We learned the necessity of this from experience in The Windy Days, as the audience was unaware that the T-Tree was interactive, and thus did not play with it.

One potential way to expose the T-Tree's affordances is by having the device output ambient audio, similarly to Jaimovich's *Ground Me!*, which also had a "significant level difference between the triggered sound and the ambient level" to establish causality between gesture and sound [4].

5.3 Tighter Integration with the T-Stick

The ultimate cause of the T-Stick failure in *live@CIRMMT* was determined to be a faulty soldering joint between the battery and the microcontroller. Although on the surface this failure has nothing to do with the T-Tree, we have realized that the T-Tree can only be as reliable as the instruments it interfaces with.

There is already an initiative in the IDMIL to create a rigorous testing framework for T-Stick hardware [12]. We suggest that this work go further, and design the T-Stick and the T-Tree as a single instrument. This could include a specialized shape of T-Tree branch that both charges and initializes T-Sticks connected to it, or the inclusion of specialized sensors (ultra-wideband, for example) on future versions of the T-Tree and T-Stick.

6. CONCLUSION

The T-Tree has done well in its two performances this year. We have evaluated it in the context of two performances, documented the improvements made since its creation, and discussed improvements to be made in the future. It is our hope that we can continue to develop the T-Tree as a DMI and IMS that is reliable, reproducible, and open to expansion.

7. ETHICS STATEMENT

We would like to acknowledge the traditional, ancestral, and unceded Indigenous lands where this project was developed. Tiohtià:ke/Montréal and the surrounding areas have historically been a meeting place for many First Nations. We strive to respect the history and culture of these diverse communities and to continue to educate ourselves on the impact of our colonial past.

The T-Tree's hardware and software are open-source. The use of off-the-shelf and 3D-printed parts aims to make this project more accessible and replicable. The source code and documentation to reproduce the instrument are made available via GitHub and we encourage the use and modification of this work as needed by users.

The T-Tree focuses on expanding the T-Stick family of instruments, and we strive to minimize waste by continuing to integrate with existing instruments and hardware.

No testing of human or animal subjects was involved in this research and there exist no conflicts of interest. No research participants were engaged. Artistic collaborators and consultants who were engaged for the project were compensated at rates at or above market as determined by the relevant union representing their creative practice.

The authors strove to have a variety of genders represented in the lab demo videos, with female, male, and non-binary participants. These videos lack participants from non-Western backgrounds, which can be improved upon in future demos.

8. ACKNOWLEDGMENTS

The Windy Days is supported by the Canada Council of the Arts and Art Neuf. This research is also supported by the Social Sciences and Humanities Research Council of Canada (SSHRC) and Natural Sciences and Engineering Research Council of Canada (NSERC) supporting the Input Devices and Musical Interaction Laboratory (IDMIL). Thanks to Brady Boettcher for the comments and Albert Niyonsenga for the technical support.

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