Performance as Research Method: Effects of Creative Use on Development of Gestural Control Interfaces

Martin Ritter
University of British Columbia
2329 West Mall, Vancouver, Canada
martin@martin-ritter.com

Alyssa Aska
University of Calgary
2500 University Drive NW, Calgary, Canada
a.aska@ucalgary.ca

ABSTRACT

This paper explores the impact of creatively informed testing on the development of gestural control interfaces. Two interfaces are explored: a motion tracking system contributed as part of the *Integrated Multimodal Score Following Environment* (IMuSE), and *MRleap* for use with the Leap Motion. Both systems have thus far been primarily implemented in conjunction with live, acoustic instruments. The IMuSE research project was initiated to design a visual tracking system that, coupled with frequency tracking and amplitude tracking, could follow a performer and determine their temporal location in a score. However, the first use of the software in performance exploited its creative potential as an expressive musical interface. Prior to this creative use, all software testing was done in a controlled environment. Testing in performance where many factors are unforeseen allowed for significant advancements in software design. Additionally, through experimentation with motion tracking software during performance, the discovery was made that there is a lack of fine motor tracking devices, especially for performers on instruments where fine gestures are required, such as the piano. *MRleap* was subsequently developed to track these fine and detailed gestures. Creatively informed research has therefore served an extremely useful purpose in the development of these expressive systems and determining their effectiveness, as well as informing future research methodologies on part of the authors.

Keywords
IMuSE, score following, Leap Motion, development,

1. INTRODUCTION

Gestural control interfaces and tracking systems are an important part of computer music research today, as much current technology employs innovative user input and interaction (including touch screens, motion tracking, and external controllers). Such interfaces are frequently used as separate musical instruments that are performed with either as solo instruments or as part of an ensemble. The authors of this paper explore the use of these gestural control systems with live instruments in performance. Two such interfaces are examined: camera tracking developed as part of the IMuSE [5, 8, 10] research project, and Leap Motion [7] software that interfaces with Max/MSP [13]. The software developed as part of IMuSE was initially intended for tight score following during performance. However, the creative applications and testing that were employed using the software demonstrated the capability of the motion tracking to function effectively both as an expressive musical device and as a means for the performer to control temporal advancement of electronics. The importance of these creative uses and how they contribute to the research practice cannot be denied; not only was the camera tracking refined and enhanced as a result, the need for a device such as the Leap Motion was discovered and subsequently implemented. This case study therefore highlights the importance of practice-based research; this is especially crucial in systems such as electronic musically expressive interfaces because there are many aspects of the concert environment that are uncontrolled and potentially unforeseen.

Practice-Based Research Workshop at *NIME'14*, June 30 – July 03, 2014, Goldsmiths, University of London, UK. Workshop organized by the Creativity and Cognition Studios, University of Technology, Sydney.

2. IMuSE

IMuSE was designed as a software-based implementation for the creation, rehearsal, and performance of score-based interactive computer music projects. Several cutting-edge technologies are used to create a modular environment that allows for seamless integration for various modes of tracking [3]. An augmented version of the music notation software NoteAbilityPro [6] is used in conjunction with Max/MSP/Jitter. Within Max/MSP/Jitter several third party technologies are employed including *antescofo~* [2], gf [1], and imubu [12] objects, all developed at IRCAM. For IMuSE to function in performance, gestures have to be recorded in rehearsal and aligned to the NoteAbilityPro score ahead of time. A gesture is defined as any continuous data that can be reproduced during performance with some degree of precision. During a performance the pre-recorded, aligned gesture is analyzed and compared to the live gesture, which allows IMuSE to communicate real-time score alignment data to NoteAbilityPro.

2.1 Testing the IMuSE System

For the majority of its lifecycle the IMuSE system was created, tested, and refined under controlled studio conditions at the Institute for Computing Information and Cognitive Systems (ICICS), at the University of British Columbia. To date, IMuSE has been used for clarinet pitch and amplitude tracking, viola bow motion tracking, piano pitch and motion tracking, and most recently, trombone pitch and slide motion tracking. While working with this array of performers and the different needs for gesture tracking software, the author also began the development of the *MR.jit Computer Vision Toolbox*. This is a collection of abstrations and bpatchers, designed to rapidly prototype gesture tracking applications in Max/MSP/Jitter.
The performers were asked to test the IMuSE system by playing a range of repertoire from Baroque to contemporary

masterpieces as well as technical exercises, extended techniques, and sketches of new pieces being written for the system. While tracking results were promising under these controlled conditions, rehearsals under performance conditions and live performance situations highlighted several areas of improvements that would be necessary to ensure system reliability.

3. Works for Piano and Motion Tracking

The motion-tracking component of IMuSE has been used in concert situation for a variety of instruments including viola, piano, and trombone. The following section of the paper will focus on selected works composed for piano and the IMuSE motion tracking system. The piano was chosen as an initial point of investigation for several reasons: the performer is mostly stationary, the tracking area is unchanging and clearly defined, and both hands are used.

3.1 Alyssa Aska - *Concurrent Shifting*

Concurrent Shifting was performed in Vancouver, Canada in October of 2012. The piece employed the camera tracking system developed during the IMuSE research project. However, the work did not use the system for its intended score following purpose; it was instead used as a gestural control interface. The pianist received instructions for dramatic gestures to be made outside of standard piano playing; these extra-musical motions as well as inherent motions occurring as a result of the musical performance were used to affect sound processing and sound synthesis. This work illuminated the creative and expressive potential of the system and its capabilities in works that combine live instruments with electronics. Additionally, this marked the first time the motion tracking software was ever extensively tested in a live concert environment. Several important factors such as lighting, accidental movement of the camera frame during performance, and extension of USB cables to enable the camera to reach the computer were discovered during this performance. The composer's tracking needs also pressured further streamlining and development of the camera tracking technology, which improved the accuracy of the system considerably for score following and as a gestural interface.

3.2 Martin Ritter - *Reach*

Reach for piano, interactive electronics, and gesture tracking is part of a larger chamber orchestra composition. This particular movement marks the work's culmination of motion tracking techniques and uses it in several different, progressively abstract ways. Initially, tracking is used only for inherent motion related to score interpretation. Subsequently, the performer receives instructions to execute extra-musical gestures. The figure below demonstrates this; the performer follows the coloured lines; the arrival pitches are not attacked. Finally, the performer is instructed to extend their hands outside of the keyboard range, demonstrating the ability of the motion tracking to literally extend the instrument. This extension triggers synthesized piano sounds from PianoTeq4 [9]. Once again, the use of the motion tracking in performance proved effective and produced results that would be otherwise impossible; the use of the area outside of the piano would not be explored in a work using the software for its conventional score-following purposes. As lighting and shadowing differs in the areas surrounding the piano, testing the system under performance conditions explored the boundaries of the tracking software and the physical range of desirable data generation.

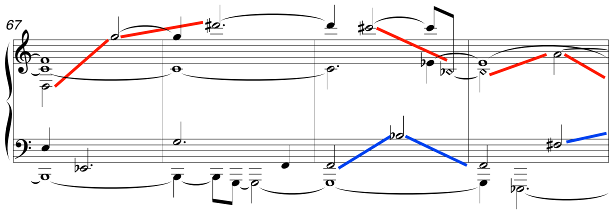

Figure 1. Score excerpt Reach

3.3 Evaluation

As has been demonstrated so far by this paper, the research and development of the software systems discussed by the authors is greatly influenced by using these systems in live situations. Evaluation of the software must be considered especially important to the practice-based approach explored in this paper. Testing this software has led the authors to use an evaluation approach that measures the effectiveness of three main areas: practicality, creativity, and formal function of the electronic device. These areas were chosen because of their pertinence to the goals of using the IMuSE system as an expressive device that can also allow a performer to advance a piece without external interference in a live performance situation. Under the controlled testing conditions originally implemented in the ICICS laboratory, IMuSE proved to be a practical, although very involved and complicated system. The time required to record data and subsequently align it for use can become tedious, making it not always time-effective when other performance factors are considered. Additionally, not all performers are available to record the data beforehand. The system itself is not creative by design; however, the freedom that score following presents enables a composer to focus on creative components of the composition. Using the IMuSE system as an expressive gestural interface proved more practical and provided more creative options. Performers were enthusiastic about the device and the looser restrictions regarding data synchronization allowed for easier set up for rehearsal and performance.

4. MRleap

The development and subsequent testing of the motion tracking systems discussed previously led to the development of new software, aimed primarily at tracking the fine movements that are incapable of reliable capture by a camera. *MRleap* [11] is a custom Max/MSP/Jitter external developed by the author for use with the Leap Motion device. It was created out of the need to further refine the motion tracking research undertaken during IMuSE, and specifically to significantly improve fine motion tracking. The external itself was designed to allow for customizable data acquisition and output. Tracking and outputting all the data points that are currently exposed in the Leap Motion SDK is very CPU intensive. The design of *MRleap* is based on the idea of persistable data options, meaning that the user can enable/disable any of the 67 currently available tracking parameters, and have them persist across sessions.

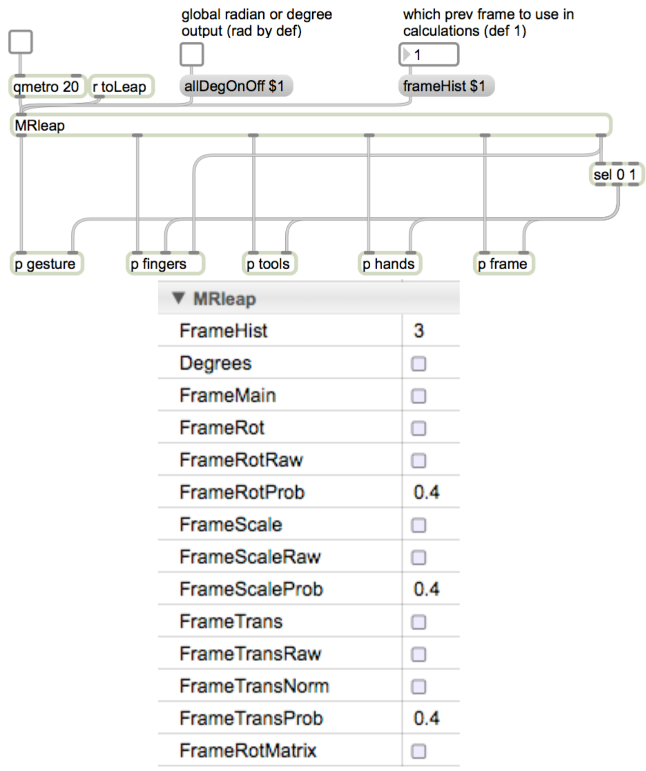

Figure 2. ***MRleap*** **in Max/MSP and example of data customization options**

4.1 Alyssa Aska – *Suite for Piano and Leap Motion*

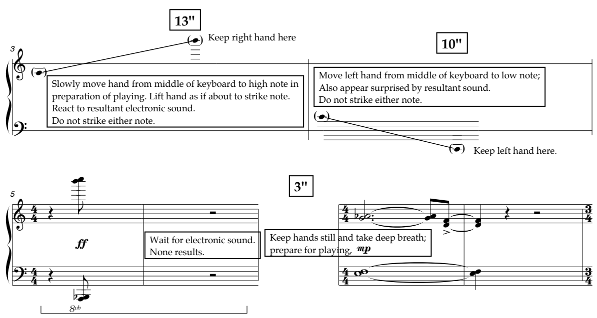

Figure 3. Score excerpt from Hyperkinesis

To date there have been two performed pieces for the Leap Motion using *MRleap*; each is a singular movement from a multi-movement composition currently being completed for piano and the Leap Motion. The suite contains six movements; a prelude and postlude which make use of the hand and finger tracking, and four numbered movements, each of which explore a different built-in gesture recognizable by the Leap. These performances have influenced *MRleap* substantially; they have tested the gestural recognition, the viability of the software in live settings, and whether the software contains bugs or other issues that might interfere with a preferred performance quality. Performance and dress rehearsal requires the software to be tested under a variety of conditions. Additionally, performance requires the software and hardware to be idle for short periods of time; for example, if the work is not first on the program set up must take place several minutes prior to actual performance. One of the more important factors that sets *MRleap* apart from other Leap Motion externals is the ability to customize which elements the Leap is tracking at any given time; this capability prevents the Leap from drawing too much CPU power, which helps to avoid potential crashes.

4.2 Evaluation

MRleap has primarily been tested in rehearsal and concert environments. It is intended to allow a composer/performer to track small and subtle movements and, extending on the original IMuSE research, advance a work using electronics with no external interaction from a master controller or other device not related to the musical expression of the performance. Therefore, in testing of the *MRleap* the following elements are examined: crashes, bugs, and software errors (practicality), performer feedback regarding device use (creativity), and the use of the device to advance electronics or inform electronic advancement (electronic device in formal function). Thus far the use of the Leap with *MRleap* has received favourable comments from performers both as an expressive device and as a score advancement system. The system is still relatively new and software issues have arisen in rehearsal and performance; these issues are resolved as they are discovered. Continued testing of the system will occur as more compositions are completed, rehearsed, and performed.

5. Future Developments

This paper has focused primarily on the creative and compositionally focused applications of the software and its implementation as creative devices. However, it should be noted that the IMuSE software, for example, was not initially developed for creative use; rather, it was developed to enhance and streamline works for live instrument and electronics by allowing the performer to control time-based events simply by playing through the piece. The practice employed by the authors in composing and having pieces performed for this software led to the development of providing increased performer control over the electronics, including time-sensitive or time-based electronics, by enabling them to interact with a separate gestural controlled interface. Future works will include pieces for Leap Motion and accordion and several works for live instruments other than piano and electronics. All of these works are intended to further the research of the software and for the integration of live performer and electronics, with special emphasis on the performer's ability to affect time-sensitive material and to advance the piece without the need for devices outside of the performance.

6. Conclusions

Creatively informed and practice based research is extremely important to the development of new systems and technologies to be used within the musical community. Many factors are uncontrollable when performing on electronic musical instruments, and therefore the more testing that is possible, the more desirable the outcome. The authors of this paper acknowledge the contribution of using the developed interfaces in performance, especially by having multiple performances exploring different parameters in the software. The authors have also discovered the ability of performance to enhance the development of software; while lab-controlled experimentation and testing has aided research, results are considerably faster when testing in such uncontrollable and diverse environments as live concert settings. Using researched technology in practice also helps to determine its capabilities and whether the intended purpose is viable. In the case of the score following discussed in this paper, practically applied research determined that while score following is possible under controlled situations, the technology is also applicable as a gestural interface that is easily and effectively used by a live performer. The score following software is useful when extreme timing precision is needed and when elements such as data recording are possible prior to performance. Performances to date have aided the development of the system as an expressive interface and as a means of controlling time-based elements in a less technically demanding way, which proves useful for quick performance turnaround and allowing a piece to be performed in many locations. The results of the research discussed in this paper informed the research methodology used for the *MRleap*; immediately after the completion of the external it was used in creative compositions and performance and continues to be used in such a way. Additionally, performance informed research of these systems has led to many other discoveries that have enhanced the performance process, such as the networking of the tracking computer and the audio generating computer. Employing this research methodology thus allows for great improvements to be made in systems and encourages the developer to work within the system, bringing out its positive qualities.

7. ACKNOWLEDGMENTS

IMuSE was funded by the Canadian Social Sciences and Humanities Research Council (SSHRC). This work was supported in part by the Institute for Computing, Information and Cognitive Systems (ICICS) at UBC.

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