Revised Selected Papers

Accademia Musicale Studio Musica

Michele Della Ventura, *editor*

2020

Proceedings of the International Conference on New Music Concepts Inspired Education and New Computer Science Generation

Vol. 7

STUDIO MUSICA

Accademia Musicale Studio Musica

International Conference on New Music Concepts Inspired Education and New Computer Science Generation

Proceeding Book
Vol. 7

Accademia Musicale Studio Musica
Michele Della Ventura
Editor

Printed in Italy
First edition: March 2020

www.studiomusicatreviso.it
Accademia Musicale Studio Musica – Treviso (Italy)
ISBN: 978-88-944350-3-0

Preface

This volume of proceedings from the conference provides an opportunity for readers to engage with a selection of refereed papers that were presented during the International Conference on New Music Concepts, Inspired Education and New Computer Science Generation. The reader will sample here reports of research on topics ranging from a diverse set of disciplines, including mathematical models in music, computer science, learning and conceptual change; teaching strategies, e-learning and innovative learning, neuroscience, engineering and machine learning.

This conference intended to provide a platform for those researchers in music, education, computer science and educational technology to share experiences of effectively applying cutting-edge technologies to learning and to further spark brightening prospects. It is hoped that the findings of each work presented at the conference have enlightened relevant researchers or education practitioners to create more effective learning environments.
This year we received 57 papers from 19 countries worldwide. After a rigorous review process, 24 paper were accepted for presentation or poster display at the conference, yelling an acceptance rate of 42%. All the submissions were reviewed on the basis of their significance, novelty, technical quality, and practical impact.

The Conferece featured three keynote speakers: Prof. **Giuditta Alessandrini** (Università degli Studi Roma TRE, Italy), Prof. **Renee Timmers** (The University of Sheffield, UK) and Prof. **Axel Roebel** (IRCAM Paris, France).
I would like to thank the Organizing Committee for their efforts and time spent to ensure the success of the conference. I would also like to express my gratitude to the program Committee members for their timely and helpful reviews. Last but not least, I would like to thank all the authors for they contribution in maintaining a high-quality conference and I hope in your continued support in playing a significant role in the Innovative Technologies and Learning community in the future.

March 2020

Michele Della Ventura

Conference Chair

Michele Della Ventura, Accademia Musicale Studio Musica, Treviso, Italy

Keynote Speakers

Giuditta Alessandrini, Università degli Studi Roma TRE, Italy
Renee Timmers, The University of Sheffield, UK
Axel Roebel, IRCAM Paris, France

International Scientific Committee

Patricia Alessandrini, Goldsmiths, University of London, UK
Jioanne Armitage, University of Leeds, UK
Suzanne Aspden, Faculty of Music, University of Oxford, UK
Jean-Julien Aucouturier, IRCAM, Paris, France
Per Bloland, Miami University, Ohio, USA
Jeffrey Boehm, Bath Spa University, UK
David Carabias Galindo, University of Segovia, Spain
Marko Ciciliani, University for Music and Performing Arts Vienna, Austria
Sally Jo Cunningham,University of Waikato, New Zealand
Ching-Hua Chuan, University of North Florida, U.S.A.
Darryl N. Davis, University of Hull, UK
Marlo De Lara, University of Leeds, UK
Elga Dorner, Central European University, Budapest, Hungary
Simon Emmerson, De Montfort University, Leicester, UK
Travis Garrison, University of Central Missouri, USA
Inés María Monreal Guerrero, University of Valladolid, Spain
Duncan Williams, University of Plymouth, UK
Andrew Hankinson, Bodleian Libraries, University of Oxford, UK
Joseph Hyde, Bath SPA University, UK
Wladyslaw Homenda, Warsaw University of Technology, Poland
Orestis Karamanlis, Bournemouth University, UK
Alexandros Kontogeorgakopoulos, Cardiff Metropolitan University, UK
Steven Jan, University of Huddersfield, UK
Tae Hong Park, New York University Steinhardt, USA
Rudolf Rabenstein, University Erlangen-Nuremberg, Erlangen, Germany
Silvia Rosani, Goldsmiths, University of London, UK
Robert Rowe, New York University, USA
Nikos Stavropoulos, Leeds Beckett University, UK
Jacob David Sudol, Florida International University, U.S.A.
Eva Zangerle, University of Innsbruck, Austria

Contents

Learning Tools, Leraning Technologies, Learning Practices

Culture and Music

Poster presentation

Computer Science

A mobile robot percussionist

Maxence Blond[1], Andrew Vardy[1], and Andrew Staniland[2]

[1] Department of Computer Science, Memorial University of Newfoundland, St John's, Canada
[2] School of Music, Memorial University of Newfoundland, St John's, Canada
blondmaxence@gmail.com, av@mun.ca, astaniland@mun.ca

Abstract. We present a robotic percussion player, intended as an accompaniment to human players which can extend the musical reach for both professional and amateur musicians. The purpose of this paper is to describe our prototype system which is able to repeat a rhythmic pattern provided by the user. In the future we intend to explore improvisation and interaction between multiple robotic percussionists. A set of robotic percussionists could collaborate by allocating components of a composition to different units. In this paper we introduce the concept of a mobile robot percussionist and show results from a preliminary experiment in which the robot replicates the input pattern of a human user. We analyze the time delays between the input and output patterns which show an error of less than 0.07s. Future steps like improvisation and multi-robot organization are also discussed.

Keywords. Mobile robot, Multi-robot systems, Robot musicianship

1 Introduction

Robotic musicianship has grown in recent years due to the attraction of technical researchers to the musical domain as well as the rich set of challenges that it presents [1]. Percussion plays a key role in any musical composition. It is often the percussionists who provide cues on tempo and dynamics to the other musicians in an ensemble. The dynamics of percussion instruments also emphasize and delineate the structure of a composition. Our goal is to explore the creation of a robotic percussionist which can fill this role when playing with a human musician. We consider three possible advantages to this approach. Firstly, a robotic percussionist could increase the range of musical expression of a composer or player. Secondly, it would provide the option of a cooperative percussion accompaniment for any musician and would be fully reprogrammable depending on the needs of the human player. Thirdly, we think that mobile robot percussionists might be a good therapeutic tool for people with various physical and mental health challenges. Working with a robotic percussionist might serve as a healing vector enabling an enjoyable and accessible interaction with another agent.

In this article, we will first introduce previous works related to robot musicianship as well as the concept of our project. Then, we will describe the hardware and software parts of our system, before describing the results of an experiment based on time delay analysis. We will finally conclude by giving new perspectives for our project.

A – Related research

Robotic musicians can be considered players which can replicate musical phrases, but also improvise. They can also be considered as instruments. The main difference lies in the range of performances that can be reached. Robotic musicians can explore super-human tempos and play new kinds of melodies (with velocity and timbre control for example) [2], allowing human players to enhance themselves. Global optimization techniques (e.g. genetic algorithms) can also be used to make robots part of the creative process of composition enabling new avenues for musical expression [3]. Robot musicians have also proved useful as a socialization tool [4].

Exploring music with a robot can also benefit other research fields. For example, designing and building a humanoid musician robot can help to understand human anatomy and muscle dynamics [5], [6], [7]. Making music with a robot can also help to develop better human-robot interaction techniques [8][9]. And last, trying to produce new melodies with algorithms can help researchers in the cognitive sciences to better understand how our brains work [10].

Many projects focus on using robots to mimic human capabilities. Some involve percussion, as our work does here. The Cog robot tries to copy human arm movements while hitting a drumhead with all of the muscles of the human arm recreated artificially [11]. Other robots aim to play the piano in a very human-like manner, such as the Wabot 2 [12], or the piano-playing hand of the University of Washington [5], which reproduces all the articulations of real human hand and arm. Shimon, from Georgia Tech's Center for Music Technology [13], can play marimba in a style similar to human players, but also has a third arm which gives it the ability to play faster and to create combinations of notes not achievable by a human. It also moves its head according to the tempo provided, which assures a strong interaction between it and the human player. Another project called Orchestrion, realised by Pat Metheny [2], consists of remotely actuated percussion instruments intended to create a huge automated orchestra.

Finally, robots can allow people to overcome physical challenges and express themselves musically. For example, the robotic drumming prosthesis from Georgia Tech allowed a drummer to play again after a significant amputation, but also achieve new musical competencies not previously available without this prosthetic device [14]. This robotic instrument has two sticks and can achieve very high hit frequencies. It can also read the EMG signals from the human player so that he remains in control.

Despite all the different kinds of robot musicians we mentioned above, one kind remains uncommon: mobile robots. To our knowledge the only use of mobile robots as robotic musicians has been the use of drones from the University of Pennsylvania, playing the James Bond theme song [15].

B – Our concept

Almost all previous attempts at robotic percussion were done with static robots [16]. That is why we decided that our main concern would be to explore the notion of mobile robot within the context of musicianship. We want to take advantage of the mobility of a robot which would enhance the range of musical expression. In particular, a mobile robot sitting on a drumhead could move to strike different parts of the drum, thus achieving different timbres and tonal qualities. Further, it would bring a visual aspect to the musical experience as the human player (and potentially an audience) would be able to appreciate the robot's movements as part of the performance.
For this paper our goal is to replicate a musical pattern produced by the human player, with control over the number of repetitions. In future steps, we would like to move on to improvisation (see section 4) and the use of a set of robots to allocate different components of a composition to different units, either by tone or instrument.

2 Description of the system

A – Hardware part

As mentioned above, our system is mobile. We use the Pololu Zumo 32U4, a differential-drive mobile robot. On each side of the robot there is one wheel driven by a DC motor and another passive wheel, with both wheels engaged within a rubber track. We have chosen this platform due to previous experience and availability, but also because it is an inexpensive and well-documented platform.
Concerning the generation of sound, we tried different approaches. We first designed a triple stick wheel fixed on a separate servomotor (see Fig. 1) which would allow the robot achieve a high frequency of hits. In our second revision we used a single stick attached to the servomotor (see Fig. 2). This single stick configuration better matches human percussionists and is more easily controllable, especially for producing different hits of different amplitudes (referred to below as hard and soft hits).

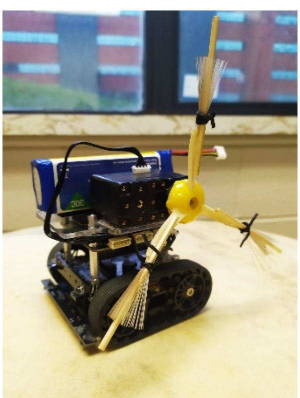

Fig. 1. Triple stick wheel robot.

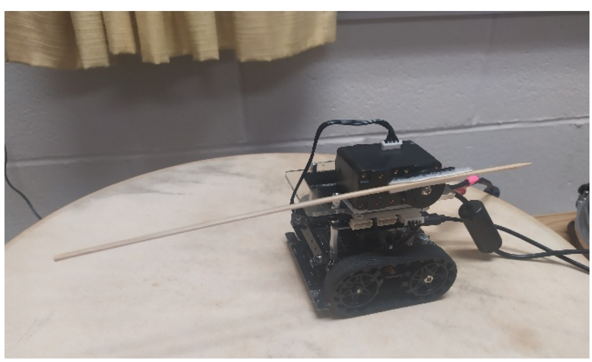

Fig. 2. Single stick robot.

The stick is actuated by HS1 smart servomotor from Lynxmotion. A Raspberry Pi 4 single-board computer is used to receive and send data via USB to our mobile robot. Different Python scripts are called depending on the action the user wants to do (record a track, repeat it with the robot, etc.).

For detecting the desired input pattern, the user plays this pattern on an electronic drum pad which is connected to a Roland TD-6 electronic percussion module. The TD-6 is connected to the audio input jack of the Raspberry Pi 4. All components of the system are shown in figure 3.

Fig. 3. All components of the system.

B – Software part

The block diagram presented in figure 4 outlines the operation of our software. Each blue block is a sub-process of our main program. The purple ones are physical devices and the other data are either inputs, outputs or intermediate files.
The first step of our program is to ask the user to give recording instructions and then produce an input pattern. This one can then either be displayed or processed to extract information about the recorded track (delays between each hit and type of hit).

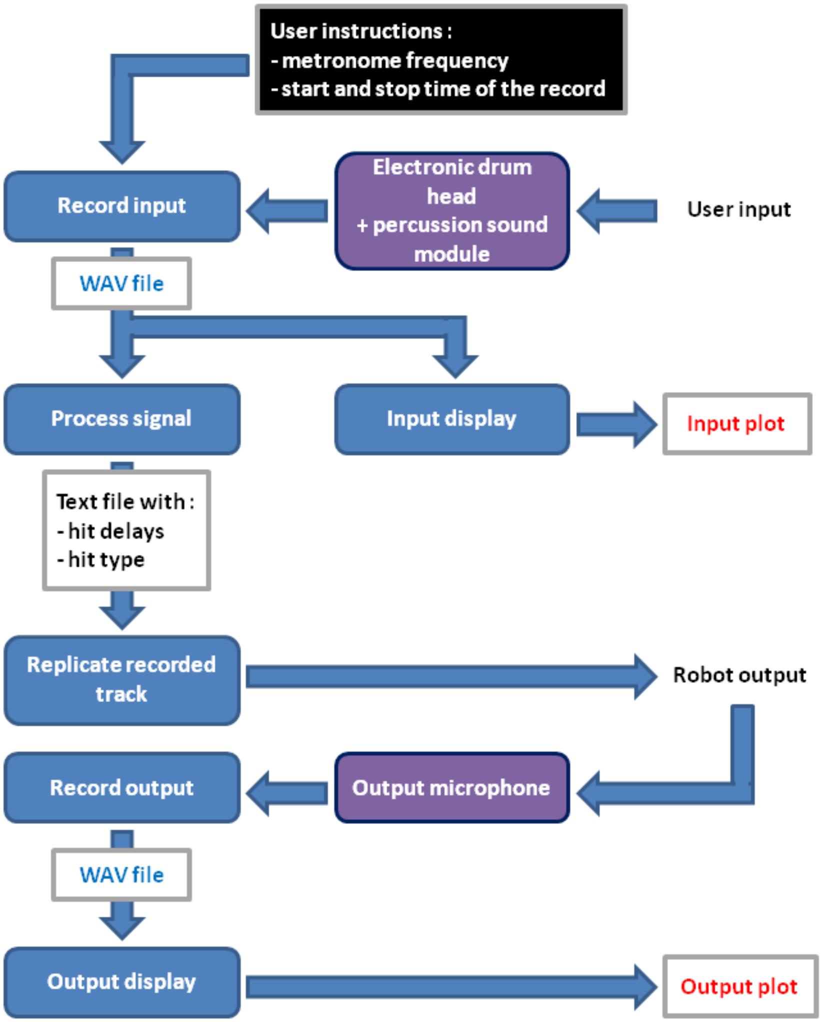

Fig. 4 - Block diagram of our software.

Our process consists in filtering the input signal in order to suppress noise. At first, we limit our study to the positive part of the signal, by taking its absolute value (see figure 5). Then, among different smoothing methods we selected the Savitzky-Golay filter. Two amplitude thresholds are defined to produce hard and soft hits. For signal values below the first threshold, every part of the filtered signal is considered as null. Between the first and the second thresholds, every part of the filtered signal is replaced by the value 0.5 (soft hits). And beyond the second threshold, we replace the signal value by 1 (hard hits) (see figure 6).

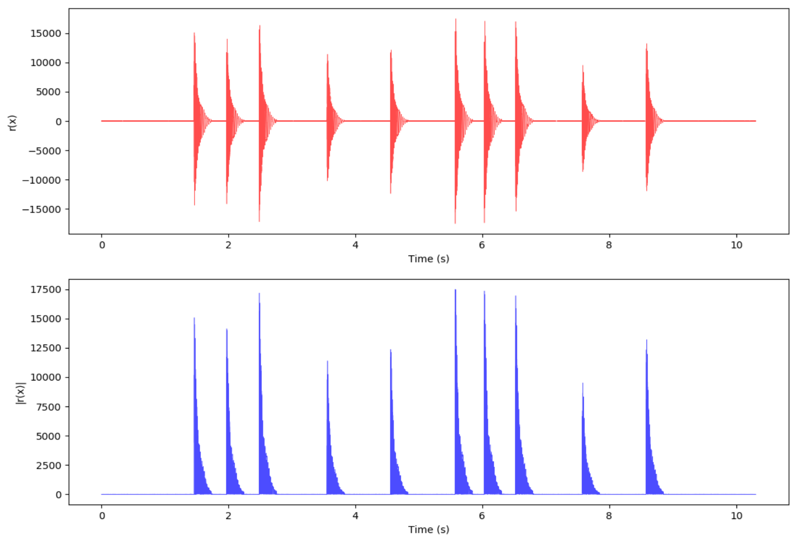

Fig. 5. At the top: input signal r(x) relatively to the time. At the bottom: absolute value of the input signal |r(x)| relatively to the time.

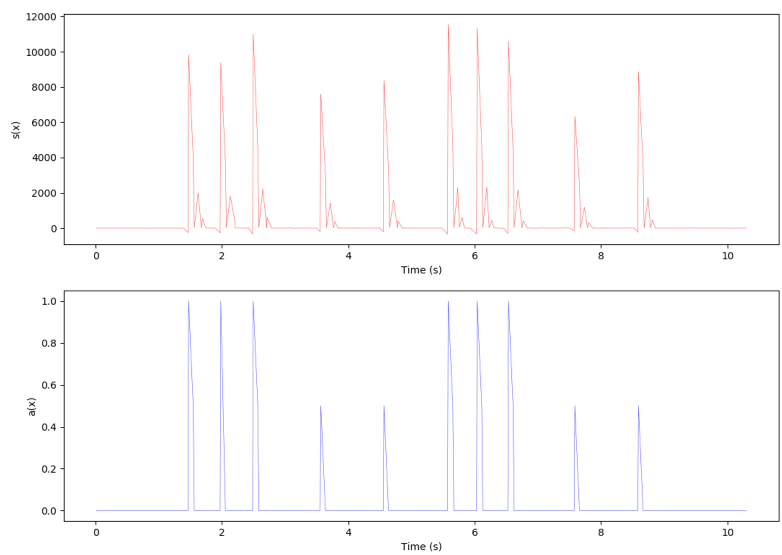

Fig. 6. At the top: smoothed signal s(x) relatively to the time. At the bottom: thresholded signal a(x) relatively to the time.

Finally, the delays between every hits of this new signal are saved in a table, and an amplitude (soft or hard) is associated to each hit.

In the next step, the robot is asked to replicate the recorded track from the data we saved previously. The physical signal is then recorded with a microphone to be compared with the user input.

3 First results

To test our method, we decided to play and record a short pattern of 4 hits (2 hard followed by 2 soft ones) during 8 seconds. Fig. 7 shows the amplitude of this input signal versus time, as well as the recorded output we asked our robot to replicate. The first peak of each signal have been aligned. For this, we choose to start the time line of the output signal at 0.83 seconds. This delay is due to the signal processing part of our software. For now, we focus on the error delays δ_i between the hits of the output signal and their counterparts of the input signal. We can see that the biggest error is 0.07 s. We can also compare between the amplitudes of the input and output signals and note that the discretization is correct.

A video of this experiment is available at this address: https://youtu.be/yUhxHezsZIc

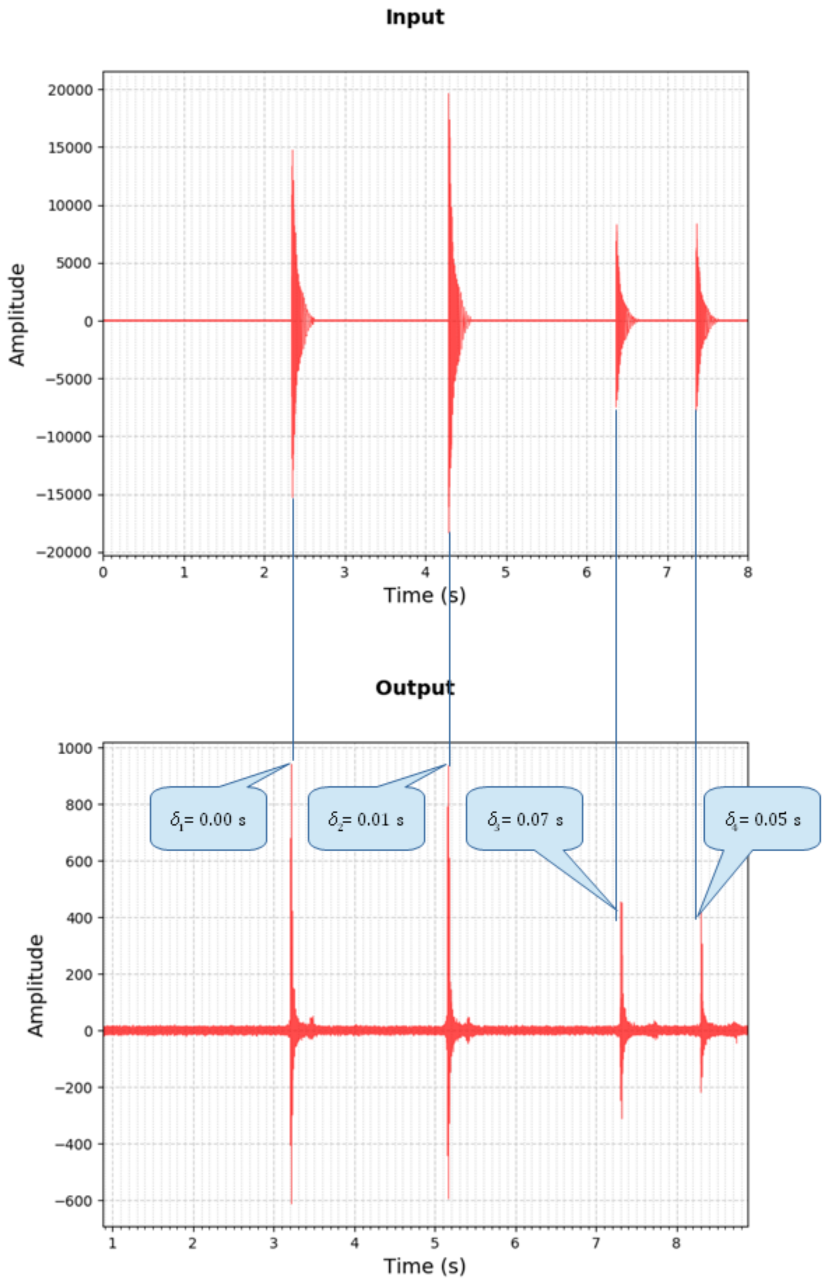

Fig. 7. At the top: amplitude of the input signal relatively to the time. At the bottom: amplitude of the output signal relatively to the time and delays δ_i between input and output peaks of amplitude.

4 Conclusion and next steps

We have shown that a mobile robot can be used as a robotic percussionist. Our preliminary experiment based on replication of user patterns provides encouragement for us to go further. We would like now to investigate improvisation. Once the robot perceives an input pattern, it may be commanded to craft a new pattern that provides emphasis or counterpoint to the input pattern. Approaches based on Hidden Markov Models such as those used for text completion may be suitable [17]. The other main direction of future work is to explore collaboration between multiple robotic percussionists. Different robots could allocate themselves different tasks. This allocation could be based on amplitude, instrument or based on some time-interleaved structure allowing the set of robots to replicate parts of a song that would be too fast for any one robot. We could also distribute the ability to improvise across the set of robots, so that some maintained principal aspects of the rhythm while others innovated. The possibilities are unlimited and could add interesting texture to human-robot ensembles.

References

[1] Bretan, M., & Weinberg, G. (2016). A survey of robotic musicianship. Commun. ACM, 59, 100-109.
[2] www.patmetheny.com/orchestrioninfo/
[3] Kapur, Ajay & Darling, Michael & Diakopoulos, Dimitri & Murphy, Jim & Hochenbaum, Jordan & Vallis, Owen & Bahn, Curtis. (2011). The Machine Orchestra: An Ensemble of Human Laptop Performers and Robotic Musical Instruments. Computer Music Journal. 35. 49-63. 10.1162/COMJ_a_00090.
[4] Bretan, M., & Weinberg, G. (2014). Chronicles of a Robotic Musical Companion. NIME.
[5] Zhang, Ada & Malhotra, Mark & Matsuoka, Yoky. (2011). Musical piano performance by the ACT Hand. IEEE International Conference on Robotics and Automation (ICRA). 3536 - 3541. 10.1109/ICRA.2011.5980342.
[6] Solis, J. & Chida, K. & Isoda, S. & Suefuji, K. & Arino, C. & Takanishi, Atsuo. (2005). The Anthropomorphic Flutist Robot WF-4R: from mechanical to perceptual improvements. 64 - 69. 10.1109/IROS.2005.1545259.
[7] Ferrand, Didier & Vergez, Christophe. (2008). Blowing machine for wind musical instrument : toward a real-time control of the blowing pressure. 1562 - 1567. 10.1109/MED.2008.4602060.
[8] Cicconet, Marcelo & Bretan, Mason & Weinberg, Gil. (2013). Human-Robot Percussion Ensemble: Anticipation on the Basis of Visual Cues. Robotics & Automation Magazine, IEEE. 20. 105-110. 10.1109/MRA.2013.2256323.
[9] vimeo.com/25929337
[10] Rowe, R. Machine Musicianship. The MIT Press, 2004.
[11] Williamson, Matthew. (2005). Robot arm control exploiting natural dynamics.
[12] Sugano, Shigeki ; Kato, Ichiro. / WABOT-2 : AUTONOMOUS ROBOT WITH DEXTEROUS FINGER-ARM - FINGER-ARM COORDINATION CONTROL IN KEYBOARD PERFORMANCE. Unknown Host Publication Title. New York, NY, USA : IEEE, 1987. pp. 90-97

[13] Weinberg, Gil & Driscoll, Scott. (2007). The Design of a Perceptual and Improvisational Robotic Marimba Player. Proceedings - IEEE International Workshop on Robot and Human Interactive Communication. 769 - 774. 10.1109/ROMAN.2007.4415189.
[14] Bretan, Mason & Edakkattil Gopinath, Deepak & Mullins, Philip & Weinberg, Gil. (2016). A Robotic Prosthesis for an Amputee Drummer.
[15] https://www.youtube.com/watch?v=_sUeGC-8dyk
[16] Weinberg, Gil & Driscoll, Scott & Parry, R.. (2005). Musical interactions with a perceptual robotic percussionist. 456 - 461. 10.1109/ROMAN.2005.1513821.
[17] R. Nikolaidis and G. Weinberg, "Playing with the masters: A model for improvisatory musical interaction between robots and humans," 19th International Symposium in Robot and Human Interactive Communication, Viareggio, 2010, pp. 712-717.

This book presents a collection of selected papers that present the current variety of all aspect of the research at a high level, in the fields of music, education and computer science. The book meets the growing demand of practitioners, researchers, scientists, educators and students for a comprehensive introduction to key topics in these fields. The volume focuses on easy-to-understand examples and a guide to additional literature.

Michele Della Ventura, editor

New Music Concepts, Inspired Education, Computer Science

Revised Selected Papers

ISBN: 978-88-944350-3-0

9 788894 435030

www.studiomusicatreviso.it