Editorial for Volume 10 Number 3: Can Machines Play Musical Instruments?

Jorge A. Ruiz-Vanoye [1], Ocotlán Díaz-Parra [1], Alejandro Fuentes-Penna [2],

Ricardo A. Barrera Cámara [3], Miguel A. Ruiz-Jaimes [4], Joaquín Pérez-Ortega[5]

[1] Universidad Politécnica de Pachuca, México.

[2] Centro Interdisciplinario de Investigación y Docencia en Educación Técnica, México.

[3] Universidad Autónoma del Carmen, México.

[4] Universidad Politécnica del Estado de Morelos, México.

[5] Centro Nacional de Investigación y Desarrollo tecnológico, México.

jorge@ruizvanoye.com

Abstract. The robots are designed to help with difficult tasks for the human being, currently carried out activities that were a main feature of the human how to perform surgeries, injections, run musical instruments among others. This paper aims to highlight the Musical Artificial Intelligent and the history of the Musicians Robots.

Keywords: Musicians Intelligent Robots; Musical Artificial Intelligence.

1. Introduction

The music serves as inspiration for everyday or extraordinary activities of the human being. So, someone can play a musical instrument is required some extraordinary motor skills and a high degree of musical intelligence that allows playing instruments and perform musical pieces.

We define in this article that there are different types of Artificial Intelligence of robots:

- Industrial Artificial Intelligence. It is the ability to execute the activities of the industry. For example, master, written or spoken the language (translation robot), reason way deductive, solving mathematical problems, graphical artistic abilities, management of vehicles and industrial machinery, sex robots, robots fight, household, military, underwater activities, and others.
- Artificial Intelligence on public health. It is the ability to perform activities related to the areas of health, for example, load a patient from a wheelchair to a bed, vaccinations, apply ointments in the human body, massage, clinical studies, among others.
- Collaborative Artificial Intelligence. It is the ability to work as a team to carry out an activity.
- Artificial Intelligence from the field of agriculture, livestock and fisheries. It is the ability to coordinate body for activities related to the field movements, as for example to feed animals, watering plants, harvest fruits, milk cows, among other aspects.
- Body Artificial Intelligence. It is the ability to coordinate the elements of the body to dance, act or do a sport.
- Musical Artificial Intelligence. It is the type of Artificial Intelligence or the ability of robots to produce, build, or play different musical instruments.

A Musician Robot is a programmed machine of Musical Artificial Intelligence by a computer to play musical instruments and creating new musical melodies by using a basis of musical knowledge used to predict new rhythms or musical melodies.

Kajitani [1] describes three steps to develop a musical robot: 1) case study to identify potential clients and applications that will have the musical robot. (2) define the musical instruments that will touch the robot. (3) develop the algorithm of the musical robot who will learn the song and make a presentation.

This paper primarily aims to highlight the Musicians Intelligent Robots. Our contributions can be summarized as surveying the most relevant aspects of the Musical Artificial Intelligent and the Musicians Robots. The remainder of this paper is organized as follows. Section 2 presents the history of the Musicians Robots; section 3 is the Musicians Intelligent Robots. Finally, conclusions and a direction for future works are given in section 5.

2. History of the Musicians Robots

Turing [2] was raised the question: "Can machines think?". Sci-fi author Isaac Asimov wrote the Three Laws of Robotics in 1942. Claude Shannon proposes the function for programming a computer to play chess in 1949. John McCarthy uses the phrase (artificial intelligence) in a proposal for a conference on Machine Learning in 1955. The logic Theorist is the first program written to mimic the human thought process in 1956. The industrial robot (Unimate) developed by George Devol its robot arm to create die castings from machines and welded components onto car chassis in 1961.

The Stanford Research Institute develops the first robots that are controlled by computers (Called Cart and Shakey) in 1970. The Stanford cart successfully navigates a room full of obstacles using sensors and software (autonomous robot) in 1979. Honda built walking humanoid robots in 1986. A medical robot (Arthrobot) developed by McEwen and Auchinlek in 1993. The World chess champion Gary Kasparov lost to the IBM supercomputer (Called Deep Blue) in 1997.

The web´s most influential piece of Artificial Intelligent Programming is launched (Google) in 1997. The first tournament that aims to have a robot football team one-day beating humans is held (RoboCup) in 1997. The Space Robot (Robonaut 2) developed by NASA / General Motors works with human-rated tools in Space (International Space Station) in 2010. The DeepQA supercomputer (IBM Watson) uses language analysis algorithms to beat two former Jeopardy champions in 2011.

Buitrago et al. [3] developed a robot with the aim of supporting fundamentals lab robotics; control is implemented with Matlab. The design of the robot considers the mechanical part, electrical circuits and software. The robot is also used to stimulate the students of early music.

There are several robots that perform various functions for humans: NEC`s PaPeRo Robot, RI-MAN, RIBA-II, Makr Shakr, JIBO, NAO, PEPPER, Alphadog, Festo smartbird, Twendy-One, Da Vinci Surgical system, NanoBot, Hummingbird, HAL robot suit, Curiosity rover, Titan, Gemionoid F., Honda ASIMO (Advanced Step in Innovative MObility).

3. Musicians Intelligent Robots

But, can a machine successfully imitate the way humans play Musical Instruments? The answer is Yes. The robot can mimic the execution of musical instruments like the guitar, the piano, the drums, bass, among others.

Wasubot is a robot based on the Wabot-2, which plays musical instruments of the keyboard, with hands and legs bass and pedal. It is capable of reading a score and talk with people using their mouth and ears [4].

Percussion robots will be present in three categories: membranophones, idiophones and extensions. The MIT researchers used oscillators on the wrist or elbow of his robot called Cog to hit a drum with a stick. The stick is rotated by what you can do free, swinging its motion damped by two pads of felt or rubber. Using a piece of tape for free movement of the lever, the number of bounces of the drum stick could be controlled [5]. Velez developed a drummer robot in 2009 [6].

Mitsuo Kawato and his team have developed a humanoid robot that plays the drum with a hydraulic system for smooth movement which could imitate human playing drums. Other robots that play the percussions were Amophic Robot, Thelxiapeia, LynxArm, DrmBot, autómata, Trimpin, among others.

Cela Rosero [7] designed and built a robotic system capable of playing four rhythms of music in a battery; every rhythm contains two Finials, they can also be programmed with musical staff two rhythms and each with two different shots. Hoang, Park and Bien [8] developed a robot that plays the piano, which can be used as an entertainment robot with older people. The robot is composed of a personal computer, an arm and a hand. A study of the shares underlying the generation of sound in the acoustic piano, which is represented through neural networks was developed to establish a relationship of the piano sound and the movement of the keys.

Carey [9] describes the German company Tronical and guitarist and EE Chris Adams as the inventive forces of the automation as a guitar retrofit kit back in 2006. The authors proposed an Electromechanics join with embedded processing to produce a system to improve the tuning and retuning. In this scenario, Gibson [10] introduced the first robot guitar. This Robot Guitar grafts a Power tune automatic tuning system from Germany's Tronical GmbH onto a version of Gibson's Les Paul electric. Unlike a guitar player, the Power tune system adjusts the tension of six strings simultaneously to bring the guitar in tune. Its founder, electrical engineer Neil Skinn worked on a patented self-tuning system since 1983.

Petersen, Solis, and Takanishi [11] develop an anthropomorphic flautist robot as a benchmark for the better understanding of the interaction between musicians and musical performance robots from a musical point of view. Describe a hands-free gesture-based control interface designed to modify musical parameters in real-time and a set of virtual controllers that a composer can manipulate through gestures of with a musical instrument. They applied vision processing to obtain MIDI messages for the flute robot.

Persad et al. [12] development of a bio-mimicking robot to play hand drums. Welty [13] discussed the Music Parts Plus, as a supplier of the high-quality musical to adopt robot-powered fulfilment services to increase order accuracy and on-time delivery.

Nikolaidis & Weinberg [14] use the computational processing power and the robotic embodiment of the model and explore creativity and improvisation in the interaction of the musical group. Related research has attempted to use musical algorithms to model human creativity using the sound generated by the computer as output through synthesis and sampling techniques.

Hoffman and Weinberg [15] and Weinberg and Driscoll [16] presented a robot that plays the marimba while listening to a human musician and based on them improvise and adapts its musical choreography and interacts with pianist through gestures. The experiment consists of introductory playback 7 notes on a grand piano played by seven human pianists. Time and timing are detected and responds to a pattern rate of the three chords of the marimba. Repeating the sequence of call and response 90 times without being specified for playing time and playing a variety of rhythms.

Li [17] proposes a piano anthropomorphic robot control with concurrent control of both hands and ten fingers, through the combination one host controller and or local driver (FPGA). The local controller manages and controls the actuators of the hands and fingers; playback music codes are encoded and integrated into the host controller to instruct the robot

3

controller FPGA or module. Decoded codes have established the positions of the hands, the angles of opening the fingers of both hands and the Pulsations of keys of the hands and fingers.

Jen-Chang et al. [18] designed a robot that plays the piano, which is based on a mechanical and electrical, control for them establishes a correlation of music theory, rhythm and piano keys. The hand of the robot uses five fingers to play the piano, which must be able to perform actions such as the rotation of fingers, pressure and lifting of fingers as a requirement to do the rhythm.

In 2013, a team of Japanese roboticists created a music-performing system named Z-Machines. This proposal explores the compositional possibilities of a guitarist with 78 fingers and a drummer with 22 arms. This robotic group performed the song 'Sad Robots Goes Funny' [19]. McKenzie [20] presented the show of Z-machines - the robot band with human sound. There is synthesized quality music. This band has a humanoid guitarist with 78 fingers, the rocking robot bangs its impressive mane of multi-coloured cables in time to the music, albeit a little jerkily, the drummer with 22 arms, and a keyboardist with green lasers hitting each key with pinpoint accuracy.

Wenz [21] mentioned the Ben Reardon's inspiration was World Expo 1988: a robot playing a classical guitar. Reardon's self-playing guitar can perform other tasks thanks to its Arduino and Raspberry Pi units.

Murphy et al. [22] analyzed the history of robotic guitars and bass guitars from the design, construction, and evaluation of two robotic chordophones. The robots were evaluated to test their precision, repeatability, and speed. The authors proposed the beginning of robotic guitar systems in the 1970's. They mention that in 1971 the Ragtime West Company built mechatronically augmented guitars, 1990 - 2000 Sound artist Trimpin created numerous iterations of Mechatronic guitars. Early 2000 began to build an ensemble of string-based instruments, 2011 Logos Foundation (directed by musical robotics pioneer Godfried-Willem Raes), ensemble a guitar like Synchro cord monochord, Early 2000: LEMUR founder Singer ensemble the GuitarBot [23], 2005: Nicolas Anatol Baginsky's Aglaopheme guitar from his Three Sirens ensemble [5].

Riley [24] mentioned the interaction between disciplines like music and technology could spark remarkably ideas when a new program promises to help your performance as a guitar player. Allen Van Wert developed an artificial intelligence program "Ultimate Picking Program" to hone in on the user's picking skills.

Teotronico is a robot with 53 fingers who plays the piano in mode pianist or reproduces midi files, presents a realistic design moving mouth, pupils, eyelids and eyebrows [25]. Haridy [26] mentioned the humans have a fascination with music-playing by robots. The project was named Automatica where some industrial robots form a giant mechanical orchestra. The results of this project were Cymatics and incredible video. There are several musicians robots that perform musical instruments: Teo Tronico, Arpeggio is a Piano Playing robot, Rohmus, Don Cuco el Guapo, WATCH and others.

But they cannot create or produce new musical genres or songs, popular or otherwise, without training or only with the basic artificial intelligence. To date have made attempts to give training a number-based set of songs and music, to subsequently request types create a new melody.

4. Conclusions

The area of Robotics in support of human activities is growing significantly. In the area of music is the same creators of robots and music lover looking for support to musicians and composers to facilitate work and save costs. However, come the day that musical robots could replace the musical activities that human beings made?

Acknowledgements

References

1. Kajitani, M. (1989), Development of Musician Robots, *Journal of Robotics and Mechatronics*. 1, 254- 255.
2. Turing AM (1950) Computing machinery and intelligence. Mind 59: 433–460.AM Turing1950 Computing machinery and intelligence. Mind59433460.
3. Buitrago Suescún, Y.A., Prieto Ramírez, J.C., and Peña Cortés, C.A. (2012). Robot educativo de bajo costo que interpreta melodías en piano. *Facultad de Ingeniería*, 21(33), 73-82.
4. Kato, I., Ohteru, S., Shirai, K., Matsushima, T., Narita, S., Sugano, S., Fujisawa, E. (1987). The robot musician 'wabot-2' (waseda robot-2). Robotics, 3(2), 143-155. doi:10.1016/0167-8493(87)90002-7
5. Kapur, A. (2005). A History of Robotic Musical Instruments. Proceedings of the International Computer Music Conference.
6. Velez, C. A., Valencia, D., Posireddy, S., Tansel, I., and Tosunoglu, S. Development of a Drummer Robot. Florida Conference on Recent Advances in Robotics, FCRAR 2009 .
7. Cela Rosero, A.F. (2007). Diseño y construcción de un sistema robótico para tocar una batería de música (Bachelor's thesis, QUITO/EPN/2008).
8. Hoang, T.V., Park, K.-H., and Bien, Z. (2008). Development of a Piano-Playing Robot with Motion-Sound Mapping. *International Journal of Assistive Robotics and Systems*, 9(3), 40-51.
9. Carey, D. (2008). Robot Guitar embeds autotuning (Under The Hood).Electronic Engineering Times. April 28, 2008.
10. Gibson (2018). Gibson's Robot Guitar Tunes Itself. *Journal of American Music Teacher*. 57(4)
11. Petersen, K., Solis, J., and Takanishi, A. (2008, August). Toward enabling a natural interaction between human musicians and musical performance robots: Implementation of a real-time gestural interface. In The 17th IEEE International Symposium on Robot and Human Interactive Communication, 2008. RO-MAN 2008. (pp. 340-345). IEEE.
12. Persad, P., Bisnath, J., and Ramkissoon, N. (2008). Developing a Tabla Playing Robot. *Journal of ITC Sangeet Research Academy*, 22, 133-22.
13. Welty, B. (2009). Picking ti win. *Material Handling Management*. 64 (11), 21-22.
14. Nikolaidis, R., & Weinberg, G. (2010, September). Playing with the masters: A model for improvisatory musical interaction between robots and humans. In RO-MAN, 2010 IEEE (pp. 712-717). IEEE.
15. Hoffman, G., and Weinberg, G. (2011). Interactive improvisation with a robotic marimba player. *Autonomous Robots*, 31(2-3), 133-153. doi: 10.1007/s10514-011-9237-0
16. Weinberg, G. (2007). Robotic musicianship-musical interactions between humans and machines. In Human Robot Interaction. InTech.
17. Li, Y. F. (2013). FPGA-Based Distributed Control Module Design for Music Playing Robot - Applied to the Anthropomorphic Piano Robot Control. *Journal of the Chinese Society of Mechanical Engineers*, 34(2), 143-150.
18. Jen-Chang, L., Hsin-Cheng, L., Kuo-Cheng, H., & Shu-Wei, L. (2014). Design of Piano-playing Robotic Hand. *International Journal of Robotics and Automation* (IJRA), 3(2), 118-130.
19. Warp (2014). Squarepusher X Z-Machines EP Music for Robots. Extract from: http://warp.net/news/squarepusher-music-for-robots/ Last visit: 06th march 2018.
20. McKenzie, S. (2014). Meet the robot guitarist with 78 fingers and coolest cable hair you've ever seen. CNN. Extract from: http://edition.cnn.com/2014/03/14/tech/meet-the-robot-guitarist/index.html. Last visit: 06th march 2018.
21. Wenz, J. (2015). Watch This DIY Robot Guitar Play Itself. Popular Mechanics. Extract from: https://www.popularmechanics.com/technology/a15060/self-playing-guitar/. Last visit: 06th march 2018
22. Murphy, J., McVay, J., Mathews, P., Carnegie, D. A., and Kapur, A. (2015). Expressive Robotic Guitars: Developments in Musical Robotics for Chordophones. *Computer Music Journal*, 39(1), 59-73. doi:10.1162/COMJ.a.00285
23. Singer, E., Fedderson, J. and Bianciardi, D. (2003). LEMUR Guitarbot: MIDI Robotic String Instrument. Proceedings of the International Conference on New Interfaces for Musical Expression, pp. 188–191
24. Riley, K. (2016). Artificial Intelligence Can Now Teach You to Play the Guitar. Extract from: https://futurism.com/artificial-intelligence-can-now-teach-play-guitar/. Last visit: 06th march 2018.
25. Spectrum, I. (2017). Music-making piano droid [The Big Picture]. IEEE Spectrum, 54(8), 16-17. doi: 10.1109/mspec.2017.8000279
26. Haridy, R. (2017). Automatica – Robots that play drums, guitar and turntables and destroy a warehouse. Extract from: https://newatlas.com/nigel-stanford-automatica-music-robots/51258/. Last visit: 06th march 2018.
27. Braiker, B. (2008). Putting a Robot in Ypur Guitar. Newsweek (International Atlantic edition). 151 (2).
28. Cheng, L., Han, L. X., Zeng, X. Q., Bian, Y. T., & Yan, H. (2015). Adaptive Cockroach Colony Optimization for Rod-Like Robot Navigation. [Article]. Journal of Bionic Engineering, 12(2), 324-337. doi: 10.1016/s1672-6529(14)60125-6
29. Focke, A. (2011). Trimpin: Contraptions for Art and Sound. Seattle, Washington: Marquand

30. Leitman, S. (2011). Trimpin: An Interview. Computer Music Journal 35(4):12-27.
31. Novianto, R., & Williams, M. A. (2011). Innate and Learned Emotion Network. In *BICA* (pp. 263-268).
32. Transperformance (2017). State of the Art Technology. Axcent Tunning System. Extract from http://axcenttuning.com/ Last visit: 06th march 2018.
33. Uncrate (2018). Self-Shredding guitar. Extract from: https://uncrate.com/video/self-shredding-guitar/. Last visit: 06th march 2018.
34. Weinberg, G., & Driscoll, S. (2007, August). The design of a perceptual and improvisational robotic marimba player. In *Robot and Human interactive Communication, 2007. RO-MAN 2007. The 16th IEEE International Symposium on* (pp. 769-774). IEEE.