Introducing the MechDrum™

By Annie Stevens

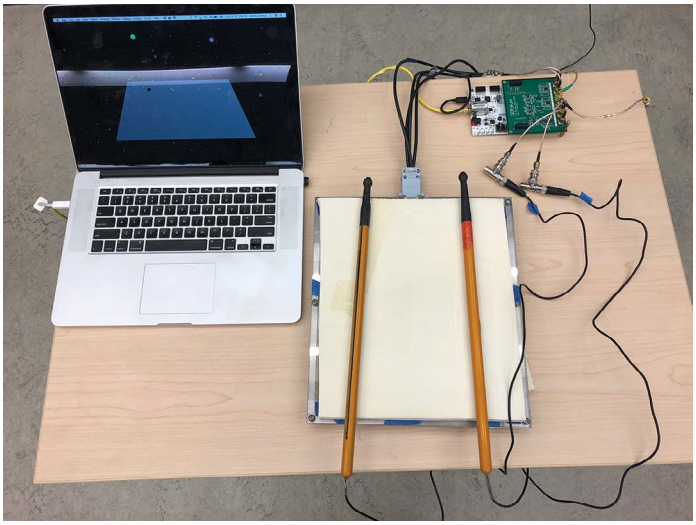
The rapid momentum of research in robotics is quickly changing the face of industries everywhere, including the music industry. With human-like robots entering the percussion arena, it's both daunting and exciting to imagine what our future holds. While I was attending the 2018 New Interfaces for Musical Expression (NIME) conference at Virginia Tech, an international conference that brings together some of the most prolific musical instrument engineers, performers, and composers, I was introduced to Robert Van Rooyen and his MechDrum™, and the percussionist behind the performance of it, Andrew Schloss.[1]

Tracing Schloss's background is pivotal in understanding his significant influence on the usage of robotics in percussion performance. Andrew Schloss is a pioneer in the development and performance of new musical instruments—most notably, his virtuosic work as a performer, developer, and composer for the radiodrum. He is an active performer and researcher all over the world, having received a Fulbright award to do research at IRCAM (Institute for Research and Coordination in Acoustics/Music) in the 1980s, as well as being awarded numerous competitive research grants from government agencies in the United States and Canada. Currently, he is Professor of Electronic Music and Ethnomusicology at the University of Victoria in British Columbia, Canada, with previous faculty positions including Brown University, the University of California at San Diego, and the Banff Centre for the Arts.

As a percussionist, Schloss began his studies at a young age with Alexander Lepak, founder of the percussion department at the Hartt School and a former principal timpanist of the Hartford Symphony. After Schloss earned his undergraduate degree in music and mathematics from Bennington College, where he studied under Henry Brant (spatial music specialist) and Joel Chadabe (early electronic music giant), he attended the University of Washington, where he studied ethnomusicology. During this time, he gained great interest in the traditional music of Cuba, a style that would continually and very significantly inform his compositions and free improvisations over the years to come. He first travelled to Cuba in 1980, a venture that has been followed by at least 20 return trips! Having dedicated a notable part of his musical career immersed in this culture, his computer music improvisations often revolve around densely complex Cuban rhythms. Widely respected by many Cuban musicians for his computer music, Schloss has performed with renowned musicians such as Jesús "Chucho" Valdés, who has expressed great interest in what Schloss is doing with technology.

Schloss first became drawn to the idea of creating music with computers when he serendipitously came across the very first issue of the *Computer Music Journal*. At the time, he was busy as a freelance musician in New York City, performing in niche experimental Broadway productions. Becoming immersed in the research presented in the journal's articles, which were entirely written by researchers from CCRMA (the Center for Computer Research in Music and Acoustics at Stanford University), he found the idea of creating music on computers enticing. Shortly thereafter, he was accepted and enrolled at CCRMA (pronounced *karma*), where he studied from 1978 to 1985.

Immediately thereafter, his first university teaching position was at Brown University. Being in such proximity to Bell Labs in New Jersey, where cutting-edge research in a multitude of technological areas was occurring, he visited the labs and met with Max Mathews, often referred to as the "father of computer music." Among his many contributions to computer music, Mathews developed a musical interface known as the *Radio Baton*,[2] which would communicate with a computer to produce music. This was the precursor for another similar interface he helped design alongside Bob Boie, the Radio Drum. When Schloss first visited the labs in the mid-1980s, he expressed interest in performing with the Radio Drum. Being a percussionist, Schloss walked away with not only a new instrument, but an entirely new direction with which to take his performance of improvisation and contemporary music. He has since gained recognition for his virtuosic performances throughout the world using what he now refers to as simply the *radiodrum*.



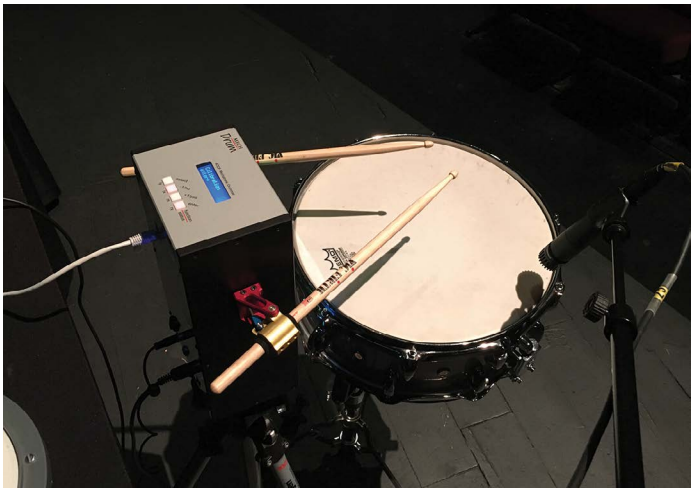
The radiodrum

The radiodrum is an interface that consists of a receiving board (antenna) and two drumsticks with metal balls (instead of tips) that serve as transmitters. Each stick transmits at a slightly different frequency, 105kHz and 115kHz, allowing the computer to distinguish the sticks. Schloss's updated version of the original Radio Drum utilizes SDR (software defined radio) technology. Because of this change, he can more easily change the frequency of the sticks if there happens to be electromagnetic interference in any given space; otherwise, interference could render the drum unplayable in certain situations. The radiodrum is played by striking the sticks on the receiving antenna board, or by simply moving them in the space above the antenna. This board is covered in soft foam and has four antennas embedded within that track the drumsticks in 3-dimensional space. The attached computer acts as an electronic gesture sensor, so in distinguishing the right and left stick across the X, Y, and Z axes, a more realistic human-like interpretation is accomplished.

When Schloss was first handed the radiodrum in 1986, he was tasked with creating software for the instrument. The purpose of this software would be first to receive the data being transmitted from the radiodrum (the signals that are received by the antenna), and then to interpret the data and properly convert it into x,y,z position. The final step, which can be arbitrarily complicated, is turning this position data into meaningful synthesized or sampled sounds. This proved to be extremely difficult until he met Miller Puckette at ICRAM in 1987. There, Puckette—in no more than two hours—wrote new code that was compatible with his own newly developed Max/MSP software. Schloss now had an entire programming language at his disposal, and he could now play percussion instruments in live performances via computer. Since Max/MSP has become standard software in the computer music genre, Schloss' radiodrum software has remained current throughout the years.

Early on in his performances, Schloss used the radiodrum to control synthe-

The MechDrum™



The MechDrum™

sized and sampled sounds via the computer. Also, he commissioned David A. Jaffe to compose for the radiodrum, which led to some of the earliest compositions for this instrument, including "Wildlife" (1991),[3] for electric violin, radiodrum, and two computers. However, Schloss found equal interest in using the radiodrum as an interface to control acoustic instruments. After some research dealing with a Yamaha Disklavier[4] grand piano, in 1996 Jaffe composed the large ensemble work "The Seven Wonders of the Ancient World," a piano concerto performed by a percussionist. In this piece, the radiodrum controls a Yamaha Disklavier by way of a computer (dubbed the "Drum-Piano"). In doing so, the audience watches the motions of the percussionist but hears the result of each gesture on the piano. Jaffe writes that this "Drum-Piano sounds unlike any other piano music because it is based on a different set of constraints. The Drum-Piano shares many characteristics of an acoustic drum, such as its rapid gestural vocabulary, and many characteristics of a conventionally-played piano, such as its decay and timbre. Yet, the composer is freed from the polyphonic limitations of conventional percussion instruments, as well as from the limitations of the geometry of the pianist's hand."[5] This fascinating approach was captured in an interview with Soledad O'Brien on MSNBC in 1996.[6]

After finding inspiration from this collaboration with Jaffe, Schloss began working with researchers in robotics; he desired to control acoustic percussion instruments by way of the radiodrum. There were several motivations for this research. First, spatial music could be explored with acoustic instruments. In this way, instruments can be placed all around the concert hall, and with a single performer on stage playing the radiodrum, it is as if the performer has 30-foot arms

reaching into the upper echelons of a hall. Second, Schloss hopes that machines might become members of the percussion ensemble, allowing performers to respond to the physical nature, as well as limitations of robotics. In some ways, this is not a far stretch from George Antheil's 1923 composition that employed airplane engines in "Ballet Mécanique." Finally, acoustic sound output is a desirable feature, especially because the source generating the sound is visible to the audience.

This last point is illuminated extensively through Schloss' collaboration with Seattle-based sound sculpture artist and composer Trimpin. Having had works appear in galleries, museums, and festivals throughout the world, Trimpin's installations feature elaborate sculptures of traditional and found instruments that are performed by robotic actuators through a MIDI connection. Past installations have included a 60-foot stack of guitars at the EMP (Experience Music Project) in Seattle and 120 Dutch wooden shoes suspended from the ceiling. For Trimpin's sound sculptures, the original performance material was entirely pre-programmed within MIDI boxes, so no live performers were involved in his exhibits. However, the idea of being able to plug into Trimpin's sculptures was intriguing for Schloss, especially since he was looking for more opportunities to perform acoustic instruments with the radiodrum, and these instruments were already rigged with actuators. Schloss's ongoing collaborations with Trimpin began in 2003 with the piece "Maravillas," co-composed by David Jaffe for nine computer-controlled toy pianos.

Throughout his many years of performing instruments with robotics, especially Trimpin's installations, Schloss always found the biggest problem to be the latency of the actuators, devices (typically electrical) that convert energy into physical motion. This need demanded research to create better actuators, to allow Schloss' movement on the radiodrum—such as striking—to be in perfect sync with the striking of the percussion instruments by a robotic interface. In 2017, a successful improvement was patented by Robert Van Rooyen, a computer science Ph.D. student studying with Schloss and George Tzanetakis at the University of Victoria. This new interface, which may forever change the percussive landscape, is known as the MechDrum™.[7]

At this point, I know there must be an imminent question on readers' minds: "But why do we need computers to perform percussion instruments?" Schloss explains that he uses this fundamental question to generate musical ideas when he is composing and performing. "To have in the back of your mind, can a human do this? At first, I thought that it was bad, that it was a non-musical parameter; then I realized this was great because, artistically, you are looking for some sort of constraint to work within and find new worlds, and I realized this is exactly what I should be doing. I should be searching that space that is unplayable by humans because that's how I'm going to find new sounds. So that's what I do, I always do things that a human can't do. At first it was to avoid being criticized, and then it was to find those sounds, and became a creative impetus."

Robert Van Rooyen demonstrates the MechDrum™ at the 2018 Guthman Competition at Georgia Tech

When I first saw a demo of the MechDrum™ at NIME, I was awestruck by Van Rooyen's compact robotic device that very accurately captured human motion in its performance on a concert snare drum. The MechDrum is *fast*, clocking in at 68 alternating strokes per second! (To compare, the record for a human performing singles strokes is 20 strokes per second.) When the robot wasn't playing incredibly fast, what struck me even more was the delicate handling of the rebounded strokes, especially at the softer dynamics; it really does capture a human-like motion. Picture a drummer softly yet intricately comping behind a soloist; this was the improvisational sound and feel I witnessed in the demonstration.

According to Van Rooyen, "The MechDrum™ uses authentic striking implements, four degrees of freedom, and innovative motion-control algorithms to render performances that closely match its human counterparts in terms of timing, dynamics, and timbre. It can be used with any percussion instrument and is capable of self-calibration with respect to the instrument."[8] A performer can use any choice of implements including sticks, brushes, and mallets with different shaft diameters. Van Rooyen further elaborates that "the four degrees of freedom refers to a mechanical engineering term that specifies four unique planes of motion. In this case, the four planes are the X and Y axis of the left and right striking implements from the instrument's perspective. This approach allows the MechDrum™ to set the striking implement tip of each side to any arbitrary location within an area that is above and perpendicular to the drum surface after system calibration. The areas can overlap, which enables rimshots and perhaps other interesting articulations."[9]

To accurately replicate a human-like performance, research included visual and audio sampling of snare drum rudiments played by percussionists. These data then informed the calibration of the MechDrum™'s features, including accurate timing, velocity (dynamics), and position on the head (timbre). Accordingly, the resulting motion control algorithms render a life-like performance. However, these algorithms would mean nothing without having actuators that can interpret this data into convincing human-like motions.

While many percussion robots exist, most of these use solenoid actuators and DC motor actuators. Solenoids are electro-magnetic actuators that take an electrical current and then move a piston or rotate a small arm. DC motor actuators are the kind of motors you would find in an electric drill, and the speed of the motor can change according to a method called pulse-width modulation (PWM).[10] Contrary to these, Van Rooyen's MechDrum™ is fundamentally different because of the industrial strength voice coil actuators (VCAs), which among many attributes provide high acceleration and accurate positioning, rendering highly accurate and expressive percussion performances.[11] In addition to using the MechDrum™ to create a wealth of new compositions for live/playback performances, Van Rooyen notes that the MechDrum™ would be useful for musicians with disabilities: "a wide variety of MIDI controllers such as keyboards, buttons, sliders, air-pressure sensors, gesture sensors, and blink detection can be mapped to compelling virtuoso class renderings. This adaptability makes a real percussion instrument accessible to people that may otherwise not be able to participate in a band or solo."[12]

Finally, what does robotic drumming mean for the future of percussion performance? This author acknowledges that it may be interesting to incorporate robotics into a percussion performance, but that the robot should not be a gimmick that negatively interferes with human performers. There should be some form of human interaction between the robot and the audience that contributes to the overall performance—whether controlling the robot through an interface like the radiodrum or playing alongside the robot in an ensemble-like setting. Readers will certainly find Schloss' conclusions in his research reassuring—that there must be a cause and effect presented to the audience in order for them to make sense of any kind of virtuosic performance. Simply hearing the MechDrum™ perform at 68 beats per second would not impress anyone; listen to any EDM track to hear that kind of speed. However, witnessing this feat during a live performance on an actual snare drum, controlled by actual human gesture, is pretty incredible. According to Schloss, "If there's no cause and effect there can't be

virtuosity. You have to see someone doing something, making something happen. It may be a juggler juggling steak knives, or it may be a guitarist, or singer… if there is no cause and effect, then there's no reason for virtuosity to exist."[13]

In witnessing Schloss' performance at NIME and through our conversations, it is clear that his inspiration for performing the MechDrum™ by way of the radiodrum is not only to showcase the virtuosity of the robot, but also to explore the sonic area beyond what a human is capable of achieving. This robot would certainly interpret the nearly impossible polyrhythmic sections in John Luther Adams' "Inuksuit" with exquisite results! There remains much research to be accomplished on what is possible in a performance or educational setting, in addition to what a live audience is willing to accept before the boundary is pushed too far. As robots become more cost efficient and accessible to the general public, it will certainly be interesting to see how they prove to be useful in our musical world, especially in classrooms, lessons, and ensemble performances.

A performance by Andrew Schloss at NIME 2018

ENDNOTES

1. Andrew Schloss' performance at NIME 2018: https://vimeo.com/283562521
2. Mathews' demonstration of the Radio Baton: https://www.youtube.com/watch?v=3ZOzUVD4oLg
3. https://www.youtube.com/watch?time_continue=69&v=GyICfj_RJvc
4. While the Yamaha Disklavier plays by itself like a player piano, it is different in that it can receive commands from a computer, which would indicate when it should play or release piano keys and pedals.
5. Jaffe, David A. *The Seven Wonders of the Ancient World*, viewed 1 September 2018, https://www.davidajaffe.com/music/the-seven-wonders-of-the-ancient-world
6. https://www.youtube.com/watch?v=mTgJFxZXZJw&feature=youtu.be
7. https://www.youtube.com/watch?time_continue=56&v=Xw0UCdOIMk0
8. Van Rooyen, R. *Mech Drum: A New Approach to Percussion*, viewed 1 September 2018, www.mechdrum.wordpress.com
9. Van Rooyen, Robert. "Re:Greetings! Questions for my article." Email essage to Annie Stevens. 14 August 2018.
10. Schloss, Andrew. "Re: Questions for the article." Email essage to Annie Stevens. 21 August 2018.
11. Van Rooyen, R. "Voice Coil Actuators for Percussion Robotics." Paper presented to New Interfaces for Musical Expression conference, 2017
12. Van Rooyen, R. *Mech Drum: A New Approach to Percussion*, viewed 1 September 2018, www.mechdrum.wordpress.com
13. Nevile, B. *An Interview with Andrew Schloss*, Cycling 74, viewed 1 August 2018, https://cycling74.com/articles/an-interview-with-andrew-schloss

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