Time to Compile: An Interactive Art Installation

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Abstract—Making sense of technology is a task for creative movers. Moreover, exchange between disciplines tends to enrich each. This paper details the in progress process of a choreographer visiting a robotics lab for extended time periods over the course of years. In particular, an interactive installation has been designed that gives audience members (participants) access to this collaboration. It is one that requires a melding of vocabularies, value systems, and skills. It is also one that unearths sense-making about humanity’s relationship with technology. The paper will review both the artistic goals and the technical implementation of the installation as well as provide discussion about the process the team went through to arrive at the in progress artistic piece: Time to Compile.

I. INTRODUCTION

Why would a robotics lab fund a choreographer’s trip from New York to Illinois? Why would a choreographer come and huddle in the cornfields for four weeks? Both are trying to keep pace with technology. How we catch up, it seems, is twofold. First, classification for each new tool, e.g., this one is a computer, this one is a robot, this one is a hammer, seems necessary. However, metrics like humanness, “complexity”, “ability to move in space”, and “frequency of necessary interactions” tend to blur the line between such distinctions. We also catch up just through experiencing which occurs through moving with technology. For example, we type on a new keyboard, testing the springiness of each key by moving our fingers across the surface. Or perhaps its a new fabric, washable cashmere, that we slide our hand along to come to some understanding of it. With robots, it can be no different.

Roboticists have worked with artists for many years. Goldberg (a roboticist) has asked questions about our relationship with technology for decades, including his work with the first teleoperated garden [6], ballet dancers and geologists [2], in active museum exhibits [4], and he notes the serendipity that occurs when these disciplines cross-pollenate [8]. Cunningham (a choreographer) worked with technology throughout his career both in musicscapes [9] and in creating movement [11]. Burton and Kulic have used Laban Movement Analysis (LMA) to create intricate, life-like active sculptures [2]. Collaboration with puppeteers has highlighted challenges in nonlinear control [3] [8].

In our work, we wanted to explore a residency of a long duration and leave the charge relatively open-ended. The exchange for roboticists is rich: students could learn from a professional dance artist and practice choreographic processes; the exchange for the artist was likewise enticing: the choreographer got a glimpse close to the machine, so to speak, and insight into the world of technology development. This allowed roboticists to explore movement design from an embodied perspective and allowed a choreographer to grapple with questions about her relationship to technology alongside its development. The result is an in progress piece, Time to Compile, and new research questions about how priming effects perception of robots and how choreographic tools can engender trust and acceptance. This paper focuses on documenting the efforts of the former, the artistic collaboration that has produced a unique tech-infused interactive installation. Time to Compile is a collaboration between New York based choreographer (Catie Cuan) and the Robotics, Automation, and Dance (RAD) Lab at the University of Illinois, Urbana-Champaign, led by assistant professor of mechanical engineering (Amy LaViers). Catie spent four weeks in June 2017, in residence at the RAD Lab, teaching movement classes to the RAD Lab engineering students and co-creating this piece with Amy, a Masters student (Ishaan Pakrasi), and an undergraduate student (Novoneel Chakraborty). There was an initial showing in June at the RAD Lab at the end of this work period. Catie returned to UIUC in December for a two week work period to further develop video, dance, and written material for Time to Compile alongside Amy and Ishaan. There was a secondary showing of this piece on December 16, 2017 at the RAD Lab. Other lab students have given meaningful input over the course of this collaboration. Time to Compile has several upcoming showings in 2018, including the Biennial Symposium at Connecticut College, the Conference for Research on Choreographic Interfaces at Brown University, Arts@Tech at Georgia Tech’s Ferst Center, and the Pygmalion Festival. Images from past showings are given in Figure 1.

The paper will first outline the themes of interest in this collaboration in Section II. Then, the artistic outline of the installation will be provided in Section III and Figure 2. Then, the specific technical implementation of the vision will be described in Section IV and Figure 3. Finally, high-level excerpts from the collaboration will be discussed (both positive and negative) in Section VI with concluding remarks offered in Section VII.

II. THEMATIC EXPLORATION

During the initial discovery period in June 2017, Catie spent several unstructured hours engaged in dance improvisation and
philosophical exploration with the various robots in the RAD Lab. She experimented with prototypical human intimacy behaviors, like hugs, hand holding, slow waltzing, and long stares into the robot “eye” nodes/animated screens. She wrote dialogue and programmed the NAO robot to speak the written lines with various pauses, simulating a theatrical conversation. Catie also wrote several short stories inspired by the notion of future physical and digital boundaries between humans and machines. While immersed in this exploration, she met with Amy and posed the question, “Are robots becoming more humanlike?” Amy argued that humankind’s dynamic plasticity and adaptability renders them more susceptible to psychological and physical change than robots. As a result, Amy posed the question in reverse, “Are humans becoming more robotlike?” and this question became a central theme of the collaboration.

Upon further exploration, Catie was frustrated by the needlessly opaque elements of the various technological tools in the RAD Lab. In choreography, there is a true immediacy between imagining movement and executing it in real time. While learning how to use various technological tools for the first time, Catie discovered a long, error-prone process of testing and iteration before the tools would execute movement patterns. Ishaan expressed a similar frustration while programming the various tools. The vastly different latency between human movement and machine movement became a second core theme and the title of the performance piece – Time to Compile. Discussions throughout the June discovery period also addressed popular media articles around machine cognition and sentience. Films like Star Wars cultivate the idea that machines experience the world through a semi-human consciousness. In discussion with Amy and other RAD Lab students, Catie came to agree that this is an inherently flawed idea and one that discounts human complexity relative to the mathematically limited organized transistors and motors that comprise robots. Fictional machines like C-3PO, and the contemporary artifices inspired by it, do not possess human physical or mental qualities but are computerized moving sculptures created and maintained by people. Revealing this flawed machine magic and cloaked human element became the third central theme: The hidden human network.

Time to Compile was thus created in response to three topics of concern: 1) The Hidden Human Network. Many technologies are powered by humans for the benefit of each other, but often this network is occluded, leaving a machine seeming quite intelligent, e.g., IBMs Watson, which is powered by the webpage postings of users all over the Internet. 2) Are humans becoming more robot-like? This question was originally posed in the reverse, but upon further inspection, it is easy to argue that the rich adaptability of humans is heavily exploited in emerging technologies (more than any particularly successful imitation of biology). With these changes, are humans finding social structures like family or friendships in embodied and personal technology experiences? 3) Time to Compile. How long does it take to find resolution with or understanding of different technologies? How long before we iterate on the first design and find a second? Who gets to investigate the inner-workings of these machines before? When have we assimilated a new technology permanently? How will we change?

The aim of Time to Compile is to reveal the hidden human network and to alter the objective action of the participants, testing the hypothesis that human plasticity can be exploited through technology. As the hidden human network is unmasked, participants recognize how this embodied illustration of the network can be reflected across the spectrum of their daily life. For example, self-driving cars are in fact machines created by humans and programmed by humans, with biases from the teams that made them. It follows simply from these machines are limited to their programmed capabilities. Self-driving cars cannot learn a choral ballad or create a floral arrangement. This realization of the hidden human network results in a reclaiming of human identity and a questioning of their own assumptions about robotics and technology.

III. LOOP DESIGN: ARTISTIC GOALS

The internet is no longer the separate, computational space; more devices are hooked to the internet than people and 50% percent of the global population is connected. Given this massive network, device and app makers have prioritized speed and ease of use over sincerity and humanism. As a result, human to human digital interactions are shallow, wide, and discrete in order to quicken and simplify engagement. Taps and likes are examples of this. Qualitative, abstract phenomenons like adoration and love have been reduced to binary on the internet.

The average American spends more than 10 hours a day staring at a screen; thus, the governing principles of digital interactions logically permeate analog lives. Digital vocabulary words like “swipe” or “DM” enter live conversation. Patterns of digitally-focused movement, from holding a cell phone to typing on a laptop, affect the physical posturing and spatial awareness of individuals even while these tools are not present. How human interpersonal relationships change in light of these digital influences is less clear. One hypothesis we posed is that humans become less sensitive to live, bodily experiences and less likely to acknowledge other humans around them. A mechanism to address this in performance would be for all audience members to participate in a moving, improvisational group exercise.

A resulting artistic goal is to have all audience participants interact with an artificial agent that represented a human moving on the other end of it. This experience represents the hidden human network in an immediate, visceral form as well as engaging the human participant in a literal mirroring of robot motion, addressing the question of “are humans becoming more robot-like?” By asking the participants to rotate from exercise to exercise, participants are challenged with new activities that vary in personal compile times. This artistic experience echoes the transition of digital influences and reactions into everyday life, while using the performance context to elevate emotional considerations and educate the public about typically inaccessible robotic technology.

A second artistic goal is for Time to Compile to evolve based on audience contribution, similar to the collective, content upload format of the internet. The audiences illustrations,
pictures, and movement appear in the piece, therefore welcoming the public into the practice of performative art-making. After each informal showing in June and December, 2017, the audience provided feedback which has impacted each work session and the overall narrative of the piece. This feedback is critical in understanding how audience members, as a sample group of the population at large, view technology and how those feelings manifest within Time to Compile. In doing so, performance becomes a rapid prototyping opportunity to mold how individuals perceive new technologies. Additionally, giving the public the opportunity to experience this technology unmasks often intimidating machines. Through each showing, the Time to Compile collaborators will be able to further develop the sophistication of their initial material and bring the public into the rich space of overlap between robotics and choreography.

A visual artistic goal is to eliminate the boundary created by phones and computers between the digital world and the “real” world, therefore creating a live representation of the internet. The piece employs soft elements (both live and pre-recorded) like sheets, skin, and sex to contrast the hard lines of robots, virtual avatars, and transistors. Time to Compile takes the form of an embodied analog for the Internet of Things where performers (including dancers and engineers) help audience members make sense of this “place” and this “time”. The mood of the piece is distant and remote yet sparkly and intriguing.

Sonically, this piece aims for multi-genre music and abstract dialogue to amplify the visual environment. Both music and speaking should seem disjointed, frictional, and circuitous. The goal was to spark confusion about the geographical and temporal location of the performance. To convey this, Catie sought music with suspended melodies, digital influence, and consistent moderato to allegretto tempos. In the most recently performed version of Time to Compile, the sound varies from speaking (both human and robot vocalizations), to music from artists like Midori Takada, Andrew Bird, and Four Tet.

IV. LOOP DESIGN: TECHNICAL IMPLEMENTATION

The Loop in its current form is performed in any large space with chairs (e.g. proscenium theaters as well as open rooms). This space is divided into 5 node labeled 0 to 4, separated by opaque curtains, with participants moving through each node once. The nodes contain technological elements (robots and virtual reality) that participants are asked to interact with. There are several small flashlights and headlamps around the stage and on the robots. This setup is named the “technological system”, and it looks like the creative teams vision of what the inside of the internet is. There are two main parts to the Loop, one static, and one interactive.

For the first, static part of the performance, participants are asked to sit in Node 0. This section contains theatrical lights, a sound system, a projector and chairs that are lined up in front of a large scrim. The performance begins when participants are asked to sit on the chairs, following which a theatrical short film is projected onto scrim. Following this, audience members are invited to enter the technological system where they begin interacting with, “The Loop”. In this second, interactive part of the piece, participants move through Nodes 1 to 4 of The Loop one by one, with interactions oscillating between simple and frustrating, simulating the feeling of alienation and satisfaction we often experience with machine and computer interfaces. The overall tone is safe, exploratory, and suspended.

During the Loop, Nodes 1 to 4 each contain one participant, along with a piece of technology that the participant interacts with, termed the “actuator”, and a means of collecting movement information from the interactive experience, termed the “sensor”. Data is transferred between successive nodes that inform the overall structure of the loop, as is explained below.

In Node 1, the participant (Player 1) is asked to engage in a movement game with the Baxter Research Robot (the actuator), a 6’ 1” tall manufacturing robot with two gripper-style arms. The Baxter robot contains an internal PC that runs its proprietary SDK software. It is connected to a Linux workstation that runs Ubuntu 14.04. This workstation runs Robot Operating System (ROS) version Indigo, a robotics middleware that allows us to send and receive commands to and from the robot using the Baxter Robots ROS Software Development Kit (SDK). The Baxter robot performs a movement sequence, and the participant is asked to recreate the sequence by mimicking the robots movements. We term this as the “mirror game”.

The participants movements are captured by the Microsoft Kinect V2 sensor, an IR camera array that allows us to track skeletal movement profiles. This sensor is connected to a Windows workstation. The information collected by the Kinect...
Sensor is processed by the windows workstation, and used in Node 2. In Node 2, the participant (Player 2) is asked to wear an HTC Vive, a Virtual Reality Headset that allows for room-scale immersion. This headset is connected to a windows workstation, running Unity 3D, a game development software for VR experiences. Once participants put the headset on, they are immersed in a large room modeled to look like a living room, where they see a virtual, humanoid avatar. This humanoid avatar receives skeleton tracking information from the Kinect V2 in Node 1, and thus follows the movements of Player 1. The participant is asked to play the mirror game with the virtual avatar. While the participant engages in the mirror game, another Kinect V1 sensor records their skeletal tracking information, that is in turn used in Node 3. This Kinect V1 sensor is connected to the Linux workstation.

In Node 3, the participant (Player 3) interacts with Nao, a small, 1’11” humanoid robot. This robot is connected to the Linux workstation running ROS Indigo, using the Naoqi SDK. The Naoqi SDK contains software that allows us to control movements of the Nao robot using the Joint Control Application Program interface (API). We are currently working on a program that will allow us to move the Nao robot using the Microsoft Kinect V1. This will allow us to pull the skeleton tracking information from Node 2, and use it to control the movements of the nao robot in Node 3. Player 3 is asked to play the mirror game with the nao. Again, the players movements are recorded by a Kinect V1, with the skeleton tracking information sent to Node 1. The Baxter Robot in Node 1 is teleoperated using this skeleton tracking information. An example of teleoperation of Nao and Baxter using the Microsoft Kinect is shown in /reddiwar2014teleoperation and /almetwally2013real. This, there is a cyclic transfer of data from Nodes 1, 2, 3, and back to 1 as participants engage in the Loop.

At the center of the loop lies a 360° camera that live-streams 360° video of the loop in process to a YouTube stream. This camera is placed in a way such that it has a view of every section of the loop. In Node 4, participants are asked to wear a Google Cardboard Virtual Reality Headset with an enclosed smartphone. This allows users to view the YouTube livestream in virtual reality, thus revealing the mechanism of the loop. This section acts as the “grand reveal”, where participants are shown the cyclic nature of the loop and that their own movements drive each of the nodes.

Audience members often express that The Loop feels like a journey. The participants, while separated in space by about 10 feet, engage with the technology (the Baxter robot or HTC VIVE) in front of them. While immersed in their discrete exercises, they are under the guise that they are having a standalone experience with a machine. In actuality, they are moving with other humans whose extracted skeletons are being tracked onto all machines in the exhibit. Therefore, through the technological elements employed, the spatial, physical, and psychological borders of the installation are manipulated by the artists through exchange between each. This porousness allows for a malleable experience where participants float in a room we design to focus on interactions rather than demographic and personal characteristics; moreover, it is human
Fig. 3. Detailed schematic of the technical implementation of the interactive component (“The Loop”) of Time to Compile. The schematic shows the relationship between sensors, actuators (the hardware of “The Loop”), participants and performers (the human elements), and data transfer between elements (the digital component that could become an archival record of the piece).

behavior, that invisibly drives the exhibit, which is revealed to participants by the end of their experience, just as the internet is driven by obfuscated humans.

V. SURPRISING SYNERGIES AND PAIN POINTS BETWEEN ARTISTIC AND TECHNICAL GOALS

You don’t know what you don’t know, and at least initially, this involves quite a bit of me being in the dark. I mean this in a few ways: in terms of process: that Amy and I haven’t worked together before and I’ve never been to UIUC (what will her students think?!?!?); in terms of vision: I think we are both expecting to build a narrative out of dance and technology but aren’t sure what that means; and in terms of stakes: that risks and opportunities may present themselves or not.... I’ve also considered how the human has been left out of the mainstream discussion when it comes to robots. There’s a popular fatalistic economic argument about robots – that robots will cost manufacturing and driving jobs – but that is more about economic restructuring than it is about human beings.

The quote above was written in an internal blog post by Catie before arriving at the RAD Lab in June 2017. It offers a window into her perspective before joining a group for an extended period of time with an open-ended charge. It demonstrates both the excitement and anxiety that preceded our collaboration (on both sides).

This collaboration between artists and engineers has highlighted opportunities to share semantics and practices across disciplines, for the creation of new art, new robots, and new academic study formats. Several challenges, which pose unique opportunities for learning and inspiration, are embedded in this pursuit, including:

- Delineating a shared language, despite differences in choreographic technologies (e.g., repetition, retrograde) and mechanical engineering technologies (e.g., transistors, control systems).
- Establishing mutual support between all collaborators, especially as skills and experience differ and as institutions undervalue body-based work.
- Determining goals for this collaboration, including a mutually compelling performance piece, valuable robotics research, interdisciplinary curriculum, and personal fulfillment for both artists and technologists.
- Creating a performance than can be understood by an audience, despite common perceptions that automated machines are quantitative and perplexing.
- Understanding the relationship between humans and the technical tools that are inspired by them.

On the one hand, we had to decode each other’s language and norms. On the other, once we’d come to internal understanding, we had to create something that can be understood by others who weren’t around for the residency period. Both tasks were daunting... Catie needed to be supported as she interfaces with opaque technological tools, which tend to impress
outsiders just because they seem hard to use, regardless of whether they are actually interesting.

That natural human reaction to technology – that it is this murky monolith, inflexible and quantitative – creates a tension that is ripe for misunderstanding. The digital technology roboticists like Ishaan use to control robots only magnifies this reaction because the tiny transistors doing all the work are invisible to the naked eye (and also hidden behind plastic encasements). Moreover, our collaboration took place in an institution (the academy) that systematically undervalues body-based work, such as, the research performed during improvisation.

What has been fruitful about this collaboration is that through a combination of confident personalities and upfront acknowledgment of these challenges, the technology employed has been viewed as a creative medium accessible to all parties and, on the flipside, the experience and ideas of technologists has been integrated into the narrative of the artistic piece. This has allowed our choreographer to deepen her understanding of the mechanisms behind, for example, a humanoid robot. It’s broadened the perspectives considered by the robotics students in the RAD Lab. Moreover, both sides have a better grasp on the complexity of humans in contrast to the simplicity of our technical tools that exist in our shadow. It’s a flip in initial expectations that still honors the excitement that brought everyone to the table.

VI. CONCLUSIONS

This paper documents an ongoing collaboration between the RAD Lab and choreographer Catie Cuan. We have diagrammed – from two distinct perspectives – an interactive art installation that accompanies live performance in Time to Compile. Moreover, we have shared insight into the internal processes of our collaboration, in hopes that it may prepare and spark similar collaborations between others.

Our future directions include more (and more polished) showings, fleshing out custom algorithmic tools to support the artistic goals of the piece (including live tracking of human forms as in [10, 11]) furthering the cross-training (training outside ones own disciplines) of the members of this collaboration, and bringing audiences new perspectives on technology’s role in daily human life, robotics, and the Internet of Things.

REFERENCES