Volume XVI
No. 1
Fall
2021

Library News

From the Dance Notation Bureau

INSIDE THIS ISSUE

Dance Notation Bureau Library
Monday - Friday 10 am – 5 pm
Appointment required

178 E 109th Street, #5
New York, NY 10029
Phone: 212/571-7011
Email: library@dancenotation.org
Website: www.dancenotation.org
Facebook:
www.facebook.com/dancenotationbureau

***Library News* is published four times a year in New York**

Editors:
Joyce Greenberg
Hannah Russ

Layout:
Mei-Chen Lu

Advisors:
Jill Cirasella, Associate Librarian for Public Services and Scholarly Communication, Graduate Center, The City University of New York
Nena Couch, Curator
Lawrence and Lee Theatre Research Institute at The Ohio State University
Libby Smigel, Dance Curator
Library of Congress

The DNB gratefully acknowledges funding support from:

New York State Council on the Arts, The Harkness Foundation for Dance, The Antony Tudor Trust, Jody and John Arnhold, and our individual contributors and members.

Dancing Robots
An Interview with Katsu Ikeuchi and Machiko Sato

By Hannah Russ

Have you ever wondered how to make a robot dance? Just teach it Labanotation. Katsu Ikeuchi, a Senior Principal Research Manager for Microsoft, and his colleague Machiko Sato, a postdoctoral dance researcher at Ochanomizu University in Japan, have made major contributions to the worlds of Artificial Intelligence (AI) and dance. They have done this by using Labanotation as a key to unlock a robot's dancing abilities. In doing so, they created a new method for preserving, promoting, and researching dance.

Many Labanotation scholars would agree that documenting movement in Labanotation has its advantages over a video recording. However, Ikeuchi and Sato are taking that concept a step further, turning a notated score into a code that can be interpreted and embodied by a robot. A product of this research has come to be known as e-intangible heritage, which involves the process of preserving and analyzing dance through robots. Their research using Labanotation to inform robot movement is also continuing to progress into fields outside of dance, and robots may soon be cooking and taking care of the elderly.

Katsu Ikeuchi has an extensive background in AI and robotics. After earning a PhD in Information Engineering from the University of Tokyo, he spent several years working at the Massachusetts Institute of Technology Artificial Intelligence Laboratory, the Ministry of International Trade and Industry in Japan, and Carnegie Mellon University, to name a few. Now at Microsoft, his research focuses on robotics theory and physics vision areas. Ikeuchi was first introduced to Labanotation about 10 years ago. While he was not trained in the field, he quickly recognized the value of this notation system in capturing key body positions that can express the essence of a cultural dance. As such, Labanotation became a major part of his e-intangible heritage research endeavors.

Machiko Sato is a dance researcher, specializing in representational art theory. In 2019, she received a PhD in Dance Studies from Ochanomizu University on the topic of 20th century theatrical dance. Her research focuses on dance history, choreography, and dance notation systems. She has also been involved in conserving and restoring dance in an e-intangible heritage form through interdisciplinary research, which combines information science technology, robotics, and Labanotation.

Hannah Russ: Mr. Ikeuchi, you first started using Labanotation during your research involving the preservation and analysis of cultural heritages, which you call "e-heritage" and "e-intangible heritage." Please elaborate on these two concepts and what has motivated you to conduct such research?

Katsu Ikeuchi:
I am interested in preserving and promoting cultural heritage using the latest technology. There are many existing cultural heritages. However, these heritages

are being lost day by day due to natural disasters such as earthquakes and typhoons or man-made disasters such as vandalism and arson. Our team has been trying to create 3D data of such cultural heritages to preserve their appearances, allow people to enjoy them, and conduct scientific research. We refer to this field as e-heritage.

Examples of our e-heritage projects include the Bayon project in which we digitized and obtained 3D data of the Bayon temple for preservation and restoration. By analyzing the 3D data and with the help of archaeologists, we proposed a new archaeological conjecture: that at least four independent groups built the Bayon temple and that these groups carved the deity faces of temple in a parallel manner. Another example is our Kyushu project, which aimed to obtain 3D geometric and photometric data of the stone chambers of 10 tumuli in Kyushu Japan. These tumuli are closed to the public, so we used our data to create virtual reality (VR) exhibitions at Kyushu National Museum. From the analysis of our data, we also obtained several new archaeological findings such as how the tumuli were constructed along with structural patterns which were originally thought not to exist there.

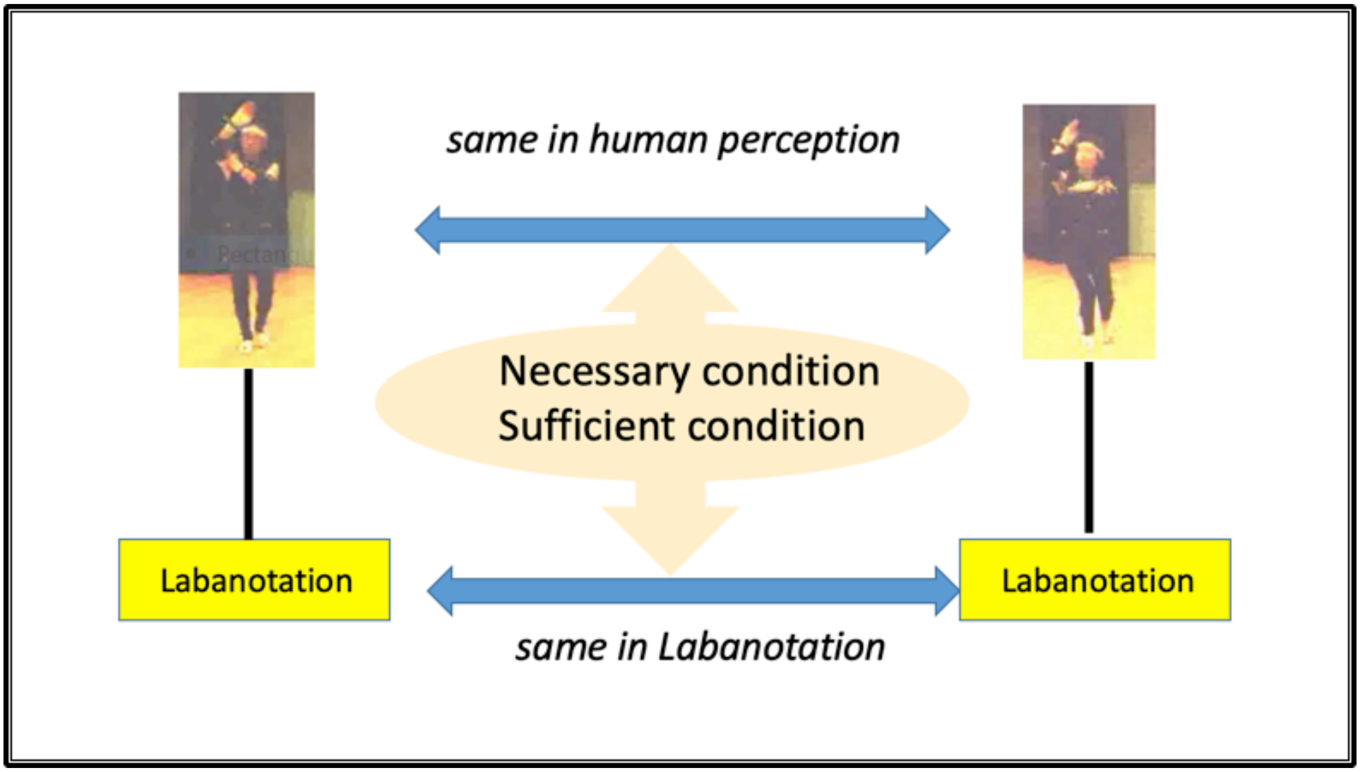
Parallel to tangible cultural heritage is intangible cultural heritage such as folk dances, folk songs and indigenous language. These intangible heritages are also disappearing due to a lack of cultural inheritance, intermarriage and modernization. We have conducted e-intangible heritage projects to preserve folk dances. For such projects, we utilize robotics theory, in particular, the “learning from observation” theories. The result is robots that can observe and understand human dance and can perform the same dances as a human. Of course, there is video recording, but is such video documentation enough? We use robotics theory to gain a deeper understanding of the dances in addition to preserving them. This is my starting point of e-intangible heritage.

Hannah Russ: What drew you to preserve dance through this e-intangible heritage form and how has Labanotation played a role in that research?

Kastu Ikeuchi:
Dance, particularly folk dance, is a central symbol of culture, and is also deeply connected to other cultural aspects such as language and music. My motivation for why we began this robot dance research was not only to display such dance, but also to obtain a deep understanding of the movement itself. As I said earlier, we are using a paradigm called “learning from observation.” Basically, we are trying to make our robot observe a human demonstration and then mimic the movement. However, just simple observation does not work well.

Between a human teacher and a robot student there is a weight difference and a dynamic difference, so direct mimicking is challenging. Instead, we have to extract the essence of the actions, and then based on such essence, recreate the motion. In fact, this kind of paradigm also occurs between a human teacher and a human student. Again, the weight and height is different between a human teacher and student, so direct mimicking also does not work. First, the student has to extract the essence of dance from observing the details of the motion, and then they create their own interpretation and their own motion with their body. So, direct-mimicking and learning a dance is a different process, and the key point in learning a dance is the essence extraction. I have been extracting the essence of actions in various domains, such as assembly actions of machine parts, knot tying actions, household actions, like cooking, and dancing. Aside from dancing, object-environment relation is the main focus. With dancing, we focus on the movements of the body parts. We are using Labanotation as the central representation of the essence of these movements.

The robot body can be divided into two parts: upper body and lower body. The robot lower body is a slightly different story from the human lower body. Because balance for the lower body is totally different for a robot, I mainly focus on upper body motion. We started by looking at a sketch of *Aizu-bandai-san* dance, a Japanese folk dance, drawn by a dance master. By observing this sketch, you can get a hint of the essence of the dance and roughly reconstruct it. The question is: how do we extract this kind of key essence from continuous motion? And how do we describe this essence? These two key issues are related to how we use Labanotation and determine the necessary and sufficient conditions needed to mimic dance. Imagine two different dancers performing a dance. You can obviously tell whether these dances are the same or different. However, for the dances that are the same, perhaps each body motion is slightly different. My question is, what is the necessary and sufficient description that guarantees a motion sequence is the same dance? In my opinion, the answer is in Labanotation. Basically, if two motion sequences can be written down in the same Labanotation, then we can say that these are the same motion sequence. Thus, Labanotation is the necessary and sufficient condition to guarantee a set of motion sequences belong to the same dance. Furthermore, from one Labanotation score, a dancer may generate subtle variations of the dance. But from the audience's perspective, they will observe such motion as more or less the same dance. What makes this the sufficient condition is that when you observe slightly different motion sequences of the same dance, you still end up with the same basic Labanotation score. This is why we need Labanotation.



Additionally, our hypothesis that Labanotation captures the essence of motion is verified by the actuality of creating robot motions. In doing so, we will learn what kind of augmentation needs to be added to the robot to make it move, and conversely, what knowledge humans use to dance.

Machiko Sato:
I had originally studied dance only in the field of the arts. I started working on the interdisciplinary project of preserving dance as e-intangible heritage after being invited by Katsu.

When trying to preserve dance in an electronic form, there are multiple directions that can be taken. One is to record a human demonstration with video or motion capture systems that attach markers to humans' joints and measure their position information in a room. The advantages are that the amount of information we can obtain is large, nuances can be discerned, it is easy to record, and the recorded material can be enjoyed intuitively without any specialized knowledge. However, since a recording is a one-time event, individual differences or failures are also recorded.

Another direction taken in preserving dance is to describe the features by subtracting individual differences and highlighting the important elements. We can do this by using drawings or illustrations found in reference books and encyclopedias as examples. In these books, illustrations are often used to represent typical and conceptual examples rather than photographs, which can also reflect individual differences. We, of course, refer to photographs and videos in our research, but our aim is more supported by illustrations.

I believe that Labanotation is effective for the following reasons. By notating as simply as possible, excessive information can be subtracted. While we have the capability to create very detailed scores using Labanotation, by choosing to keep it simple, information can be reduced to accentuate the important features. As a result, Labanotation helps us illuminate which features constitute a certain dance. The folk dances that we are going to preserve electronically do not have an "original creator," unlike artistic dances. Perhaps there was once an original choreographer. But as a dance has been repeated and handed down over generations, the existence of the creator disappears, and the dance, shared among everyone, becomes a folk dance. Of course, the issue of identifying a work's creator or original form also exists in theatrical dance. However, in the case of folk dance, it is more difficult and sometimes impossible to identify the original form.

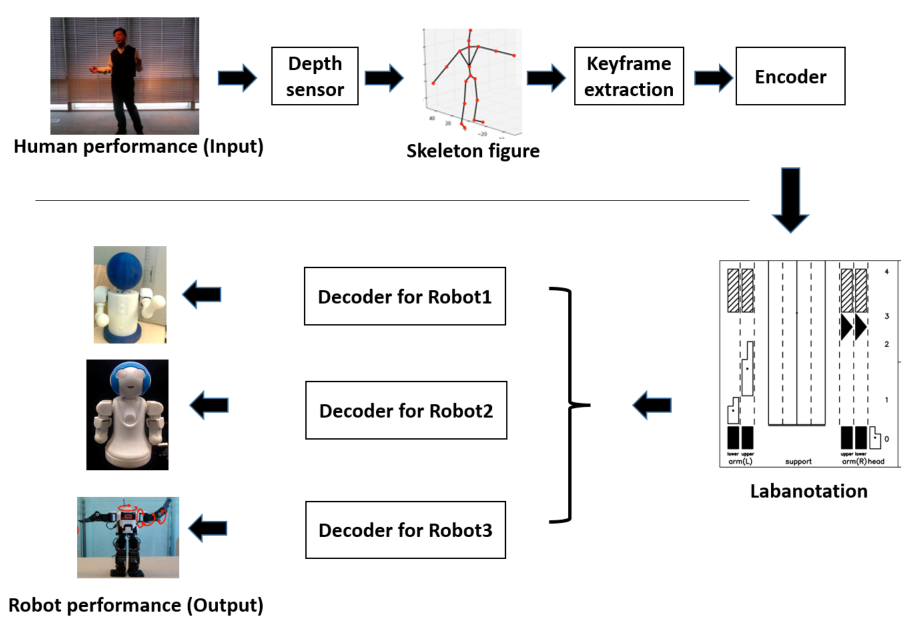
If you observe a folk dance, you will find that there are more or less variations depending on the performer and the moment of observation. So, we need to take several examples and compare them to determine what makes the folk dance distinctive, what Katsu calls, the essence. By using Labanotation, we can create full scores of certain variations and compare these individual cases of the dance. By examining the commonalities, we will be able to find out what are the characteristic elements of that folk dance. On the other hand, if we examine the differences, we can see the range of nuances. After considering the attributes of the performers and actually dancing myself to check if it is reasonable, I will create a score to represent a "typical" example.

Another advantage of Labanotation is that it makes it possible to measure the degree of similarity among other communities' similar folk dances. Once you have created a typical score for each of several folk dances, it is possible to calculate the similarities among these dances by comparing the scores using statistical methods. While this is beyond my field of research, this may lead to ethnographic insights into cultural exchange or societal structure and so on.

Lastly, Labanotation can be applied to research with robots. Even more noteworthy is that the method of describing movement through Labanotation has an affinity with robots. If these transcribed folk dances can be demonstrated with robots, the research results can be given back to a wider range of people beyond the Laban community. Humanoid robots have motors built into their joints. In order to move the robot, it needs information on how to operate the motors, specifically in which direction and for how long to move the limbs. In other words, Labanotation serves as a flow diagram to give motion instructions to the robot. In addition, by juxtaposing the robot demonstration with the actual folk dance, the validity of the research can be verified.

Hannah Russ: Can you elaborate on how exactly a robot reads and interprets Labanotation and the technology you are using?

Katsu Ikeuchi:
Human movement is a continuous motion. It is too much information to be recorded by computer systems. So certainly, we need a system to compress or deduce that information. However, we should not do it randomly. We should compress this information by adhering to human common-sense. What we have found is that this kind of compression can be realized through Labanotation.

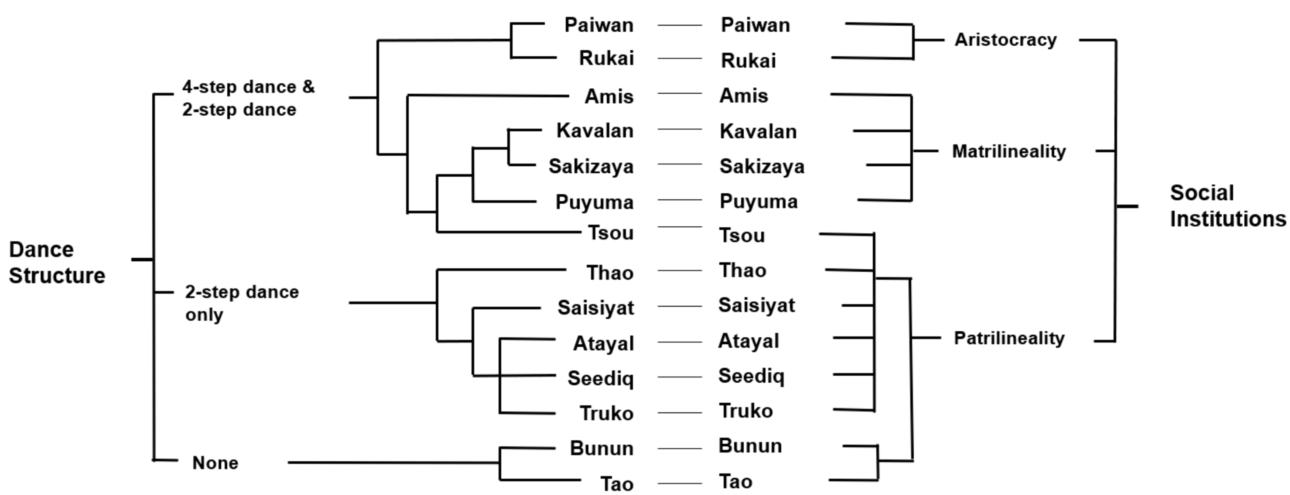


To capture the essence of movement sequences, we are using a digitization system that detects the key poses. Microsoft's open source library has a technology called LabanotationSuite, which is a gesture authoring tool that uses Kinect[1] data to generate upper-body Labanotation symbols. These Labanotation symbols are written in a digital format, which work as a code that can be read by the robot. These symbols are interpreted by the robot and the robot generates upper-body motion.

[1] "Kinect" refers to Microsoft Kinect, a motion capture device that can produce 3D stick figure sequences of movement.

Hannah Russ: What other types of dance are you using e-intangible heritage to preserve?

Katsu Ikeuchi:
The purpose of e-intangible heritage is to preserve endangered cultures. One such endangered intangible heritage is Taiwanese indigenous dance. The reason why we are interested in Taiwanese dance is because the Taiwanese people are considered the origin of the Austronesian peoples who have inhabited much of the South Pacific for thousands of years. If we analyze Taiwanese indigenous dances, maybe we can easily understand other dances and societies from the South Pacific. However, these dances are disappearing due to modernization and because they do not exist in any written forms. One of my students collected and converted festival dances of 14 ingenious tribes in Taiwan into Labanotation. The important point is that with Labanotation, not only is it useful for reconstruction, but it can also be used to understand the meaning of a dance and what that dance reveals about society. For example, we can classify these dances into one taxonomy by using Labanotation and the revealed dance structure. We found that the taxonomies of the dances align with the taxonomy of their social structures and the taxonomy of their languages. The DNA-based taxonomy did not correspond to the dance-based taxonomy. From this, we concluded that societal structure and dance structure are deeply connected.



Machiko Sato:
As Katsu said, the preservation of intangible culture is one of the most important issues in modern society. As society develops, each person's life tends to become more individualized. It has been pointed out that folk performing arts, which have been nurtured in daily life through close interaction with people in local communities, are in danger of decline due to such changes in social structure. Researching the culture that has been nurtured in a community will not only deepen one's connection between the place and oneself but will also energize community building and create a sense of respect for individuality among cultural communities. I believe that the preservation of folk dances as e-intangible heritage will contribute to addressing such social issues.

Recently, I started to make Labanotation scores of *Bon Odori*, which is a Japanese traditional folk dance that is practiced nationwide in various styles. It is also designated as an important intangible cultural legacy of Japan. Generally, *Bon Odori* is danced at traditional Japanese summer festivals, so you may have an opportunity to see it if you come to Japan during the holiday season. While there are many theories about its origin, this dance is strongly related to the introduction of Buddhism to Japan. It is said to have originated during prayers for a good harvest or requiem.

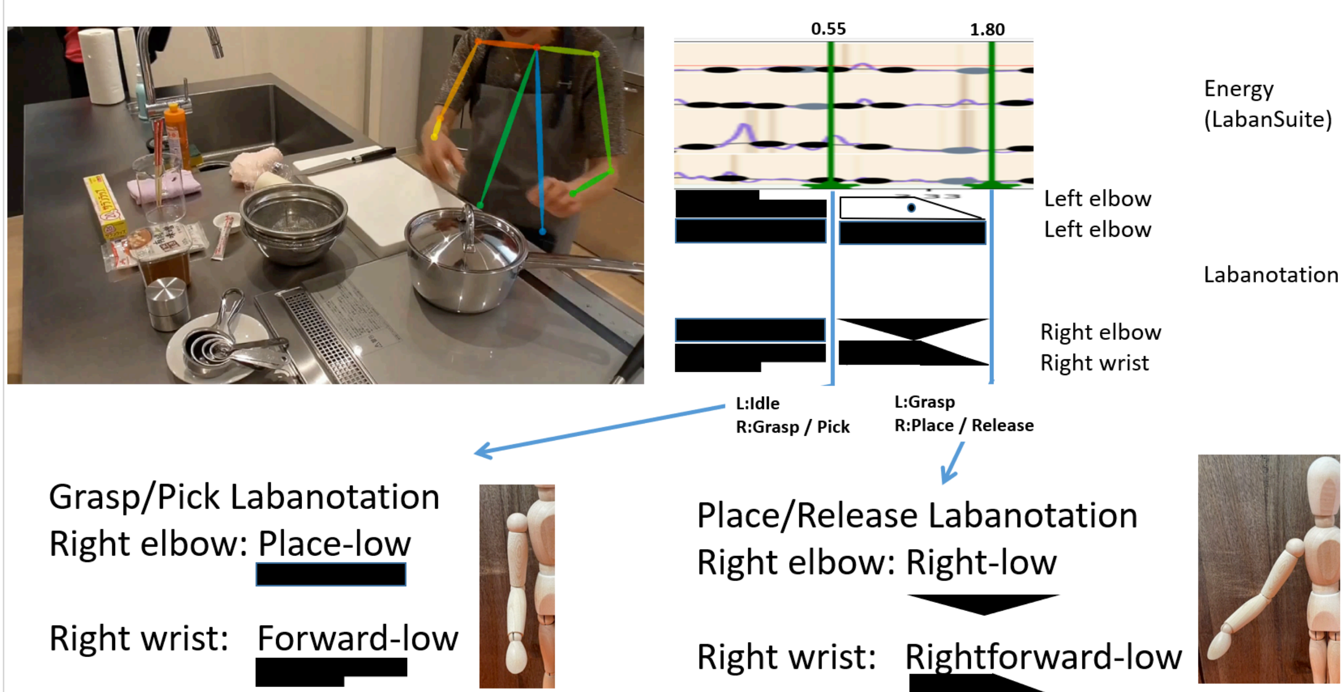
We are currently working with an archive in Akita Prefecture, which is known as a treasure house of folk performing arts. The archivists there have a high awareness of the need to preserve and pass on folk dance and folk songs to future generations. My role is to transcribe the dance, convert it into a text format suitable for computers as well as robots, and check the simulation results. Before the robot is actually run, computer generated simulations are performed to test it.

Another researcher is trying to create an automatic Labanotation writing system. I work with this researcher to check the output results against my own written scores as needed. This project is just getting started. Once we have collected a certain amount of data, we plan to analyze the dance characteristics among the various *Bon Odori* dances and consider their systemic relationships.

Hannah Russ: Are you using Labanotation in other research projects and in fields other than dance?

Katsu Ikeuchi:
We have a couple of other ongoing Laban-based research projects. One is a gesture service robot. Basically, Microsoft has a lot of text generating systems and robots that create sound, but if we can make a robot accomplish actions, that is even more fantastic. We are trying to make a robot generate a gesture based on text, and for that, we are using Labanotation. We are creating a so-called gesture library that pairs a word with a gesture. Each gesture is written using Labanotation. To date, we have classified common concepts into 40 classes, and have assigned gestures to each concept. The method to create these gestures involves a human performing the gesture and LabanotationSuite generating the notation, which the robot will execute. Recently, we converted this system to be video based so we can generate Labanotation symbols for gestures from YouTube videos as well.

Another project for which we are using Labanotation involves the "learning from observation" system for a multi-modal household service robot. The purpose of this robot is to assist and take care of the elderly. One area we are interested in is cooking. Body movement information is necessary for this system so that the robot moves in a way that captures the intention of the cooking action and imitates an action that is similar to movement that would be expected by the elderly or their caregivers. Thus, by recording human movements with Labanotation, we can then provide the necessary movement information to the robots and produce the desired motions. Here we are also analyzing cooking videos by using the 2-D Labanotation system, which produces a score from video for the robot to interpret.



Machiko Sato:
In addition to recording and preserving dances, I am currently pursuing my interest in visualizing dances electronically from existing types of dance notations. In our research so far, we have found that some of the content of a dance score is hard for the robot to execute. A simple example is the support column in Labanotation. In a simple Labanotation score, the support

column describes the direction of the center of weight shift, but it does not specify when and how the legs should start moving or how the balance should be maintained. These are left to the judgment of the performer, and we understand and execute them implicitly. However, as mentioned earlier, humanoid robots operate the motors attached to their joints, so they need information directly related to them. This means that some information currently needs to be replaced or supplemented in order for the robot to walk using Labanotation.

Therefore, we are also working on analyzing the Stepanov notation system as an approximate notation. Both Stepanov notation and Labanotation involve three-dimensional manipulation of the body. However, there is a difference in the representation of a walking motion. In the Stepanov method, steps are represented by the flexion and extension of the joints of the legs. This is just like expressing a walking motion by using only the gesture column in Labanotation. This information is more robot friendly, but it still seems that a robot is inadequate at understanding weight shifts on the grounded leg. Thus, I am currently researching how the formal characteristics of dance notation systems affect the electronic representation of movement.

Hannah Russ: Can you elaborate on your motivation for exploring types of notation other than Labanotation?

Katsu Ikeuchi:
First of all, we have been using Labanotation to point to which poses are important. Through Labanotation, more of the dance's essence is extracted. But, unfortunately, there is still something missing. Usually, such missing components are augmented by human common sense. Since a robot does not have such common sense, it blindly repeats the Labanotation. Some of the motion is awkward. With Machiko, we are trying to extract what kind of augmentation is occurring during the reconstruction, and that is an important research issue. The purpose of AI research is to extract this common sense and, as a result, lacks dynamic and kinematic subtleties. The reason why I am interested in the Stepanov project with Machiko is to explore the commonalities and differences between Stepanov notation and Labanotation reconstruction.

Hannah Russ: You both have spoken about how your research involves the intersection of art and science. What do you think is the importance of advancing this emerging field?

Katsu Ikeuchi:
Based on the e-intangible data that we collect, we can conduct cyber humanities and cyber archaeologies, reintegrating art and science to create new interdisciplinary fields. Originally, in the middle ages, art and science were taught in the same place, that is, at universities. However, in the 20th century, these two disciplines were developed separately due to the prevalence of reductionism, and society as a whole tended to become a bit distorted. In the 21st century, we believe that a healthy society can be formed by combining the arts and sciences once again through holism, and by creating new, integrated disciplines for humanities.

For more information on this research:

E-Intangible heritage:

- Cheek to Chip: Dancing Robots and AI's Future
https://1drv.ms/b/s!AvBN9IME73O5gehmS0FVl5yFtXhOUw?e=C8HXOV
- Analyzing Taiwanese Indigenous Folk Dances via Labanotation and Comparing Results from Interdisciplinary Studies
https://1drv.ms/b/s!AvBN9IME73O5gpMlFUrhwD1oF3UnrQ?e=HSs75R
- Describing Upper-Body Motions Based on Labanotationfor Learning-from-Observation Robots
https://1drv.ms/b/s!AvBN9IME73O5gpMzT9npWuD-QE9DqQ?e=I8RiU2

E-Tangible heritage:

- The Great Buddha Project: Digitally Archiving, Restoring, and AnalyzingCultural Heritage Objects
https://1drv.ms/b/s!AvBN9IME73O5gegxMO6rUOKkMga68Q?e=2uWfuH
- Flying Laser Range Sensor for Large-Scale Site-Modelingand Its Applications in Bayon Digital Archival Project
https://1drv.ms/b/s!AvBN9IME73O5geguNWhZq4F13BWUog?e=2XEzKf
- Preah Vihear Project: Obtaining 3D point-cloud data and its application to spatial distribution analysis of Khmer temples
https://1drv.ms/b/s!AvBN9IME73O5gpMkXPl-F2GUjb-fyw?e=Q0Bxwi