

**Topic-Setting Program to Advance Cutting-Edge  
Humanities and Social Sciences Research**  
(Area development program)

**Progress Report**  
(Summary of Final Report)

**[Project Title]**

UX design research to adapt Japanese traditional performing arts techniques and contents  
to the advanced robot industry.

**Core-Researcher:** Shinobu Nakagawa

**Institution:** Osaka University of Arts

**Academic Unit:** Faculty of Arts

**Position:** Professor

**Research Period:** FY 2017- FY 2020

## 1. Basic information of research project

Research Area	Technological innovation and Japanese aesthetics and sensibility
Project Title	UX design research to adapt Japanese traditional performing arts techniques and contents to the advanced robot industry.
Institution	Osaka University of Arts
Core-Researcher (Name, Academic Unit & Position)	Shinobu Nakagawa, Faculty of Arts, Professor
Project Period	FY2017 – FY2020
Appropriations Plan (¥)	FY 2017 520,000 JPY
	FY 2018 5,850,000 JPY
	FY 2019 5,389,000 JPY
	FY 2020 1,404,000 JPY

## 2. Purpose of research

This research comprehensively extracts the unique aesthetic sense brought about by the stylistic beauty peculiar to traditional performing arts, and try to reproduce those aesthetics in the robot.

Through this research, it is possible to realize a robot with beauty that makes people feel comfortable or enriches their lives. This research opens up a new perspective in the social sciences.

In this research, the craftsmanship of this traditional performing arts will be applied to the multifaceted advanced robot industry including virtual (CG and information icons) in addition to actual robots.

This research focuses on the direction of UX design that enhances the emotional value generated from the user experience.

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In addition, humanities researchers in traditional performing arts will collaborate with researchers in information engineering, mechanical engineering, musicology, physiology, and design in different fields. This research will proceed by applying their own data acquisition methods and analysis methods to the research of traditional performing arts.

## 3. Outline of research (Including study member)

The procedure of this research is to collect data on the craftsmanship of traditional performing arts (Noh and Bunraku) and analyze them. From the results, the mechanism of sound and movement in Noh and Bunraku will be clarified quantitatively.

Those mechanisms are incorporated into advanced robots, etc. The ultimate goal of this research is to verify whether traditional performing arts can be utilized in the advanced robot industry.

In addition, Japanese animation with roots in traditional performing arts will be analyzed, adapted, and verified in the same way.

These series of researches are promoted in collaboration with researchers from different fields such as humanities, science and engineering, and arts. In the process, pursuit from other areas will find new discoveries in their own area and seek to develop the area.

The performers, traditional performing arts researchers (social sciences), information engineering, physiology, musicology, design studies, robotics, etc. analyzed the data. The result was implemented in advanced robots (including CG robots).

In Noh research, discussions were held with Noh researchers, and a hypothesis was made to adapt to robots. Since Noh is a spatial art, its time, space, and force rhythm were first extracted. Experiments proceeded with measures to adapt them to robots.

Data collection of time, space, and force rhythm was carried out by data collection of music, dance, and breathing of top Noh performers. In addition, since Noh is an art of interim, a comparison of acting between exquisite and constant was also verified at the same time.

Furthermore, the beat is based on breathing in Noh and beating in Western music. From them, experiments were conducted in which the time signature of Noh and the time signature of Western music were adapted to robots. In addition, a comparative experiment of its acceptability was also conducted.

In Bunraku's research, sound and movement data were collected and analyzed from demonstrations by leading performers of Tayu, Shamisen, and puppeteers. In the previous research in Bunraku, the skeletal expansion and contraction of Bunraku dolls was extracted. In addition to these, the pursuit of a characteristic structural mechanism that invites the illusion of the audience was carried out.

It was sought to see how the movements of these structures are related to sounds. For example, the rapidity of Noh (three divisions of speed) and the synchronization of fluctuating sounds and movements.

The results obtained from these were incorporated into robots (including CG robots). Experiments were also conducted to measure their impressions.

#### Research project team structure

Separation of principal investigator / group leader / coordinator	Full name	Affiliation / Department / Job (Specialty)	Division of roles
Principal Investigator	Shinobu Nakagawa	Osaka University of Arts, Faculty of Art and Design, Professor	Supervision / planning promotion
Group Leader	Yoichi Yukizane	Jissen Women's University, Faculty of Life Sciences, Department of Contemporary Life, Professor	Software system management promotion
Group Leader	Koichi Osuka	Osaka University, Graduate School of Engineering, Department of Mechanical Engineering, Professor	Engineering system general promotion
Sharer	Akira Omoto	Kyushu University, Graduate School of Arts and Engineering, Professor	Survey analysis from acoustic engineering
Sharer	Reiko Yamanaka	Hosei University, Noh Research Institute, Professor	Survey analysis from traditional performing arts and Noh
Sharer	Yukiya Kawaguchi	Rikkyo University, Faculty of Letters, Professor	Survey analysis from traditional culture and ethnology
Sharer	Cai Dongsei	University of Tsukuba, System Information Systems, Associate Professor	Survey analysis from information engineering
Sharer	Hayato Kondo	Tokyokaiyo University / Academic Research Institute / Professor	Survey analysis from engineering
Collaborator	Yoko Takahashi	Visiting Researcher, Kyoto City University of Arts	Survey analysis from Noh
Collaborator	Toshifumi Tanaka	Kongo-ryu Shihan, Noh performer, Part-time lecturer, Faculty of Informatics, Osaka Electro-Communication University	Survey analysis from Noh
Collaborator	Takanori Fujita	Professor, Kyoto City University of Arts / Professor	Survey analysis from Noh
Collaborator	Yuka Nagamatsu	Soai University Art Produce Major / Lecturer Professor,	Music data processing
Collaborator	Mieko Osuga	Faculty of Robotics & Design Engineering, Osaka Institute of Technology / Professor	Survey analysis from physiology
Collaborator	Yoshiyuki Kamakura	Faculty of Robotics & Design Engineering, Osaka Institute of Technology / Professor	Survey analysis from physiology
Collaborator	Tomonari Higaki	Osaka University of Arts, Faculty of Art and Design, Visiting Professor	Survey analysis from musicology

#### 4. Research results and outcomes produced

In Noh, the mechanism of sound and movement of breath-based time signature (Western music is beat-based time signature) became clear. In addition, Noh's unique time signature rhythm design, design patterns for creating "exquisite spaces", and the mechanism of breath-taking in Noh have been quantitatively clarified.

In addition, since Noh is a folk performing art, it is thought that an integrated control design will be possible in the future in a daily living space where multiple robots and intellectual information groups coexist, so that people can feel the comfort close to nature.

A comparative experiment was conducted by inputting data on the time signature of Noh and the time signature of Western music into the CG image of the living space where the CG robots move. As a result, it became clear that people accept CG images due to the incompatibility of Noh.

Bunraku data was also incorporated into a simple CG robot. Through the impression evaluation experiment for each exaggerated expression, it became clear that the effect of movement peculiar to Bunraku is accepted by people.

Also, regarding the relationship between sound and movement, the effect of "fluctuation", in which the movement is slightly deviated and synchronized with the change in pitch, was clarified. It was also clarified that it is possible to create a robot motion similar to the emotional expression motion of Bunraku by deep learning the three divisions of Jo-ha-kyu speed with a small robot.

From these, it is considered that by applying Bunraku data, the advanced robot will have a sense of life like a Bunraku doll.

[Presentation status of research results, etc.]

##### ① Thesis

1. Research to Elucidate The Design Law between Exquisiteness, which is the Skill of a Nogaku Artist, Shinobu Nakagawa, Tomoya Higaki (Osaka University of Arts), Takanori Fujita, Hajime Takahashi (Kyoto City University of Arts), Japan Toshio Naka (Nōgaku artist, Kyoto City University of Arts), Tohoku Cai, Shun Dan (Tsukuba University), Mie Osuga, Yoshiyuki Kamakura (Osaka University), 2020 Japan Ergonomics Kansai Branch Conference, P.11-12, 2020
2. Design Research That Adapts The Beat and Disagreement Mechanism of Noh to The Integrated Control of Robot Groups, Shinobu Nakagawa, Tomoya Higaki (Osaka University of Arts), Takanori Fujita, Hajime Takahashi (Kyoto City University of Arts), Japan Toshiki (Kyoto Ryu Nogaku Artist, Kyoto City University of Arts), Cai Dongfang, Dan Shun (Tsukuba University), Mie Osuga, Yoshiyuki Kamakura (Osaka University of Science), Japan in 2020 Ergonomics Kansai Branch Conference, P.13-14, 2020
3. Mechanism of "Breath" in Nogaku (Part 1) -Characteristics of "Breath" of Percussion Instruments, Takanori Fujita, Hajime Takahashi (Kyoto City Art University), Toshihito Naka (Kyoto Ryu Nogaku artist, Kyoto City Art University), Shinobu Nakagawa, Tomoya Higaki (Osaka University of Arts), Cai Dongfeng, Shun Dan (Tsukuba University), Mie Osugami, Yoshiyuki Kamakura (Osaka University), 2020 Annual Japan Ergonomics Kansai Branch Conference, P.15-16, 2020
4. Mechanism of "Breath" in Noh (Part 2) -Substantial Content of "Matching Breath", Takanori Fujita, Hajime Takahashi (Kyoto City Art University), Toshiya Tanaka (Noh performer, Noh) Kyoto City University of Arts, Shinobu Nakagawa, Tomoya Higaki (Osaka University of Arts), Cai Dong-soo, Shun Dan (Tsukuba University), Mie Osuga, Kamakura Yoshiyuki (Osaka University of Technology), 2020 Japan Ergonomics Kansai Branch Conference, P.17-18, 2020
5. Design Research That Adapts The Time Signature Mismatch Mechanism of Noh to The Integrated Control of Robots, Shinobu Nakagawa, Tomoya Higaki (Osaka University of Arts), Takanori Fujita (Kyoto City Art University), Yuka Nagamatsu (Souai University), Chihiro Kawanishi (Kyoto Koka Women's University), JSSD Japanese Society for Design, Peer Review
6. Design Study That Adapts Noh's Time Signature Mechanism for Robot Control. Shinobu Nakagawa, Tomonari Higaki, Yuka Nagamatsu, Chihiro Kawanishi, Takanori Fujita, Yoko Takahashi, Toshifumi Tanaka, Yoshiyuki kamakura, The 30<sup>th</sup> International Symposium on Industrial Electronics, ISIE2021, Kyoto, Japan, 20-23 June, Peer Review

7. Comparative Culture Research on the Emotional Impact of Humanoid Robots, Shinobu Nakagawa, The 5th International Conference on Design Engineering and Science ICDES2020, Kitakyusyu, Japan, November 3-5, 2020
8. Robot motion design using bunraku emotional expressions-focusing on Jyo-Ha-Kyu in sounds and movemants. Ran Dong, Yang Chen, Dongsheng Cai, Shinobu Nakagawa, Tomonari Higaki, Nobuyoshi Asai ADVANCED ROBOTICS 34(5) 299 - 312 March 2020
9. The beauty of breaking rhythms: affective robot motion design using Jo-Ha-Kyu of bunraku puppet. Yang Chen, Ran Dong, DongSheng Cai, Shinobu Nakagawa, Tomonari Higaki, Nobuyoshi Asai Special Interest Group on Computer Graphics and Interactive Techniques Conference, SIGGRAPH 2019, Talks, Los Angeles, California, USA, July 28 - August 1, 2019.
10. Motion Analysis using Hilbert-Huang Transform and Its Applications to Robot Motion Synthesis. Ran Dong, Graduate School of Systems and Information Engineering University of Tsukuba, March 2020
11. Consideration fromTraditional Performing Arts Design Method to Apply Mental Jiu-Jyutsu, Shinobu Nakagawa, Toshin, Japan Design Society 3rd Branch Research Presentation Summary Collection 2020.3.21
12. Design Method That Controls and Integrates Information That is Useful to The Subject's Consciousness and Unconsciousness, Shinobu Nakagawa, Toshin, Japan Design Society 4th Branch Research Presentation Summary P.40 2020.2.1.
13. Analysis of Emotional Expression Mechanism of Sound and Movement in Bunraku Dolls-Focusing on Jo-ha-kyu-Liu Fei, Cai Tosei, Toshin, Nakagawa Shinobu, Higaki Tomoya IPSJ Research Report (Web) 2019 (CG-175) Vol.2019-CG -175, No.8, 1-4
14. Robot Emotional Expression Mechanism that Adapts Bunraku Sound and Movement Techniques, Shinobu Nakagawa, Tomoya Higaki, Tosei Cai, Tosei, Ryuhi, Proceedings of the Academic Lecture of the Robotics Society of Japan (CD-ROM) 37th ROMBUN NO.3F3-05 2019 September 3, 2014
15. Emotional Expression Mechanism of Robots That Adapt Bunraku Technology, Shinobu Nakagawa, Tomoya Higaki, Tosei Cai, Tatsumi, Liu Fei, JSSD Japanese Society for Design Research Presentation Summary 66 2019
16. Emotional Expression Mechanism of Robots That Adapt Bunraku Technology, Shinobu Nakagawa, Tomoya Higaki, Tosei Cai, Tosei, Ryuhi, 60th Annual Meeting of the Japan Ergonomics Society P.23 2019.6.16
17. Development of Robot Exaggeration Expression Mechanism Extracted from Bunraku Dolls, Itsuto Kondo, Hitoshi Yamaguchi, Koichi Osuga, Shinobu Nakagawa, ROBOMECH2019, 2019.6.5
18. Robot Emotional Expression Mechanism That Adapts Bunraku's Sound and Movement Technology, Shinobu Nakagawa, Tomoya Higaki, Tosei Cai, Tosei, Liu Fei, Ergonomic System Tournament 2019, March 8, 2019
19. Robot Emotional Expression Mechanism That Adapts Bunraku Sound and Movement Techniques, Shinobu Nakagawa, Tomoya Higaki, Tosei Cai, Tosei, Liu Fei, Kansai Branch Meeting of Human Design Society, February 2, 2019
20. Mechanism Analysis of Jo-ha-kyu in Bunraku, Tosei, Cai Tosei, Shinobu Nakagawa, Tomoya Higaki, 2019 IEICE General Conference, 2019-03-20
21. "Bunraku Doll Motion Analysis and Robot Motion Design Using Hilbert-Fan Transformation", Tosei, Cai Tosei, Nakagawa Shinobu, Higaki Tomoya, CG Technology Implementation and Mathematics 2018, 2018-09-30

22. Extraction of Bunraku "Zu" Using Hilbert-Fan Conversion, Chen Yang, Toshin, Shinobu Nakagawa, Tomoya Higaki, 2019 IEICE General Conference, 2019-03-20
23. Design Method That Controls Information That is Used Unconsciously and Integrates It into Consciousness, Shinobu Nakagawa, Journal of Japan Society for Information Management Vol.38 No.4, P.12-16, 2019.3.10
24. Emotional Expression Mechanism of Robot Sound and Movement That Adapts The Knowledge of Bunraku, Shinobu Nakagawa, Tomoya Higaki, Tosei Cai, Toshin, 36th Annual Meeting of the Robotics Society of Japan, August 21, P124-124, 2018
25. Robotics Design for Adapting Bunraku Techniques That Are Unconsciously Used by Humans, Shinobu Nakagawa, 36th Robotics Society of Japan Academic Lecture Journal, August 21, P100-100, 2018
26. Evaluation of Acceptability from AComparative Cultural Perspective in Humanoid Service Robot Design, Shinobu Nakagawa, 65th Spring Meeting of the Japan Design Society, P.8, June 23, 2018
27. "Analysis of Movement Characteristics of Japanese Dance and Western Dance Using Hilbert-FanTransformation-Focusing on Dance Movement Analysis of AyaBambi-", Tatsumi, Cai Tosei, Nobuyoshi Asai, Information Processing Society of Japan Research Report. Report (CH), 2018-CH-117 (4), 1-4 (2018-05-05), 2188-8957

## ② Lecture

1. Japan Ergonomics Society Kansai Branch (invited lecture), Designing The Mind from The Craftsmanship of Traditional Performing Arts (Noh + Bunraku) to advanced robots, Shinobu Nakagawa, March 23, 2019, about 120 people (100 researchers, 20 students) )
2. Yamagata University Soft Matter Consortium 4th Symposium (Invited Lecture), Designing the Mind from the Craftsmanship of Traditional Performing Arts (Noh + Bunraku) to Advanced Robots, Shinobu Nakagawa, August 28, 2018, Approximately 150 people (100 researchers, 50 people from companies and media)
3. Stream Cafe sponsored by Osaka Institute of Technology, Robot Design Learned from Traditional Performing Arts, Shinobu Nakagawa (Osaka Institute of Technology), Osaka Institute of Technology Umeda Campus, 2021/3/27, Approximately 50 people (50 people in general)

## ③ Symposium

1. 2020 Japan Ergonomics Kansai Branch Conference, 2020/12/12, Planning Session 1, Design Study of Pause, Breathing, and Beating Disagreement in Traditional Performing Arts "Noh", Chairman Shinobu Nakagawa (Osaka University of Arts)