Motion Characteristics of Bon Odori Dances in Areas along Ushu Kaido Road in Akita Domain

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In this study, we focus on an investigation into the variation of Bon Odori dances in the areas along Ushu Kaido Road in Akita Domain (Akita Han, existed in the early-modern times of Japan) and its cause. We analyze the motion-capture data of the above dances to quantitatively clarify the aspect of motion-style variation. We also analyze the documents describing the local history of the districts where the dances have been passed down, to obtain the knowledge of the factors that might have provided the extracted motion-style variation. The obtained results suggest that the difference of motion style between the dances of Koto Area (i.e., the northern area of Ushu Kaido Road) and those of Senboku Area (i.e., the southern area) might have been caused by the difference in the diversity of industry.

1. Introduction

In Akita Prefecture, Japan, a lot of folk performing arts have been passed down. Particularly in the local communities along Ushū Kaidō Road, which was the main highway of Akita Domain (Akita Han) in the early-modern times (**Figure 1**), many attractive *Bon Odori*[*1] dances have been handed down [1].

The characteristics of *Bon Odori* dances in the above areas vary depending on regions [1]. In particular, the characteristics of the dances in the northern area of the Road (i.e., eastern coast of Hachirōgata Lagoon, hereinafter Kotō Area[*2]) are greatly different from those in the southern area (i.e., inside of Yokote Basin, hereinafter Senboku Area[*3]). According to Ref. [1], in fact, these dances are classified into different groups. Although the above difference is estimated to have been caused by the difference of origin or ways of passing down, much information on the old days of the dances themselves is now lost, and therefore the exact causes are still uncertain.

Taking the above facts into consideration, we focus on an investigation into the variation of *Bon Odori* dances in the areas along Ushū Kaidō Road and its cause; this is the main purpose of this study. To accomplish the investigation, we first extract the motion characteristics of the dances by analyzing the motion capture (Mocap) data of them. The aspect of motion-style variation is quantitatively clarified through this process. In the analysis, we extract the time-domain characteristics (rhythmic style) and the spatial-domain characteristics (posture variation) [2]. In Refs. [2] and [3], the above characteristics of the dances belonging only to a single district in each of Kotō and Senboku Areas were extracted. In contrast, the overall tendency of a set of multiple districts in each of the Areas is investigated in this study.

To obtain the knowledge of the factors that might have provided the extracted motion-style variation,

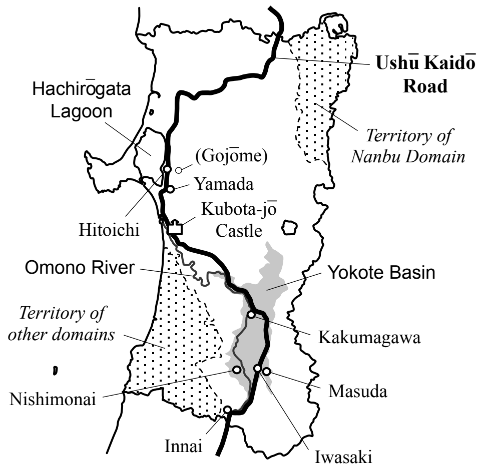

Figure 1 Akita Domain in the early-modern times.

*1 *Bon Odori* is a type of Japanese folk dance performed during the annual Buddhist festival called *O-Bon* (or simply *Bon*).
*2 The word 'kotō' means the eastern coast (or part) of a lake (or a lagoon).
*3 This area has traditionally been called the 'Senboku Sangun' area since it consists of the three counties (i.e., Senboku, Hiraka and Ogachi Counties, the word 'sangun' means three counties). In this study, we call this area 'Senboku Area' for simplicity.

Table 1 *Bon Odori* dances along Ushū Kaidō Road.

District	Dance (index[a)])	Motion capture data			
		No.	Length [s][b)]	Sensor	Dancer
Hitoichi	*Dendenzuku* (D)	3	6.6	A	A
	Kitasaka (K)	4	5.5	A	A
	Sankatsu (S)	4	11.6	A	A
Yamada	*Kitasaka* (K)	5	5.5	C	B
	Dagasuko (D)	4	6.9	C	B
	Sankatsu (S)	3	11.8	C	B
Kakumagawa	(no particular name)	1	59.3	A	C
Masuda	(no particular name)	2	69.2	A	D
Iwasaki	*Otoko Odori* (Ot)	1	72.6	A	E
	Onna Odori (On)	1	73.8	A	F
Nishimonai	*Ondo* (O)	3	44.5	B	G,H[c)]
	Ganke (G)	3	41.1	B	G,H
Innai[d)]	*Innai Ginzan Odori* (Od)	4	29.3	A	I
	Innai Ginzan Ondo (On)	2	39.4	A	I

The above data were acquired by the authors through the motion-capture experiments in which experienced dancers danced.

Sensor system
A: MotionStar Wireless (Ascension Technology Corporation) (30 fps)
B: MotionStar Wireless with LIBERTY (Polhemus)× 2 (30 fps)
C: MVN (Xsens) (120 fps)
Dancer
A-D, F-I: Female
E: Male
a): Used in Figure 2.
b): Mean value at each dance.
c): Dancer G: 2 Mocap data streams, Dancer H: 1 Mocap data stream.
d): Although the dances of Innai are performed at the dates different from those of the *Bon* festival, we added them as the samples of Senboku Area, considering the theory that they had no small influence on the *Bon Odori* dances of this area [4].

we also analyze the documents describing the local history of the districts where the dances have been passed down. We use a technique of qualitative data analysis together with that of quantitative data analysis frequently used in text mining. The former is introduced to appropriately grasp the context of document data (which is difficult to be adequately understood by using only a text-mining approach), whereas the latter is adopted to quantitatively clarify the structure of the information obtained by qualitative data analysis.

2. Motion-capture Data Analysis

2.1 *Bon Odori* dances along Ushū Kaidō Road

Table 1 shows the *Bon Odori* dances analyzed in this study. As shown in Figure 1, the dances belonging to the Hitoichi and Yamada districts are the samples selected from Kotō Area, whereas those belonging to the Kakumagawa, Masuda, Iwasaki, Nishimonai and Innai districts are the samples from Senboku Area. One can recognize that the number of the dances passed down in a single district in Kotō Area is generally larger than that in Senboku Area. It is also noted that the performance length of the dances in Senboku Area is much longer than that in Kotō Area.

To extract motion-style characteristics from the Mocap data of the above dances, we perform the rhythmic-style and posture-variation analyses [2]. The former gives two time-domain quantities (beat intensity and rhythm complexity), whereas the latter gives 12 spatial-domain quantities (the average amounts and fluctuations of spread along the frontal, vertical and sagittal axes and on the frontal, sagittal and horizontal planes [5]). In this case, the total number of the quantities becomes 14. In other words, the motion-style characteristics of a dance are given as a point in a high-dimensional space with 14 coordinate axes. To make it easier to understand the obtained characteristics, we use a dimensionality-reduction procedure newly introduced in this study.

2.2 Time-domain Analysis: Rhythmic-style Analysis

Prior to performing rhythmic-style analysis, we first obtain a one-dimensional motion-speed time series from the displacement of $J = 16$ joints (shoulders, elbows, wrists, fingers, knees, ankles, toes, neck and head, including end effectors) [2]:

$$v(n) = \frac{\sqrt{\sum_{j=1}^{J} \sum_{\gamma=x,y,z} \{p_{j,\gamma}(n+1) - p_{j,\gamma}(n)\}^2}}{\Delta t} \quad (1)$$

where $p_{j,\gamma}(n)$ (γ: x, y or z) is the γ-coordinate of the jth joint at the nth frame (coordinate system: fixed to the pelvis) and Δt is the sampling time, respectively. The values of $p_{j,\gamma}(n)$'s are filtered to eliminate jitter (by using a Gaussian filter, cut-off frequency: 9.0 Hz), and normalized by the body height to reduce the influence of difference in body constitution.

By using the above time series, we estimate the degree of beat intensity (BI) as follows [2]:

$$q_{\mathrm{BI}} = \frac{1}{2} \log \frac{\sum_{n=1}^{N} \{v(n) - v_0(n)\}^2}{N} - A \log(\tau \Delta t) \quad (2)$$

where τ is the frame number giving the first positive peak of the autocorrelation of $v(n)$ (regarded as the beat interval), $v_0(n)$ is the moving average of $v(n)$ (period: τ), N is the total number of frames in a Mocap data stream and A is the weighting coefficient to the beat-interval element $\tau\Delta t$ (set as $A = 0.25$), respectively. The first term of this formula evaluates the strength of motion-speed surges inducing beats, whereas the second term evaluates the pace of tempo. The stronger motion-speed surges are, or the quicker the tempo is, the larger the value of q_{BI} becomes.

As for rhythm complexity, on the other hand, we use the value of approximate entropy (ApEn) [6], [7] obtained from $v(n)$:

$$\boldsymbol{\mu}(n) = \left[v(n) \quad v(n+\tau') \quad \cdots \quad v(n+(m-1)\tau')\right]^{\mathrm{T}}$$

$$d(\boldsymbol{\mu}(n), \boldsymbol{\mu}(j)) = \max_{k=1,2,\cdots,m} (|\, v(n+(k-1)\tau') - v(j+(k-1)\tau') \,|)$$

$$C_n^m = \frac{\sum_{j=1}^{N-(m-1)\tau'} \theta(r - d(\boldsymbol{\mu}(n), \boldsymbol{\mu}(j)))}{N-(m-1)\tau'}$$

$$\Phi^m = \frac{\sum_{n=1}^{N-(m-1)\tau'} \log C_n^m}{N-(m-1)\tau'}$$

$$q_{\mathrm{ApEn}} = \Phi^m - \Phi^{m+1} \tag{3}$$

where $\tau' = \mathrm{round}(0.2\tau)$, $m = 4$, $r = 0.5 \times$ (standard deviation of $v(n)$) and $\theta(x)$ is the Heaviside function, respectively. The value of q_{ApEn} becomes large when the variation of motion speed shows a large amount of complexity.

2.3 Spatial-domain Analysis: Posture-variation Analysis

In posture-variation analysis, the spatial distribution of the positions of $J' = 19$ joints*4 is statistically summarized. First, we quantify the distribution of these joints at each frame using the variances and covariances of coordinate values [2]:

$$\bar{p}_\gamma(n) = \frac{1}{J'} \sum_{j=1}^{J'} p_{j,\gamma}(n) \qquad (\gamma: x, y \text{ or } z)$$

$$\sigma_{\gamma\eta}(n) = \frac{1}{J'} \sum_{j=1}^{J'} \{p_{j,\gamma}(n) - \bar{p}_\gamma(n)\}\{p_{j,\eta}(n) - \bar{p}_\eta(n)\} \tag{4}$$

A set of six values obtained from Eq. (4) represents the spread along the three axes of movement (frontal, vertical and sagittal axes) and that on the three planes of movement (frontal, sagittal and horizontal planes). We regard these values as the components of the feature vector $\boldsymbol{f}(n)$ characterizing a posture in the nth frame [2]:

$$\begin{aligned} \boldsymbol{f}(n) &= [\, f_1(n) \quad f_2(n) \quad f_3(n) \quad f_4(n) \quad f_5(n) \quad f_6(n) \,]^{\mathrm{T}} \\ &= [\, \sigma_{xx}(n) \quad \sigma_{yy}(n) \quad \sigma_{zz}(n) \quad \sigma_{xy}(n) \quad \sigma_{yz}(n) \quad \sigma_{zx}(n) \,]^{\mathrm{T}} \end{aligned} \tag{5}$$

Finally, we statistically summarize the tendency throughout an entire motion sequence as the 12-dimensional feature vector $\boldsymbol{F}$ as follows [2]:

$$\bar{f}_i = \frac{1}{N} \sum_{n=1}^{N} f_i(n) \qquad (= \sigma_{\gamma\eta\,\mathrm{mean}})$$

$$\bar{s}_i = \sqrt{\frac{1}{N} \sum_{n=1}^{N} \{f_i(n) - \bar{f}_i\}^2} \qquad (= \sigma_{\gamma\eta\,\mathrm{SD}})$$

$$\begin{aligned} \boldsymbol{F} &= [\, \bar{f}_1 \quad \bar{f}_2 \quad \cdots \quad \bar{f}_6 \quad \bar{s}_1 \quad \bar{s}_2 \quad \cdots \quad \bar{s}_6 \,]^{\mathrm{T}} \\ &= [\, \sigma_{xx\,\mathrm{mean}} \quad \cdots \quad \sigma_{zx\,\mathrm{mean}} \quad \sigma_{xx\,\mathrm{SD}} \quad \cdots \quad \sigma_{zx\,\mathrm{SD}} \,]^{\mathrm{T}} \end{aligned} \tag{6}$$

where $\bar{f}_i$'s represent the average amounts of spread throughout an entire motion sequence (former three: along the three axes of movement, latter three: on the three planes of movement), whereas $\bar{s}_i$'s represent the fluctuations of spread during an entire motion sequence (also corresponding to the axes and planes of movement).

2.4 Dimensionality Reduction

It is well known that a technique of principal component analysis (PCA) [8] is often used as a dimensionality-reduction method. However, PCA may underestimate the influence of rhythmic-style characteristics consisting of only two of the 14 quantities. Therefore, we adopt the following procedure to avoid the underestimation of rhythmic-style characteristics.

Prior to executing the procedure, each of the 14 quantities is standardized (with zero mean and unity standard deviation) throughout a set of all the Mocap data streams used in the analysis. After the standardization, the normalized distance (with unity mean) of each Mocap-data-stream pair in the rhythmic-style space and that in the posture-variation space are calculated:

$$d'_{\mathrm{R}}(j,k) = \sqrt{\{q'_{\mathrm{BI}}(j) - q'_{\mathrm{BI}}(k)\}^2 + \{q'_{\mathrm{ApEn}}(j) - q'_{\mathrm{ApEn}}(k)\}^2}$$

$$d'_{\mathrm{P}}(j,k) = \sqrt{\sum_{i=1}^{6} [\{\bar{f}'_i(j) - \bar{f}'_i(k)\}^2 + \{\bar{s}'_i(j) - \bar{s}'_i(k)\}^2]}$$

$$\bar{d}_{\mathrm{R}} = \frac{1}{M^2} \sum_{j=1}^{M} \sum_{k=1}^{M} d'_{\mathrm{R}}(j,k)$$

$$\bar{d}_{\mathrm{P}} = \frac{1}{M^2} \sum_{j=1}^{M} \sum_{k=1}^{M} d'_{\mathrm{P}}(j,k)$$

$$d_{\mathrm{R}}(j,k) = \frac{d'_{\mathrm{R}}(j,k)}{\bar{d}_{\mathrm{R}}} \tag{7}$$

$$d_{\mathrm{P}}(j,k) = \frac{d'_{\mathrm{P}}(j,k)}{\bar{d}_{\mathrm{P}}} \tag{8}$$

where $q'_{\mathrm{BI}}(j)$ and $q'_{\mathrm{ApEn}}(j)$ are the standardized BI and ApEn of the jth Mocap data stream, $\bar{f}'_i(j)$ and $\bar{s}'_i(j)$ are the standardized posture-variation components of the jth data stream, M is the total number of data steams, and $d_{\mathrm{R}}(j,k)$ and $d_{\mathrm{P}}(j,k)$ are the normalized distances between the jth and kth data streams in the rhythmic-style and posture-variation spaces,

*4 The waist and hips (i.e., zero-speed joints in the coordinate system fixed to the pelvis) are added to the joint set used in the rhythmic-style analysis to grasp the spread of the whole body more accurately. This is the main point modified from the procedure used in Ref. [2].

respectively.

Next, the normalized distance of each Mocap-data-stream pair, including both the rhythmic-style and posture-variation components, is calculated:

$$D'(j,k) = \sqrt{d_{\mathrm{R}}(j,k)^2 + d_{\mathrm{P}}(j,k)^2}$$

$$\overline{D} = \frac{1}{M^2}\sum_{j=1}^{M}\sum_{k=1}^{M} D'(j,k)$$

$$D(j,k) = \frac{D'(j,k)}{\overline{D}} \quad (9)$$

where $D(j,k)$ is the normalized distance between the jth and kth Mocap data streams. In Eq. (9), the distance in the rhythmic-style space and that in the posture-variation space are evaluated with the same weighting. As a result, the underestimation of rhythmic-style characteristics is avoided.

Then, the distance of each dance pair is calculated. Since a set of Mocap data for a single dance generally consists of multiple data streams as shown in Table 1, we use the Earth Mover's Distance (EMD) [9]. The influence of the distribution of Mocap data streams included in a single dance is taken into account by using EMD. Eq. (9), i.e., the distance between single Mocap data streams, is used as the ground distance in EMD as follows:

$$D_{\mathrm{EMD}}(\mathrm{P},\mathrm{Q}) = \frac{\sum_{j=1}^{M_{\mathrm{P}}}\sum_{k=1}^{M_{\mathrm{Q}}} D(j,k)u(j,k)}{\sum_{j=1}^{M_{\mathrm{P}}}\sum_{k=1}^{M_{\mathrm{Q}}} u(j,k)} \quad (10)$$

where $D_{\mathrm{EMD}}(\mathrm{P},\mathrm{Q})$ is the EMD between the dances P and Q, $u(j,k)$ is the flow from the jth Mocap data stream to the kth one (obtained by solving a transportation problem [9], jth and kth: belonging to P and Q, respectively), and M_{Ω} (Ω: P or Q) is the number of the data streams included in the data set of the dance Ω, respectively. Here, we solve the transportation problem under the following conditions:

$$\sum_{k=1}^{M_{\mathrm{Q}}} u(j,k) = \frac{1}{M_{\mathrm{P}}}, \quad \sum_{j=1}^{M_{\mathrm{P}}} u(j,k) = \frac{1}{M_{\mathrm{Q}}} \quad (11)$$

This means that every dance is evaluated with the same weighting, regardless of the number of Mocap data streams included in a data set of each dance. Finally, every dance is plotted in a two-dimensional space by applying a multidimensional scaling technique (MDSCAL [10]) to the obtained EMDs.

2.5 Results of Motion-capture Data Analysis

Figure 2 shows the results of the Mocap data analysis. The vectors representing the quantity-axes

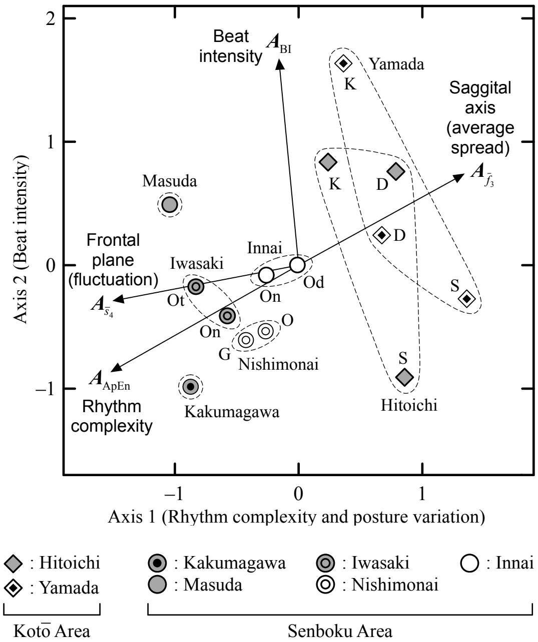

Figure 2 Motion-style characteristics of *Bon Odori* dances along Ushū Kaidō Road. (Method: MDSCAL, Stress: 0.088)

were derived from the correlation coefficients between the quantity values and the coordinates in the two-dimensional space as follows:

$$\boldsymbol{A}_{\mathrm{BI}} = R^{\mathrm{BI}}_{\alpha_1,\alpha_2}\frac{[r_{\mathrm{BI},\alpha_1} \quad r_{\mathrm{BI},\alpha_2}]^{\mathrm{T}}}{\left|[r_{\mathrm{BI},\alpha_1} \quad r_{\mathrm{BI},\alpha_2}]^{\mathrm{T}}\right|} \quad (12)$$

$$\boldsymbol{A}_{\mathrm{ApEn}} = R^{\mathrm{ApEn}}_{\alpha_1,\alpha_2}\frac{[r_{\mathrm{ApEn},\alpha_1} \quad r_{\mathrm{ApEn},\alpha_2}]^{\mathrm{T}}}{\left|[r_{\mathrm{ApEn},\alpha_1} \quad r_{\mathrm{ApEn},\alpha_2}]^{\mathrm{T}}\right|} \quad (13)$$

$$\boldsymbol{A}_{\bar{f}_i} = R^{\bar{f}_i}_{\alpha_1,\alpha_2}\frac{[r_{\bar{f}_i,\alpha_1} \quad r_{\bar{f}_i,\alpha_2}]^{\mathrm{T}}}{\left|[r_{\bar{f}_i,\alpha_1} \quad r_{\bar{f}_i,\alpha_2}]^{\mathrm{T}}\right|} \quad (14)$$

$$\boldsymbol{A}_{\bar{s}_i} = R^{\bar{s}_i}_{\alpha_1,\alpha_2}\frac{[r_{\bar{s}_i,\alpha_1} \quad r_{\bar{s}_i,\alpha_2}]^{\mathrm{T}}}{\left|[r_{\bar{s}_i,\alpha_1} \quad r_{\bar{s}_i,\alpha_2}]^{\mathrm{T}}\right|} \quad (15)$$

where $\boldsymbol{A}_{\Omega}$ is the vector representing the direction and magnitude of the axis of the quantity Ω, $R^{\Omega}_{a,b}$ is the multiple correlation coefficient between the quantity Ω and the variables a and b, $r_{\Omega,a}$ is the correlation coefficient between the quantity Ω and the variable a, and α_1 and α_2 are the coordinates of Axes 1 and 2 in the two-dimensional space, respectively. In Figure 2, only the quantity-axes each having the $R^{\Omega}_{\alpha_1,\alpha_2}$ value exceeding 0.7 are shown*5.

As seen in Figure 2, Axis 1 is roughly parallel to the axes of $\boldsymbol{A}_{\mathrm{ApEn}}$, $\boldsymbol{A}_{\bar{f}_3}$ and $\boldsymbol{A}_{\bar{s}_4}$, whereas Axis 2 is

*5 In Figure 2, the magnitude of each quantity-axis was enlarged twice to make it easier to grasp the whole state of the distribution in the two-dimensional space.

Table 2 Average EMD in each district.

Hitoichi	Yamada	Kakumagawa	Masuda	Iwasaki	Nishimonai	Innai
0.993	1.072	/	/	0.434	0.447	0.502

parallel to $\boldsymbol{A}_{\mathrm{BI}}$. As for the rhythmic-style characteristics, the dances of Kotō Area and those of Senboku Area were separated mainly by the difference of rhythm complexity ($\boldsymbol{A}_{\mathrm{ApEn}}$). As mentioned in Section 2.1, the performance length of the dances in Senboku Area is much longer than that of Kotō Area. The long performance time might have given rise to the complexity of rhythmic structure in Senboku Area. With regard to the posture-variation characteristics, on the other hand, the dances of Kotō Area showed the spread in the front-back direction along the saggital axis ($\boldsymbol{A}_{\bar{f}_3}$), whereas those of Senboku Area showed the fluctuation on the frontal plane ($\boldsymbol{A}_{\bar{s}_4}$) perpendicular to the saggital axis. That is to say, the two Areas provide contrastive characteristics not only in the time domain but also in the spatial domain.

As for the characteristic distribution of Kotō Area, both the Hitoichi and Yamada districts showed the same tendency that the dances belonging to a single district gave a wide variety of motion styles. In contrast, each set of the dances belonging to a district in Senboku Area gave a relatively narrow range of variation. The average EMD in each district, shown in **Table 2**, quantitatively substantiates the above tendency; the districts in Kotō Area gave average values almost twice larger than those of the districts in Senboku Area. As mentioned in Section 2.1, each of the districts in Kotō Area has handed down a larger number of dances than that in Senboku Area. The obtained results indicate that each district in Kotō Area not only has a large number of *Bon Odori* dances, but also provides a remarkable diversity of their motion styles. This is the most striking feature shown in the Mocap data analysis.

3. Document Analysis

3.1 Documents Used in the Analysis

To obtain the knowledge of the factors that might have provided the characteristics extracted in the Mocap data analysis, we perform document analysis using the documents shown in **Table 3**. These are the documents describing the local history of the municipalities*6 each of which includes one of the districts where the analyzed dances have been passed down. In addition, we also use a document describing the local history of Gojōme Town, considering the fact that the Gojōme district had a great influence on the surrounding districts, as the commercial center of Kotō Area [19]. We use the parts of the documents related to the ages from the medieval times to the early-modern times (i.e., the period *Bon Odori* dances spread around the country [20]).

Table 3 Analyzed documents describing local history.

District	Document	No. of coded paragraphs
Gojōme	‘The History of Gojōme Town’ (Gojōme Town History Compilation Committee, ed., 1975) [11]	991
Hitoichi	‘The History of Hachirōgata Town’ (Hachirōgata Town History Compilation Committee, ed., 1977) [12]	234
Yamada	‘A Record of Shōwa Town’ (Shōwa Town Record Compilation Committee, ed., 1986) [13]	413
Kakumagawa	‘The History of Ōmagari City’[a)] (Ōmagari City, ed., 1999) [14]	752
Masuda	‘The History of Masuda Town’ (Masuda Town History Compilation Committee, ed., 1997) [15]	697
Iwasaki	‘The History of Yuzawa City’ (Yuzawa City History Compilation Secretariat, ed., 1965) [16]	433
Nishimonai	‘The Local History of Ugo Town’ (Ugo Town Local History Compilation Committee, ed., 1966) [17]	525
Innai	‘The History of Ogachi Town’ (Ogachi Town Local History Compilation Committee, ed., 1961) [18]	236

All documents: written in Japanese.
a): There is no description about the medieval times in “Ōmagari.”

First, we apply a technique of qualitative data analysis to the above documents to extract items regarded as the main constituents of them. Next, the obtained results are analyzed by using a technique of correspondence analysis [8] to quantitatively clarify the relationship between the documents and the extracted items.

3.2 Qualitative Data Analysis: Template Analysis

We apply template analysis [21], one of the techniques of qualitative data analysis, to the documents. In qualitative data analysis, each of the ‘segments’ in a document (or a set of documents) is manually ‘coded’ by investigating their meanings and context. The distinguishing feature of template analysis in qualitative data analysis is that a list of codes (i.e., a template) representing items identified in document data is provided. The template is generally organized in a hierarchical structure to clarify the relationship among the extracted items.

We regard each of the paragraphs constituting the analyzed documents as a segment coded in the analysis. Table 3 shows the number of the paragraphs coded in each document. As a result of coding, a set of 59 items classified into 16 fields was extracted as a

*6 These municipalities are the ones existed prior to the so-called great merger of municipalities in the Heisei era carried out in the mid-2000s. We selected this situation to keep the extracted information on each of the districts as pinpoint as possible.

Table 4 Categories, fields and items extracted by template analysis.

Category	Field	Item
Industry	Agriculture	1. General matters 2. *Kokudaka* (amount of rice yields) 3. *Kenchi* (land survey for imposing tax) 4. *Nengu* (rice paid as land tax) 5. *Jinushi* (a landlord in landlord-tenant farmer system) 6. Land ownership for rice fields 7. Development of new rice fields 8. Agricultural water 9. Crop failure 10. Utilization of rice for commercial purposes 11. Income from jobs other than farming 12. Grass sampling 13. Fruit cultivation
	Forestry	14. General matters 15. Firewood
	Fishery	16. Inshore fishery 17. River fishery 18. Fishery in Hachirōgata Lagoon
	Manufacturing	19. General matters 20. Ceramics 21. Metal work 22. Lacquerware 23. Woodworking 24. Natural asphalt 25. Liquor
	Mining	26. Mining
	Commerce	27. *Ichi* (market) 28. Trade
Community life	Transportation	29. Roads 30. River traffic 31. Post towns
	Culture	32. Education 33. Medicine 34. Hunting 35. Belief and performing arts
	Architecture	36. Castles 37. Palaces 38. Housing
	Migration	39. Migration from other regions
	Disaster	40. Flood damage 41. Fire
Politics	Clan	42. *Andō* Clan 43. *Onodera* Clan 44. *Satake* Clan 45. Other clans
	Administration	46. General matters 47. Organization 48. Population 49. Law 50. Financial affairs
	Battle	51. Northern region of Akita Domain 52. Southern region of Akita Domain 53. Other regions
Background knowledge	Geography	54. Northern region of Akita Domain 55. Southern region of Akita Domain 56. Other regions
	History	57. Northern region of Akita Domain 58. Southern region of Akita Domain 59. Other regions

template. **Table 4** shows the fields and items extracted in the analysis. As shown in Table 4, the extracted fields are further classified into four categories.

3.3 Quantitative Data Analysis: Correspondence Analysis

To quantitatively clarify the relationship between the obtained template and the analyzed documents, we apply a technique of correspondence analysis [8] to the two-way table giving the frequencies of the extracted items in each document. We use the values of the relative frequency of each item, instead of the absolute frequency, to eliminate the influence of the difference of document length.

Figure 3 shows the results of the analysis. Axis 1 is regarded as corresponding to the difference between Kotō and Senboku Areas; the districts in Kotō Area are mainly located on the right side, whereas those in Senboku Area are located on the left side. As for Axis 2, it is unclear what kind of variation this axis means. However, if one can venture to say, the difference between the northern and southern parts in each Area can barely be seen along this axis (top: northern part, bottom: southern part).

3.4 Discussion on the Results of Document Analysis

The most striking feature obtained by the document analysis is seen in the distribution of the items belonging to the fields of ‘Industry.’ In Figure 3, almost only the items of ‘Agriculture,’ in particular those related to rice cultivation (2-11 in Table 4, the same hereinafter), concentrated around the districts in Senboku Area. In contrast, the items corresponding to various industrial fields such as ‘Forestry,’ ‘Manufacturing’ and ‘Commerce’ were scattered around the districts in Kotō Area.

Focusing on Gojōme Town that was the commercial center of Kotō Area, the items of ‘Ceramics’ (20), ‘Metal work’ (21) and ‘Trade’ (28) are located nearby. According to the paragraphs coded as the above items in the document of Gojōme Town [11], the workers of ceramics and metal work were the immigrants who migrated from the provinces other than Dewa Province including the territory of Akita Domain, such as Mino and Kaga Provinces. In fact, part of the above paragraphs was coded also as ‘Migration from other regions’ (39). In

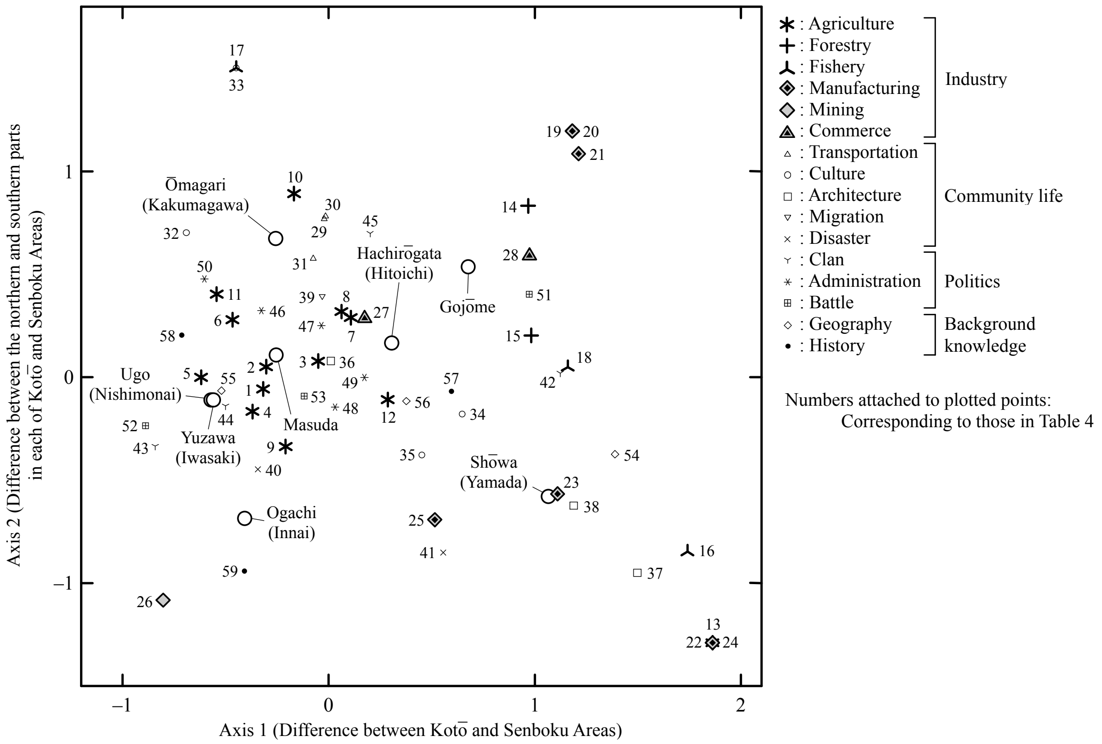

Figure 3 Distribution of document characteristics (from the medieval times to the early-modern times). (Method: Correspondence analysis, Correlation coefficients: 0.573 (Axis 1), 0.449 (Axis 2))

addition, it is also described that the merchants from Noto Province often came to sell lacquerware products (known as *Wajima-nuri*). The influx of human resources and articles from other regions might have brought about a cultural variety in the Gojōme district.

At the same time, these paragraphs describe that various products including the above ones had been sold in the market (called *Ichi* in the early-modern times) of the Gojōme district, and many people came there from the other districts in Kotō Area. The paragraph coded as '*Ichi*' (27) in the document of Hachirōgata Town (corresponding to the Hitoich district) [12] also describes the influence of *Ichi* of the Gojōme district. Such a situation might have made the cultural diversity of the Gojōme district spread over the surrounding districts. Although there still remains uncertainty, the above descriptions suggest a possibility that this situation might have affected the diversity of the motion styles of the *Bon Odori* dances in Kotō Area shown in Figure 2.

As for Senboku Area, on the other hand, almost only the items corresponding to rice cultivation were concentrated around the districts in this area as already mentioned. Although this situation might have been related to the unification of the motion style of the dances passed down in this area, there is still no clear evidence to support this theory.

Focusing on the scarce items corresponding to the industrial fields other than 'Agriculture' around the districts in Senboku Area, the item of 'Mining' (26) is located near Ogachi Town (corresponding to the Innai district). The Innai district was a mining town neighboring to the Innai silver mine [4]. According to part of the paragraphs coded as 'Mining' in the document of Ogachi Town [18], its amusement quarter attracted many professional dancers, i.e., *Geisha* dancers, as the mine prospered. In fact, these paragraphs were coded also as 'Belief and performing arts' (35). These paragraphs also describe that the dancers were those who came from the cultural front line such as Edo, the capital of the country, or Ōsaka, the commercial city in the Kamigata region. As already mentioned in Refs. [4] and [20], their sophisticated dancing style, including the rhythm complexity, is estimated to have affected that of the folk dances passed down in the Innai district,.

As shown in Figure 1, the Innai district and the other districts in Senboku Area were connected by Ushū Kaidō Road and Omono River that was a water route between the Innai district and the capital of Akita Domain where Kubota-jō Castle existed. This distribution network might have caused the similarity of the motion style of *Bon Odori* dances, particularly that of the rhythm complexity shown in Figure 2, in Senboku Area.

4. Conclusions

By using the proposed approach including both Mocap data analysis and document analysis, we obtained a new insight into, or at least a slight clue to, the variation of *Bon Odori* dances in the areas along Ushū Kaidō Road. It suggests that the difference of motion style between the dances of Kotō Area and those of Senboku Area might have been caused by the difference in the diversity of industry. However, uncertainty in the obtained results was not sufficiently removed at the present stage. This means that the development of a method to validate the appropriateness of the obtained results is needed to eliminate uncertainty. This will be the subject of future work.

Acknowledgments This study was supported by Grants-in-Aid for Scientific Research (No. 26370942) of Japan Society for the Promotion of Science. The motion-capture data of the *Bon Odori* dances passed down in the Yamada districts were provided by Akita University's Center of Community Project "Regional Development Aimed at Promoting an Independent Aging Society in Which All Individuals Have Value."

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