Quantitative motion analysis of the Japanese folk dance "Hitoichi Bon Odori"

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Bon Odori is a Japanese folk dance performed during the annual Buddhist festival called *O-Bon*. *Hitoichi Bon Odori* is known as one of the top three *Bon Odori* dances in Akita Prefecture. In this study, we present a trial to investigate the motion characteristics of *Hitoichi Bon Odori* through quantitative motion-capture data analysis. The characteristics of rhythmic style and posture variation are extracted in the analysis. The extracted characteristics were compared with those of the other members of the top three *Bon Odori* dances, i.e. *Kemanai Bon Odori* and *Nishimonai Bon Odori*. The most striking feature of *Hitoichi Bon Odori* shown in the obtained results was its large expanse of motion characteristics. It was quantitatively confirmed that the expanse was much larger than those of the other dances in both of rhythmic style and posture variation. This tendency was consistent with the oral traditions of the three dances.

1. Introduction

Bon Odori is a Japanese folk dance performed during the annual Buddhist festival called *O-Bon*. *Hitoichi Bon Odori* is known as one of the top three *Bon Odori* dances in Akita Prefecture [1]. The remaining two are *Kemanai Bon Odori* and *Nishimonai Bon Odori*. Among these dances, only *Hitoichi Bon Odori* is classified into the category *Odori Nenbutsu* (invocations to the Buddha, performed while dancing), whereas the remaining two into *Nenbutsu Odori* (dances accompanying the recital of Buddhist chants) [1]. Besides, these three belong to the different groups distinguished by geographical location as will be mentioned later. Such differences are thought to have produced the motion characteristics peculiar to *Hitoichi Bon Odori* [1].

So far, the motion characteristics of *Hitoichi Bon Odori* have been investigated mainly through qualitative procedures such as researchers' observations, hearing surveys or literature searches [1][2]. In this study, we adopt the approach of motion-capture (Mocap) data analysis. This allows us to evaluate motion characteristics more objectively and quantitatively, and thereby understand the position of *Hitoichi Bon Odori* among the folk dances of Akita Prefecture more deeply.

To make it easier to grasp the aspect of dance motion, we separate the process of motion analysis into two parts: the extraction of time-domain characteristics (rhythmic style) and that of spatial-variation characteristics (posture variation). We compare the characteristics extracted from *Hitoichi Bon Odori* with those of *Kemanai Bon Odori* and *Nishimonai Bon Odori*.

2. *Bon Odori* of Akita Prefecture

2.1 Distribution of *Bon Odori* dances in Akita Prefecture

The *Bon Odori* dances of Akita Prefecture are largely classified into three groups distinguished by geographical location: Coastal Area Group (CA), Yoneshiro River System Group (YRS) and Omono River System Group (ORS) [2].

The distribution of the top three *Bon Odori* dances is shown in **Figure 1**. *Hitoichi Bon Odori* is regarded as one of the members of CA, since its home ground, namely the Hitoichi district of Hachirogata Town, exists in the coastal area. Dances belonging to CA are often categorized as the *Dagujigu* type [1] (*Dagujigu*: an onomatopoeia describing drum beats, presumed to represent dynamic movements). On the other hand, *Kemanai Bon Odori* is regarded as belonging to YRS, due to the fact that the Kemanai district of Kazuno City is adjacent to Kosaka River which is a tributary of Yoneshiro River. As for *Nishimonai Bon Odori*, it is regarded as belonging to ORS, since Nishimonai River flowing near the venue of the *O-Bon* festival in Ugo Town is part of Omono River System.

The Mocap data of the top three *Bon Odori* dances

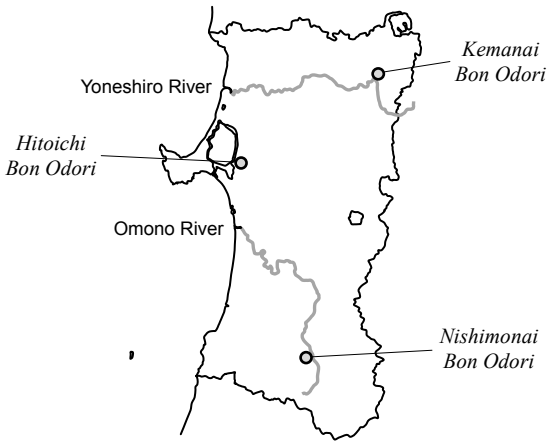

Figure 1 Distribution of the top three *Bon Odori* dances in Akita Prefecture.

analyzed in this study are shown in **Table 1**. Multiple data streams are prepared at every dance. The following three sections will give overviews about the features of these dances.

2.2 Overview of *Hitoichi Bon Odori*

Although there is a legend that Ennin (794-864, a priest of the Tendai school) established *Hitoichi Bon Odori* [3], its origin is in fact uncertain. According to Masumi Sugae's work [4], however, it is highly possible that the archetype of *Hitoichi Bon Odori* existed at least in the early nineteenth century, namely in the Edo period.

It is said that a variety of motion styles in the choreography of *Hitoichi Bon Odori* were gradually organized into two dances, i.e. *Dendenzuku Odori* and *Kitasaka Odori* [5]. These dances are known as those with a dynamic quick tempo [1], and their vigorous movements are considered to be comparable to those of Native American dances [5]. As suggested in [1], this property, i.e. the property of *Dagujigu* seen in CA, may be attributed to the fact that the Hitoichi district belonged to the coastal-area territory of the Hiyama Andō clan (one of the military clans in medieval Japan, having several key ports for the *suigun* navy) [1].

It has been passed down, on the other hand, that *Sankatsu Odori* having a graceful slow tempo was later introduced from outside [1]. The origin of *Sankatsu Odori* is also not known exactly, but one theory states that it may have come from the old capital city of Kyoto [5]. This theory, i.e. the theory suggesting the connection with elegant Kyoto-style culture, well explains the reason why the rhythmic style of *Sankatsu Odori* is so graceful.

Figure 2 shows the choreography of *Hitoichi Bon Odori*. The keyposes shown in this figure are the ones selected based on the explanation about the motion sequences of this dance in [1]; we gave one keypose to each unit gesture. It is indicated that the IQR values of keypose intervals are much smaller than the medians of them in all the dances[*1]. This means that

Table 1 Motion capture data of *Bon Odori* dances.

Dance		Index	No. of frames	Dancer
Hitoichi Bon Odori	*Dendenzuku Odori*	#1	195	A
		#2	200	A
		#3	195	A
(CA, *Odori Nenbutsu*)	*Kitasaka Odori*	#1	163	A
		#2	156	A
		#3	170	A
		#4	167	A
		#5	163	A
		#6	190	A
	Sankatsu Odori	#1	353	A
		#2	367	A
		#3	359	A
		#4	322	A
Kemanai Bon Odori	*Dainosaka Odori*	#1	308	B
		#2	323	B
		#3	343	B
(YRS, *Nenbutsu Odori*)	*Jinku Odori*	#1	294	B
		#2	276	B
		#3	324	B
Nishimonai Bon Odori	*Ondo*	#1	1,341	C
		#2	1,336	C
		#3	1,326	D
(ORS, *Nenbutsu Odori*)		#4	1,341	D
	Ganke	#1	1,236	C
		#2	1,231	C
		#3	1,235	D
		#4	1,219	D

Frame rate: 30 fps
Motion capture: Magnetic-sensor systems
Hitoichi: MotionStar Wireless (Ascension Technology Corporation)
Kemanai and *Nishimonai*: MotionStar Wireless with LIBERTY (Polhemus) ×2
Dancers
A: Female (with more than ten years' experience in dancing *Hitoichi Bon Odori*)
B: Female (with more than ten years' experience in dancing *Kemanai Bon Odori*)
C: Female (with more than ten years' experience in dancing *Nishimonai Bon Odori*)
D: Female (with more than ten years' experience in dancing *Nishimonai Bon Odori*)

[*1] We use quartiles as the statistics characterizing the distribution of keypose intervals, instead of means and standard deviations. In the case that intervals are grouped into two values, for example, the mean value becomes a value which does not exist in the actual interval values. When the total number of intervals is an odd number, this can be avoided by using the second quartile, i.e. the median. In the case that the total number of intervals is an even number, we supplement a series of interval values with a minimum interval to make the total number an odd number. We selected a minimum interval as a supplement value since more detailed movements can be reconstructed by using shorter keypose intervals.

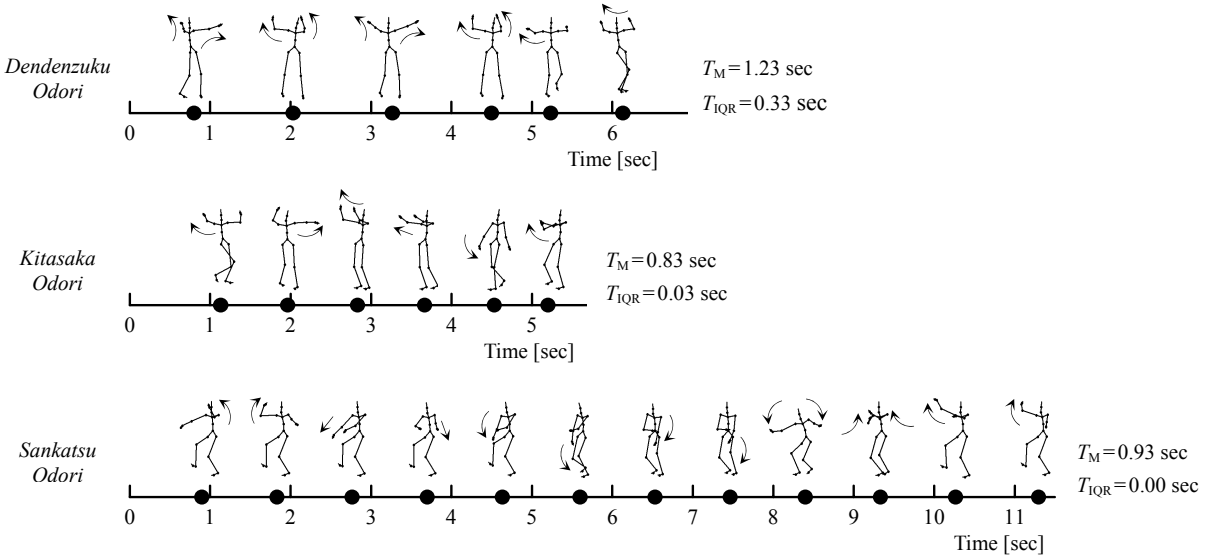

Figure 2 Choreography of *Hitoichi Bon Odori* (motion capture data: #1).

each dance gives a series of keyposes arranged at substantially regular intervals. As for the medians, on the other hand, values smaller than those of the other dances are given as a whole, as will be shown later.

It can also be recognized in Figure 2 that both the upper and lower parts of the body move relatively vigorously in *Dendenzuku Odori* and *Kitasaka Odori*, whereas the lower part is kept motionless throughout the former half of *Sankatsu Odori*. The latter property, i.e. making gestures while standing with an elegant posture, is considered as one of the causes of the gracefulness seen in *Sankatsu Odori* [1].

As mentioned in Section 1, *Hitoichi Bon Odori* is classified into *Odori Nenbutsu*. The original format of *Odori Nenbutsu* is that dancers themselves invoke the name of the Buddha (i.e., chant the *nenbutsu*) while dancing [6]. Although the phrases chanted by the dancers of *Hitoichi Bon Odori* have little to do with the *nenbutsu* at the present time [1], the format that dancers vocalize while dancing has been inherited from generation to generation. This has given dancers the pleasure of dancing while calling out to each other, and thereby made *Hitoichi Bon Odori* "*Odoru Odori*" (dances recommended to be danced by all the people attending the *O-Bon* festival) rather than "*Miru Odori*" (dances to be appreciated) [1].

The festival of *Hitoichi Bon Odori* is held in Hachirogata Town on August 18-20.

2.3 Overview of *Kemanai Bon Odori*

The origin of *Kemanai Bon Odori* (consisting of *Dainosaka Odori* and *Jinku Odori*) is uncertain, same as the case of *Hitoichi Bon Odori*. However, the connection with the *Nenbutsu Odori* of Kyoto has been pointed out [2][6][7]. In the performance of *Nenbutsu Odori*, unlike *Odori Nenbutsu*, dancers and chanters (or accompanists) are separated from each other [6]; *Kemanai Bon Odori* is in fact performed in this style. The choreography of *Kemanai Bon Odori* is often characterized by elegance and refinement [7]. This may suggest the influence of elegant Kyoto-style culture. Due to its simple but sophisticated motion sequences which also give the feel of Kyoto-style culture, *Kemanai Bon Odori* is regarded as "*Miru Odori*" rather than "*Odoru Odori*" [1].

Figure 3 shows the choreography of *Kemanai Bon Odori*. The keyposes in this figure are the ones used in [7] for illustrating the details of the choreography. It is shown that the IQR values of keypose intervals are much smaller than the medians of them. This means that intervals between keyposes are almost regular in both of *Dainosaka Odori* and *Jinku Odori*. It is also recognized that the values of medians are longer than those of *Hitoichi Bon Odori*. Longer between-keypose intervals can bring gentle transitions between postures, and thereby the elegant and refined impression may be produced.

As mentioned in Section 2.1, *Kemanai Bon Odori* belongs to YRS. According to [2], the folk performing arts belonging to YRS are marked by large-sized drums used in musical performances. On the other hand, however, no distinctive motion characteristic symbolizing the choreography of the dances belonging to YRS has been reported up to the present.

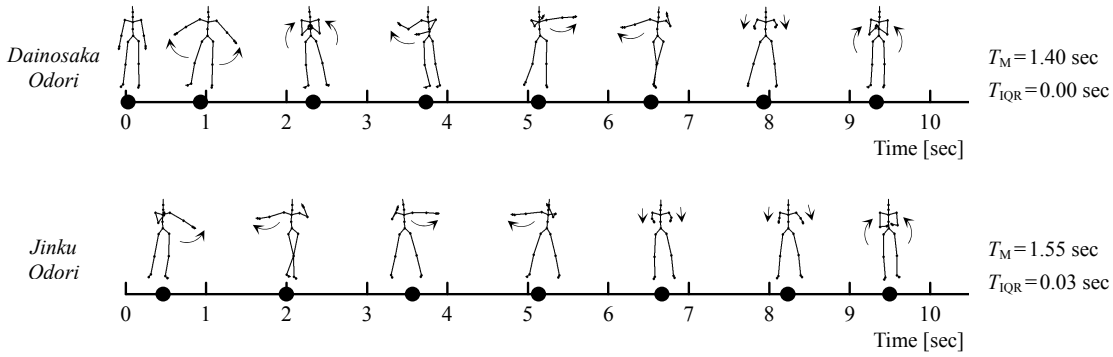

Figure 3 Choreography of *Kemanai Bon Odori* (motion capture data: #1).

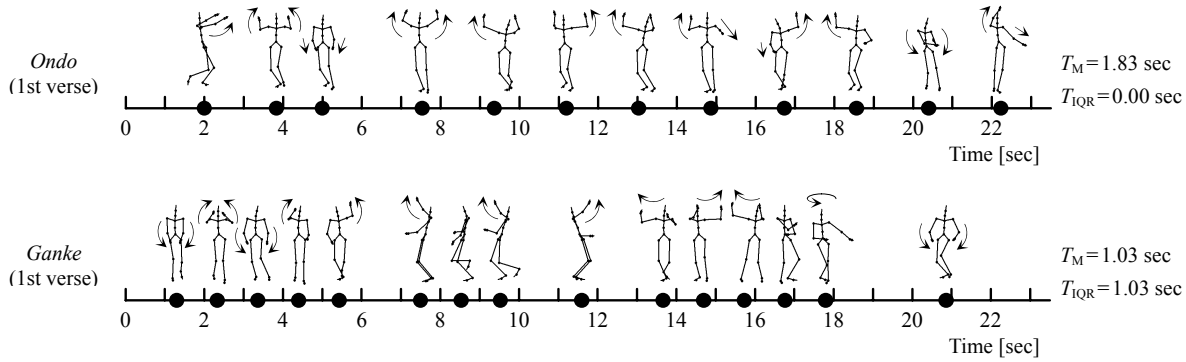

Figure 4 Choreography of *Nishimonai Bon Odori* (motion capture data: #1).

Therefore, the characteristics mentioned above may be limited to the case of *Kemanai Bon Odori*.

The festival of *Kemanai Bon Odori* is held in Kazuno City on August 21-23.

2.4 Overview of *Nishimonai Bon Odori*

As for *Nishimonai Bon Odori* (consisting of *Ondo* and *Ganke*), there are several oral traditions about its origin. A typical one is that the vassals of the Onodera clan (ruined after the Battle of Sekigahara in 1600) started it to pray for the dead soul of their feudal lord [8][9]. It is said that at that time one of the *Hōnen Odori* dances, established in the thirteenth century by a monk named Genshin, was incorporated [8][9]. According to [8], this dance was originated from the drama style *Ennen* including a variety of elaborate performance forms [6]. In fact, the motion sequences of *Nishimonai Bon Odori* consist of a relatively long series of various sophisticated movements: e.g., graceful arm movements suggestive of a rice ear waving in the wind [8], etc. This tendency, i.e. elaborate motion sequences, is often seen in the dances belonging to ORS [10].

The above motion feature is extremely fascinating, and recently it is becoming an important factor to attract tourists [11]. Due to this situation, many people recognize *Nishimonai Bon Odori* as "*Miru Odori*" [1][11]. As mentioned in Section 1, on the other hand, *Nishimonai Bon Odori* is also classified into *Nenbutsu Odori* because of its performance style, i.e. separation between dancers and chanters [1].

Figure 4 shows the choreography of *Nishimonai Bon Odori*. The keyposes in this figure are the ones used in [12] for illustrating the details of the choreography. The number of keyposes in *Ondo* is 25 and that in *Ganke* 29 (both consist of two verses[*2]). These numbers are much larger then those of *Hitoichi Bon Odori* and *Kemanai Bon Odori* (i.e. the numbers less

[*2] Two verses have almost the same length in both of *Ondo* and *Ganke*. In Section 4, an entire motion sequence including both of two verses is analyzed as one dance.

than or equal to 12). In addition, the IQR value of keypose intervals in *Ganke* is considerably large compared with those of the other dances, although that in *Ondo* is almost zero. These data indicate the elaborateness of the choreography of *Nishimonai Bon Odori*. It is also shown that the values of medians, especially that of *Ondo*, are longer than those of *Hitoichi Bon Odori*.

The festival of *Nishimonai Bon Odori* is held in Ugo Town on August 16-18.

3. Analysis Methods

3.1 Comparison of motion characteristics

As mentioned in Section 2, the dances analyzed in this study have a variety of motion styles. To enable the comparison of motion characteristics among such dances, extracting motion characteristics in a unified format is desirable. As for both of rhythmic style and posture variation, fortunately, relatively simple analysis methods providing motion-characteristic data in a unified format were already proposed [13][14]. We adopt these methods as follows.

3.2 Extraction of rhythmic-style characteristics

To extract the rhythmic-style characteristics of each dance, we use a modified version of the method proposed in [13]. The degree of beat intensity and that of rhythm complexity is evaluated in this method.

First, we obtain a one-dimensional motion-speed time series from the displacement of $J = 16$ points (shoulders, elbows, wrists, fingers, knees, ankles, toes, neck and head):

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

where $p_{j,\gamma}(n)$ (γ: x, y or z) is the γ-coordinate of the jth point at the nth frame (coordinate system: fixed to the pelvis) and Δt the sampling time (Δt = 0.033 sec), 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 height of the body 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:

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

where τ is the frame number giving the first positive peak of the autocorrelation of $v(n)$ (regarded as the beat interval), $v_0(n)$ the moving average of $v(n)$ (period: τ), N the total number of frames and A the weighting coefficient to the beat-interval element $\tau\Delta t$, respectively. We obtained Eq. (2) by applying a logarithm transformation to Eq. (2) of [13]. This modification allows us to adjust the weighting ratio between the speed-variation element (the first term of (2)) and the beat-interval element (the second term of (2)); we finally set $A = 0.2$. The larger the speed variation in each beat interval is, or the quicker the beat appearance is, the larger the value of BI becomes.

As for rhythm complexity, on the other hand, the value of approximate entropy (ApEn) [15][16] obtained from $v(n)$ is used [13]:

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

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

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

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

$$\mathrm{ApEn} = \Phi^m - \Phi^{m+1} \quad (3)$$

where $\tau' = \mathrm{INT}(0.2\tau)$, $m = 3$, $r = 0.25 \times$(standard deviation of $v(n)$) and $\theta(x)$ is the Heaviside function, respectively. Equation (3) represents the ApEn model including the time-delay parameter τ' [16]. We adopt this model since the time scale of autocorrelation in Mocap data is generally much longer than Δt. The ApEn value becomes large when the variation of motion speed shows a large amount of complexity.

3.3 Extraction of posture-variation characteristics

As for the extraction of posture-variation characteristics, we use the method proposed in [14]. This method statistically summarizes the spatial distribution of the 16 points used in Eq. (1) as a 12-dimensional feature vector.

First, the distribution of the above points is quantified at each frame using the variances and covariances of coordinate values:

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

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

As shown in **Figure 5**, a set of six values obtained from Eq. (4) represents the dispersion 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 treat these values

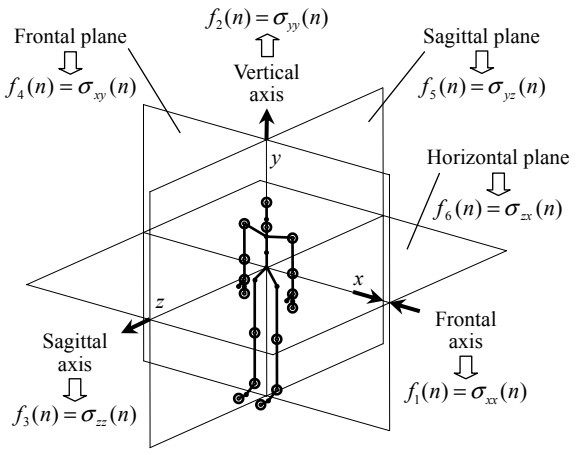

Figure 5 Extraction of posture variation.

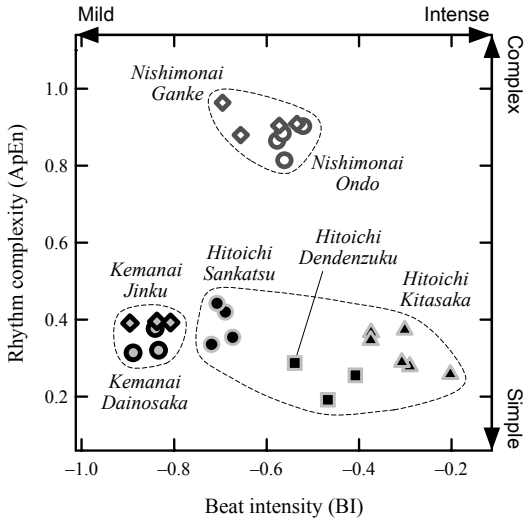

Figure 6 Distribution of rhythmic style.

as the components of the feature vector $\boldsymbol{f}(n)$ characterizing a posture in each frame:

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

Finally, the tendency throughout an entire motion sequence is statistically summarized as the 12-dimensional feature vector $\boldsymbol{F}$ as follows:

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

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

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

The former six components represent the dispersion averaged throughout an entire motion sequence. Three of them correspond to the dispersion along the three axes of movement, whereas the remaining three to the dispersion on the three planes of movement. On the other hand, the latter six components represent the fluctuation of dispersion during an entire motion sequence. These six components also correspond to the axes and planes of movement respectively.

4. Results and Discussion

4.1 Rhythmic-style characteristics

The distribution of the rhythmic-style characteristics of all the Mocap data in Table 1 is shown in **Figure 6**. The top three *Bon Odori* dances formed their respective clusters. The within-cluster variances of these dances are shown in **Table 2**. From these data, one can recognize that the cluster of *Hitoichi Bon Odori* spread more widely than those of *Kemanai Bon Odori* and *Nishimonai Bon Odori*. In particular, the spread in a horizontal direction, i.e. the variety of beat intensity, was remarkable. As mentioned in Section 2.2, *Hitoichi Bon Odori* had originally consisted of two quick-tempo dances (*Dendenzuku Odori* and *Kitasaka Odori*), and *Sankatsu Odori* having a graceful slow tempo was later introduced from outside. The obtained results are consistent with this oral tradition.

Table 2 Within-cluster variances (rhythmic style).

Hitoichi Bon Odori	*Kemanai Bon Odori*	*Nishimonai Bon Odori*
0.897	0.050	0.116

(Values of BI and ApEn: Standardized)

As for rhythm complexity, *Hitoichi Bon Odori* was located at the area of "Simple." Its simplicity was much higher than that of *Nishimonai Bon Odori* well known for its sophisticated movements. As already described in Section 2.2, *Hitoichi Bon Odori* has been regarded as "*Odoru Odori*" rather than "*Miru Odori*." This may have brought a simple rhythmic style everyone can easily dance.

It is also shown that *Sankatsu Odori* was located at the area close to that of *Kemanai Bon Odori*. This suggests that these dances might have some property common to both of them. As mentioned in Sections 2.2 and 2.3, it has been pointed out that both of *Sankatsu Odori* and *Kemanai Bon Odori* show the possi-

Table 3 Factor analysis of posture-variation characteristics.

Component	Factor Loading		Communality
$\sigma_{xy\,\mathrm{mean}}$	0.908	-0.197	0.864
$\sigma_{xx\,\mathrm{SD}}$	0.872	0.289	0.844
$\sigma_{xz\,\mathrm{SD}}$	0.863	0.236	0.801
$\sigma_{yy\,\mathrm{SD}}$	-0.762	-0.065	0.586
$\sigma_{yz\,\mathrm{SD}}$	-0.698	0.473	0.711
$\sigma_{xy\,\mathrm{SD}}$	0.568	0.327	0.430
$\sigma_{yz\,\mathrm{mean}}$	0.142	0.903	0.835
$\sigma_{yy\,\mathrm{mean}}$	0.029	0.849	0.722
$\sigma_{xx\,\mathrm{mean}}$	0.356	0.751	0.691
$\sigma_{zz\,\mathrm{SD}}$	0.226	0.658	0.484
$\sigma_{zz\,\mathrm{mean}}$	-0.161	0.427	0.208
$\sigma_{xz\,\mathrm{mean}}$	0.250	-0.266	0.133
Contribution	33.4%	27.5%	Total: 60.9%
	⇩ Transverse motion	⇩ Direction on sagittal plane	

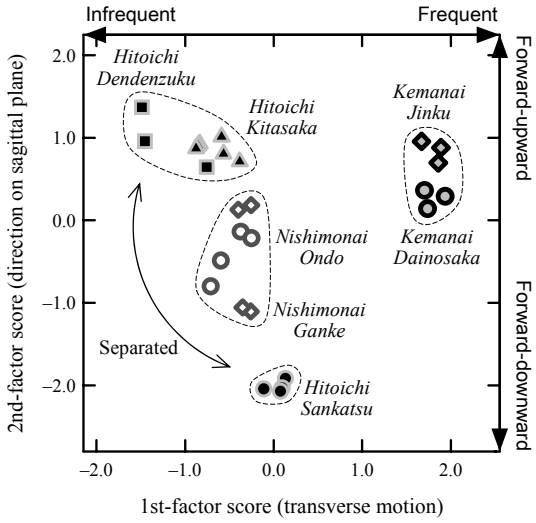

Figure 7 Distribution of posture variation.

bility of having the connection with Kyoto-style culture. The obtained results could support this theory.

4.2 Posture-variation characteristics

To grasp the distribution of posture-variation characteristics in a low dimensional space, i.e. on a plane, we applied factor analysis to the set of the feature vectors obtained from all the Mocap data in Table 1. These data were analyzed by the principal factor method with the normal varimax rotation for an $l = 2$ factor model (l: number of common factors) [17]. The obtained result is shown in **Table 3**. Although the number of common factors was only two, the total contribution of them greatly exceeded 50%. The first factor is regarded as corresponding to transverse motion since it is dominated mainly by $\sigma_{xy\,\mathrm{mean}}$, $\sigma_{xx\,\mathrm{SD}}$ and $\sigma_{xz\,\mathrm{SD}}$; all of them include the x component corresponding to a transverse direction. On the other hand, the second factor, dominated mainly by $\sigma_{yz\,\mathrm{mean}}$ and $\sigma_{yy\,\mathrm{mean}}$, can be interpreted as that representing the direction of dispersion on the sagittal plane corresponding to the yz plane.

The distribution of posture variation, obtained from the factor scores of all the Mocap data, is shown in **Figure 7**, and the within-cluster variance of each dance is shown in **Table 4**. In Figure 7, the cluster of *Hitoichi Bon Odori* was separated into two parts in a vertical direction, i.e. distinguished by the aspect of posture variation on the sagittal plane. The cluster of *Nishimonai Bon Odori* was put between them. The within-cluster variance of *Hitoichi Bon Odori* thereby increased as shown in Table 4.

As mentioned in Section 2.2, the lower part of the body is kept motionless in the former half of *Sankatsu Odori*. During this period, the right foot is raised in a forward-downward direction on the sagittal plane, and at the same time the arms are gently moved. The gracefulness of *Sankatsu Odori* remarkably appears in this situation. In *Dendenzuku Odori* and *Kitasaka Odori*, on the other hand, the arms are vigorously raised in a forward-upward direction as shown in Figure 2. This movement can be considered as contributing to the enhancement of the *Dagujigu* property. Such a contrast between *Sankatsu Odori* and the remaining two is quantitatively reflected in the separation of the cluster shown in Figure 7.

Table 4 Within-cluster variances (posture variation).

Hitoichi Bon Odori	*Kemanai Bon Odori*	*Nishimonai Bon Odori*
2.299	0.126	0.286

As for the factor of transverse motion, on the other hand, the distinctiveness of *Kemanai Bon Odori* was rather emphasized than that of *Hitoichi Bon Odori*. In fact, the action of reaching out an arm in a transverse direction, shown in Figure 3, is a distinctive motion in *Kemanai Bon Odori*. As pointed out in Section 4.1, the rhythmic-style characteristics of *Kemanai Bon Odori* were considerably close to those of *Sankatsu Odori*. Nevertheless, *Kemanai Bon Odori* showed extremely different posture-variation characteristics from those of *Sankatsu Odori*. This means that the property common to both of them would be unassociated with any spatial aspect of dance motion.

4.3 Discussion

The most striking feature of *Hitoichi Bon Odori* shown in the above results is its large expanse of mo-

tion characteristics. It was confirmed that the expanse was much larger than those of *Kemanai Bon Odori* and *Nishimonai Bon Odori* in both of rhythmic style and posture variation.

The above feature may be attributed to the fact that *Hitoichi Bon Odori* is regarded as "*Odoru Odori*" (originated from the format of *Odori Nenbutsu* as mentioned in Section 2.2). In old times, according to [1], people who came to the Hitoichi district from other places[*3] attended the *O-Bon* festival, and performed the dances inherited in their own hometowns. Even people from other places were allowed to dance freely because *Bon Odori* had been recognized as "*Odoru Odori*" there. Such a custom is thought to have led to the introduction of new dance styles from outside. This kind of oral tradition, i.e. introducing dance styles later from outside, is not seen in both of *Kemanai Bon Odori* and *Nishimonai Bon Odori*. It seems to be reasonable to think, therefore, that this situation was at least one of the factors which caused the expanse of motion characteristics only for *Hitoichi Bon Odori*.

The above tendency was quantitatively clarified by analyzing Mocap data. This suggests that the introduction of Mocap data analysis into the investigation of folk dances is really effective.

5. Conclusions

The main contribution of this study is the introduction of Mocap data analysis into the investigation of the folk dance *Hitoichi Bon Odori*. The proposed approach gave a successful outcome that motion characteristics peculiar to *Hitoichi Bon Odori* were quantitatively clarified. The next step would be to increase the number of dances used in the analysis. It is expected that the obtained results will further expand our knowledge about the folk performing arts of Akita Prefecture.

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[*3] There were many visitors to the Hitoichi district which had prospered since the early Edo period as a post town.