Transition of Historical-Map Characteristics of Akita City in the Edo Period

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Abstract: In this study, the overall transition perspective of the historical-map characteristics of the castle town in Akita City throughout the Edo period is visualized. We pay attention on the shape of the road-moat network in the castle town around Kubota Castle. The characteristics of the geometric-deformation style of the above shape are quantitatively visualized as a simple two-dimensional scatter plot. It is confirmed in the visualization process for the set of the four historical maps of the castle town that the reproduction accuracy, or the deformation style, of the shape of the road-moat network plays an important role to emphasize the peculiarity of the map created in the late Edo period.

Keywords: historical map, Akita City, Kubota Castle, castle town, map deformation

1. Introduction

Now, Akita City is the capital of Akita Prefecture, Japan. In the Edo period (1603-1868), the central area of Akita City developed as a castle town around Kubota Castle built by the Satake clan, i.e., rulers of Akita Domain (part of current Akita Prefecture) [1]. Today, there remain several historical maps in each of which the state of the above castle town in the Edo period is recorded [2]. Most of them were created so as to reproduce the state of the castle town as accurately as possible to precisely report the geometric situation of the town to the Tokugawa shogunate, or to specify the territory of each district [2],[3]. However, as will be mentioned later, there is a map that does not accurately reproduce the geometric situation of the castle town, even though it was created in the period later than that in which more accurate maps were created. The reason and purpose to create such a map are still unknown. In the research and investigation of the castle town in Akita City, to our knowledge, there is no example positively examining the state of the reproduction accuracy of geometric situation in the historical maps, and thereby, the cause of the lack of geometric accuracy shown in the maps including the above one is still unclear.

On the other hand, it is well known that geometric distortion, or deformation, is generally often seen in historical maps, and there is a research example focusing on utilizing information on the above deformation for characterizing each historical map [4]. As already mentioned, there is a map of the castle town in Akita City in which the geometric situation of the town is not accurately reproduced, i.e., the map is deformed. Considering the above situation, we try to extract the characteristics of the historical maps of the castle town in Akita City, using the information on their geometric deformation, and compare them with each other. In particular, we place importance on quantitatively summarizing map-deformation characteristics into a small number of evaluation indices. This allows us to concisely visualize the transition of the historical-map characteristics as a simple scatter plot in a low-dimensional space. It is thereby expected that an opportunity to gain a new insight into the geometric deformation of the maps, which has not been positively examined, from the overall transition perspective concisely visualized in the scatter plot.

To quantitatively evaluate the geometric situation of a given historical map, we pay attention on the directions of principal line elements in the town layout, such as roads and moats, which play an important role in determining the structure of the castle town. By statistically analyzing the data of line-element directions in a given historical map, an evaluation index providing information on the state of map deformation is obtained. On the other hand, another evaluation index is obtained by calculating the structure scale of a set of the line elements included in a given map. As a result, a simple two-dimensional scatter plot visualizing the transition of the geometric historical-map characteristics of the castle town in Akita City throughout the Edo period is obtained. In particular, the peculiarity of the map deformed with a specific style is concisely clarified. This emphasizes the necessity of quantitatively investigating the state of the reproduction accuracy of geometric situation in the historical maps of the castle town in Akita City.

2. Castle Town in Akita City

2.1 Structure of the Castle Town in Akita City

As already mentioned in Section 1, Kubota castle was built by the Satake clan. The construction of Kubota castle began in 1603, and Yoshinobu SATAKE, the first feudal load of Akita Domain, entered it in 1604 [1],[5]. Kubota castle is a *Hirayama-jiro* type castle (castle built on a hill in a plane) without *Tenshu* (main tower), including two *Kuruwa* compounds without stone wall [1].

Figure 1 shows the structure of the castle town around Kubota Castle in Akita City. The main part of the castle town consists of three areas colored in Fig. 1: the *San no Kuruwa* (*Third compound*, purple), *Shi*

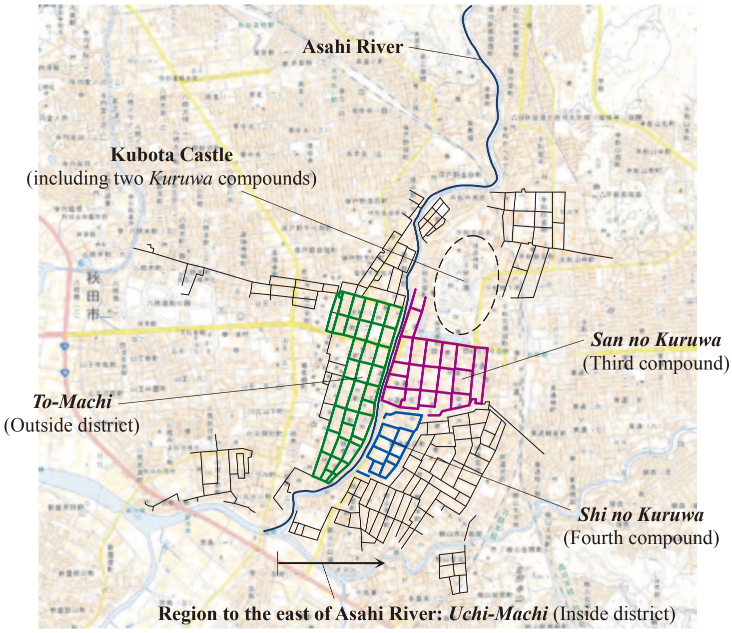


Fig. 1 Structure of the castle town of Kubota Castle (Background: image data of the present map of Akita City, downloaded from the web site of the Geospatial Information Authority of Japan <https://maps.gsi.go.jp/help/intro/>).

no Kuruwa (*Fourth compound*, blue) and *To-Machi* (*Outside district*, green) areas [1]. Although each of these areas (and in addition the area to the south of *Shi no Kuruwa* and the northeastern part of the town) was built with a relatively regular grid plan, the directions of their base axes are not in parallel and shifted from the meridian [6]. The layout of the main part of the castle town was almost established in the middle of the 17th century [1], and the development of its entire area including the surrounding areas was almost completed in the early 18th century [7].

2.2 Historical Maps of the Castle Town

In this study, we analyze four historical maps of the castle town in Akita City. As already mentioned in Section 1, the directions of principal line elements in the town layout are analyzed. We manually extract the line elements comprising a road-moat network of the castle town from each historical map. The historical maps analyzed in this study are shown in **Fig. 2** (The extracted road-moat network of each map is also drawn in Fig. 2 as a set of black lines.).

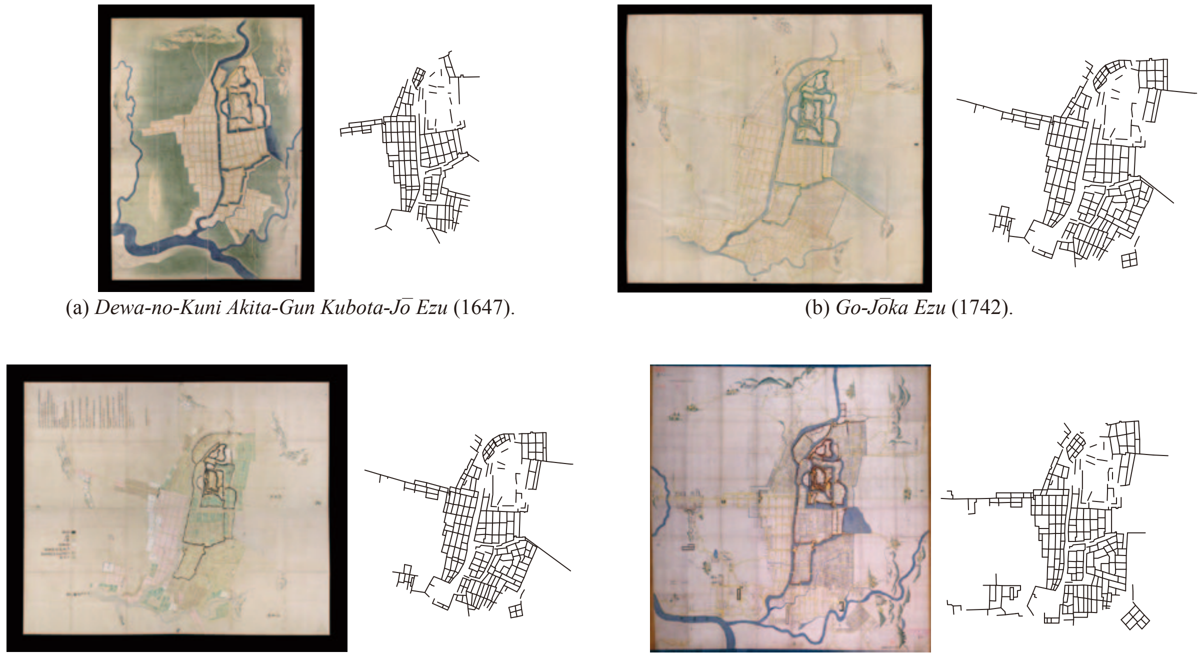
The map shown in Fig. 2 (a) is *Dewa-no-Kuni Akita-Gun Kubota-Jō Ezu* (*The pictorial map of Kubota Castle in Akita County, Dewa Province*) created in 1647 (early Edo period, 348 cm long and 252 cm wide) [8], and the road-moat network extracted from it consists of 419 line elements. This map is the copy of the official pictorial map submitted to the Tokugawa shogunate [8]. According to Ref. [3], it was pointed out in the mid Edo period that an error in the setup of the four directions of east, west, north and south existed in the castle-town maps created in the early Edo period. The map of (a) is included in them. In fact, the road-moat network of (a) seems to be rotated counterclockwise from the actual orientation shown in Fig. 1.

The map shown in Fig. 2 (b) is *Go-Jōka Ezu* (*The pictorial map of the castle town*) created in 1742 (mid Edo period, 299 cm long and 326 cm wide[*1]) [8], and the road-moat network extracted from it consists of 639 line elements. According to Ref. [3], the map revision work to correct the above direction error started in 1741. The orientation of the road-moat network of (b) is actually closer to that of Fig. 1 than that of (a). From this fact, one can see that the map of (b) is one of the revised maps created to correct the direction error.

The map shown in Fig. 2 (c) is *Go-Jōka Ezu* (*The pictorial map of the castle town*) created in 1759 (mid Edo period, 179 cm long and 221 cm wide[*2]) [8], and the road-moat network extracted from it consists of 638 line elements. This map is also the copy of the official pictorial map submitted to the Tokugawa shogunate [8], as in the case of (a). The orientation of

[*1] This map originally puts east on top, and the map shown in Fig. 2 (b) is rotated 90 degrees clockwise to put north on top in accordance with the current conventions in surveying. The values of length and width are those of the rotated map.

[*2] This map originally puts south on top, and the map shown in Fig. 2 (c) is rotated 180 degrees to put north on top. The values of length and width are those of the rotated map.



(a) *Dewa-no-Kuni Akita-Gun Kubota-Jō Ezu* (1647). (b) *Go-Jōka Ezu* (1742).

(c) *Go-Jōka Ezu* (1759). (d) *Ushū Kubota Ōezu* (1828).

Fig. 2 Historical maps of Akita City and extracted line elements (Image data: downloaded from "Akita Prefectural Archives Digital Archive" <https://da.apl.pref.akita.jp/koubun> ((a)-(c)) and "Akita Prefectural Library Digital Archive" <https://da.apl.pref.akita.jp/lib/> ((d))).

the road-moat network of (c) is closer to that of Fig. 1 than that of (a). This means that the direction error was also corrected in this map, as in the case of (b).

The map shown in Fig. 2 (d) is *Ushū Kubota Ōezu* (*The large-size pictorial map of the Kubota district in Dewa Province*) representing the state of the castle town around 1828 (late Edo period, 159 cm long and 155 cm wide[*3]) [9], and the road-moat network extracted from it consists of 677 line elements. The background of its creation process, i.e., the reason and purpose to create this map, is unknown [2], unlike the other maps in Fig. 2. As for the road-moat network of (d), it is seen that not only its orientation but also its shape is different from those of Fig. 1. In other words, only this map shows a noticeable tendency of geometric distortion, or deformation. This map is the one already mentioned in Section 1 as a map that does not accurately reproduce the geometric situation of the castle town in Akita City.

3. Historical Map Analysis

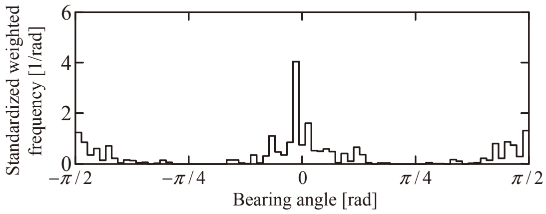
3.1 Distribution of Line-Element Directions

As already mentioned in Section 1, we try to summarize the map-deformation characteristics of a given historical map into a small number of evaluation indices to quantitatively and concisely visualize the characteristics of the historical maps as a low-dimensional scatter plot. This section presents the details of the line-element data in the road-moat networks extracted from the four historical maps. These data will be used as the basic data to estimate the values of the evaluation indices that will be introduced in the next section.

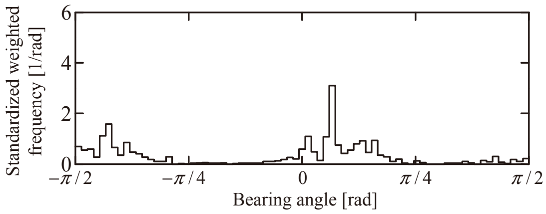
Figure 3 shows the weighted line-element bearing-angle histograms of the road-moat networks (weight: line-element length). It is seen that the histogram of (a) (the 1647 map, the early Edo period) has a relatively high peak near zero. In the histograms of (b) and (c) (the 1742 and 1759 maps, the mid Edo period), on the other hand, their peaks are lower than that in (a) and shifted from zero. As for the histogram of (d) (the 1828 map, the late Edo period), bearing angles are concentrated not only to zero but also to $\pm\pi/2$. As already mentioned in Section 2.1, the base axes of the grid areas in the castle town are shifted from the meridian. This means that the directions of many line elements are shifted from both of zero and $\pm\pi/2$. This tendency disagrees with that shown in (d). Therefore, it is reasonable to think that the map of (d) seems to be deformed with 'verticalization (concentration to zero)' and 'horizontalization (concentration to $\pm\pi/2$)' (i.e., aligned).

Figure 4 shows the weighted histograms of line-element direction deviations from the present map (weight: line-element length). The broken lines

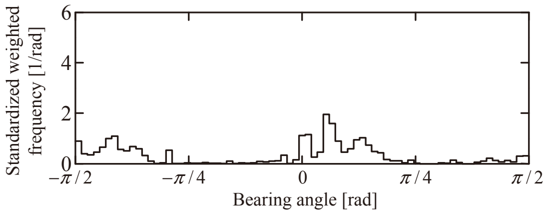
*3 This map originally puts east on top, and the map shown in Fig. 2 (d) is rotated 90 degrees clockwise to put north on top. The values of length and width are those of the rotated map.



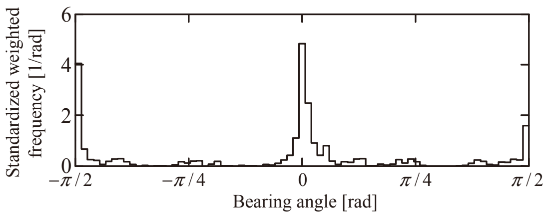
(a) *Dewa-no-Kuni Akita-Gun Kubota-Jō Ezu* (1647).



(b) *Go-Jōka Ezu* (1742).

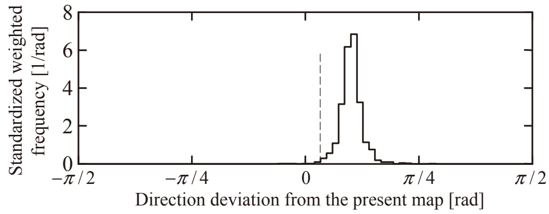


(c) *Go-Jōka Ezu* (1759).

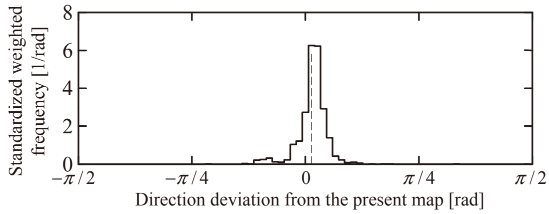


(d) *Ushū Kubota Ōezu* (1828).

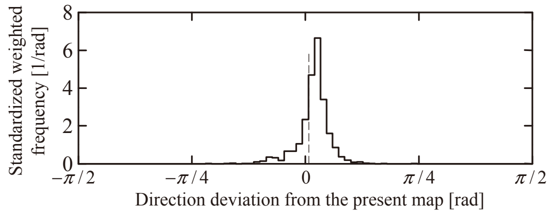
Fig. 3 Weighted line-element bearing-angle histograms (weight: line-segment length).



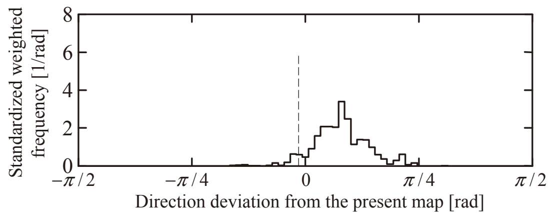
(a) *Dewa-no-Kuni Akita-Gun Kubota-Jō Ezu* (1647).



(b) *Go-Jōka Ezu* (1742).



(c) *Go-Jōka Ezu* (1759).



(d) *Ushū Kubota Ōezu* (1828).

Fig. 4 Weighted line-element direction-deviation histograms (weight: line-segment length, broken line: magnetic declination in each period).

in the histograms correspond to the magnetic-declination values in respective periods*4. In the histogram of (a), deviation values are relatively concentrated on one point giving a peak. Although the histograms of (b) and (c) also show the same tendency, there is a difference in their peak positions. The peak of (a) is shifted from both zero and the magnetic-declination point, whereas those of (b) and (c) are close to the magnetic-declination points of respective periods. This means that the original orientation of the road-moat network is more faithfully reproduced in (b) and (c) than in (a). In the histogram of (d), on the other hand, direction-deviation values widely spread and the height of its peak is much lower than (a), (b) and (c). The above spread in (d) might have been caused by the deformation with verticalization and horizontalization, i.e., alignment, of the road-moat network.

*4 The magnetic-declination values in respective periods are obtained by converting the values shown in Fig. 15 of Ref. [10] (representing the variation of the magnetic declination at Tokyo in the Edo period) to those of Akita City. According to Ref. [10], the directions of east, west, north and south in the maps created in the Edo period are adjusted so as to match the orientation of the magnetic needle of a compass.

3.2 Derivation of Evaluation Indices for the Historical Maps of Akita City

Considering the above tendencies, we derive evaluation indices for the historical maps of the castle town in Akita City to quantitatively and concisely evaluate the maps. The first index is derived as follows.

As mentioned in Section 3.1, one of the historical maps shows the tendency of verticalization and horizontalization. To evaluate this tendency, we classify the line elements in each historical map into two categories to divide the elements into the ‘vertical’ and ‘horizontal’ groups. **Figure 5** shows the process of the grouping. First, bearing angles of all the line elements in a given historical map are acquired (Fig. 5 (a)). The obtained bearing angles are classified into two groups by cluster analysis (The group average method [11] is used). In the cluster analysis, dissimilarity between two line elements is evaluated by the absolute difference between their bearing angles. This value is regarded as a distance between them.

In the calculation of the absolute difference, the periodic boundary condition is used to connect the $-\pi/2$ point with the $\pi/2$ point to regard these two points as those giving the same 'horizontal' orientation (Fig. 5 (b)). In this case, a distance between two bearing angles, e.g., between the points A and B in Fig. 5 (c), is selected from the actual absolute difference between these two points (distance between A and B in Fig. 5 (c)) and the absolute difference obtained by changing the position of one of the two points into the corresponding position over the boundary (distance between A and B′ in Fig. 5 (c)). A shorter distance is adopted as that between these points. As for the two groups obtained by the cluster analysis, the one including the $\pi = 0$ point is regarded as the vertical group, whereas another one is regarded as the horizontal group (Fig. 5 (d)). After grouping, π is added to each of the less-than-zero bearing angles of the horizontal-group line elements to guarantee the continuity of the angle value in the group (Fig. 5 (e)).

Next, the weighted bearing-angle mean and kurtosis of each group, $\theta_{\alpha\mathrm{m}}$ and k_α (α: 'V' for the vertical group and 'H' for the horizontal group, weight: line-element length) are calculated as follows [12]:

$$\theta_{\alpha\mathrm{m}} = \frac{1}{V_{\alpha 1}} \sum_{i=1}^{N_\alpha} w_{\alpha i}\theta_{\alpha i} \tag{1}$$

$$k_\alpha = \frac{K_{\alpha 4}}{K_{\alpha 2}^2} \tag{2}$$

$$V_{\alpha p} = \sum_{i=1}^{N_\alpha} w_{\alpha i}^p, \quad K_{\alpha 2} = \frac{V_{\alpha 2}}{V_{\alpha 1}^2 - V_{\alpha 2}} m_{\alpha 2},$$

$$K_{\alpha 4} = \frac{V_{\alpha 1}^2 (V_{\alpha 1}^4 - 4V_{\alpha 1}V_{\alpha 3} + 3V_{\alpha 2}^2) m_{\alpha 4}}{(V_{\alpha 1}^2 - V_{\alpha 2})(V_{\alpha 1}^4 - 6V_{\alpha 1}^2 V_{\alpha 2} + 8V_{\alpha 1}V_{\alpha 3} + 3V_{\alpha 2}^2 - 6V_{\alpha 4})} - \frac{3V_{\alpha 1}^2 (V_{\alpha 1}^4 - 2V_{\alpha 1}^2 V_{\alpha 2} + 4V_{\alpha 1}V_{\alpha 3} - 3V_{\alpha 2}^2) m_{\alpha 2}^2}{(V_{\alpha 1}^2 - V_{\alpha 2})(V_{\alpha 1}^4 - 6V_{\alpha 1}^2 V_{\alpha 2} + 8V_{\alpha 1}V_{\alpha 3} + 3V_{\alpha 2}^2 - 6V_{\alpha 4})},$$

$$m_{\alpha p} = \frac{1}{V_{\alpha 1}} \sum_{i=1}^{N_\alpha} w_{\alpha i}(\theta_{\alpha i} - \theta_{\alpha\mathrm{m}})^p$$

where $w_{\alpha i}$ and $\theta_{\alpha i}$ are the weight (i.e., length) and bearing angle of the ith line element belonging to the group of α, respectively, and N_α is the total number of the line elements belonging to the group of α. When a map is strongly verticalized, the θ_{Vm} value comes close to zero and the k_{V} value becomes larger. Similarly, the θ_{Hm} value comes close to $\pi/2$ and the k_{H} value becomes larger when a map is strongly horizontalized.

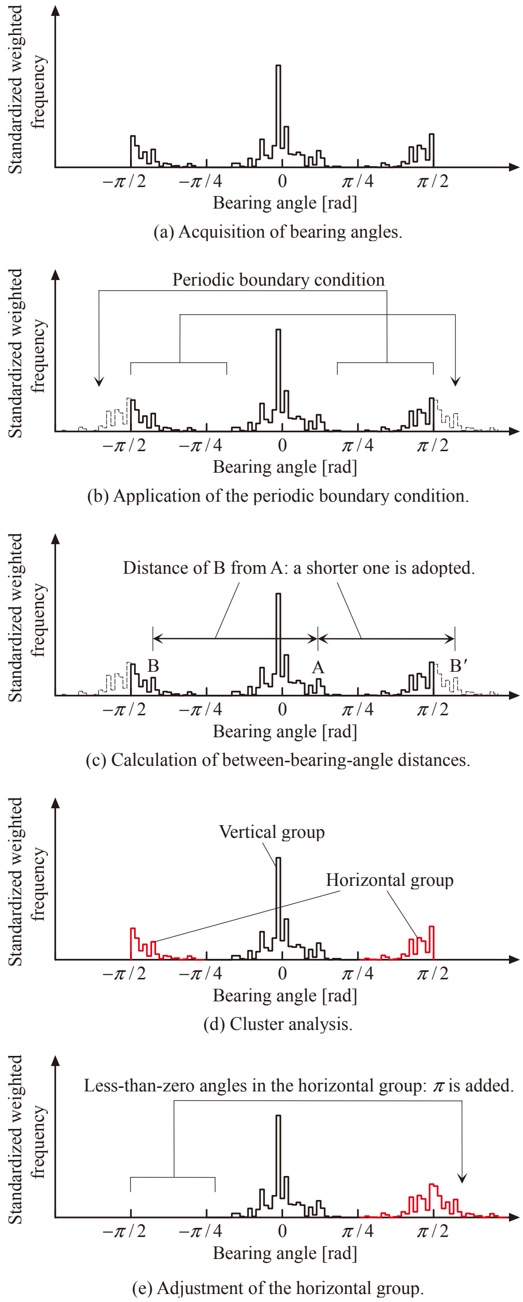


Fig. 5 Grouping of the bearing angles of line elements.

On the other hand, we also evaluate the tendency shown in the distribution of direction deviations of the line elements. Specifically, the weighted mean and kurtosis of the direction deviations of all the line elements in a given historical map, θ_{Dm} and k_{D}, are calculated as follows [12]:

$$\theta_{\mathrm{Dm}} = \frac{1}{V_{\mathrm{D1}}} \sum_{j=1}^{N_{\mathrm{D}}} w_j \theta_{\mathrm{D}j} \tag{3}$$

$$k_{\mathrm{D}} = \frac{K_{\mathrm{D4}}}{K_{\mathrm{D2}}^2} \tag{4}$$

$$V_{\mathrm{D}p} = \sum_{j=1}^{N_{\mathrm{D}}} w_j^p, \quad K_{\mathrm{D2}} = \frac{V_{\mathrm{D2}}}{V_{\mathrm{D1}}^2 - V_{\mathrm{D2}}} m_{\mathrm{D2}},$$

$$K_{\mathrm{D4}} = \frac{V_{\mathrm{D1}}^2 (V_{\mathrm{D1}}^4 - 4V_{\mathrm{D1}}V_{\mathrm{D3}} + 3V_{\mathrm{D2}}^2) m_{\mathrm{D4}}}{(V_{\mathrm{D1}}^2 - V_{\mathrm{D2}})(V_{\mathrm{D1}}^4 - 6V_{\mathrm{D1}}^2 V_{\mathrm{D2}} + 8V_{\mathrm{D1}}V_{\mathrm{D3}} + 3V_{\mathrm{D2}}^2 - 6V_{\mathrm{D4}})} - \frac{3V_{\mathrm{D1}}^2 (V_{\mathrm{D1}}^4 - 2V_{\mathrm{D1}}^2 V_{\mathrm{D2}} + 4V_{\mathrm{D1}}V_{\mathrm{D3}} - 3V_{\mathrm{D2}}^2) m_{\mathrm{D2}}^2}{(V_{\mathrm{D1}}^2 - V_{\mathrm{D2}})(V_{\mathrm{D1}}^4 - 6V_{\mathrm{D1}}^2 V_{\mathrm{D2}} + 8V_{\mathrm{D1}}V_{\mathrm{D3}} + 3V_{\mathrm{D2}}^2 - 6V_{\mathrm{D4}})},$$

$$m_{\mathrm{D}p} = \frac{1}{V_{\mathrm{D1}}} \sum_{j=1}^{N_{\mathrm{D}}} w_j (\theta_{\mathrm{D}j} - \theta_{\mathrm{Dm}})^p$$

where w_j and $\theta_{\mathrm{D}j}$ are the weight (i.e., length) and bearing-angle deviation of the jth line element, respectively, and N_{D} is the total number of the line elements. When the shape of the road-moat network is faithfully reproduced in the historical map, the θ_{Dm} value comes close to zero and the k_{D} value becomes larger.

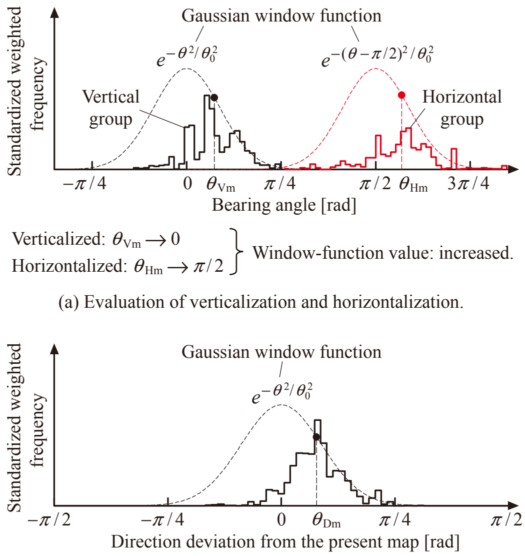
As already mentioned in Section 2.1, the base axes of the grid areas in the castle town are shifted from the meridian. Therefore, the reproduction accuracy of a map is deteriorated as the map is highly aligned, i.e., verticalized and horizontalized. In other words, deformation for alignment (i.e., with verticalization and horizontalization) and high-accuracy reproduction are in the relationship of trade-off.

Considering the above characteristics, we summarize the properties of all the statistics θ_{Vm}, k_{V}, θ_{Hm}, k_{H}, θ_{Dm} and k_{D} in a single evaluation index to concisely represent the trade-off relationship as follows:

$$q = k_{\mathrm{V}} e^{-\theta_{\mathrm{Vm}}^2/\theta_0^2} + k_{\mathrm{H}} e^{-(\theta_{\mathrm{Hm}} - \pi/2)^2/\theta_0^2} - 2k_{\mathrm{D}} e^{-\theta_{\mathrm{Dm}}^2/\theta_0^2} \tag{5}$$

where q is the evaluation index and θ_0 is the user parameter (we set $\theta_0 = \pi/8$). **Figure 6** shows the overview of q. The exponential part in each term represents the window function having the Gaussian-distribution form. This is introduced to evaluate the mean position of a line-element set. In the case that the weighed mean θ_{Vm} is close to zero, i.e., the map is verticalized, the $e^{-\theta_{\mathrm{Vm}}^2/\theta_0^2}$ value becomes larger (Fig. 6 (a)). Similarly, the $e^{-(\theta_{\mathrm{Hm}}-\pi/2)^2/\theta_0^2}$ value becomes larger when θ_{Hm} is close to $\pi/2$, i.e., the map is horizontalized (Fig. 6 (a)), and the $e^{-\theta_{\mathrm{Dm}}^2/\theta_0^2}$ value becomes larger when θ_{Dm} is close to zero, i.e., the original shape of the road-moat network is faithfully reproduced (Fig. 6 (b)). These window-function values are used as the weights of the properties of verticalization, horizontalization and reproduction.

On the other hand, the kurtosis part in each term represents the degree of concentration upon the mean value, i.e., θ_{Vm}, θ_{Hm}, or θ_{Dm}. As a result, the q value becomes large when a given map is strongly verticalized or horizontalized (i.e., highly aligned), whereas



(a) Evaluation of verticalization and horizontalization.

(b) Evaluation of reproduction.

Kurtosis (degree of concentration upon the mean value)

Weight (window-function value)

$$\begin{aligned} q = {} & k_{\mathrm{V}} \cdot e^{-\theta_{\mathrm{Vm}}^2/\theta_0^2} && \rightarrow \text{Verticalization} \\ & + k_{\mathrm{H}} \cdot e^{-(\theta_{\mathrm{Hm}}-\pi/2)^2/\theta_0^2} && \rightarrow \text{Horizontalization} \\ & - 2k_{\mathrm{D}} \cdot e^{-\theta_{\mathrm{Dm}}^2/\theta_0^2} && \rightarrow \text{Reproduction} \end{aligned}$$

Fig. 6 Evaluation index for deformation/reproduction of a road-moat network.

it becomes small when the original shape of the road-moat network is faithfully reproduced, due to the negativeness of the $2k_{\mathrm{D}} e^{-\theta_{\mathrm{Dm}}^2/\theta_0^2}$ term. The coefficient '2' in this term is introduced to match its weight with that of the sum of the verticalization and horizontalization terms.

We also use another evaluation index as the second index. A road-moat network can be regarded as a graph, and its space complexity $O(M+N)$ (M: number of edges and N: number of vertices) [13] represents the structure scale of the graph. Therefore, we adopt $M+N$ as the index representing the structure scale of the castle town.

3.3 Results and Discussion

Figure 7 shows the scatter plot obtained by calculating the two evaluation indices of the four historical maps of the castle town in Akita City. It is seen in the scatter plot that the $M+N$ value (structure scale of the castle town, horizontal axis) becomes larger as the time passed. However, the increase between the 18th and 19th centuries (from the group of (b) and (c) to (d)) is much smaller than that between the 17th and 18th centuries (from (a) to the group of (b) and (c)). This means that the structure scale of the castle town was almost saturated in the mid Edo period. As al-

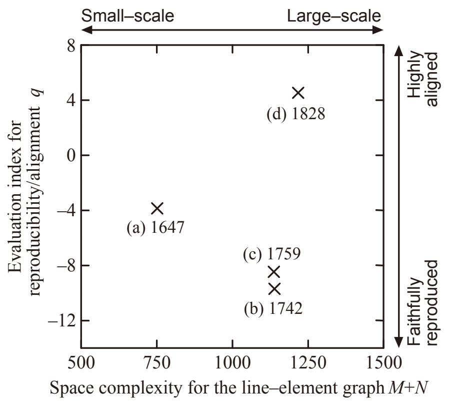


Fig. 7 Scatter plot for the map-characteristic evaluation indices.

ready mentioned in Section 2.1, the development of the entire area of the castle town was almost completed in the early 18th century, and the tendency seen in the scatter plot is consistent with this fact.

As for the index q (degree of reproduction/deformation, vertical axis), the tendency that the original shape is faithfully reproduced is stronger in the 18th century ((b) and (c)) than in the 17th century ((a)). As already mentioned in Section 2.2, the maps of (a) and (c) are the copies of the official pictorial maps submitted to the Tokugawa shogunate, whereas that of (b) was created to correct the error in the setup of the four directions of east, west, north and south. In other words, all of these three maps were created so as to reproduce the original shape of the castle town as accurately as possible to precisely report or record the geometric situation of the town. Great effort to improve the reproduction accuracy of the maps in the early and mid Edo period is clearly represented in Fig. 7 as a declining tendency from (a) to the group of (b) and (c).

On the other hand, the tendency of strong deformation for alignment (i.e., with verticalization and horizontalization) is remarkable in the map of (d) created in the 19th century. Nowadays, map deformation with verticalization and horizontalization is often performed to improve the readability of a given map [14]. As for historical maps, those deformed with the intention of improving readability can be seen in the maps of the city of Edo [10]. A typical example is the set of the maps of *Edo Kiri-Ezu* (*Divided maps of the city of Edo*) [10],[15]. The entire area of the city of Edo was divided into several tens of partial maps, and each of them was published as a portable map used by ordinary citizens (However, it seems that their deformation style does not necessarily depend on verticalization and horizontalization[*5].). The typical size of the partial maps is about 40 cm long and 60 cm wide [10]. This size is much smaller than that of the map of (d) (159 cm long and 155 cm wide).

It is reasonable to think that the above characteristics, i.e., smallness and deformation with the intention of improving readability, are those not only seen in the *Edo Kiri-Ezu* maps, but also commonly seen in the portable use of a map. As for the map of (d), its largeness is inconsistent with the characteristic of smallness required for portable use.

Examples of large-size historical maps in each of which the entire area of a city or a town is summarized as a single map, as in the map of (d), can be seen in the maps of *Edo Ōezu* (*Large-size pictorial map of the city of Edo*) [10]. According to Ref. [10], the maps of *Edo Ōezu* are large-size maps created so as to faithfully reproduce the geometric and resident situation of the mapped area in detail on a wide plane. As already shown in Fig. 7, however, the map of (d) shows a remarkable tendency of deformation with verticalization and horizontalization, and thereby the reproduction accuracy of geometric situation is deteriorated. This means that the characteristics of the map of (d) do not necessarily match those of *Edo Ōezu*, even though its name includes the word '*Ōezu* (*Large-size map*).'

As mentioned above, there are at least two types in the maps of the city of Edo: the portable small-size deformed maps (*Kri-Ezu*) and the large-size accurate maps (*Ōezu*). As for the maps of the castle town in Akita City, those of (a), (b) and (c) can be regarded as corresponding to the latter type. On the other hand, the map of (d) cannot be regarded as corresponding to both the former and latter types. In fact, the map of (d) is deformed with verticalization and horizontalization, even though its size is large enough to make it possible to faithfully and accurately record the geometric situation of the castle town in detail, and is too large for portable use.

The above peculiarity of the map of (d) created in the late Edo period was concisely visualized in the scatter plot of Fig. 7. In particular, the tendency of deformation with verticalization and horizontalization, which is not seen in the other historical maps of the castle town in Akita City (and rarely seen even in those of the city of Edo), was clearly indicated. To our knowledge, there is no research example pointing out the peculiarity of the map of (d) from the viewpoint of the reproduction accuracy, or the deformation style, of geometric situation in the castle town. This new viewpoint was found in the process of visualizing the transition of the historical-map characteristics

[*5] Although towns with a grid layout are seen in six of the 28 *Owariya-Ban Edo Kiri-Ezu* maps, for example, it cannot be clearly confirmed whether the grid layout is formed by verticalizing and horizontalizing the road networks of the towns or not. (The *Owariya-Ban Edo Kiri-Ezu* maps: stored in the National Diet Library Digital Collections, <https://dl.ndl.go.jp/info:ndljp/pid/1286680?tocOpened=1>).

of the castle town in Akita City throughout the Edo period.

On the other hand, there remains an issue that the reason and purpose to create the map of (d), i.e., *Ushū Kubota Ōezu*, are still unknown. From the overall perspective of the transition of map characteristics shown in the obtained scatter plot, one can see that there might have been a policy change in map production between the mid and late Edo period. It might have been related to the reason and purpose to create the map of (d). Further work is needed to find out the cause of changing the map-production style at the late Edo period.

4. Conclusion

In this study, the overall transition perspective of the historical-map characteristics of the castle town in Akita City throughout the Edo period is visualized. The information on the geometric-deformation style of the historical maps is quantitatively extracted to concisely visualize their distribution in a simple two-dimensional scatter plot. It is confirmed in the visualization process that the reproduction accuracy, or the deformation style, of geometric situation in the castle town plays an important role to emphasize the peculiarity of the map created in the late Edo period. To clarify the reason and purpose to create such a map in the late Edo period will be the subject of future work.

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