Integrating Art and Functionality: A Study of Yoshida Hatsusaburo's Panoramic Transit Maps

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***Abstract*—Transit maps play an important role in visually representing the connectivity of public transportation networks. Together with attributes, such as station names, service lines, and nearby points of interest, these maps provide an overview to facilitate effective decision-making during trip planning. Historically, transit maps were designed and developed diversely reflecting cultural and technological contexts, while later most transportation companies switched to the London Tube Map style due to its clarity and popularity. In this paper, we review the 20th-century Japanese transit maps, particularly panoramic maps that were prominently featured in travel guides. These maps employed artistic and functional design principles assisting visitors to gain an overview of the area, differing substantially from modern schematic styles. We compare their design principles, particularly in Hatsusaburo Yoshida's panoramic transit maps, with the modern guidelines, to identify key components in conveying information effectively. A quantitative evaluation on the distortion of panoramic transit maps with OpenStreetMap is incorporated to show the precision of the maps. In summary, this study contributes to the understanding of Japanese panoramic transit maps by revisiting and analyzing historical design practices and to address future challenges in the creation of transit maps.**

***Index Terms*—Panoramic Maps, Metro Maps, Schematic Maps, Graph Drawing, Information Visualization**

I. Introduction

The concept of panoramic painting was originally defined by the portraitist, Robert Barker in the 18th century [18], who generalizes the idea of bird's-eye views by introducing an immersive experience with very large paintings to the audience. Nowadays, both the terms *panorama (パノラマ図)* and *bird's-eye view (鳥瞰図)* are used to describe the manipulation of perspectives in an artwork [16], facilitating a drawing with multiple viewpoints, which are designed to appear visually consistent [10], [13]. Such a design, especially on landscape illustrations, allows the readers to capture the overview of a large area without losing some detailed information. In this paper, we use the term *Panoramic Transit Maps*, to describe panoramic maps that also include the connectivity of public transportation systems as part of the design [2], [11], [12]. Particularly, we will study and analyze such maps designed by a Japanese illustrator and cartographer, Hatsusaburo Yoshida (吉田 初三郎, March 4, 1884 - August 16, 1955), who has been considered as a pioneer for creating panoramic transit maps [3], [5], [15].

Figure 1 shows the most well-known panoramic transit map illustrated by Yoshida. As shown in the figure, the *Keihan Main Line* is drawn nearly horizontally at the center of the canvas, and important stations are highlighted using circles with larger radius. Yoshida used variants of red color as the main visual encoding for transportation networks to actively capture readers' attention. These design principles are inherited by the map design community since nowadays many published travel guidebooks still follow such a design as reported by Wu et al. [29]. Different from classical London Tube Maps [23], one sees in the background of the transit network, a panoramic view of the Kyoto Prefecture and the Osaka Prefecture in the Kansai region of Japan, providing an overview of the area. Along with the *Keihan Main Line*, the *Yodo River* is drawn almost in parallel to this railway line, which partially reflects the fact that the railway system is built along with the direction of the *Yodo River*. On the left of the map, a road network of Kyoto city is shown using a grid-like structure, highlighting such an alignment in the city. Finally, landmarks, mostly area names, Buddhist temples, and Shinto shrines, are highlighted using text labels. Note that this map was originally published in the form of a pamphlet, where in the front shows the panoramic transit map and in the back collects several textual details for the relevant landmarks in the neighborhood.

This map was highly praised by the Emperor Showa, who was on a Keihan Train for a school trip back then. Later, due to the tourism boom in Japan, this style of maps was then widely spread from Taisho to Showa era. In this paper, we look into the design principles introduced by Yoshida and his colleagues and compare them with the modern principles summarized by Wu et al. [28]. Meanwhile, we discuss the advantages and disadvantages of using such design principles based on the visualization strategy. As Yoshida claimed that his maps take precision into account, due to the technological limitation of the time, we analyze the results by comparing Yoshida's panoramic transit maps with more precise digital maps (i.e, OpenStreetMap). Finally, we summarize our findings and discuss potential research direction based on the findings.

The contributions of this paper are summarized as follows:

- A summary of 20th-century *Panoramic Transit Maps* of Yoshida in Japan.
- A comparison of such *Panoramic Transit Maps* and modern transit map design principles [28].
- A quantitative analysis based on our hypotheses.

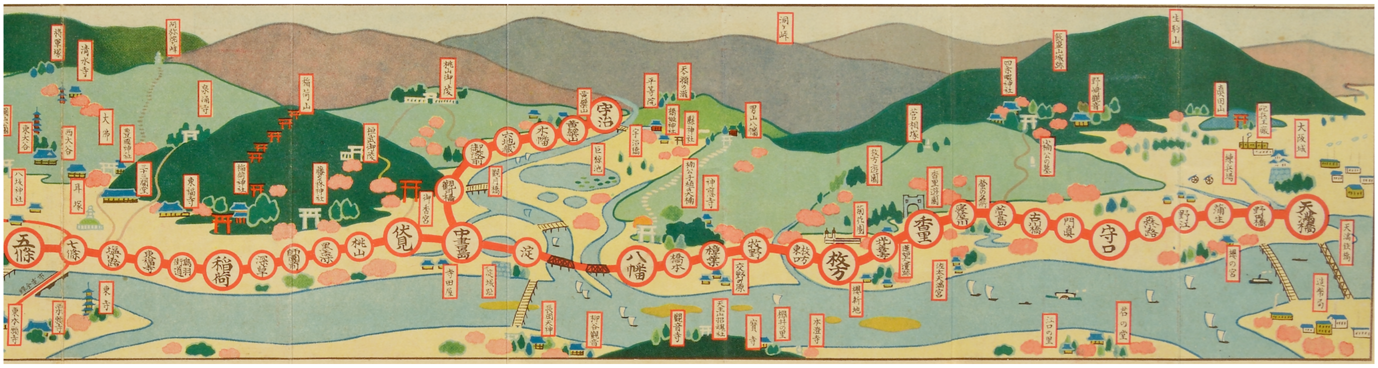


Fig. 1: Keihan Train Information (京阪電車御案内, 1913). Courtesy of Heibonsha and Fuchu Art Museum, Japan [26].

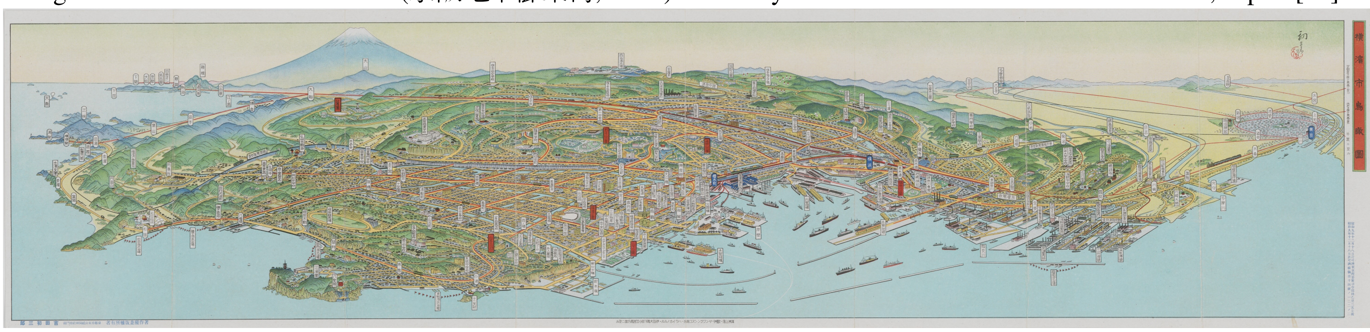


Fig. 2: Yokohama City (横浜, 1935). Courtesy of International Research Center for Japanese Studies, Japan [17].

In Section II, we briefly introduce the historical background and the design process of Yoshida's panoramic transit maps. Then, we compare his design with modern transit map design principles in Section III. We therefore choose *deformation* as a common design principles to quantitatively analyze the misalignment in Section IV. Finally, in Section V, we summarize several take-home messages from this study.

II. Background of Yoshida's Design

Although Yoshida is not the only panoramic transit map designer in Japan [4], he and his collaborators created a leading amount of transit maps during the period. This section will focus on a short introduction of Yoshida and the development of his design by summarizing the study of Hotta [15].

A. About Yoshida

Yoshida was born in 1884 in Kyoto Prefecture, Japan. Although Yoshida showed his early interest in art, due to financial hardships and the Russo-Japanese War (1904-1905), he had to quit school and joined as a pattern designer at a Yuzen (友禅, i.e., a Japanese resist dyeing technique) printing shop, as well as military services. After the war, Yoshida aimed to become a Western-style painter and studied under Takeshiro Kanokogi (鹿子木 孟郎), the director of the Kansai Art Academy. After consulting Kanokogi, Yoshida made a life decision and became a commercial artist by creating his company, Yoshida-Sha (吉田社). Later the company was renamed to Taisho Meisho Zue-Sha (大正名所図絵社) and then Kanko-Sha (観光社). The turning point came in 1913 for Yoshida when the managing director of Keihan Train Company requested the company to design a map (Figure 1) for a railway pamphlet, which was read by Emperor Showa (as crown prince at the time) next year [15].

By the 1920s, Yoshida's maps had become highly sought after by local governments, railways, and tourism associations due to the expansion of rail networks and the tourism boom in Japan [9]. The orders for Yoshida's design came not only from Japan [6]–[8] but also from Taiwan (an annexed territory of the Empire of Japan at the time) and Manchuria (part of northeast China nowadays). However, during World War II, Yoshida's maps were considered undesirable from a counterintelligence perspective, as they might reveal military secrets, such as ports. After Yoshida's death, he was forgotten until after a large-scale retrospective was held at Sakai City Museum in Osaka Prefecture in 1999. Yoshida's work is then reevaluated. At the time of publication, there were practical items; however, with the advent of more technical and precise maps, the use of panoramic maps was reduced. Currently, Yoshida's maps are mainly preserved as artworks and historical documents, also for research purposes. Base on the study of tInternational Research Center for Japanese Studies, Yoshida is said to have created more than $1,600$ pieces of work in his life [17].

B. Yoshida's Map Design Process

As shown in Figure 1, one can consider Yoshida's design to be a blend of art and function. This is because Yoshida's design often captures the essence of the regions, including illustrations of local landmarks, flora, and fauna, which enables the maps to be cultural documents as much as navigational tools. Such panoramic transit map design bridges between Japanese

Layout and Geometry		Text and Image Labels		Visual Variables	
Layout Types	✓	Consistency	✓	Colour	✓
Relative Position of Stations	✓	Label Proximity	-	Line Styles	✓
Global Scale Distortion	✓	Overlap-free Labels	✓	Station Styles	✓
Spatially-separated Stations	✓	Name Orientation	✓	Landmarks	✓
Even Spacing of Stations	-	Typography	x		
Simplification of Trajectories	✓				
Symbolic Shapes	-				
Co-routed Lines	x				
Zone Partitioning	x				
Landscape Composition	✓				
Route-Centered Design	✓				

The symbol ✓ indicates active design principles, - represents minimal or neutral design principles, and x shows that the principles are entirely excluded.

TABLE I: An extended taxonomy from Wu et al. [28].

Fig. 3: Schematized Curvilinear design of London Underground [28].

traditional art, such as Ukiyo-e (浮世絵) and cartography. Based on the study of Hotta [15], Yoshida outlined the process of creating his panoramic transit maps in six main steps: (S1) *Field Survey and Sketching*, (S2) *Conceptual Idea Design*, (S3) *Preliminary Sketch*, (S4) *Coloring*, (S5) *Binding and Editing*, and finally (S6) *Printing*.

In step (S1), Yoshida described his maps as "not drawn by hand, but by foot and by head". Yoshida considered himself a "labor artist," so it seems that he explored everywhere drawn on the maps. On average, it took about four months to complete a single panoramic transit map. Yoshida's team worked hard to ensure both artistic precision and geographical accuracy. He also mentioned that for larger-scale projects, such as city-wide maps (Figure 2) or depictions of famous mountains, production times could extend to over a year [15].

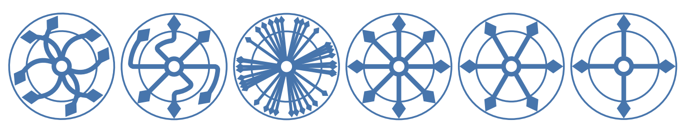
In the company, Yoshida seemed to be the main contributor of steps (S1)-(S3), while step (S4) is often distributed to other colleagues in the company under the supervision of Yoshida. Step (S5) is often responsible by one specific colleague Inagaki, and step (S6) was handled with the cooperation of printing companies, such as Watada Printing [15]. To facilitate steps (S2) and (S3), Yoshida tended to set a focus area as a starting point and then collected hundreds of sketches around the area to determine the layout of the landscape by applying some general design ideas. According to Yoshida, the structure of the map is built on top of the nature of the landscapes but further includes the following arrangements: mainly (a) the focus point is expanded to show the details, and (b) the rest is to find the balance to depict the relationship with the transportation systems. Even for a single railway trail, one has to think carefully about the balance and angles with the main body – according to Yoshida [15]. However, due to the large amounts of productions, others criticized Yoshida's works have fallen into one single pattern as the style we see nowadays. Yoshida, as an artist, was understandably displeased by this criticism; however, it is reasonable to acknowledge that the design principles naturally converged over time due to their proven effectiveness, by looking at the evolution of design.

III. Comparison with Modern Visualization Design

Wu et al. [28] investigated modern transit map layout studies and categorized these works based on the map design, automatic algorithms, and human perception studies. In this section, we aim for extracting similar and dissimilar ideas between this survey and Yoshida's maps to see if there exists common or conflicted principles. We mainly borrow the taxonomy by Wu et al., and explain correspondingly Yoshida's design. Table I provides an overview of the design principles from Wu's transit map taxonomy [28] that are incorporated in Yoshida's maps. In the table, the symbols ✓, - and x indicate whether the design principle is actively used, minimally or neutrally applied, or entirely absent in Yoshida's panoramic transit maps, respectively. Principles found only in Yoshida's maps are highlighted in jungle green.

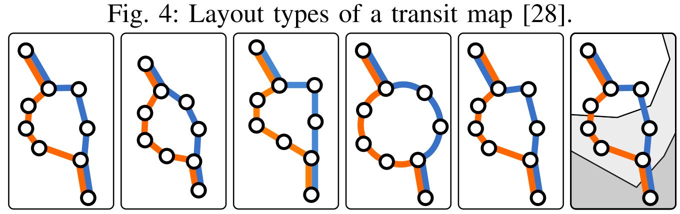
A. Layout and Geometry

Layout and geometry are used to define the main transit map body, and the corresponding design criteria have been extensively discussed [28].



Curvilinear (a) Concentric (b) Multilinear (c) Octolinear (d) Hexalinear (e) Tetralinear (f)

Fig. 4: Layout types of a transit map [28].



Original Layout (a) Spatially-separated (b) Simp. of Traject. (c) Symbolic Shapes (d) Co-routed Lines (e) Zone Partitioning (f)

Fig. 5: Factors influencing original geographical structures.

1) **Layout Types:** There exist multiple layout types in modern transit map design, including curvilinear, concentric,

(a) Naritasan Panoramic View (b) Naritasan Transportation Map

Fig. 6: (a) Naritasan panoramic view (成田山全景, 1918). (b) The enlarged version of Naritasan transportation map on the left bottom corner of (a). Courtesy of International Research Center for Japanese Studies, Japan [17].

Fig. 7: Illustrations of famous places along the Keio Railway Line (京王電車沿線名所繪, 1930). Courtesy of International Research Center for Japanese Studies, Japan [17].

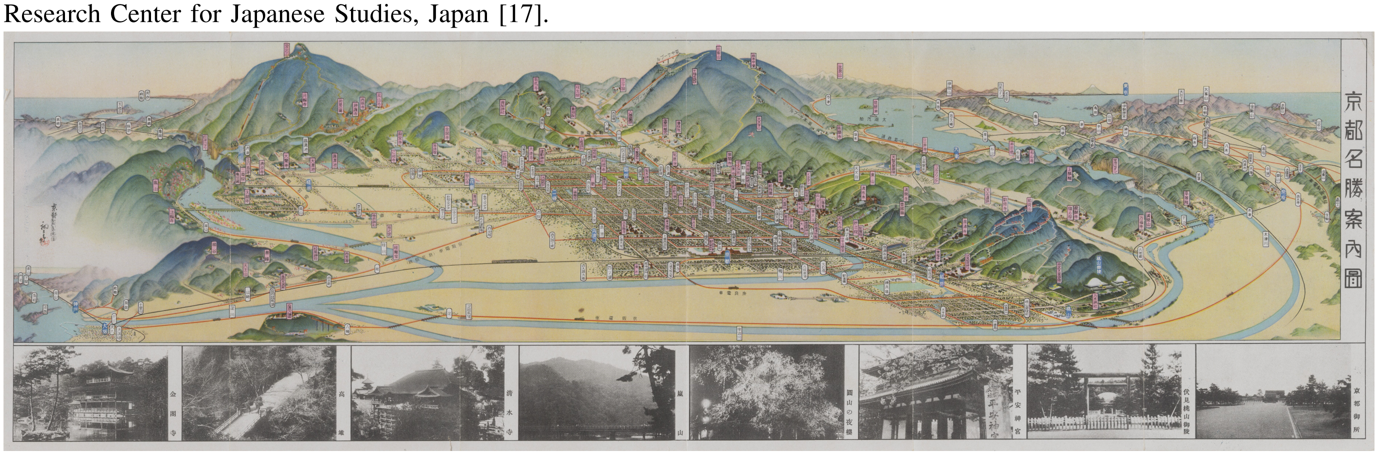
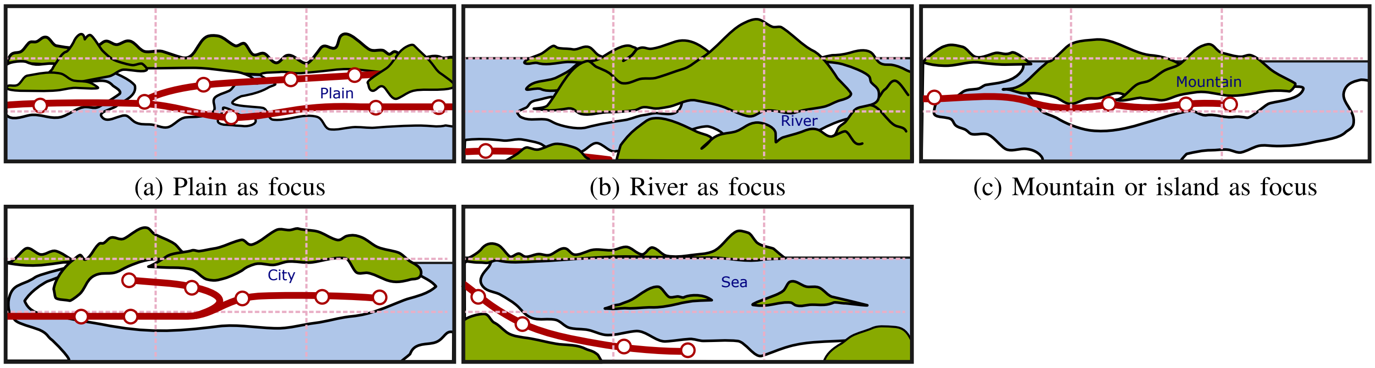


Fig. 8: Kyoto scenic spot guidebook (京都名勝案內圖, no date). Courtesy of International Research Center for Japanese Studies, Japan [17].

multilinear, octolinear, hexalinear, tetralinear styles (Figure 4). While Yoshida's Keihan Train map was drawn in 1913, which was twenty years earlier than Harry Beck's Tube map (1933), several design ideas are similar. As mentioned in (S2) and (S3), angles of railway lines are crucial for map harmony, Yoshida's design (e.g., Figures 1 and 2, Figure 6(a), and Figure 8) can be mainly categorized into *Schematized Curvilinear* as shown in a London Underground example (Figure 3), where curves are main layout types and topological details are decimated. In some cases (Figure 6(b) and Figure 7), straight lines and polylines are interchangeably used, which fall into the category of multilinear layout, as shown in Figure 4(c).

2) **Relative Position of Stations:** To preserve the geographical accuracy of the transit maps, relative positions of station pairs (i.e., north-south and west-east orientations) are preserved. Yoshida also introduced this principle, particularly in relation to potential conflicts with users' mental models of the area (Figures 1 and 7).
3) **Global Scale Distortion:** Map designers enlarge the central focus area relative to context areas to address spacing challenges. This approach minimizes visual clutter caused by congestion and enhances the legibility of the most critical region. Yoshida also took this principle into consideration, while mainly using a bird-eye-view



(a) Plain as focus (b) River as focus (c) Mountain or island as focus

(d) City as focus (e) Sea or lake as focus

Fig. 9: Landscape composition types of Yoshida's panoramic maps. The figures are the recreation of the figures by Hotta [15], while transit networks are added (red) to show common line placement strategies with landscape composition.

distortion strategy as shown in Figures 1, 2 and 6 to 8.

4) **Spatially-Separated Stations:** Each station must be positioned in a distinct location, a fundamental rule of transit maps that ensures no station overlaps with another. Due to the nature of transportation infrastructure, this principle is also reflected in Yoshida's maps (Figures 1 and 7).
5) **Even Spacing of Stations:** Harry Beck's Tube map suggested equalizing the distances between adjacent stations along lines (Figure 5(b)). This approach promotes a compact representation, supports an organized grid alignment, and helps expand a dense central area. Since Yoshida's panoramic transit maps often come with the landscape, this principle always comes as a side-effect for placing station name labels in a dense area (Figures 1 and 7).
6) **Simplification of Trajectories:** Wu et al. mentioned that in the initial phase of transit map design, geographical layouts were progressively simplified by smoothing out topographical details from the lines (Figure 5(c)). Such simplification facilitates fast route navigation in practice [28]. As Roberts [22] also noted, maintaining topographical accuracy presents a conflicting challenge in schematic map design. However, in Yoshida's maps, this challenge has been relaxed due to the introduction of landscape features (e.g., mountains, rivers, landmarks, etc.). See Figures 1, 2 and 6 to 8.
7) **Symbolic Shapes:** Emphasizing transit lines with unique topologies, such as circular routes, can enhance the overall visual clarity of the network (Figure 5(d)). Modern transit maps use circles, stadium-shape, and so forth for representing circular routes [1]. Such symbolic shapes can only be implicitly detected in Yoshida's maps (Figure 2 right), where circular routes in Tokyo are represented as multiple non-perfect circles, for example.
8) **Co-Routed Lines:** When multiple transit lines share consecutive stations, there are various options for rendering them in modern transit maps (Figure 5(e)). For instance, the lines can be tightly bundled without gaps, or spaced apart to emphasize their individuality. One typical characteristic of Yoshida's maps is that the highlighted transportation networks, including railway networks, bus networks, and so on, are always rendered in one color regardless of whether the lines share the same sets of stations (Figures 2 and 7).
9) **Zone Partitioning:** Fare zones are a concept in western transit networks, and thus cannot be found in Yoshida's maps.
10) **Landscape Composition:** Distinct from typical transit maps that show the complete transportation networks of a city, Yoshida took a different approach. Yoshida's panoramic transit maps are more topic-centered, meaning that they are mainly designed for sightseeing. Therefore, the connectivity of the transportation systems is as equally important as landmarks in the area. The landscape of the area is taken into design to accelerate the planning process as such. Figure 9 depicts five typical composition patterns identified in Yoshida's work, categorized based on their thematic focus: plains, rivers, mountains, cities, and seas. At the time without the Internet, such a map provided a summary that is needed for a journey (Figures 1 and 7).
11) **Route-Centered Design:** When designing a map for a railway company, Yoshida tended to highlight the lines by putting them at the center of the canvas (Figures 1 and 7). Several followers in Japan were influenced by this design principle since one can still find it in many published traveling guidebooks in Japan [29].

B. Text and Image Labels

The placement of textual and image labels is a key factor in ensuring that a transit map is highly comprehensible. Major criteria are summarized as follows:

1) **Consistency:** Annotating station nodes with their names is a fundamental requirement (Figure 10). For internal labeling, station names are positioned near or within the node itself. In contrast, external labeling places names around the map's boundary, typically connected

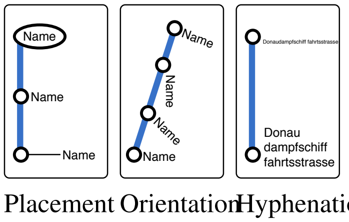


Fig. 10: Labelling styles.

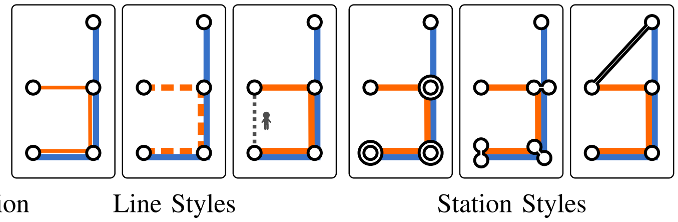


Fig. 11: Possible line and station styles.

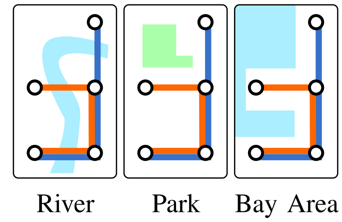


Fig. 12: Landmark examples.

to the node with a leader line. Since Kanji (Japanese writing system) is meant to be read in a top-down fashion and short, Yoshida's transit maps potentially escaped the challenges of placing long station names. Therefore, Yoshida put station names directly on top of the corresponding stations (Figures 1, 2 and 6 to 8). Additional large images showing landmarks are placed using the boundary labeling strategy (Figures 7 and 8).

2) **Label Proximity:** When labeling a station node, particularly with internal labeling, it is preferable to minimize the distance between the node and its name to strengthen the perception of proximity. As mentioned above, the distance between a station and its label in Yoshida's map is 0, as labels are directly placed overlapped with the stations.
3) **Overlap-Free Labels:** To ensure legibility, station name labels must not overlap. Yoshida has two strategies here. On the one hand, if the map is designed for railway companies, label sizes, and spacing are tuned for this reason (Figures 1 and 7). On the other hand, Yoshida does not draw all station names on the maps. Instead, unimportant stations are often eliminated in large-scale maps for managing visual clutters (Figures 2 and 8).
4) **Name Orientation:** In a Western-style map, for better readability, station names are expected to be aligned horizontally as much as possible. Diagonal or vertical orientations are not preferable but can be used to avoid conflicts. Yoshida mainly uses vertical alignment for station names and landmark names, while in some specific cases, such as the name of a railway line, horizontal orientation is chosen (Shonan Denki Tetsudo (湘南電気鉄道) in Figure 2).
5) **Typography:** Typographic principles play a significant role in the legibility of modern maps, which often involves balancing the selection of letters for station names with the layout of transit lines. In Yoshida's maps, all labels are handwritten and have less flexibility.

C. Visual Variables

Additional visual variables may influence the clarity of the maps, and here we discuss the main visual variables.

1) **Color:** Color is a key visual element that effectively distinguishes transit lines. To enhance clarity, modern transit maps could maximize the perceptual distance between each pair of transit line colors. In Yoshida's maps, the colors are selected based on the color palette of Ukiyo-e, while red color is often used to emphasize the transit networks. In conflict with modern transit maps, Yoshida sometimes kept the identical color of railway lines but changed the colors of name labels for differentiating different railway services (Figures 1, 2 and 6 to 8).
2) **Line Styles:** Line styles can indicate service plans along fixed routes, such as express versus local trains, as well as attributes like regularity, frequency, and capacity in modern maps (Figure 11). Yoshida used thicker lines for main railway services, as well as solid, dashed, or black-and-white patterns to differentiate other minor lines (Figure 7).
3) **Station Styles:** Node styles for stations can vary in size, shape, and silhouette width, with adjustments made based on the type and significance of each station, particularly interchange stations (Figure 11). In the early stage of Yoshida's map, stations are often drawn as circles, while later rectangular or stadium shapes in combination with colors are used instead (Figures 1 and 7).
4) **Landmarks:** Incorporating representative landmarks, such as topographical features and points of interest, can enhance the understanding of a map's context (Figure 12). As a typical landmark, Mount Fuji is often drawn on Yoshida's maps. Other features such as abstract symbols of sightseeing spots (e.g., shrines, etc.), nature (e.g., flowers, trees, etc.), or facilities (e.g., trains, ships, bridges, etc.) are placed to tell the stories about the regions (Figures 2, 6 and 7).

IV. Quantitative Analysis

One prior work has investigated and analyzed important routes on Yoshida's panoramic transit maps using kernel density estimation [25]. The main idea is to extract the saliency of landmarks, roads, and railways implicitly designated by map designers, and compare if this fits users' attention in a user study. To assess different evaluation metrics, in this paper, we focus on a quantitative analysis of the distortion present in Yoshida's 1936 panoramic map of Akita City (Figure 13, hereafter referred to as "the Akita map"). The landscape composition of the map primarily aligns with the type (d) "City as Focus" illustrated in Figure 9. By georeferencing the map to modern geographic data, we aim to identify distortion patterns, relate them to Yoshida's design principles discussed

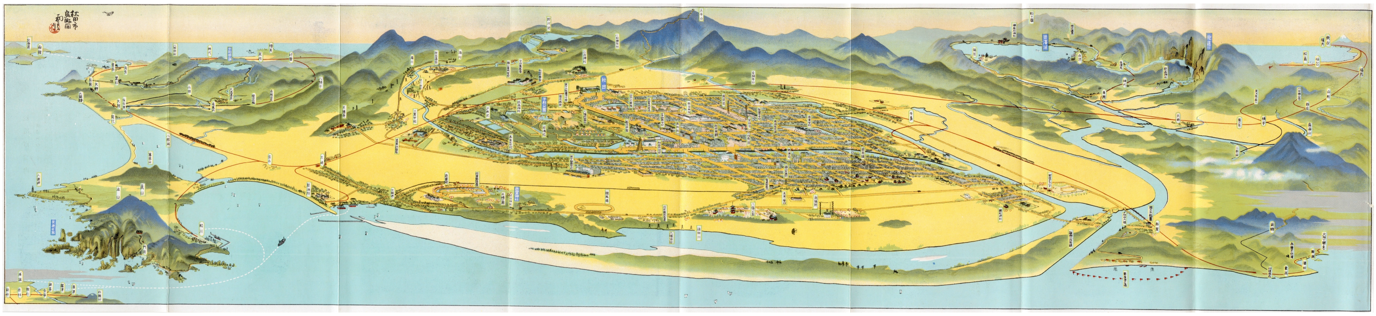


Fig. 13: Panoramic map of Akita City published in 1936. Courtesy of International Research Center for Japanese Studies, Japan [17].

in previous sections, and gain a deeper understanding of the map's cartographic style and intended purposes.

A. Methodology

The Akita map was georeferenced to a modern OpenStreetMap layer using a web-based tool we developed. Control points were manually placed on identifiable stations, landmarks, and intersections. The final georeference utilized 361 control points across the entire map, with 301 of those concentrated in the central city area. A Triangulated Irregular Network (TIN) was established using the geographic coordinates of the control points. Corresponding triangles, sharing the same control points as vertices, were formed in the Akita map's image coordinate plane (Figure 14). Metrics of affine transformation between the corresponding triangles on the two maps were then calculated to visualize how each local patch of the map is distorted. As the Akita map lacks a consistent map scale to form a comparable coordinate system with the contemporary map, metrics like distance distortion and area distortion are not directly applicable. Therefore, we chose scale mean, anisotropy ratio, and rotation as measures for relative comparisons. In addition, the Procrustes distance was calculated to measure shape distortion.

1) **Scale Mean:** This metric arises from the singular value decomposition (SVD) or affine decomposition applied to each local triangle. When mapping from geographic coordinates to image coordinates, a linear transformation matrix A is obtained. Singular value decomposition yields:

$$A = U \begin{pmatrix} \sigma_1 & 0 \\ 0 & \sigma_2 \end{pmatrix} V^\top,$$

where σ_1 and σ_2 are the singular values. The scale mean is then defined as the average of these two singular values:

$$\text{scale mean} = \frac{\sigma_1 + \sigma_2}{2}.$$

This quantity captures the overall uniform enlargement or reduction of a local patch. A scale mean approximating 1.0 indicates that the patch's size in the map image does not differ substantially from its real-world counterpart. Values greater than 1.0 indicate that a given patch is drawn larger, whereas values below 1.0 signify compression. As the two coordinate systems have different units, this measure is not dimensionless without further normalization. However, it remains sufficient for identifying relative differences in distortion from area to area.

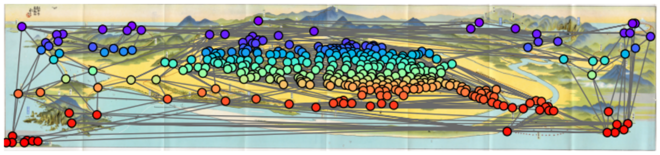
2) **Anisotropy Ratio:** Using the same singular values σ_1 and σ_2 from A, the anisotropy ratio is defined as:

$$\text{anisotropy ratio} = \frac{\sigma_1}{\sigma_2}.$$

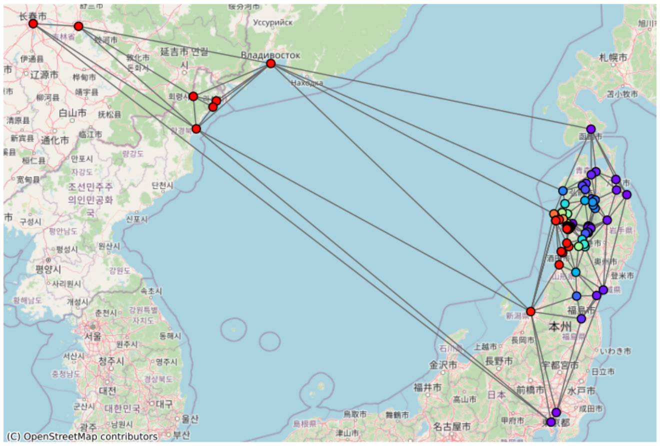
This metric indicates whether one principal axis of the local transformation experiences greater stretching relative to the orthogonal axis. A value of 1.0 signifies perfect isotropy or uniform scaling of the two triangles, implying no shear. A value greater than 1.0 indicates anisotropic stretching, with one direction elongated more than the other. Extremely high ratios (e.g., 10, 20, or larger) suggest significant shear or near-collinearity, indicating the local patch is strongly "skewed."

3) **Rotation:** In the affine decomposition $A = R\,S$, where R is an orthogonal rotation matrix and S is a symmetric matrix. Equivalently, via the SVD $A = U\Sigma V^\top$, a pure rotation factor $R = UV^\top$ can be identified. The rotation angle θ is typically obtained from the entries of R, for instance, through $\arctan 2(\,R_{2,1},\,R_{1,1})$. Rotation measures the angular displacement by which the triangle is "turned" relative to real-world coordinates. Angles near zero indicate minimal reorientation, while large positive or negative angles indicate notable twisting.

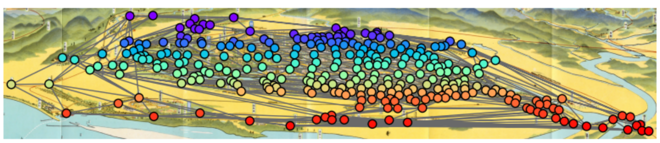
4) **Procrustes Distance:** This metric quantifies shape discrepancies between two configurations, such as triangles, after removing the effects of translation, uniform scaling, and rotation. This is achieved by first translating each configuration to a common centroid, then scaling them to an equivalent root-mean-square (RMS) distance from their respective centroids, and finally rotating one configuration to minimize the least-squares distance to the other. The resultant RMS distance between the optimally aligned coordinates defines the Procrustes distance. A



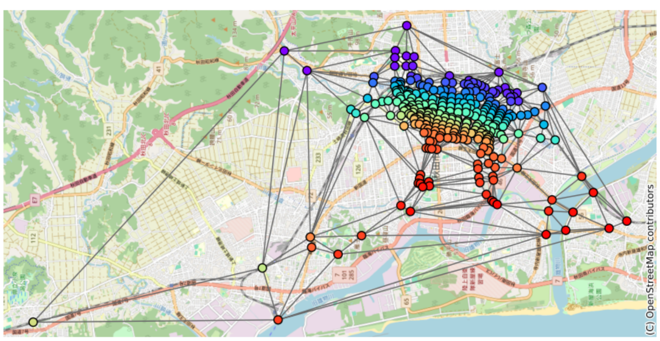
(a) Control points on the whole map image



(b) Control points of (a) on OpenStreetMap



(c) Control points in the central area (Akita City)



(d) Control points of (c) on OpenStreetMap

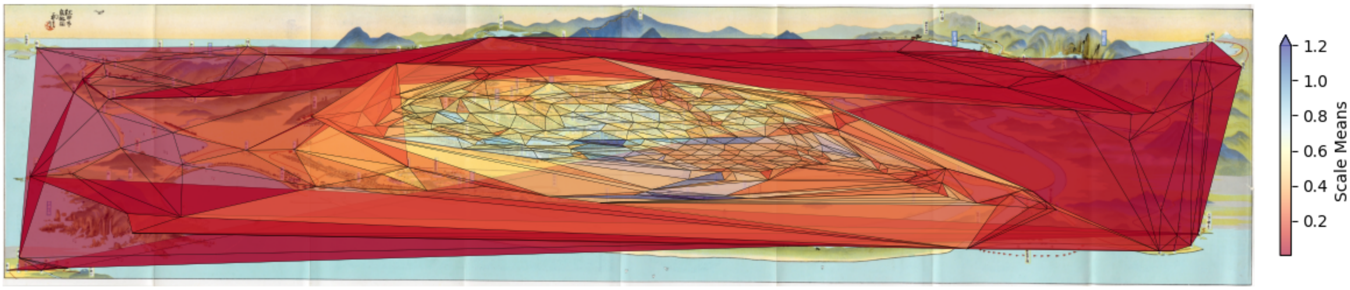
Fig. 14: Control points inputted to the Akita map and the TIN established based on the geographic coordinates.

value of zero indicates perfect shape congruence once uniform size and orientation are discounted. Larger values (e.g., 0.5, 0.8, or beyond 1.0) reveal increasing shape distortion not explainable by simple uniform scale or rotation alone.

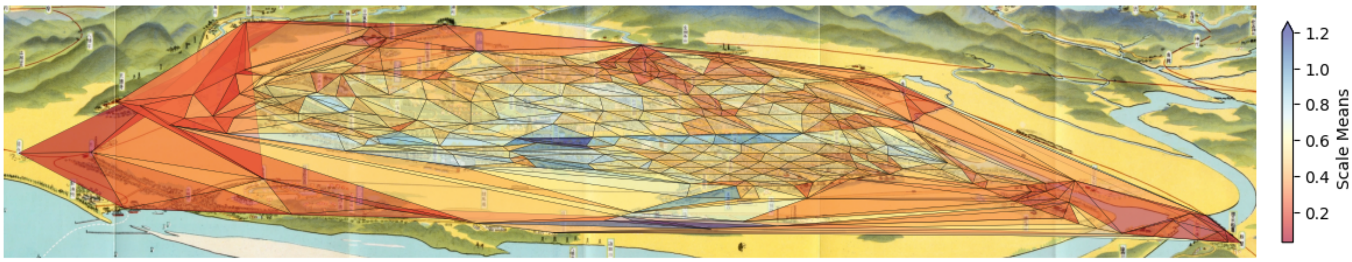
B. Experimental Results

Four measures were calculated for each triangle in the TIN using the full dataset of 361 control points, which formed 712 triangles. These values were visualized with colored triangles overlaid on the map image to facilitate comparisons of distortions among different areas (Figure 15(a), Figure 16(a), Figure 17(a), Figure 18(a)). The same process was conducted with a subset of 301 control points focused on the city center, forming 593 triangles. Visualization with this subset provided a zoomed-in view of the central part of the map, Akita City (Figure 15(b), Figure 16(b), Figure 17(b), Figure 18(b)). The data distributions are visualized with histograms (Figure 19 and Figure 20).

1) **Scale Mean:** Figure 15(a) shows that the city area tends to have moderate scale factors (e.g., 0.4–0.8 or around 1.0), implying it is not significantly magnified or shrunk. The areas outside the city, especially at the edges and corners, have significantly lower values, implying that the triangles in those areas are strongly compressed. A comparison of the histograms also supports the observations from the map overlay. Figure 19(a) shows an obvious peak close to zero, which does not appear in Figure 20(a). In the zoomed-in view of the city area (Figure 15(b)), triangles colored in blue (values around 1.0) can be observed, indicating highly exaggerated areas, which include a main river flowing through the city and several important sightseeing spots and landmarks, such as parks, schools, and the city hall.
2) **Anisotropy Ratio:** From Figure 16, we can observe typical values of 2 to 5 in the city area, while areas further from the city have more values above 5, or even over 20. The comparison of histograms in Figure 19(b) and Figure 20(b) also suggests that there are more extreme values outside the city area. These observations imply that the city area is more evenly scaled and less sheared than the outlying areas, while areas outside the city are more twisted in different directions. These observations align with Yoshida's distortion strategy, where the city area is enlarged and depicted in detail with a perspective view, while the context area employs a fish-eye-like effect to encompass a wider geographic range. Large swaths of the map boundary show these red/purple areas, especially in the top and bottom areas, revealing strong anisotropic distortion used to fit the full scenery into the panoramic layout. In the central area, we can also find thin red/orange triangles between the built-up city area and the surrounding railways or rivers, implying intentional omission in those areas.
3) **Rotation:** From the histograms in Figure 19(c) and Figure 20(c), we can find a broad negative peak near -150° to -100°. Similar to the distributions of scale means and anisotropy ratios, the city area shows a smaller spread of values, meaning the central area is more evenly rotated than the outside areas. This matches the observation from Figure 17, which shows an obvious difference in colors between the city area and the periphery, implying different distortion strategies applied in these two areas.
4) **Procrustes Distance:** As this measure only reflects shape differences without considering scale changes, its explanatory capability of map distortion may be less than the affine transformation metrics. Nevertheless,

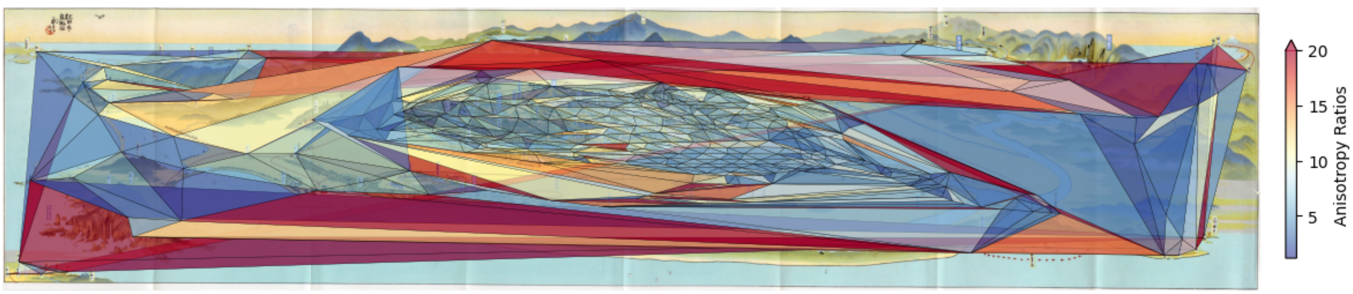


(a) Scale mean distribution on the whole map

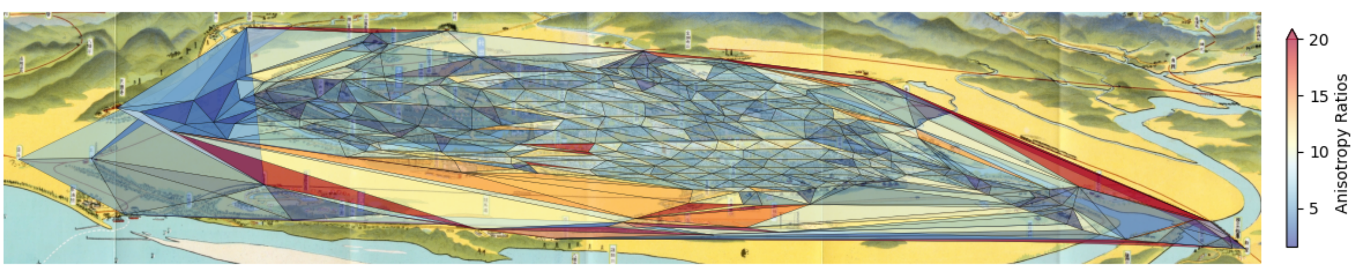


(b) Scale mean distribution at the central area

Fig. 15: Visualization of scale mean values of the triangles in the TIN.



(a) Anisotropy ratio distribution on the whole map



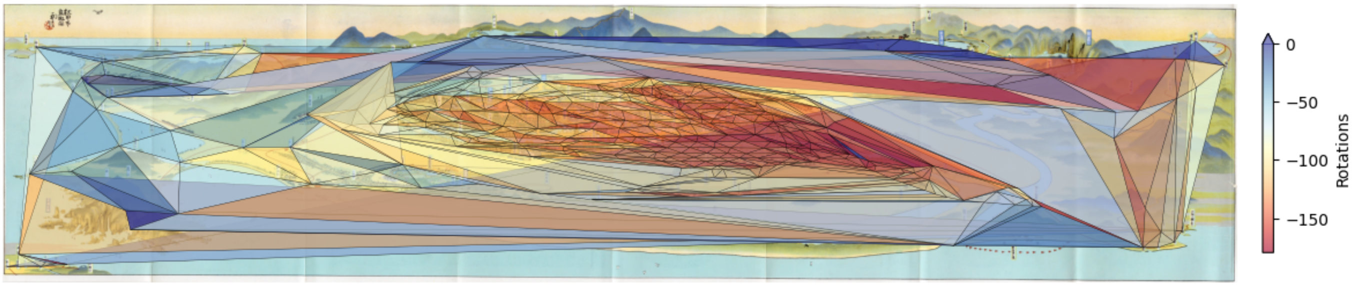
(b) Anisotropy ratio distribution at the central area

Fig. 16: Visualization of anisotropy ratio values of the triangles in the TIN.

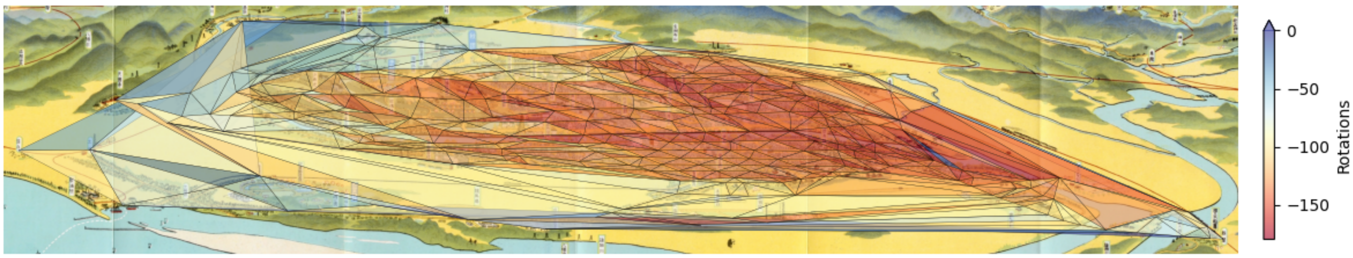
Figure 18 still illustrates distinct differences in value distributions between the built-up city area and other areas. The built-up districts show most values around 0.4 to 0.6, while the rural parts and the edges of the map exhibit greater variability and more extreme values.

C. Discussion

The quantitative analysis of the Akita map reveals a systematic and intentional pattern of distortion that aligns with the design principles outlined in Section II. The central city area exhibits a relatively low and consistent distortion, characterized by moderate scale mean values (Figure 15), a more uniform distribution of rotation angles (Figure 17), and relatively lower anisotropy ratios and Procrustes distances (Figures 16 and 18). This suggests that Yoshida employed a perspective-like approach in the city core, as if a single "camera" or viewpoint were focused on the center, aligning with his principle of expanding the focus point to highlight its features with greater detail and accuracy. The observed distor-

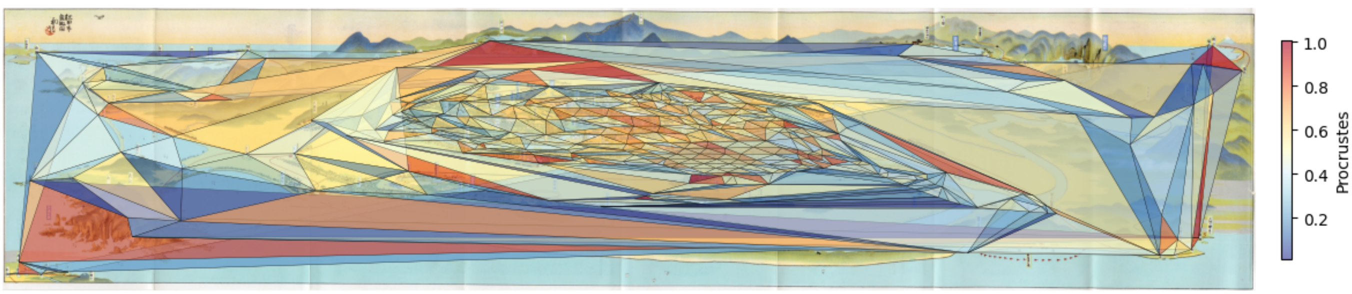


(a) Rotation distribution on the whole map

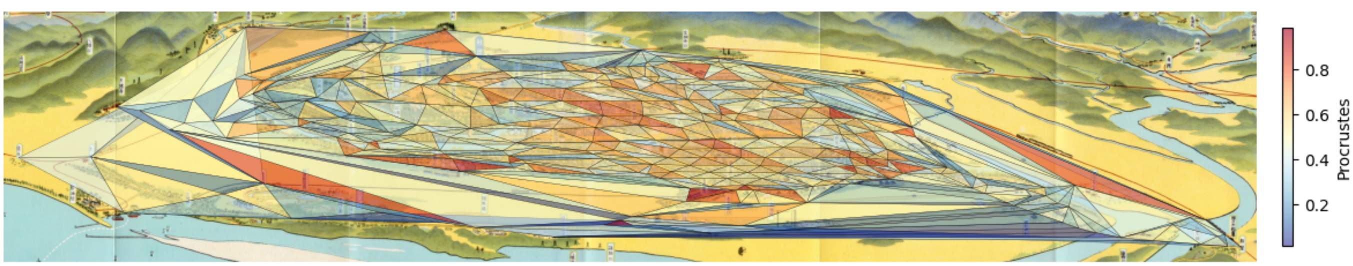


(b) Rotation distribution at the central area

Fig. 17: Visualization of rotation values of the triangles in the TIN.



(a) Procrustes distance distribution on the whole map

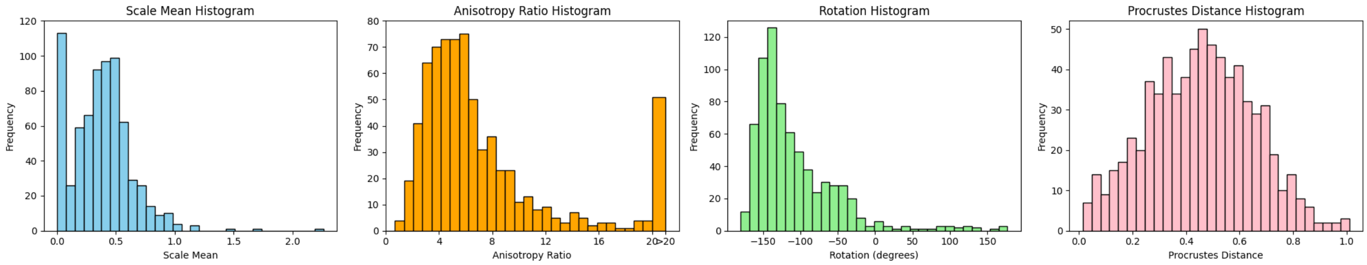


(b) Procrustes distance distribution at the central area

Fig. 18: Visualization of Procrustes distance values of the triangles in the TIN.

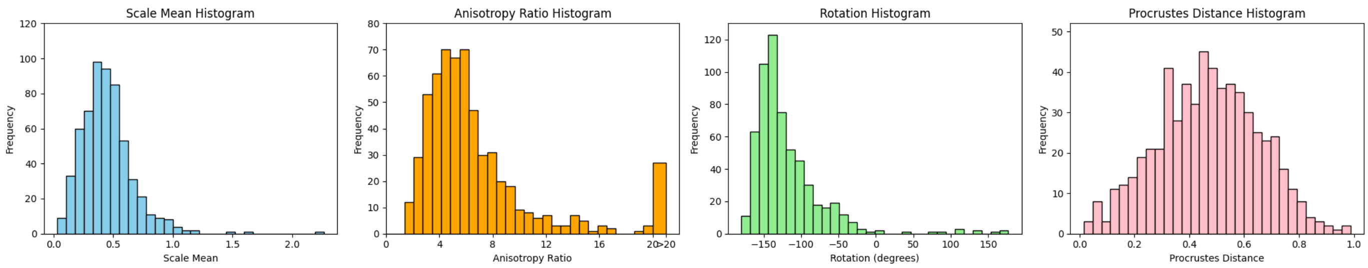
tion patterns, particularly the contrast between the relatively accurate city core and the increasingly distorted periphery, strongly support the classification of the Akita map as a "City as Focus" composition, as outlined in Section II (Figure 9).

Moving outwards from the city center, the map exhibits a marked shift towards a more "panoramic" or fish-eye-like distortion. The peripheral areas, particularly at the map's edges and corners, display significantly stronger compression and stretching, more extreme rotations, and larger jumps in Procrustes distances (Figures 15 to 18). This indicates a more localized, "patch-by-patch" approach to warping these regions, consistent with Yoshida's technique of encompassing a wider geographic range and emphasizing connections to distant locations. The localized areas of higher scale mean around prominent landmarks and the concentration of high-scale-ratio triangles along transportation routes (Figures 15 and 16) further corroborate Yoshida's practice of exaggerating important features and prioritizing the representation of key



(a) Scale mean (b) Anisotropy ratio (c) Rotation (d) Procrustes distance

Fig. 19: Histograms of scale mean, anisotropy ratio, rotation, and Procrustes distance values from all triangles on the Akita map.



(a) Scale mean (b) Anisotropy ratio (c) Rotation (d) Procrustes distance

Fig. 20: Histograms of scale mean, anisotropy ratio, rotation, and Procrustes distance values from triangles at the central area of the Akita map.

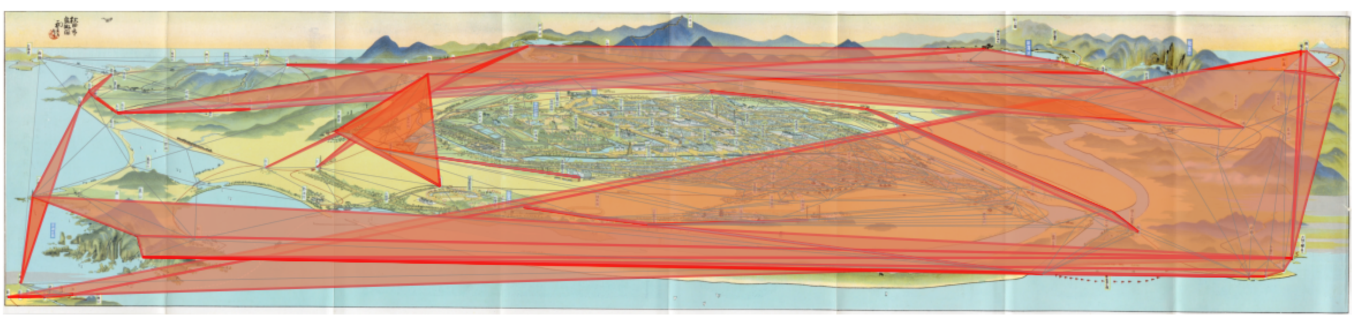


Fig. 21: Reversed triangles (highlighted in red) when the TIN established with geographic coordinates transformed to the Akita map image.

transportation networks.

The observed distortion patterns are not random but reflect deliberate design choices made by Yoshida to achieve specific artistic and communicative goals. While sacrificing strict geographic accuracy in the periphery, the map effectively emphasizes key landmarks, transportation routes, and the overall character of the region, fulfilling its purpose as a visually engaging and informative representation of Akita City and its surroundings in 1936. However, it is important to acknowledge a limitation of the current analysis. Due to the significant distortions in some areas of the Akita map, particularly in the periphery, the TIN generated based on geographic coordinates can result in reversed triangles in the map's image coordinate system (Figure 21). This reversal is not directly captured by the four distortion metrics employed in this study. While these metrics provide valuable insights into the overall patterns of scale, rotation, and shear, future analysis should address this limitation by incorporating methods to detect and account for triangle reversals when calculating distortion.

V. Conclusion and Future Challenges

This paper has revisited the transit map design principles introduced in the panoramic transit maps in the 20th-century of Japan. Based on our observation, many design principles are overlapped with the modern transit map design (e.g., global scale distortion), while some are very specific to Yoshida's style (e.g., landscape composition). Some argue that Yoshida's maps are out-dated due to the development of digital maps with high accuracy; however, panoramic maps are still relevant for certain use cases. For example, route planning in ski resorts [21] and hiking [20], and general cable car networks [24],

[27] since all of them involve landscapes and road networks. We further summarize potential research topics as below:

- **Integration Tools for Historical Insights:** One clear value of Yoshida's maps is to support the study of the culture and history in the Taisho to Showa era, as they serve not only as practical navigation tools but also as cultural artifacts that reflect the social, technological, and artistic contexts [17]. Yoshida's maps often incorporate detailed seasonal illustrations and landmarks, providing insights into historical urban landscapes, transportation infrastructure, and aesthetic preferences. Such unique features may engage map readers and showcase the changes from the old times in a more attractive form. Although the maps themselves are static, one can digitalize them and further create animation to convey the story in the era as being done in *The animation of Along the River During the Qingming Festival* [14].
- **Personalized Storytelling Transit Maps:** Personalizing transit maps is still a fundamental challenges in the field [28]. This includes the integration of heterogeneous datasets, such as the topographical details of the network system, points of interest, and user-specific preferences, requiring robust data processing and management systems. Moreover, the automatic creation of maps is still an ongoing topic due to its complexity in time and space. Together with the visual clarity, all potential challenges may influence users' trust in the final outcomes. Even with the modern LLMs [19], the automatic generation of transit maps remains challenging.
- **Educational WimmelTransitMaps:** As another educational application, panoramic transit maps can be used to create Wimmelmaps, which are with highly detailed pictures to tell stories, for learners who would like to explore the area in an illustrative form. To the best of our knowledge, there is no automatic approach that has been developed for this purpose. The approach involves the integration of action-based image generation, storytelling design, and map integration.
- **Transit Maps as Visual Metaphors:** As Wu et al. have mentioned [28], transit maps can be used as a visual metaphor for visualizing data containing relationships, such as social networks and biological networks. The integration of landscape design may broaden the applications for such a concept.

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