Data Visualization Combining 3D Maps and 3D City Models

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Abstract

In recent years, everything in the real world has been connected to a network and data utilization in virtual space is accelerating. We are also working on solutions such as labor-saving on inspections and optimizing facility operations by utilizing the data we collect.

On the other hand, there is a global trend to achieve carbon neutrality. The hurdles to achieving this are high, and it is necessary to discuss the big picture of the urban environment, not just individual facilities.

Therefore, we are building a platform for integrating data from multiple infrastructure facilities, and then combining it with other related data to visualize the urban environment.

1 Preface

In Japan, the national government, local governments, and companies have begun various initiatives to achieve carbon neutrality by 2050.

As a manufacturer that has supported social infrastructure, we are promoting sustainability management and expanding our range of eco-friendly products. For example, in our High Voltage Substation for Green transformation (GX), in addition to highly reliable eco-friendly products, we have combined the Internet of Things (IoT) to reduce the labor required for inspections. For details, please refer to “MEIDEN CONNECT for problem solving and value creation” (see p.10).

However, achieving carbon neutrality is an extremely high hurdle. Not only are individual technological innovations required, but also behavioral changes aimed at reducing greenhouse gas emissions including carbon dioxide are needed, and ultimately structural changes in society as a whole are also required. The Ministry of the Environment of Japan is developing a new national movement to strongly support behavioral changes and lifestyle changes among citizens and consumers[(1)].

Against this background, it is expected that there will be an increasing demand to visualize the urban environment, not just individual products and infrastructure facilities. Therefore, we have built a platform for integrating data from multiple infrastructure facilities and are working on visualizing urban environments by combining it with other related data. This paper introduces a technology for visualizing urban environments that combines 3D maps and 3D city models to visualize a variety of data based on human-centered design.

2 3D Maps and 3D City Models

3D maps are maps that display spatial information such as terrain, buildings, and cities in three dimensions. 3D maps can accurately express actual spatial relationships, shapes, and three-dimensional effects that cannot be fully expressed by conventional flat maps or models.

2.1 Initiatives that Utilize 3D Maps

3D maps are used in a variety of fields, including urban planning and disaster prevention. They are also used in urban planning simulations. They can model the behavior of cities under various scenarios, such as urban growth and development, traffic flow prediction, and disaster risk assessment. We also reproduce the appearance of cities by placing various city data obtained from real space on these 3D maps and consider how to use them. Since it is not realistic to build a 3D map from scratch, we use services that are available in society. We use services that operate at high speed even when a large amount of data is placed on the 3D map and have a high degree of map customization.

2.2 3D City Models

3D city models make it possible to reproduce the three-dimensional shapes of buildings and civil engineering structures in digital space. In addition, the 3D city models are created based on real geospatial information, and the locations and sizes of cities are the same as in reality. Therefore, they are not only beautiful to look at, but can also be used in various situations that require numerical information, such as various simulations. There are several services that create and distribute these 3D city models. Here, we introduce a service called PLATEAU, provided by the Ministry of Land, Infrastructure, Transport and Tourism of Japan, which distributes 3D city models nationwide for free.

2.3 PLATEAU

Project PLATEAU is developing 3D city models for the whole of Japan and promoting their open data. The 3D city models provided by PLATEAU contain data on cities, such as "architectures" such as houses and buildings, "urban planning decision information" such as urban planning areas, "land use" showing the use of land, and "roads" and "bridges" that are urban infrastructure. These are created based on 2D city planning basic maps developed by local governments (prefectures and municipalities), with height information from aerial surveys added, and survey information such as basic urban planning surveys added.

Processing this data on a computer can create a digital twin of a city that can be used in a variety of fields.

3 Design of Color Scheme

When deciding on the color scheme for the data visualization, we thought that it should be designed so that anyone can view it regardless of age or gender.

For example, when choosing a color palette, it is important to use not only high-contrast colors or color changes, but also patterns, symbols, and animations, taking into consideration the vision of people with color vision deficiencies and the elderly.

In this visualization, human-centered design was applied to improve visual accessibility to viewers, and data visualization was implemented with visibility in mind.

We developed the data visualization with the idea of "realizing visibility that is easy to understand and easy to see for customers with diverse color vision" and "realizing the effect of controlling the impression given to customers and linking them to emotions".

3.1 Psychological Effects of Color

Color is an important element in information transmission and meaning. Different colors express meanings and emotions and play a role in clearly conveying information. By selecting the appropriate color, the impression given to customers can be controlled and the effect of linking them to emotions can be created.

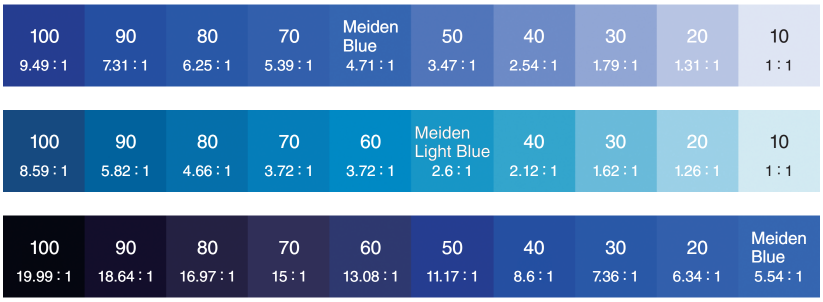
Fig. 1 shows a diagram of the relationship between color and psychological effects. When applying the main color of the data in this visualization, we considered the psychological effect of color and subdivided similar languages according to color. We considered keywords that would lead to changes in citizens' behavior, and the keywords that came up are the ones whose colors change in the figure. Among them, blue colors contain many keywords such as "safety, mysterious, trust, and future", so we decided to use them as the main color direction to apply to this visualization.

Fig. 2 shows the color palette we created. The color palette adopts a color model consisting of three elements: hue, saturation, and value or brightness. The color palette was created by lowering the brightness by 10 from the main color. This adjusts the balance between the background color and the character color.

Orange	Blue	Yellow	Violet
· Vitality · Energy · Pleasant · Warm · Creativity · Bright · Harmonious · Adventurism	· Calmness · Reliability · Safe · Cool · Modesty · Mysterious · Security · Stability	· Active · Humorous · Hopeful · Healthy · Bright · Active · Energetic · Happiness	· Noble · Creative · Intelligence · Beauty · Attractive · Luxurious · Graceful · Royal
Direction	Story	Beyond imagination	Intuitive
Entertainment	Fantastic	Emotion	Sixth sense

Fig. 1 Diagram of Relationship between Color and Psychological Effects

It shows the relationship between color and psychological effects, and lists the keywords that were raised in this theme.



HSB: A color model consisting of the three elements of H (Hue), S (Saturation), and B (Value or Brightness).

Fig. 2 **Created Color Pallet**

The color pallet created for this visualization is shown based on Fig. 1. At the top and middle stages, the brightness is regulated by 10 steps based on the Meiden Blue and Meiden L Blue. At the bottom stage, the brightness is raised by 10 steps based on the Meiden Blue set at the lowest level of brightness. The contrast ratio with white text was examined.

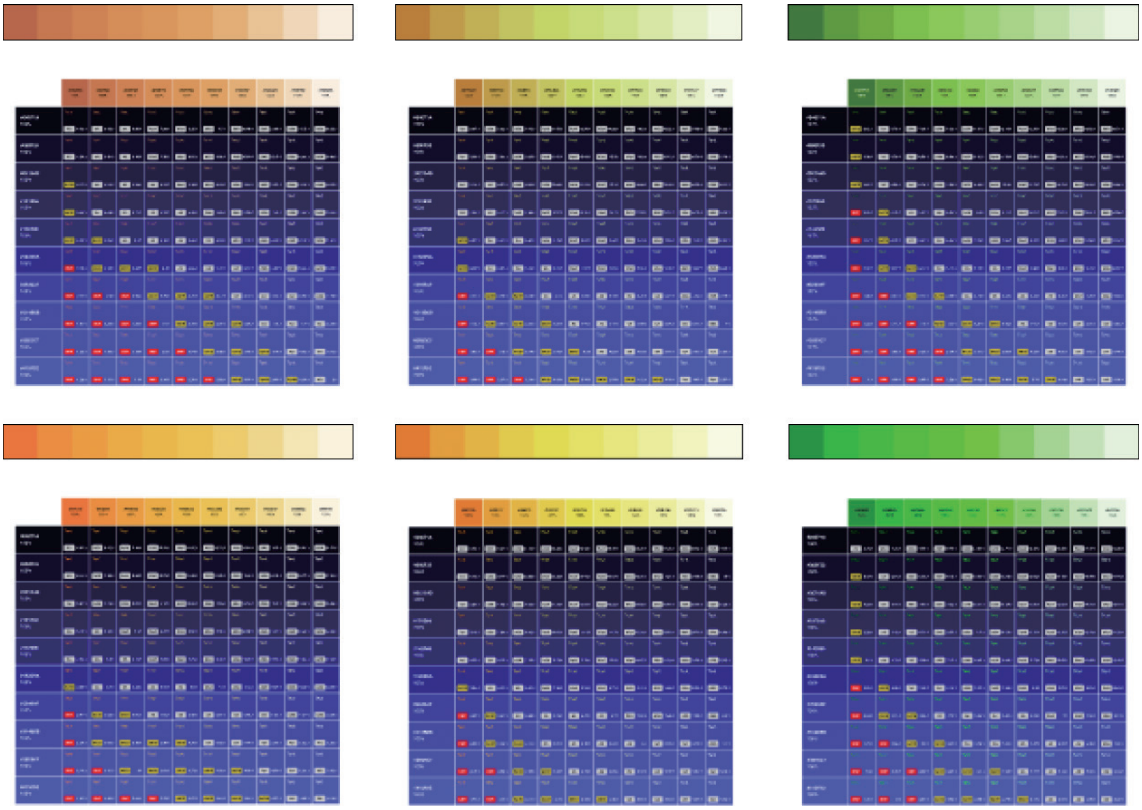


Fig. 3 **Diagram Combining Background Map and Data Colors**

It shows combinations of data colors that are easy to see for the color palette in Fig. 2. The horizontal axis represents the data color, and the vertical axis represents the background map color. Six patterns of data color were examined for the same background map color. Combinations where the contrast ratio is guaranteed are represented by white on the table, those where it is barely guaranteed are represented by yellow, and those where it is not guaranteed are represented by red.

3.2 Accessibility

For accessibility, we aimed to ensure a contrast ratio of 4.5 : 1 or more between text, data, and background color (i.e., map color) based on the international guidelines of Web Content Accessibility Guidelines (WCAG).

Generally, a person with 0.5 vision requires a contrast ratio of $3 \times 1.5 = 4.5 : 1$. Originally, the contrast ratio was determined by the ratio of background color to text, but this visualization had to be composed of a combination of map elements (e.g., roads, green spaces, place names, water), data, and text.

Fig. 3 shows a diagram combining background map and data colors. We created combinations of map colors for roads, green spaces, place names,

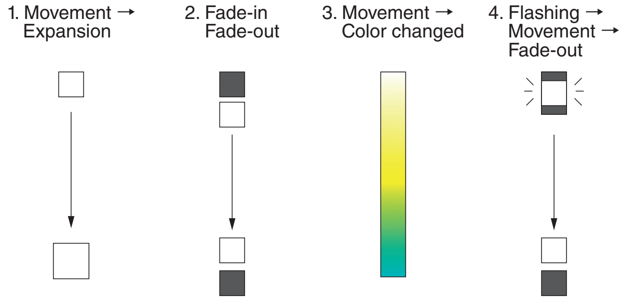


Fig. 4 **Pattern of Data Animation**

The pattern of animation after consideration of visualization is shown.

Figure	Point size	Green view index	Color	Zoom level	Explanation
	10 px	30%~		Narrow region	The green view index of 30% or more is shown.
	8 px	30~25%		Narrow region	The green view index of 30~25% is shown.
	8 px	25~20%		Narrow region	The green view index of 25~20% is shown.
	4 px	20~15%		Narrow region	The green view index of 20~15% is shown.
	4 px	15~10%		Narrow region	The green view index of 15~10% is shown.
	2 px	10~5%		Narrow region	The green view index of 10~5% is shown.
	2 px	5~0%		Narrow region	The green view index of 5~0% is shown.

Fig. 5 **Diagram of Size of Data Points**

The size of data point is changed according to the size of map display and the result of consideration is shown.

water, text, and data colors. For each combination, we checked whether the contrast ratio was guaranteed and applied a color scheme that satisfied 4.5 : 1.

By selecting a color scheme that weakens the contrast of map colors and suppresses the color difference, a tone is created between the data and text, making it easier to understand. On the other hand, excessive use of colors should be avoided as it makes the visualization difficult to read. We also took into consideration the text on the map (e.g., place names, labels) and improved legibility by considering a font, size, and line spacing that are visually easy to read.

3.3 Visual Attributes

In data visualization, various visual attributes are used to visually represent information. These attributes are effective in highlighting the features of data and visualizing patterns and trends. Visual attributes are classified into position, length, orientation (angle), thickness, and color, and can represent different values and relationships.

Fig. 4 shows a pattern of data animation. We thought that applying animation to data would be useful for changing data and progressing patterns. By animating the movement and transformation of elements, we can visually convey the process of change and smoothly express data changes.

Fig. 5 shows a diagram of the size of data points. This diagram shows the size of points displayed at narrow and wide areas depending on the zoom level. At high zoom levels, the map is displayed in detail, and at low zoom levels, the entire map is displayed. We thought that changing the size, color, and movement of points relative to the road width would lead to enhanced individual accessibility.

4 Example of Implementation

Taking the above into consideration, we actually placed a 3D city model on a 3D map and performed visualization by overlaying various data on it. In this study, we selected image data taken of the city with a 360° camera and people flow data, as data that can be obtained by our company. People flow data can be obtained by having people walk around the city with their smartphones. This enabled us to achieve a visualization that allows people to intuitively understand the state of the city.

4.1 360° Image Data

A 360° camera was attached to the top of a car to take videos of the city, and images of each point were cut out from the videos and placed on a map. In addition to simply placing images, the green view index of information that can be obtained from the images was also placed on the map. This green view index indicates the proportion of green contained in the image. A high green view index gives a sense of peace[(2)]. Fig. 6 shows the visualization of 360° images and green view index.

4.2 People Flow Data

We collected people flow data by having people move around various locations with their smartphones, which required installing an app that can detect smartphone movements. Fig. 7 shows the visualization of people flow data.

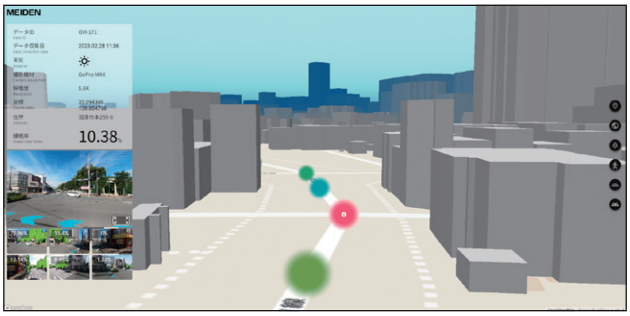


Fig. 6 **Visualization of 360° Images and Green View Index**

The 360° images and green view index actually visualized on a 3D map are shown. In consideration of a contrast between data and the map, the data is treated so that it becomes easily visible.

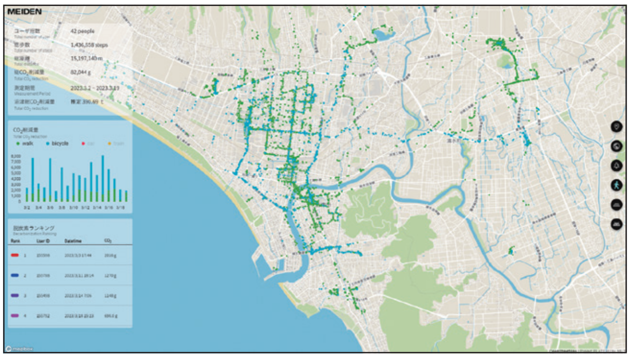


Fig. 7 **Visualization of People Flow Data**

The people flow data actually visualized on a 3D map is shown. In consideration of a contrast between data and the map, the data is treated so that it becomes easily visible.

5 Postscript

We introduced our initiatives to utilize visualization that combines 3D maps and 3D city models.

In the future, we will increase the amount of data we handle, increase the variety of expressions, and improve the visualization of urban environments based on data, aiming to create content that can contribute to the realization of carbon neutrality.

・PLATEAU is a registered trademark of Ministry of Land, Infrastructure, Transport and Tourism in Japan.

・All product and company names mentioned in this paper are the trademarks and/or service marks of their respective owners.

《References》

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