# DEVELOPMENT OF GENERATING SYSTEM FOR ARCHITECTURAL COLOR ICONS USING GOOGLE MAP PLATFORM AND TENSORFLOW-SEGMENTATION

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**Abstract.** In this research, the goal is to develop a generating system for architectural color icons using Google Map Platform and Tensorflow-Segmentation. There has been no case of developing a system that allows users to visualize the color tendency of buildings as architectural color icons for each building element from images of various regions. It is considered meaningful to be able to create criteria for decision making in architecture and the urban design by developing a system to clarify the current state of the architectural colors. It will contribute a rise in the consciousness of landscape conservation and be essential for the design of architectures and public objects. This paper includes the explanation of development method, use experiments, and consideration of five problems among architectural color icons creation. It is assumed that the accuracy of the present system will be better as the technology improves.

**Keywords.** Google street view; machine learning; image segmentation; color palette; color analysis.

## 1. Introduction

### 1.1. RESEARCH BACKGROUND

#### *1.1.1. Architectural color icons and color palette*

The info-graphic of the color of the abstracted building presented in "Geography of the Color" [1] is called architectural color icons. A color palette is information defining a combination of colors. These are significant design tools that shares an image of design with others.

#### *1.1.2. Noisy-color pollution*

In order to decide colors in architecture and urban design, consideration must be given to the surrounding environment and existing buildings in order to improve the landscape as well as the taste of the owner. In the 1980 's, noise pollution causing discomfort to people by public color is a problem in Japan. The 2004 landscape law was enacted. With this, each municipality reads the history, culture and environment of the land, creates color pallets and guidelines, and limits the range of colors that can be used for buildings.

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*1.1.3. Japanese "Color Guidelines"*

Request for establishment of legal system concerning landscape from local government, underwritten by Ministry of Land, Infrastructure and Transport, landscape law was enacted in 2004 in Japan . (3) There is a color guideline that complements the intention of this landscape law, concrete recommended colors and usage with diagrams and photographs, etc., and the resolution of the guideline differs for each municipality created.

## 1.2. 2.3 FIVE PROBLEMS AMONG ARCHITECTURAL COLOR ICONS CREATION

From 1.1, it is necessary to construct a platform that can prepare architectural color icons as color guidelines equally provided for any area in addition to existing regulations. Five problems to be solved are conceivable in generating architectural color icons.

1. Color features of the target area; The architectural color design which does not consider the color features of the target area becomes a noise problem.
2. Labor and time saving; In the existing method, since the measuring person actually visits the site and measures the color with eyes, a lot of labor and time are required.
3. Non-experts can also create; Color Guidelines Visual sense color measurement requires expert knowledge, and color icon creation is high for non-experts.
4. Dynamic framework; In response to diversified demand, it is difficult to construct a dynamic framework that changes the scale of the target area not only as a single point but also as a line as a sequence, as a wide area.
5. Visual image; Opportunities for sharing concrete visual images closer to reality are uneven.

## 1.3. PREVIOUS RESEARCHES

*1.3.1. J.P. Lenclos" Geography of Color"*

A French colorist J.P. Lenclos actually visited various countries and regions and generated "architectural color patterns" representing the color palette adapted to the area from the architectures of the land, allowing users to readily imagine the application of the design.

*1.3.2. Automatic analysis of interior colors of secondhand cars by Recruit Co., Ltd.*

Using the image analysis API "Image Paradise", automatic interpretation of interior colors of secondhand cars by machine learning was developed. It is analyzed that plurality of photographic images is registered by dealers, discriminates objects in the images, and determines the color. As a result, time and labor for color determination are saved and the part of the working process is designed automated.

*1.3.3. "Automatic color palette"*

J. Delon, A. Desolneux, J. L. Lisani, A. B. Petro. developed a system that generates color palettes of major colors from input images, using Automatic Color Palette (ACoPa) algorithm and K-means method.

1.4. POSITIONING

For the five problems above, the three previous researches introduced and thisresearch are positioned as follows. In this research, by referring to the technique of the past research, the system is developed to solve five problems in architectural color icons creation.

| | 1-1-1 Landscape improvement | 1-1-3① Labor & time saving | 1-1-3② For non experts | 1-1-3③ Dynamic framework | 1-1-3④ Meaning of color |
|---|---|---|---|---|---|
| 1-2-1 | ○ | × | × | △ | ○ |
| 1-2-2 | × | ○ | △ | × | ○ |
| 1-2-3 | △ | ○ | ○ | ○ | × |
| This Research | ○ | ○ | ○ | ○ | ○ |

Figure 1. Positioning table of previous studies and this research.

1.5. 1-4. PURPOSE OF RESEARCH

In this research, the goal is to solve five problems among architectural color icons creation through the development of architectural color icons generating system using Google Map Platform and Tensorflow-Segmentation.

**2. System development method**

2.1. SYSTEM DEVELOPMENT FLOW

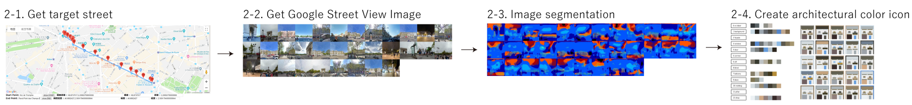



Figure 2. System development flow by 4 sections.

2.2. OBTAIN TARGET STREET

*2.2.1. Reasons to use the Google Map Platform*

Google Map holds enormous data of more than 200 countries and regions, and it can visualize the world. More than 25 million data are updated from over 1,000 data sources every day, and data can be used from Application Programming Interface (API). There is Google Street View Images, one of the services. Google Street View Images can acquire environmental information of a moving space (street) experienced by a human as an image of visual information.

Human beings acquire visual information of landscape from experiences moving in everyday life and recognize the color of the environment. The information on the Google Map platform is inferred to be highly affinity when constructing a system to analyze the color of the environment. In addition, by using the Google Map platform, it is possible to acquire environmental information in areas where Google Map is supported no matter where in the world.

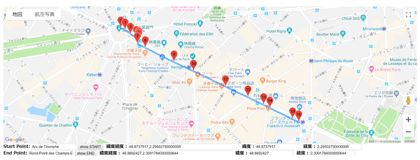
*2.2.2. Obtain target street*

Get color tendency on the environment represent for target street using information on the Google Map platform. Open a web site using the Google JavaScript API so that target street can be set from website. Therefore, the target street can be changed as necessary. If you want to analyze not only linear analysis but also planar area, cover the information of the area you want to analyze by increasing the number of streets.

*2.2.3. Target Street Acquisition Flow*

1. Enter start point and end point in natural language. (It is also possible to input latitude and longitude as it is)
2. Acquire target street.

2-2.①



2-2.②

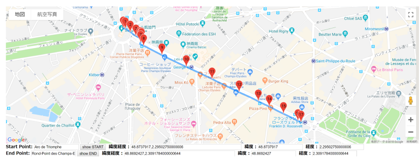


Figure 3. Target street acquisition flow.

## 2.3. 2-2. GET GOOGLE STREET VIEW IMAGE

From the same web site, obtain as much of the Google Street View image of the target street as possible with the major latitude and longitude constituting the target street.

*2.3.1. 2-2-1. Flow of acquisition of Google Street View image*

1. Obtain the major latitude and longitude of target street.
2. Adjust the main latitude and longitude of the target street so that it catches the building.
3. Automatically calculate the location and heading operations of Street View Options and capture the front of the facade of the building as an image in a state close to a rectangle.
4. Download the Google Street View image using the Google Chrome extension

Image Downloader * on the terminal that runs the image segmentation program.

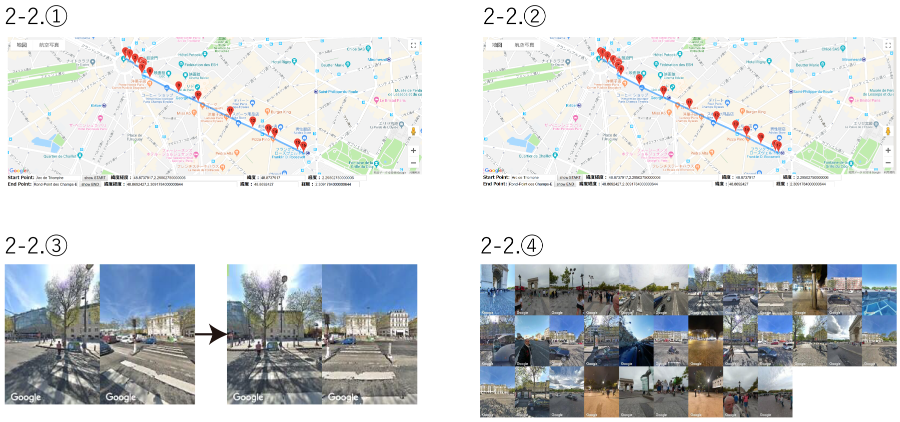



Figure 4. Flow of acquisition of Google Street View image.

## 2.4. INFERENCE BY IMAGE SEGMENTATION

By making a color pallet for each building element, it becomes easier to apply it to architectural design. We identify building elements from the Google Street View image and use image segmentation to automatically analyze what colors are used for each building element.

Many applications of image classification technology using machine learning exist. Generally widely known are image classification for identifying what the image is, image detection for identifying what is in the image, and so forth. The image segmentation (segmentation) which identifies the meaning of the image area. In image segmentation called Semantic Segmentation, the meaning indicated by that pixel is classified into classes for each pixel rather than detection of the entire image or part of the image.

In this study, a learning model is prepared in advance using the program Tensorflow-Segmentation of image segmentation and using CMP Facade Database as teacher learning data. For this time, keep mini batch size 100 and epoch number 500 with default settings. Further, the inference result is allocated to the teacher class 12 by quantifying the color difference.

### *2.4.1. Tensorflow-Segmentation*

Learning and inference based on convolutional encoder-decoder architecture of Tensorflow-Segmentation using machine learning open source software library TensorFlow (TM). Google Street View Add modifications to make it easier to imagine the image.

*2.4.2. CMP Facade Database*

Use CMP Facade Database of the Center for Machine Perception as teacher data. This consists of 378 rectified facades images with 13 classes. (Facade, molding, cornice, pillar, window, door, sill, blind, balcony, shop, deco).

*2.4.3. Class distribution by quantifying color difference*

Distribute inference results to teacher class 12 by quantifying color differences. We compare class distribution results by different calculation formulas and used a low-cost approximation equation for matching RGB values to human vision based on the Euclidean distance method.

*2.4.4. Flow of inference by image segmentation*

1. Load the downloaded Google Street View image
2. Correct the Google Street View image to the image size of the teacher data
3. Infer the meaning for each pixel of all images based on the model created at the time of learning
4. Distribute gradation-like inference results to classes by pixel
5. Save the segmentation result assigned to 12 classes as an image

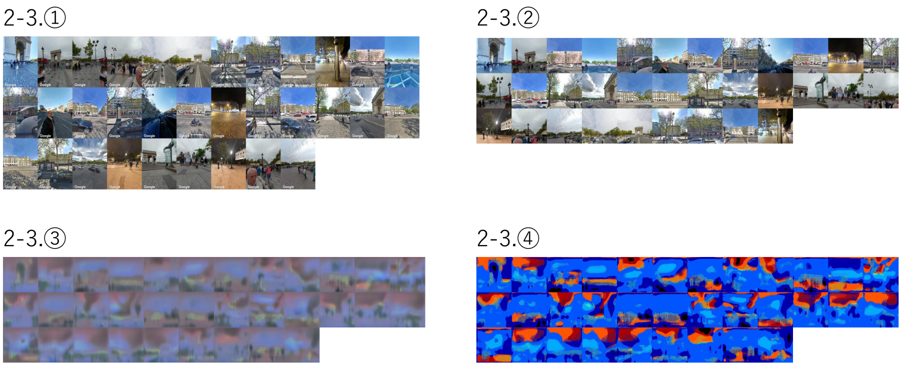



Figure 5. Flow of inference by image segmentation.

2.5. GENERATION OF COLOR PALETTE AND ARCHITECTURAL COLOR PATTERN

The color information acquired for each building element from the image is clustered by the K-means method to acquire up to 10 representative colors of up to 10 types. At this time, add all the segmentation results of the downloaded Google Street View image and create a color palette for each building element. (Frequently used in descending order from the left) 12 classes Choose colors randomly from the color palette of some building elements and generate infographics with 25 kinds of architectural color icons imitating a two-story house. By doing so, it can express the color trends appearing on the analysis target street, making it easier to compare for each region analyzed.

### *2.5.1. Flow of generation of color palette and architectural color pattern*

1. Summarize what colors are used for each class for each target street
2. Clustering is performed using the specified number of times K-means method based on Euclidean distance in RGB space
3. Select colors one by one from inside the color palette of each class and generate the building color icon.
4. Generate the icon of 25 and make it the architectural color pattern.

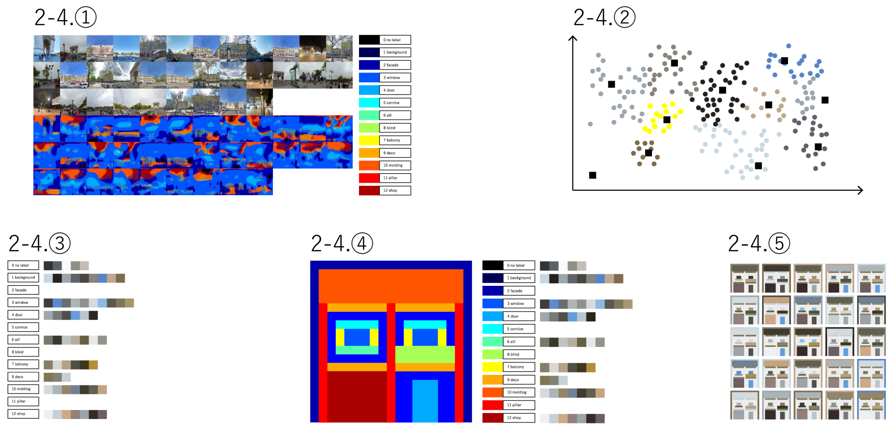



Figure 6. Flow of generation of color palette and architectural color pattern.

## 3. Use experiment

It is conducted an experiment using this developed system, for following four sample target streets; Champs Elysées in Paris, Times Square in New York, Hellengrat Avenue in the center of Amsterdam, Sannasaka in Kyoto.

Target area name, number of acquired Google Street View images, latitude and longitude of start point and end point, target street on Google Map, Google Street View image, inference result of image segmentation, color palette for each building element, target street Compare architectural color icons.

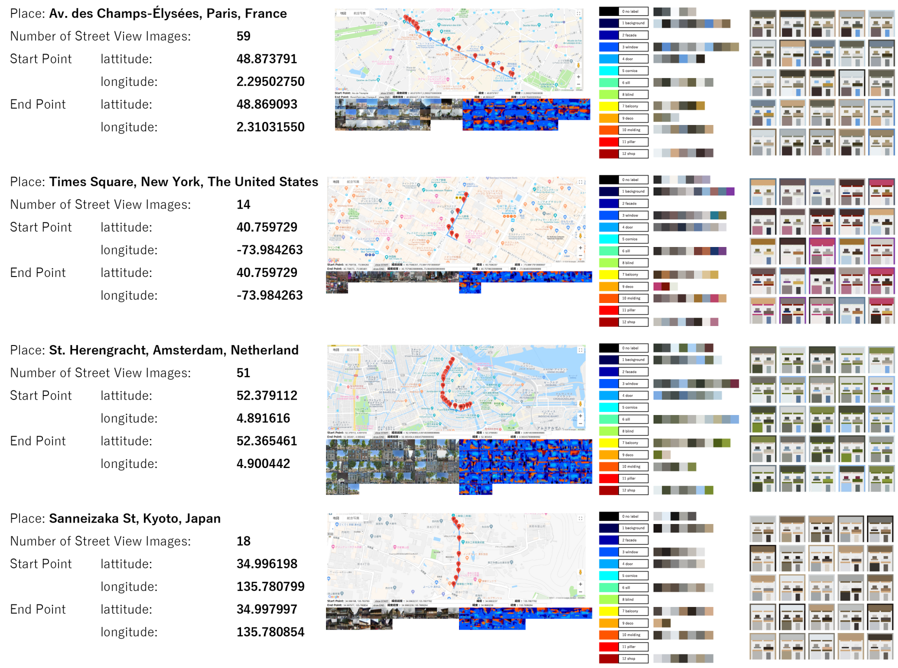



Figure 7. use experiment of this system for following four sample target streets.

## 4. Consideration

### 4.1. FIVE PROBLEMS IN ARCHITECTURAL COLOR ICONS CREATION

A system to clarify the current state of architectural colors are developed in various regions. From the experiments, it was demonstrated that the architectural color icons of four different cities were developed. This section considers the effectiveness of the system on whether the five issues in the generation of the architectural color icon are solved.

1. The color of the landscape greatly affected the area, and the colors of the architectural color icons changed. In addition, it became possible to represent the color as a sequence due to the feature of Google Map.
2. With the area where Google Maps Platform is compatible, it is possible to generate the architectural color icon from anywhere, saving the labor and time of visiting the site. Depending on the number of images, processing time can be varied.
3. This system is developed to automate and to enables creation of architectural color icons without expert knowledge. Experiments on usage including experts and non-experts is set as future tasks.
4. With the automation using the Google Map Platform, it was possible to dynamically generate architectural color icons of different scales.
5. Architectural color icons express the color tendency of the target street and presented a combination of multiple colors to clarify how the landscape is created

by many architectures.

## 4.2. FUTURE IMPROVEMENTS

Many problems remain in improving accuracy. We assume that these problems will be improved with future technological improvements. Experiments on the usefulness of this system and experiments on the method of use are subjects for the future.

2-1: With the route that can be obtained from Google Map, it is necessary to exclude factors that hinder the acquisition of building information by taking pictures from both pedestrian spaces on a large road.

2-2: The number of points acquired from Google Map uses the maximum number of latitude and longitude values that can be directly acquired at present. When it comes to increasing the number of points more than now, it is considered that results closer to the real environment can be obtained. In addition, since the color values from the Google Street View image have been referenced, values different from the actual color will come out due to time, season, weather, camera type etc etc. By improving the technology of Google Map Platform, it is predicted that color value correction with high precision will be possible by linking information on the conditions captured on the Google Street View image.

2-3: Since learning data deformed into a rectangle is used, it is difficult to recognize objects often included in Google Street View images such as sky, road, planting, people. By predicting that sky, road, planting, people and building elements often included in Google Street View images are generated as learning data, it is predicted that more accurate building color icons can be created.Also, because the architectural styles used in the learning CMP Facade Database are limited, image segmentation with a different architectural style is difficult. By creating data including various architectural styles, it will be possible to deal with various architectures around the world.

2-4: From the inference result of image segmentation, it is necessary to improve teacher data and discretization method by color difference quantification for the problem that 12 classes of building elements do not exist.Since the icons expressing the building elements were unified in a uniform form, it is a system that makes it easy to recall two-storied houses as an example of application to the design. By recognizing the type of building included in the Google Street View image from image recognition and by changing the display icon it will be possible to deal with various styles of architecture as well.

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### 4.3. PROSPECTIVE

Due to the spread of this system, it becomes possible to visualize which “part” affects the landscape and how the “whole” is changed. From the passage of time, the co-evolved “part” and the “whole” will create distinctive features of color for each region in the state of half bottom up, half top down. It can be said that the architectural color icons generation system, which is a new selection indicator of colors used in anywhere, will create diversity in architectural color and enrich the world.

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