# The Simultaneous Presentation Technique of Multiple Images by Using Mosaic Image

**Yuta Suzuki**
University of
Electro-Communications
1-5-1 Chofugaoka.
Chofu, Tokyo 182-8585, Japan
suzuki@vogue.is.uec.ac.jp

**Hideki Koike**
University of
Electro-Communications
1-5-1 Chofugaoka.
Chofu, Tokyo 182-8585, Japan
koike@vogue.is.uec.ac.jp

## Abstract
Every image has optimal viewing distance to be recognized. This distance depends on many variables such as screen size, content size, etc. When these sizes are not appropriate for viewing distance, it is hard for viewers to recognize the image's contents. As a solution to this problem, we propose a method to present optimal images depending on distance. More specifically, by applying the "Mosaic image" and a saliency-based method, we propose the method to generate superimposed image which can present different images simultaneously to two areas. Additionally, we propose a digital signage as an application of our method.

## Author Keywords
attentive UI, mosaic, saliency, digital signage, visualization

## ACM Classification Keywords
H.5.2 [User Interfaces]: Graphical user interfaces (GUI).

## General Terms
Human Factors

## Introduction
Every image shown on displays or projected on walls has optimal distance for viewer to recognize its contents. The distance depends on each size such as screen size and

contents size and so on. When these sizes are not appropriate for distance of viewers, it is hard for viewers to recognize the image's contents.

This problem which caused by each size and viewing distances is more prominent when the screen size is bigger. For example, if the contents on the screen is big, viewers who are near the screen will find it hard to recognize the contents despite being aware of the image's existence(Figure 1). On the other hand, if the small contents is shown on the screen, viewers who are far from the screen are hard to recognize the contents despite recognizing the existence of the image. It would be beneficial to have an image appearing on screen that can be recognized by as many viewers as possible in order to prevent loss of experience.
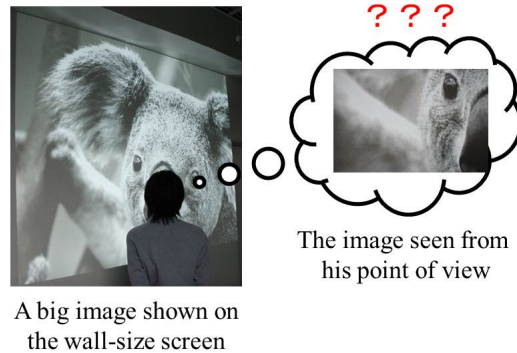


**Figure 1:** The problem of a big screen/display.

As a solution of this problem, presenting multiple images simultaneously to each viewer by optimizing these images to each distance can be considered(Figure2).
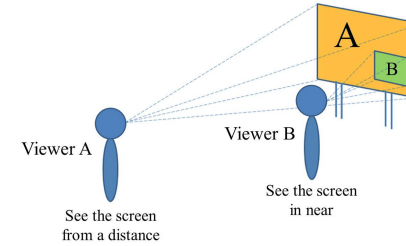


**Figure 2:** Selectively providing of images.

For example, in Figure 2, image A will be presented to the viewer A who is far away from the display. At the same time, image B will be presented to the viewer B who is close to that. Via this method, each viewer can recognize different images that are optimized to their spatial distances using the same display area.

In this paper, we propose a method to present optimal images depending on distance based on the idea mentioned above. More specifically, by using the feature of "Mosaic image" and a saliency-based method, we realize the method to generate superimposed image which can present different images simultaneously to two target distances, one is the near area from the screen and the other is the area far away from the screen. Additionally, we propose a digital signage as an application of our method.

## Related work

There are number of solutions for presenting different images by optimizing these images for each viewer. Some of them use mobile devices with the wall sized display. The wall sized display is used to show public information, while the mobile device such as a mobile phone is used to present private information or more detailed information.

These systems are practical solution to present public and private information. However, we want to explore a technology to show multiple information on a single display.

Vogel et.al proposed a method to present different information depending on the distance between the display and viewers [1]. They hypothesized that the distance between the display and viewers is a measure of interests of the viewers to the displayed contents. The system shows different images by sensing the position of the viewers. The system, however, can not show different images simultaneously on the same area to different users. And their system requires viewers to wear special devices in order to measure the viewer position.

Matsushita et.al developed Lumisight Table which can display four different information to users depending on their position [2]. They used four projectors and special films called Lumisity film which diffuses the light coming from specific direction and passes the light coming from the other direction. However Limisight Table presents different images based on angles where a viewer see the screen, and has not mentioned about a way to present images based on viewer's distance. Additionally, the system requires a large-scale hardware composition.

The hybrid image project at MIT [3] showed interesting results on showing two images on a single display. By combining a low frequency image and a high frequency image, the hybrid image can show two different images depending on the distance from the screen image is shown. The method, however, requires strong similarity between two images and has strict limitation of its use of color.

Photomosaic can be considered as one of the methods to present different images to multiple viewers simultaneously. Photomosaic is an art technique in which a large amount of small images constitute a big whole image. By seeing the image closely a viewer can see each small image. And by seeing the image away from it, the viewer, this time, can see whole image. However, small images, in general, are too small to present information. And also, the distance between the region where viewers can see small images and the region where viewers can see whole image is so wide.

## Proposed method

Figure 3 shows a basic idea of our approach. This image is a famous painting by Salvador Dali. People who are far from the painting will see the image of Abraham Lincoln which is drawn like mosaic image. On the other hand, people who are close to the painting will see the image of his wife. These facts suggest that the painting can present different images depending on viewing distances using the same display area in physical space.
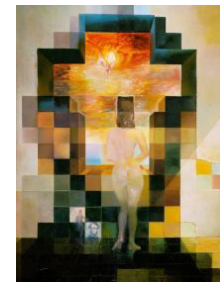


**Figure 3:** Dali's paingting.

Referring to this painting, we focused on the mosaic image as a element to realize the way for providing different pictures depending on distance. Mosaic image is the image where pixel values in the certain area are replaced by a representative value such as average of

these pixel values (Figure 4). At the same time, it can be considered as a coarse-resolution image.
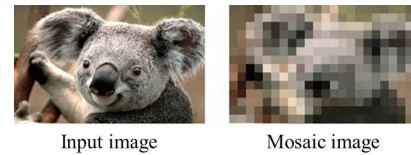


Input image      Mosaic image

**Figure 4:** The example of mosai image.

If the size of the mosaic tile is large to some extent, the resolution of the mosaic image is low. Thus it will be difficult to recognize the contents of the image when it is viewed from nearby. On the other hand, if the same mosaic image is viewed from far position, the mosaic image can be recognized as an image because each mosaic tile becomes so small that it can be recognized as a pixel. Based on this characteristic, we propose a method to display different images to viewers depending on their distance from the screen by superimposing mosaic image and normal images. The basic concept of our proposed method is illustrated in Figure 5.
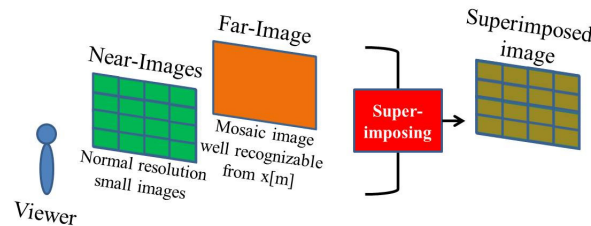


**Figure 5:** Overview of our proposed method.

First of all, the image for the viewer far from the screen is converted to mosaic image (referred as "Far-Image").

The resolution of the image is set to the specific value that the viewers can recognize its contents well from $X(m)$. Next, the several normal resolution images for the near viewer (referred as "Near-Image") to the screen are arranged. By overlaying both images into a single image, we can generate an image which can provide different images to two distance ranges.

## Prototype of superimposed image

We made prototype of superimposed images which can provide different images for two sides by simply changing the transparency rate of Near-Images.
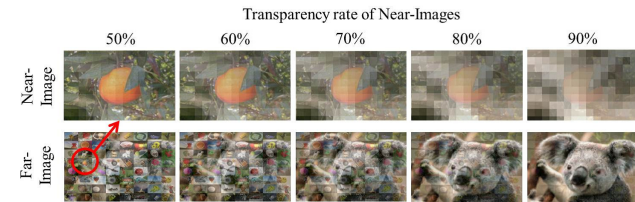
*Making process of prototype image*



**Figure 6:** Result image by simple superimposing method.

The concrete process of making superimposed image is below. First, we convert an image for distant viewers to mosaic image (Far-Image). The mosaic tile size is set to $12 \times 12(pxl)$. Then, for near side viewers, 64 images (Near-Images) are overlaid on Far-Image. Finally, we adjust the transparency rate of all Near-Images. We selected the transparency rates of Near-Images 50%, 60%, 70%, 80%, and 90%. The result images are shown in Figure 6.

As you can see, for example in 70%'s superimposed image, Far-Image and Near-Image are simultaneously shown in the same space.

*Problem of the process of prototype image*
Figure 6 shows that the result images can present different images for two sides. But when the transparency rate is 50%, 60%, and 70%, the visibility of the Far-Image is comparatively poor to one of Near-Images, while 80%, 90% image can provide higher visibility regarding to the Far-Image. However, the Near-Images in 80% or 90% image is hard to recognize the contents.

The visibility of Far-Image and Near-Images directly affect the information presentation quality of this system. Thus, increasing the visibility of both Far-Image and Near-Images as much as possible is important. But simply decreasing the transparency of Near-Images as shown in Figure 6 is not enough to balance these visibilities. Therefore, we decided to apply "the visibility improving process" in superimposing process for balancing the visibilities of Far-Image and Near-Images as much as possible under the trade-off.

## Process of making superimposed method including the visibility improving process

The superimposing process which includes our visibility improving processes is shown in Figure 7. The visibility improving process is composed of 4 steps. In this section, we will explain the detail of each step of the visibility improving process.
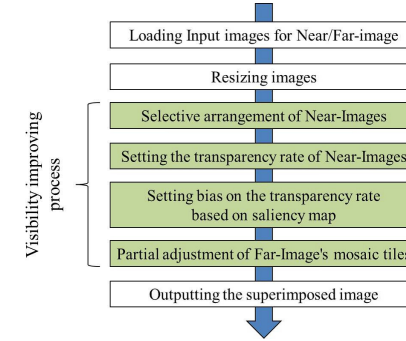


**Figure 7:** The superimposing process.

*Selective arrangement of Near-Images*
In a simple-superimposing process, Near-Image is arranged in order of reading images. But if the difference between colors of Near-Image and corresponding area of Far-Image is big, both visibilities become low. So it would be better to put each Near-Image on the area of the Far-Image such that it has a similar color arragement to the Near-Image. This process realizes the arrangement in order to reduce a confliction in the color space as much as possible.

Like the way of generating photo mosaic, This process set the Near-Image into corresponding area of Far-Image by comparing the feature vector generated from each image or area. However, unlike general photo mosaic which uses a large amount of small images, This arrangement needs to be conducted under the condition that the number of Near-Images are restricted. Therefore, in this process, we set a priority into each areas depending on importance, and have the selection of a Near-Image conducted in the order of the priority. How to set priority of each area of Far-Image is shown in Figure 8.
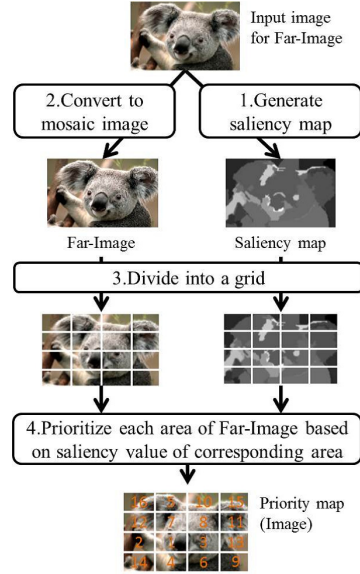
**Figure 8:** The process of making Priority map.

First of all, from a input image for Far-Image, the saliency map and Far-Image are generated. And then, the saliency map and Far-Image are divided into a grid. The size and number of these grid areas corresponds to the number of the Near-Images

After that, the sum of pixel value of each area on the saliency map is calculated, and the priority is set into all areas of Far-Image based on the value to acquire Priority map. After generating the Priority map, using the priority, select a Near-Image that has the most similar color arrangement to each area and designate the Near-Image to that area. This step is continued until all the Near-Images are arranged. Saliency map is a topographically arranged map which represents visual saliency of an input image

[4]. In most cases, an image includes a main subject. And there is a tendency which the region of the main subject is to be a high saliency region in the image. Therefore, the object which has high saliency pixels in the image is considered as the important region which determines the recognition of the image. The way to generate saliency map has been proposed by several researches. Among that, we use the method proposed by Cheng et.al. [5].

*Setting the transparency rate of Near-Images*
In the simple superimposing process, the transparency rates of the Near-Images were set manually from 50% to 90% by 10 point. However, it would be better that the transparency rates are set automatically based on input images. Therefore, we implemented the processing to set the Near-Image's transparency rates where the visibility for both the Near-Image and the Far-Image are as high as possible. More specifically, for each Near-Image, the transparency rate where the visibility of the superimposing image has similar color arrangement to both Far-Image and Near-Image is calculated. The algorithm of this process is shown in Figure 9.

First, by using i-th Near-Image, named as $NI_i$, and i-th area of Far-Image, named as $FI_i$, which area is corresponding spacially to the $NI_i$, i-th superimposing image $MI_{(i;\alpha)}$ is generated with the candidate value of transparency rate. We use values from 5% to 95% in increment of 5 point as a candidate of transparency rate. After that a $MI_{(i;\alpha)}$ was generated, $NI_i$, $FI_i$ and $MI_{(i;\alpha)}$ are divided into 9 grid areas each, and then, averages of L*, a*, b* value of each area are calculated for making a feature vector of these three images. These vectors generated from three images have 27 (L*, a*, b* averages of each of 9 areas) elements respectively. When acquire feature vectors of $NI_i$, $FI_i$, $MI_{(i;\alpha)}$, two distances are

calculated by using the Euclidean distance. One is the distance between $NI_i$, and $MI_{(i;\alpha)}$ as $DN_{(i,\alpha)}$, the other is the distance between $FI_i$ and $MI_{(i;\alpha)}$ as $DF_{(i;\alpha)}$. And finally, $|DF_{(i;\alpha)} - DN_{(i;\alpha)}|$ is calculated as a score $S_{(i,\alpha)}$. the above processes is continued until all candidate values of transparency rates are performed, and after that, the $\alpha$ with the minimum score is determined as a final transparency rate of the Near-Image. The result image generated via above processes is shown in Figure 10.
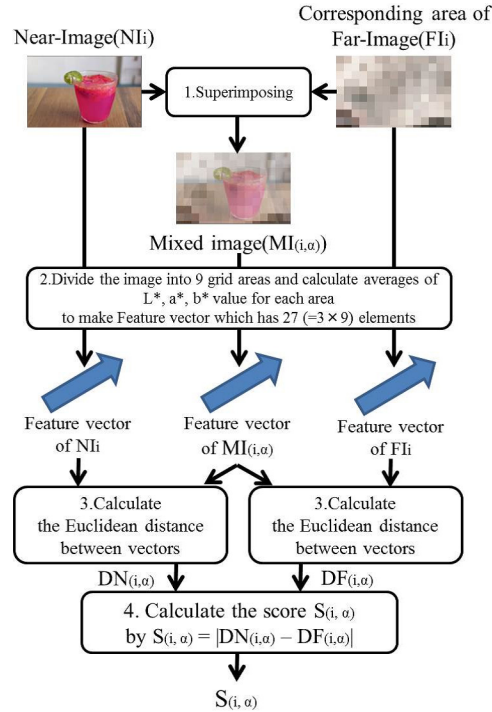


**Figure 9:** The process of setting transparency rate.



**Figure 10:** The result image set transparency rate.

*Setting bias on the transparency rate based on saliency map*
As we can see in Figure 10, the visibility of Near-Images are mostly recognizable. However, the visibility of Far-Image is still difficult to recognize. This problem may have been caused by the Far-Image experiencing discontinuity in the color space, since the optimization for the transparency rate of the Near-Images is performed in units for each Near-Image.

So we implemented the process to improve the visibility of Far-Image by reducing the discontinuity of Far-Image in the color space. But, at the same time to improve the Far-Image's visibility, this processing requires that visibilities of Near-Images are kept as much as possible. Background areas of each Near-Image are considered as one of the big elements that affect the discontinuity of Far-Image. When the difference of background color between adjacent images are big, or the difference of background color between a Near-Image and corresponding area of Far-Image is big, superimposing

image will be more discontinuous. As the solution to the problem, we implemented the process to improve the visibility of Far-Image while keeping the visibility of Near-Images as much as possible by increasing the transparency rate of these region which are considered as regions of low importance. The flow of this process is shown in Figure 11.
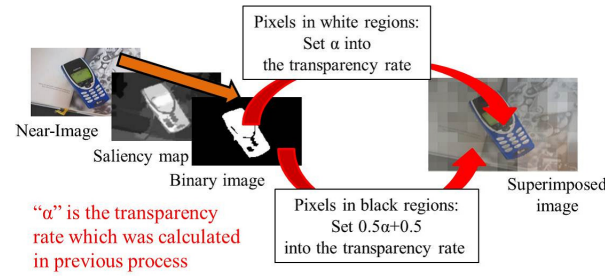


**Figure 11:** The process of setting bias on transparency rates.



**Figure 12:** The result image set bias on transparency rates.

First of all, the saliency map is generated from each Near-Image. And then, the binary image from each

saliency map in which white pixels represent high saliency pixels, and also black pixels represent low salient pixels is generated. We use Otsu's algorithm as binarization algorithm. Basing on the binary image, the transparency rate $\alpha$ calculated in previous section is set into the pixels corresponding to white region. And the transparency rate which is higher than $\alpha$ is set into the pixels corresponding to black region. The superimposed image which is processed by this processes is shown in Figure 12.

*Partial adjustment of Far-Image's mosaic tiles*
In the previous section, we mentioned about the processing to have the visibility of Far-Image improve by increasing the transparency rate of low salient regions in Near-Images. Since the process makes portion of Near-Images difficult to be recognized, it needs that the important regions of Near-Image are easy to recognize. Under the present situation, however, even if in those important regions, there are several regions which are hard to recognize that contents because of the edges between mosaic tiles these regions are overlaid. So, we implemented the processing which smooths color gradient of between adjacent mosaic tiles corresponding to important region of Near-Images. The result processed is shown in Figure 13.



**Figure 13:** Smoothing of edges between mosaic tiles.

## Result image and comparison

The superimposed image which made by the superimposing process including the all of visibility improving processes is shown in Figure 14. For comparison, the result image made by simple superimposing with $\alpha = 50\%$ is shown in Figure 15.
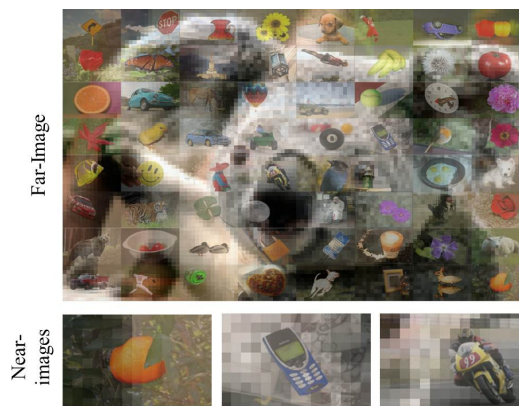


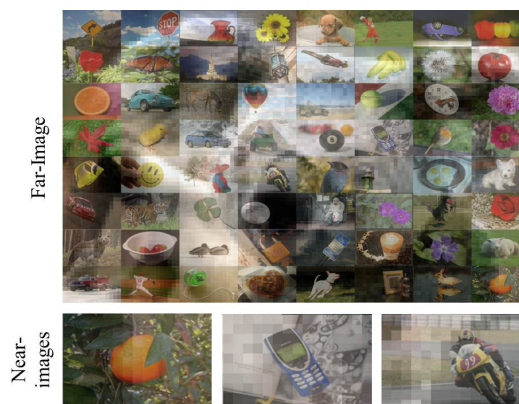**Figure 14:** A superimposed image by proposed method



**Figure 15:** The prototype image (transparency rate=50%).

As you can see when comparing Figure 14 and Figure 15, in regard to the visibility of Far-Image, the superimposed image generated by our method has comparatively high visibility. For the near image, while there are many images which visibilities are almost unchanged as compared with the case of simple superposing method, several images' visibilities are lower than images generated by simple superimposing method. But even in such images, we can say that there is no major problem in the recognition of the contents. From these results, it can be said that this visibility improving processes meets the purpose which is "to improve the visibility of Far-Image without giving a big change to Near-Images' recognition"

## Application

We developed a digital signage system using the proposed method. This system is intended to be installed in a public space such as the airport. As the contents of the signage, we selected images for tourists. Specifically, under the theme of Okinawa, we set Shurijou into Far-Image, and set 64 pictures related to Okinawa into Near-Images. Figure 16 shows the superimposed images for this application. The image was generated by the proposed method, including visibility improving processes. This digital signage system is composed of the 58 [inch] display, PC for processing, and Microsoft Kinect. The reason for installing the Kinect will be described later. The superimposed image is displayed with $1440 \times 900$ [pxl]. In addition to the above, we implemented the interaction element into the system. When a near side viewer is in a position close enough to display, so that the display area in front of the viewer is blocked by him/her, these are a blind spot for a viewer who are far away from the display. Thus, for viewers who are close to the display, we can present clear images of Near-Images without disturbing presenting an image for viewers who are far

away from the display. In order to take advantage of this situation, we installed a Kinect under the display. By sensing the distance and position of the face of a viewer who is in the target area of Near-Image, the system able to present a personal window through which the viewer can see clear Near-Images (Figure 17).
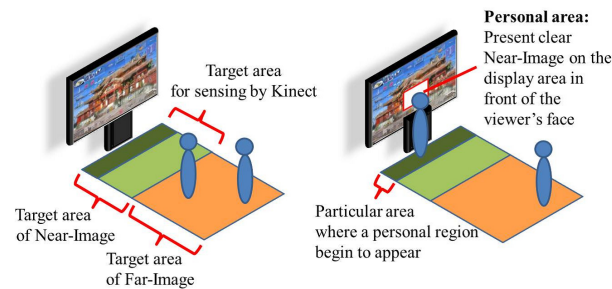


**Figure 16:** The superimposed image for the application.



**Figure 17:** The superimposed image for the application.

## Conclusion
In this paper, we proposed a basic idea of the system which can simultaneously provide different images to several viewers depending on distance by utilizing characteristics of mosaic image. We confirmed that the simple superimposing image can provide different images to two distances simultaneously, but the visibility of both Near-Images and Far-Image were not enough. Therefore, we added the procedure to increase these visibilities by performing visibility improving processes. In addition to the proposed method, in the future we would like to reveal the relationship between mosaic tile size and viewer distance in order to control the mosaic tile size which is well-recognized from specific distance.

## References
[1] Vogel, D., and Balakrishnan, R. Interactive Public Ambient Displays: Transitioning from Implicit to Explicit, Public to Personal, Interaction with Multiple User. In Proc. UIST, ACM Press (2004), 137-146.

[2] Matsushita, M., Iida, M., Ohguro, T., Shirai, Y., Kakehi , Y., and Naemura, T. Lumisight Table: A Face-to-face Collaboration Support System That Optimizes Direction of Projected Information to Each Stakeholder. In Proc. CSCW, ACM Press (2004),

[3] Oliva,A., Torralba, A., and Schyns, P. Hybrid Images. ACM Transactions on Graphics (TOG), vol. 25, no. 3 (2006), 527-532.

[4] Itti, L., Koch, C., and Niebur, E. A Model of Saliency-Based Visual Attention for Rapid Scene Analysis. IEEE Transactions on Pattern Analysis and Machine Intelligence (1998), 1254-1259.

[5] Cheng, M.-M., Zhang, G.-X., Mitra, N. J., Huang, X., and Hu, S.-M. Global contrast based salient region detection. In Proc. Computer Society Conference on Computer Vision and Pattern Recognition, IEEE Press (2011), 409-416.