Development of a Region-of-Uninterest (ROU) Detection System for Multimedia Applications

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***Abstract*—There are many research activities on Region of Interest (ROI) in the research fields of image recognition, used for medical treatments and sport video analysis. Especially, many researches on Region of Interest have been conducted in the research area mainly on image processing. It is important to extract a region which is not an interest area in order to avoid the false negative of an area of interest, rather than ROI. The authors previously proposed the concept of Region of Un-interest (ROU). It is much meaningful to consider a currently uninteresting area, ROU, but will become a useful area in future. In this paper, we describe a ROU detection system, which can be applicable to many multimedia application. The system was designed and developed to show the ROU effectiveness. In this paper, we also describe how our ROU concept can be used, by applying the three applications, such as Map, Movie, and Costume monitoring, using our ROU detection system.**

***Index Terms*—ROI extraction ;Domain decomposition; Picture graphics processing; Map application;**

I. Introduction

MUCH research is being conducted on the Region of Interest (ROI) in the field of image recognition[1][2][3][4], especially for medical treatments and sport video analysis. Similar fields of image information research that use features such as image color fields and imaging range feature extraction exist in image recognition research. However, ROI [5] is by far the most popular study area and much research remains to be conducted [6][7]. ROI is used in many fields and therefore, it is clear that various utility values exist in ROI.

It is worthwhile utilizing several areas of an image that are not currently used. They can be considered as those areas of an image that can be used even though they are of no particular interest to a user. By positioning such parts of an image as available areas, it may be possible to clarify their utility value. Consequently, the concept of Region of Un-interest (ROU) was proposed in [8]. the range with a possibility that the important role is played as territory is defined as one ROI. Three ROU extraction methods as well as ROU definition, the ROU utility, were also explained in [8].

In this paper, we describe a ROU detection system to apply the ROU concept for many multimedia applications to show the effectiveness of the ROU concept.

Section 2 describes the related work, including ROI in the medical field, and ROI in the sports science field. Section 3 describes a structure and functions of our ROU detection system. Three ROU applications are described in Section 4, followed by showing the evaluation results and discussions. Finally the paper concludes in the last section.

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II. Related work

ROI is a method of efficiently acquiring a required domain in order to use a specific area of an image with a user. Moreover, users observe the fields of an image and are concerned about an unconscious but specific place. Medical and sport fields are discussed below as examples of application of ROI.

A. ROI in the medical field

Yamamoto et al. [6] used ROI in a distribution method in radiotherapy to identify brain tumors outside an axis in an MR perfusion image obtained using pulsed continuous ASL (pcASL). They proposed it as technology for the labeling of CASL that leads to research and improvement in the signal to noise ratio. It distributes over the ROI the spin of the blood flow from the cervix after labeling by pcASL, and is collected by the spiral SE method.

In addition to the above research, ROI is used in various areas, such as in extraction of cancer cells and measurement of brain cells, and is closely interrelated with medical treatment.

B. Use of ROI in the sports science field

Kim et al. [7] analyzed sports programs based on an ROI framework for TV programs. To analyze sport videos, they defined Semantic Regions of Interest (SROIs) based on Motion Vector Space (MVF), and detected the players and ball in a stadium as important objects.

Further, because the proposed SROI framework facilitated the design of more than two effective architectures, it enhanced sport video data management.

III. The ROU concept and detection of ROU [8]

A. The ROU

The concept of ROU is shown in Figure 1. This figure is a part of an original movie and its snapshot. It contains the scene and one woman in the middle. When many movie viewers watched this picture, they tend to focus their eyes on one woman in the middle. So, the focused region in the middle is supposed to be a region of interest (ROI). There are many other regions besides this ROI. For instance, there are two to four regions around the ROI that are not interesting to them currently. These regions are the upper-right, the lower-right, the upper-left, and the lower-left corner regions. We define these regions as Region of Un-interests, ROU. These regions can be used for displaying a message such as a telop or an emergency message.

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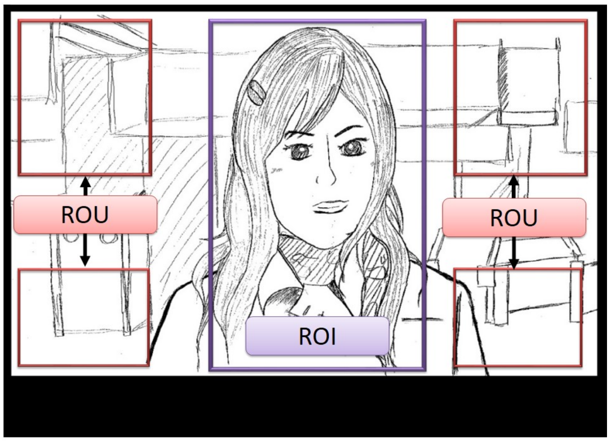

Fig. 1. ROU concept

Fig. 2. Example ROU

ROI indicates the areas of an image graphically chosen in the picture to focus on for image analysis. In contrast, ROU is an area of an image that produces utility value because a user is not directly interested in that area of the image that is not included in the ROI. Thus, the concept underlying ROU is that the area may play a role in the future.

Another example of an ROU is shown in Figure 2.

The areas defined as ROUs are as follows:

1) The areas of the image that are virtually black (for images in grayscale mode)
2) The areas of the image that have unsuitable focus and for which a base does not exist
3) The areas of the image where an object does not exist
4) The areas of the image where change is virtually nonexistent (in the case of an animation).
5) The domain which fills 1) to 4) and maintains some fixed size to an object picture

For example, an ROU could be a signboard on the roadside that is encountered when a car passes by. In such a case, the driver is more concerned with the objects that aid in driving the car, such as lane, car order, signals, and road signs. If these objects are considered indispensable and set as ROI, the advertisement signboard on the road-side is actually not required by the driver as it is not of as primary importance as the items in the ROI, or will not be observed. However, by being in the field of vision, the information may be unexpectedly viewed for a moment.

B. Usefulness of ROU

1) The necessity for ROU and The difference from ROI: Although ROU is stated as another ROI, ROU was proposed not as simple ROI but as a different area of the image [8]. Identifying the areas that are not included in the ROI as ROU helps to reduce false negatives in the ROI. However, extracting ROU as ROI is not advisable because various problems arise if this is carried out.

The existence of ROI is indispensable in order to extract ROU. If the focus is not placed on ROI, it is virtually impossible to identify the areas of the image considered to be unnecessary. Although ROU has very less use as an area of an image, it reveals the areas of the image that may play an important role. Therefore, the existence of a portion with utility value as clear as the ROI is needed for an object image or an object screen. Furthermore, the unobserved area of an image cannot be identified without the field of image information with a clear utility value. Thus, if this area of an image is not found, it is impossible to draw another type of ROI, i.e., ROU.

2) The effect of ROU : One of the most outstanding points of ROU is that it does not overlap with a ROI, and are not an obstacle to the ROI. For example, telops and other extraneous information can appear in TV programs in many cases. When a viewer watches a TV program, s/he primarily focuses on objects, such as a performer, or a player and a ball. These appearances are restricted to specific domains in many cases. When one views a TV program, the telop information may overlap with an important object, making it difficult to acquire information in many cases. Thus, it is difficult to precisely ascertain whether problems will arise with the appearance domains.

Consequently, in order not to interfere with the object, i.e., ROI, being observed when a viewer is watching, the ROU must be utilized. By using ROU, it becomes possible for a TV program to make extraneous information, such as a telop and wipe, appear without them overlapping with the important object being observed by viewers.

C. ROU EXTRACTION METHOD

The fundamental ROU extraction methods utilize the following procedure. First, data of a certain fixed range are prepared and converted to data that can be extracted by an ROU extraction system. Although this conversion varies with the type of data to be used, the final data become a grayscale picture that can be processed. Next, the changed data are used and ROU extraction is performed. Two or more ROU extractions are achieved by repeating the process. Unlike ROI extraction, ROU extraction from one feature quantity or condition is difficult. Furthermore, when extracting ROU from an animation, a real-time technique is required. Consequently, the Naïve, extraction by more efficient grid division, and the LR method, which is accompanied by an increase in efficiency, have been proposed for ROU extraction. We explain in detail how ROU extraction is performed. We utilize a grayscale image $G_{i,j}$ that is applicable to P with a value of $M * N$, generated by conversion beforehand. G

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represents the bit data of the image, whereas i, j are its coordinate values.

1) Naïve method: The Naïve method is the simplest ROU search method. It uses a two-dimensional point, and calculates ROU using the fields of the image of q from the fields of the image to the lower part of p, from the right side. ROU is set to (i, j, p, q) when the fields of the image to the right of p and the fields of the image to the lower part of q are set to ROU from $G_{i,j}$. B_x expresses x-direction block size and B_y expresses y-direction block size. Moreover, $AVG(x, y)$ is a coordinate value stored when it asks for the average of each block. $AVG_(x', y)$ and $AVG_(x', y')$ also have the meaning same as a coordinate value stored on that occasion.

2) The grid division extraction method (Grid division): The grid division extraction method aims at increased efficiency over the Naïve method. In this method, the picture is divided into a rough grid and ROU is searched for in every cell of the grid. Because this extraction method extracts ROU as an aggregation rather than by extracting bits one at a time, ROU is efficiently extracted. Block rectangle is the rectangle made using many grids divided by generateBlocks. Block rectangle serves as a rectangle which can serve as ROU by becoming the biggest size.

First, grayscale transformation of the image is carried out and bit data displays in the certain stage. Next, the picture is decomposed grids. The image is then divided into a rough grid and extracted from the left to the right for every grid, and then, the first grid that satisfies the definition value f. This left edge is Left End (LE). Progress direction we examine one by one the grid from LE. The section where this object rectangle ends is set as the Right End (RE). The next stage starts when the right side of the image is reached. The grid is extracted as before. Further, when the target grid is discovered and LE is discovered on the upper row, let RE of the upper row also be an object rectangle. Further, let this rectangle be the candidate ROU. By repeatedly performing this process, rectangles that serve as candidate ROUs are extracted in various sizes. By following this step, it becomes possible to discover two or more ROU(s) in the grid division extraction method.

IV. ROU DETECTION SYSTEM

A. Structure

The section is explained the structure of our ROU detection system. This system is composed of three components shown in Figure 3, which are Pre-processing, ROU detection, and Post-processing components.

In the pre-processing component, a given data, such as an image or a map, is transformed into a grayscale image even in the case of a map. This component also divides the transformed image into a smaller size bit-map image. This conversion is necessary to apply our ROU detection method for many types of applications, because input data features differ in applications. Then, the main component, ROU extraction component can extract ROUs as a common gray-scale bit-map image is given.

The ROU detection component detects ROU for the given converted image. One of the two detection methods, Naïve and Grid-division methods, described in the previous section, is used to detect ROUs.

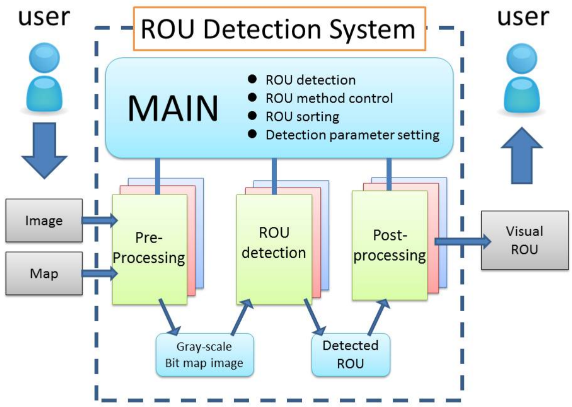

Fig. 3. ROU Structure

The post-processing component adjust the extracted ROUs for a specific application. For example, it is necessary to overlap the detected ROU with the given image or map in an application oriented way.

For the interface between components, such as Pre-processing to ROU detection, and ROU detection to Post-processing, special files are used in our system, as shown in the figure.

B. Functions

As shown in Figure 3, the system provides four functions to users, which are (1) ROU detection, (2) Detection method control, (3) Detection parameter setting, and (4) Detected ROU sorting. Users can use these functions via main component of the system as shown in Figure 3.

ROU detection
: This function is the main function of the system, which detects ROU from the input grayscale bit-map image.

Detection method control
: Users can select one of the three detection methods that were proposed and implemented. The system execute the specified detection component.

Detection parameter setting
: There are several parameters for controlling ROU detection, such as grid-size, gray-scale size and resolution, and various thresholds. Users can obtain ROU suitable for their application by changing these parameters.

Detected ROU sorting
: A set of detected ROU can be sorted with many aspects, such as area or the average level of gray scales. It is useful in the case when many ROU are detected.

V. ROU APPLICATIONS

A. Three ROU applications

We developed three applications, i.e., map, movie, costume applications, to show the usefulness of our ROU detection methods and ROU detection system.

For the map application, unavailable but important areas can be detected as an ROU. For the movie application, a

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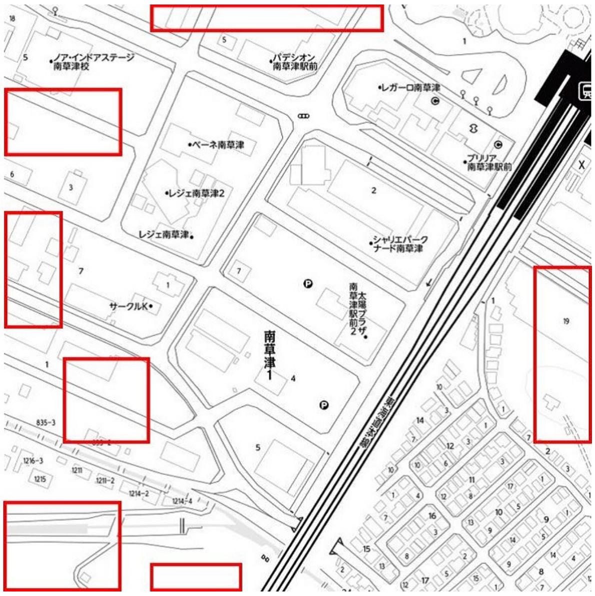

Fig. 4. ROU for MAP

detected ROU can be used to display captions. During a commercial movie, additional information can be attached to an ROU, whereas most important messages are displayed in an ROI. In the costume application, it is assumed that there are several actors. If a viewer has an interest in an actor's costume and would like to know more details about it, such as the manufacturer, a shop where it can be purchased, or its price, a detected ROU is automatically selected and can be used for displaying such messages on a future TV.

B. ROU for map application (MAP)

For our developed map application, the system can output an ROU after it is detected, as shown in Figure 4. In this figure, seven ROU areas are detected, the largest of which is located at the lower-left corner, where it can be made most available for future use. Such availability is due to the ROU, which is not currently being used, being close to both the station and several houses.

Using our system, the part that is not presently being used can be found overlaid on a given map. In addition, a territory that has not yet been developed can be viewed through an ROU on a map. Therefore, an overlaid ROU can be used for urban development and supporting the identification of unused land. Although various kinds of ROIs exist on a map, our system can detect an ROU, not an ROI, in a unified manner using the preprocessing component for map. For example, a station, a convenience store, a school, and a factory all may exist in an ROI on a map. An ROU can be chosen as a future ROI that will become available at a future date.

Because detecting an ROU from a map is quite different from detecting an ROU from an image, it is difficult to detect an ROU from various viewpoints. Therefore, we developed a unified method for converting a map into a gray-scale bit-map image as follows.

First, land marks and map symbols are marked on a map. Next, a colored circle is drawn around each marked point. The radius of the circle is determined based on the importance of the point, such as whether it is a land mark or a map symbol. A road or a river can also be converted in the same way as a land mark. Overlapped regions are differentiated based on color. As more circle regions are drawn around a point, the color at the point becomes darker. Finally, the map is converted into an image by considering the uses of the current region calculated from these landmarks, symbols, rivers, roads, and other marks. After changing the map into a gray-scale bit-map image, the ROU detection component detects the ROUs and outputs them to users, overlaid on the input map, as shown in Figure 4.

Fig. 5. ROU for MV

C. ROU application to movies (MV)

Currently, the location displaying captions are fixed at the bottom or top, or on the right or left, within the movie area. Because captions are necessary for certain types of viewers, captions location should be dynamically determined so as not to hinder an important area, i.e., an ROI, of the movie. Using our detection system, captions display region within a frame image of a movie can be determined. The image shown in Figure 5is an example of an ROU detected by our system. The image shown here is a frame of a musical. At the lower-right corner of this image, the most appropriate region for placing the song lyrics is selected from the detected ROU.

There is another application similar to this ROU movie application. When a serious event suddenly occurs, an urgent message regarding the event should be delivered to TV viewers as quickly as possible. Although it would be natural to place this type of messages at the center of the image owing to its urgency, not all viewers may need to see it. Thus, it is important to determine an appropriate region for placing messages intended for certain users.

D. ROU application to costumes requests (Costume)

Although this application is not yet possible, because TV services that can overlay message information over the TV screen exists, an ROU detection system can produce an ROU as an appropriate region for a user request.

It is assumed that a TV service exists in which a user can receive their query results over a TV image after they select an actor using a certain input device such as a mouse or pointer. One of the query types requested by the user is to find the selected actor's costume information.

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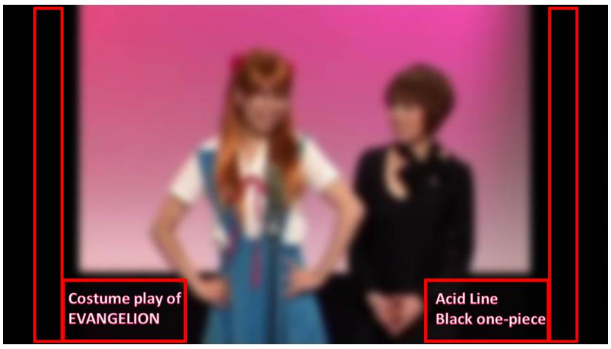

Fig. 6. ROU for Costume

Figure 6 shows an example of a detected ROU. The system outputs two ROUs, one at the lower-right corner and the other at the lower-left corner. The resulting information, such as the brand of the costume and its features, can be put in these two ROUs. A viewer who would like to purchase and wear the same costume the actor is wearing can easily obtain the desired information without having to watch the TV drama.

Currently, the system is not connected with future TV services, and can only detect and display these ROUs using the main TV frame image.

VI. Evaluations

A. Evaluation method

Two evaluation experiments is conducted to confirm the effectiveness and efficiency of the ROU, using developed ROU applications. In the first experiment, we measure the processing time for detecting ROU. The second experiment checks the detection accuracy. We calculates three measures, that is the precision, the recall, and F-measure, as frequently used The average of the measure values calculated from ROU are calculated. to compare the information retrieval methods. We compare two ROU detection methods, Naïve and Grid division methods in the three applications.

Through the experiments, we picked up ten images for each application and used to detect ROU. All test data, the input image of the ROU detection component, has a size of the 800 $*$ 800 bits. Grid size was set to 20 $*$ 20. In MAP application, we prepared a table containing point list and their important values. In the case when the importance level is 1, the related radius is set to 1.0cm on the map. When the level is 2, then the radius is set to 1.5cm. When the level is 3, the radius is 2cm. The scale of maps used in this experiment is $1/1500$. The grayscale level of circles is set to 130.

ROU was extracted and the three applications used to estimate the image utilized as test data based on the extraction time required and F-measure of ROU extraction area. F-measure of ROU extraction was computed based on the average precision of ROU of each picture, and average recall. In addition, the average precision of ROU and the average recall of ROU are shown in Table III and Table IV. We define a correct answer of ROUs for each data as an area which satisfying all the five requirements on ROUs explained in the previous section. In the experiments, an extracted ROU is judged by checking correct answers with ROU detection result when the extracted ROU area includes one of the correct ROU areas.

TABLE I
Distribution of Importance

Importance 3 (100m)	Large-sized important installations with public responsibility, such as a station, a school, a factory, or an amusement park.
Importance 2 (50m)	Medium-sized important zones, such as a convenience store, a service area, a shrine, a temple, IC of a highway, a nursery school, or a bank.
Importance 1 (25m)	Point hard cores, such as a bus stop, a mailbox, or a signal

TABLE II
ROU extraction time required

	MAP[ms]	MV[ms]	Costume[ms]
Naïve	84.2	62.7	61.8
Grid division	102.6	96.3	92.1

TABLE III
The evaluation result in each extraction method (MAP)

	Average precision	Average recall	F-measure
Naïve	0.21	1.00	0.42
Grid division	0.52	0.82	0.64

TABLE IV
The evaluation result in each extraction method (MV)

	Average precision	Average recall	F-measure
Naïve	0.38	1.00	0.56
Grid division	0.48	0.77	0.59

TABLE V
The evaluation result in each extraction method (Costume)

	Average precision	Average recall	F-measure
Naïve	0.42	1.00	0.58
Grid division	0.57	0.81	0.62

B. Evaluation results and considerations

As Table II shows, it was found that a Naïve method can detect an ROU faster than a grid division method. However, Tables III, IV and V show that F-measure of the grid division method obtains higher values for all test data. In terms of precision, the grid division method is also higher than the Naïve method, in all applications. Therefore, it can be concluded that the use of the grid division method is better for these three applications.

An issue to be resolved was determined. An issue occurs when a white background image is used. When a background is white or a similar color, the ROU is difficult to find even if an ROU may exist. This is because the ROU is defined as a color near black. To resolve the issue, we are considering using an RGB image, and not a grayscale image, as an input of the ROU detection component.

We noticed that when applying ROU detection to an animation movie, it takes a long time to detect the ROU because animation images may change rapidly. It should also be necessary to reduce the ROU detection time.

VII. Conclusion

In this paper, a ROU detection system is described, with explaining the outline of ROU and the utility of ROU. With three ROU applications, we evaluate the system as well as ROU concept from viewpoints of the processing time and the detection accuracy. From the experiments, we confirmed that ROU and our ROU detection system is useful to find un-used area identification for maps and images.

The remaining issues include development of more accurate ROU detection and less ROU detection time, and development of other ROU applications to expand the usefulness of ROU concept.

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