Efficient Annotation Visualization Using Distinctive Features

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Abstract. Annotation is often used for supplement real objects in Augmented Reality. Previous researches on the annotation have been focused on optimal label placement, where annotations are placed close to the objects while avoiding overlapping. However, optimally placed annotations are still hard to recognize when the number of annotations is large. Human eyes may easily perceive an object by seeing its distinctive features. In this paper, we proposed visualization methods for easily perceivable annotations using distinctive features. The proposed methods are based on studies of effects of colors, depth, style, and transparency of the annotations.

Keywords: Augmented Reality, Mixed Reality, Annotation, Usability, Human Factors, Visualization, View Management.

1 Introduction

Augmented Reality is associating virtual world with real world by integrating information into their counterparts. People can see the objects in physical world and virtual objects at the same time through HMD or monitor screen.

The annotation is one of the important AR topics [1] as users are easily able to figure out or understand the objects in physical world by reading the attached information tag simultaneously. There used to be problems how to avoid annotation overlapping and provide appropriate label placement when lots of annotated objects are placed on a limited space in AR. In order to solve these problems, various researches on label placement methods and algorithms have been conducted. However, there are only a few studies conducted on annotation visualization methods. If there are small numbers of objects labeled, ideal spatial layout may not be the main issue to consider avoiding label overlapping. Otherwise, we have to think about how to reduce the reaction time for AR users to find and read the annotations.

One approach is to give visual distinction which would help to get more attention on a certain intended object. Moreover, well-organized annotations by visual distinction would provide additional functionality to support better memorization, thinking, and clarification [5].

In this paper, several annotation visualization methods are suggested, and evaluations were carried out together with existing general annotation visualization

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methods to determine which method is more efficient. Usability tests were conducted by adopting each method we proposed on a couple of cases. Our suggested visualization methods are to display annotations distinctively based on the degrees of importance or correlation among them accordingly.

As an application of AR annotation, we have tested the map visualization. The world map contained a large number of annotations in a limited space. As a result, it turned out that our suggested visualization methods demonstrated better results than existing general label placement methods in terms of attention and searching time. It can be predicted from the test results that usability will be greatly improved in AR by adopting our annotation methods.

We expect that more researches on the efficient annotation visualization methods should be conducted and contribute on progress of AR view management [3] technology.

2 Background Research

Unlike static graphic environment which usually does not often change background color in real time, various condition on background and objects has to be concerned and text color and style greatly affect readability of annotation under AR or Virtual Reality environment.

There are researches on label placement and view management related directly and indirectly to AR annotations. Azuma et al. mentioned that appropriate label placement to objects in real world is one of important AR issues [2]. Spatial layout of annotation on AR screen is a problem of view management which is an important AR researching area. Through their researches, Azuma et al. have tested various label placement algorithms including 2D label placement, and adaptation to 3D objects using view management techniques.

There are previous studies on label placement about how to place labels on a static map. The static map labeling problem is NP-hard, and a fast approximation might have O(nlogn) complexity [7].

Azuma et al. suggested cluster-based method and he conducted user tests by comparing their method with three existing methods; greedy depth first placement, discrete gradient descent, and simulated annealing algorithm [12]. The test result revealed that their method presented the best performance compared to the existing ones. Their research included user test, calculating reaction time how fast users could read AR data tags.

Leykin and Tuceryan described a pattern recognition approach to determine readability of text labels on textured background by comparing computed contrast features as the difference between mean intensities of labels and their surrounding vicinity [8] and Gabbard et al. presented an experiment which examined text legibility with various color and style of text on various background in outdoor Augmented Reality [9]. They showed that readability is greatly affected by texture of background, text style and etc., but their researches did not suggest how to stress certain labels against to others or how to effectively differentiate more important labels.

Placing city name tags on the static map is one of the commonly used applications for label placement research. Jaochim et al. have studied on general information and operation by using an augmented static map [4]. That could be an example of AR visualization on paper maps.

3 Efficient Annotation Visualization

Annotation is a common and consistent method [16] to add extra information on the contents and knowledge by including additional explanation of those annotations which improves the quality of the contents.

Furthermore, Bottoni, et al. dedicated that "annotation supports different cognitive Functions such as *remembering* – by highlighting the most significant parts of the annotated document, *thinking* – by adding one's own ideas, critical remarks, and questions, and *clarifying* – by reshaping the information contained in the document into one's own verbal representation" [5].

As aforementioned, there have been many researches on annotation placement and related algorithms. These researches focused on simple annotation placement, not considering visualization styles or methods.

We have suggested efficient annotation methods which support additional cognitive functions when labeling objects according to their degree of importance or correlation.

First, if there is neither correlation nor difference of importance among them, the existing simple label placement method would be satisfactory.

Second, when priority exists, (or objects need to be recognized based on degree of importance), users are able to read or find labels quicker if the labels are distinguishable according to their priority or degree of importance.

Third, in the case when the objects have correlation, users are easily able to access to the labels when associated objects are presented in a group. Mechanical repairing manual can be a good example of grouping. Users may understand more efficiently if related parts or equipments are displayed in group-manner.

Lastly, there are cases that the degree of importance and correlation are combined together. Even in these cases, combined grouping and distinction methods are expected to improve users' accessibility to annotations.

In order to adopt distinction and grouping methods, we need to classify them in graphical points of view. It is known that humans perceive things better when one object is distinctive to the next or surrounding ones. This is called 'Pop-out effect'[11].

If this pop-out effect is presented on labels of higher priority, users can pick them up better. By means of distinction method, transparency, depth, color, size, and font style were selected for giving graphical difference, and by means of grouping method, color and link were selected to present correlation.

3.1 Transparency

Fig. 1 shows that important objects are displayed vividly while the rest are dim. It gets easier to clarify objects as labels of lower transparency are more easily perceivable, and enables users to find objects of high importance quickly. On the contrary, if the objects are of low importance, it took more time for users to find them out, or some users even failed within a given time. In case of transparency, it is difficult to present level of transparency acceptable to most users. We have used only two levels of transparency (low and high) for objects of importance.

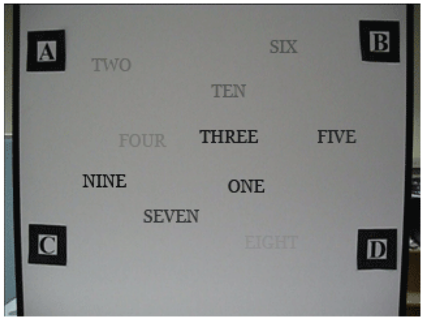

Fig. 1. Annotations with different level of transparency

3.2 Size

Generally, using different sizes of letter is a most commonly used method for map annotation. Continents are annotated by large letters, and the smaller letters for country names. Sizes of letters are getting smaller for capital cities and other cities and so on as shown on Fig. 2.

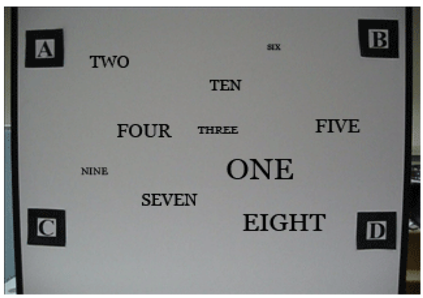

Fig. 2. Annotations with different sizes

3.3 Depth

The labels with 3D depth may present degree of importance. The labels placed in the front attract more of users' attention. Another advantage is that labels can be displayed in several layers based on importance. It is similar to use of different letter size but no overlapping happens due to being displayed in 3D.

3.4 Font Style

It is helpful to use noticeable font style for important labels. Bold and Italic font styles usually attract more attention, but there is a limitation to express several grades of importance.

3.5 Color

Fig. 3 shows the differentiation by applying colors on labels. Colors rather indicate brightness or clarity than grant the degree of importance. That means it might not be an appropriate method to display degrees of importance. On the other hand, color differentiation can be used for grouping method. When the labels with the similar characteristics or activities are displayed in same color, users notice them more easily.

Fig. 3. Annotations with d different colors

3.6 Link

Links can be effectively used for connecting related labels if objects are dependent on each other. When several groups of associated labels are located together on the limited space, applying different colors for grouping would make users difficult to perceive them efficiently, but connecting related labels with lines can be effective. Fig. 4 shows an example of link.

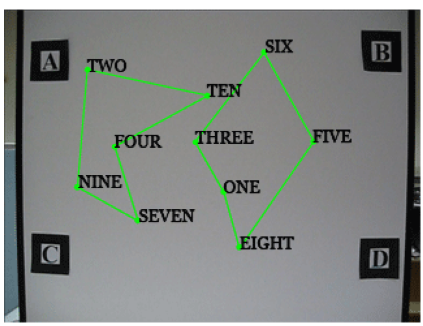

Fig. 4. Annotations connected with links

3.7 Hybrid Method

We may combine two or more methods mentioned above, such as size-color combination, transparency-color combination, and etc. Fig. 5 shows an example of size-color combination.

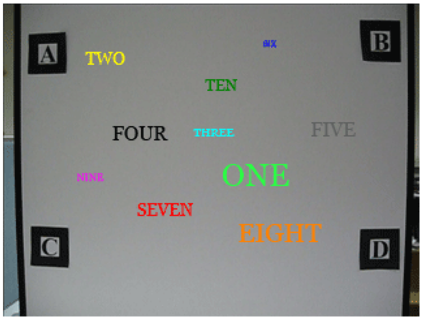

Fig. 5. Annotations with different sizes and colors

Several visualization methods for distinction and grouping are suggested as above. There might be more methods available in addition to the methods that we have described.

4 Experiment

4.1 Usability Testing

Usability has been regarded as an important awareness factor of the system quality since interactive systems have been introduced [10]. Usability can be explained objectively by measuring accuracy rate and performance time while users achieve tasks in a given system.

The concept of usability evaluation includes tests on the interactivity between the system and the users during performing tasks, and the objective and subjective data from the evaluation result could be useful explanations on usability issues [6]. Among the available usability test methods, laboratory usability testing is mainly selected for new or improved interface testing. Current studies reveal that usability testing is a widely adopted evaluation method [14] together with Heuristic Evaluation [13].

In this paper, we consulted Rubin's guide [15] about usability testing. Rubin defined usability testing as an experiential data collecting technology. It was claimed that usability test could be conducted while observing test procedures of representative users executing representative tasks. The procedure of usability test divided into 6 stages. 1) Planning, 2) Selecting participants, 3) Test material preparation, 4) Testing, 5) Obtaining test result, 6) Data analysis & suggestion.

We performed usability testing with our suggested annotation methods and observed how these methods add better cognitive functions.

We evaluated each annotation method with preliminary experience tests, and based on the result, two best methods were chosen for augmented map test. Ten people with average age of 25 were selected to participate in each test.

4.2 Preliminary Experiment

In this test, ten independent participants were presented on computer screen with total of different thirty words, in which six were differentiated with suggested efficient methods. All participants viewed all words, and they were requested to say seven words which attracted their attention most one by one. Number of differentiated words in those seven words was counted.

We hypothesized that those seven words represented more perception of importance than others. The words chosen in the given test were the most frequently occurring surnames from United States Census Bureau which are easy and well-known enough so that there was no discrimination for distinction on meaning and only efficient method illustrated degree of importance or priority. In the test of size method, selected six words were enlarged by 15% bigger and in color, cyan was chosen which provided high legibility based on [9].

Fig. 6. Preliminary tests with color and font method

Table 1. Number of matched words

Method	Min	Max	Median	Mean
Size	3	6	4.5	4.4
Font Style	0	3	1	0.9
Color	4	6	6	5.5
Size-Color	5	6	6	5.7

Table 1 summarizes the result. The result showed that the differentiated words using color annotation method attracted more attention to participants than others. Different font styles of words did not work as much as color method. This test represented that certain annotations could be expressed priority implicitly through efficient annotation method.

4.3 Experiment: Augmented Map

We conducted user tests by using color and size-color annotation methods which gave best result from the preliminary experiment and measured the reaction time to see in which environment users were able to find labels quickly. Static Map was chosen as a test application because it contained a lot of labels displayed over the screen. Relatively well-known cities and low-recognized cities were selected to be searched for, and reaction time was recorded.

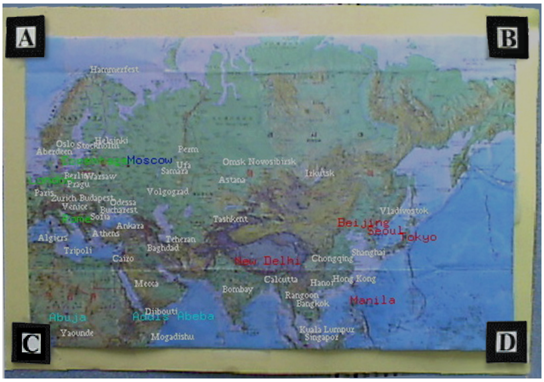

Fig. 7. Augmented Map annotated with size and color

Table 2. Reaction time in seconds

Method	Min	Max	Median	Mean
Simple	1	53	20.5	22.7
Color	1	50	10.5	14.3
Size-Color	1	45	6.0	9.4

Table 2 shows the test result. Compared to simple annotation method, it was shown that size-color combination annotation enabled users to find out cities much quicker.

5 Conclusions and Future Works

This paper presented various efficient annotation visualization methods. Each visualization method realized distinction and grouping by expressing the degrees of importance and the correlation among objects. Evaluation result revealed that, compared to existing general placement methods, suggested annotation methods shortened the searching time and given AR tags were found more easily and quickly. Although small number of users took part in the tests, the provided result was very meaningful because it revealed that usability would be greatly improved by adopting efficient annotation visualization methods in AR.

In conclusion, due to tremendous development of computer processing technology, real-time annotation distribution is no longer a surprise. Even overlapping or time delaying issues have been overcame. Rather, in this super rapid processing environment, users are more interested in how quickly they perceive information they are looking for.

More researches and development on AR environment should be directed towards satisfying these needs and interests. We plan to keep continuing further studies on AR annotation visualization to fulfill this demand. We also plan to perform researches on different evaluation methods such as Heuristic method in AR environments. We believe that further suggestions for improving current usability issues would be made through these future works.

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