Nano AR: Mobile AR Application Gives Highly Immersed Experience By Utilizing Familiar Action

Shintaro Kitazawa
National University of Singapore
21 Heng Mui Keng Terrace,
#02-01-01, I3Building, 119613
Singapore
Woof.design675@gmail.com

Koh Sueda
National University of Singapore
21 Heng Mui Keng Terrace,
#02-01-01, I3Building, 119613
Singapore
Apochang.jp@gmail.com

Henry Been Lirn Duh
National University of Singapore
21 Heng Mui Keng Terrace,
#02-01-01, I3Building, 119613
Singapore
eledbl@nus.edu.sg

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Abstract
This paper presents the design of Nano AR, a novel mobile AR application that gives highly immersed experience. In consideration, the interaction that link with familiar action will stimulate the user's immersive sense. In Nano AR, as a concrete example of this, the user can view the multiple layered AR contents on the same spot on the paper through an USB/iPhone microscope or iPhone's camera with digital zooming function, and the AR contents can be switched by adjusting the magnification ratio or zooming ratio, as like in use of a microscope in a real world.

Author Keywords
Interaction design, AR/VR, user interface, user experience, discovery learning, familiar actions

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User Interfaces – Interaction styles

General Terms
Design; Human Factors

Introduction
We propose this new mobile AR application with its interaction system. The focus of the concept is to enhance the user's engagement and the immersion on

the AR contents by the interaction that is transferred from human's familiar actions. For example, the interaction of Micro AR is linked with the action of to use magnifying glass that include peephole metaphor. [12][13] Also the action of dialing can be easily imagined as adjusting something such as sound volume, magnifying ratio, zooming ratio and so on. This familiar action is functioning as metaphor of switching multiple layers in Nano AR. This will give the users to be surprised and stimulate user's immersive sense deeper by showing unexpected AR view of the different layer.

For to make sure of the idea of the interaction and familiar action, we made the prototype from the combination of existing technologies. It has been developed based on Random Dot Markers program [15], and this prototype achieve both showing multiple contents and low visibility of the markers.

Related Works

In the past few years, the hardware specification of the handheld device was developed rapidly. At the same time, the mobile augmented reality was being developed as well. We believe however, that the interaction of the mobile AR application on the market might not be considered enough. [7] Most were focusing only on the visualization or the contents that were displayed on the screen. The posture for use is still unnatural for the human being, as keeping this posture is as if to shoot a photograph.[17] On the other hand, many researchers have presented new interactions for handheld devices and the mobile AR, and the concept of the use of the peephole or magnifying glass has been proposed as well. [1] [3] [10] However those were still a futuristic ideas for practical usage because of the hardware specifications**.** But after rapid development of handheld devices, there was possibility to make practical AR application with the concept of the use of the peephole or magnifying glass. This possibility has been appeared as Micro AR.[12] [13]

In *Meditation on a Hobby Horse*[4], Gombrich says that the imagination is not increased by the imitation of the object's external form, but by the substitution that is involved with the action (e.g. for a baby, the thumb with a sucking action is a substitution of a mother.). We considered that this theory of substitution is having important roll for the interaction that linked with the familiar actions.

From technical side, the marker for AR environment had been developed by many researchers and companies.[1][5][10] On the other hand image recognition AR is getting popular and existing on the hand held devices.[9] However, marker based AR is still stands. Because marker based AR has advantage of capability on low performance devices and its low building costs. As interesting research of marker based AR, nested structural AR marker has been proposed.[15] *A Nested Marker* shows multiple nested structure. And this marker can improve the accuracy of detection by using multiple nested marker, and it enables users to enclose to see the detail of the AR contents. However, This marker is not for showing multiple AR contents. Random Dot Markers[16] is not for nested structure originally. But we are interested in its low visibility from naked eyes. We have thought that Random Dot Markers is good material for Nano AR.

Design

Significance of the familiar actions: We applied the familiar actions to the interaction of Nano AR / Micro AR. To describe more precisely, Peephole metaphor, Theory of substitution and the action of to use microscope (dialing action) are applied.

The conventional use of a loupe/microscope involves an immersive action that is similar to the action of peeping. We make the immersive sense deeper than the conventional AR applications by applying this peeping action to our interaction system. At the same time, we utilize the theory of substitution from *Meditation on a Hobby Horse* [4]. The aim of this approach is to enable the users to "substitute" Micro AR/Nano AR for a real magnification lens/microscope. Here, the term "substitute" means that the user is able to see the similarity between something virtual and the real thing. Consequently AR contents could be related with the real action more easily.(See Figure 1.)

From the observations of the demonstration sessions that we have done before [13][14], some common feedback were given from the visitors such as surprises by appearing unexpected contents or getting in to the small AR world to try to find something on the screen by visitors them selves. We consider that those user's experiences are strengthened by the interaction of familiar action.

Figure 1. The image of Peephole Metaphor and the theory of substitution.

MicroAR, A Base of Nano AR: Micro AR is the prototype that works on an iPhone with a simple optical magnifying glass and extremely small AR markers on the paper media. [13][14] The user can see a small world on the paper media through an iPhone by using a magnifying glass. The application works with the conventional black/white markers and an AR tool kit [5]. For use of a magnifying glass with the iPhone, we designed an exclusive device. (See Fighure 2.) The user can peep into the extremely small AR world through a magnifying glass and a display. The magnified AR view is as if a different layer from the view of naked eyes.

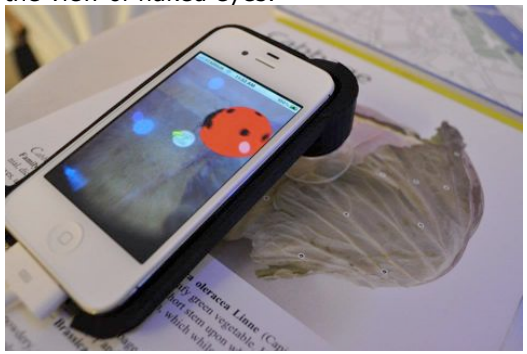

Figure 2. An exclusive device of Micro AR.

Nano AR

General Concept of Nano AR: Nano AR is a mobile AR application that utilized the action of using a microscope.[6] The user can see multiple layered contents on the same spot of the paper as like a real microscope.

We use an USB/iPhone microscope and *Random Dot Markers* [16] instead of a magnifying glass and the conventional black/white markers (See Figure 3) of Micro AR. While we gave several demo sessions of The Micro AR, some of the user told us that conventional AR

marker is too easy to find by naked eyes. In short, these users didn't get immersed in the AR contents. To solve this problem, we utilize *Random Dot Markers*. It is suitable to make the marker like invisible. Moreover, the markers are able to be layered. By using these materials, the user can see multiple digital contents within the same place, as in a real microscope. Nano AR further ignites a user's immersion by the changeable AR content, and it can be used to perform tangible actions by varying the magnification rate. Currently the program is developed on both iOS and Windows PC.

Figure 3. Conceptual image of Nano AR and the action of using microscope.

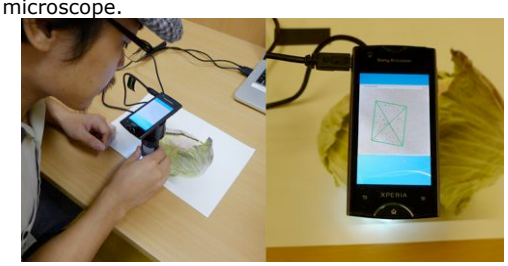

Figure4. A scene showing the use of the Nano AR, which is running on Windows PC, USB microscope and smartphone. Smartphone has been used as a display for testing the interaction.

There are benefits to use Random Dot Marker for Nano AR.

1. Random Dot Marker program can be operate by low performance device such as smartphone or tablet.
2. The Random Dot Marker is able be layered, this is definitely important for Nano AR to make it like microscope. Original Random Dot Marker had not assumed the layered structure. We contrive to make the marker suitable for microscope like usage. We will take up this in the next chapter.
3. The marker is able be nearly invisible from naked eyes. A cause is that the printed graphic on the paper is made from the dots, and Random Dot Marker is made from the dots as well. As a result of printing the marker on the graphic, the marker goes undercover in to the unrelated dots. (See figure 5.)
4. Random Dot Marker program does not need all of the dots for detecting the marker. This provide that Random Dot Marker is tough from getting dirty. This will give the profits in the situation that children play with Nano AR application.

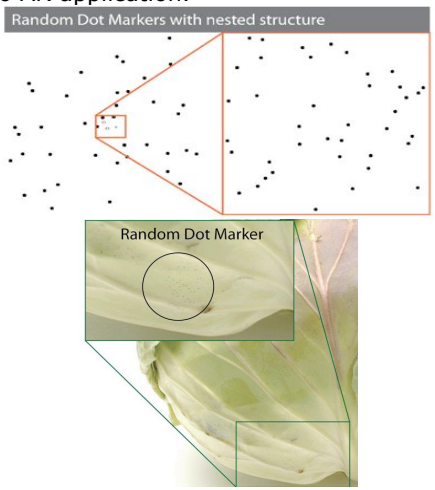

Figure5. The image of layered structure, and Random Dot Marker on the paper.

Contrivance for Nano AR : We had some experiments for improving the detection of extremely small Random Dot Marker. From the result, we found that the position of dot needs to accompany with the nozzles of printer. Otherwise, the shape of the dots is collapsed and blurred. We made an experimental grid that is divided by 300 dpi to decide the position of the dots by Adobe Illustrator. (See figure 6.) By adjusting the position of the dots with this experimental grid, the dots enable to appear clearly. As a result, the detection is improved well.

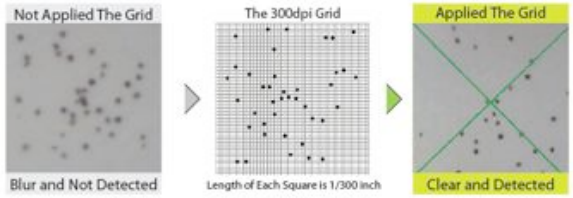

Figure 6. The image of an experimental grid for to print the dots clearly.

Potential Applications

As we described, Nano AR is able to display multiple contents on the same spot of the paper as like a real microscope, and the contents in the display is digital object as a matter of course. A real microscope enable us to observe the things what we cannot see by our naked eyes, moreover the ratio is adjustable. The adjustable function on Nano AR can be applied to many contexts such as the sizes, the timeline, the distance, and so on. For example, the user can view the history from past to future, or Showing a food chain is one of the ideas. These ideas of potential applications are applicable to educational usage. (See Figure 7.)

Figure 7. The idea of AR space travel by Nano AR.

Discussion and Future Work

Nano AR supposes to be the hint to invent new interaction on the mobile AR applications. However Nano AR still needs developments both on interaction and technical side. For interaction side, we have to conduct the user experiment to make sure that our concept of interaction is giving benefits to the users correctly. We will examine how effective Nano AR and its interaction are. And Micro AR needs the user test as well. There will be some points of the user test. One is the difference of the user's immersion between conventional applications and Micro AR / Nano AR. And second one is how natural the interaction of Micro AR / Nano AR is. For the experiment, more practical applications of Nano AR are needed, as we described at previous part.

For technically, there is room to develop on marker detection process of Nano AR. Currently program of Nano AR is detecting the difference of the contrast on the graphic of the paper. However the program get confused by mis-detecting the dots of the print as part of the marker sometimes. This problem is happened when the contrast gap is too strong. This means current prototype has limitation at the contrast of the graphic on the paper. Improvement of this point will make Nano AR to work smoother and make us to use

more beautiful graphic on the paper, moreover smooth usability will develop the user's immersion.

We are hoping that this conceptual prototype of the interaction will contribute to the area of Augmented Reality and mobile interactivity by showing how familiar action give the effect to the applications. Furthermore, with some technical development and user experiment in near future, Nano AR concept will be applicable to discovery learning and other education related designs.

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