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Developing Vision-Based Digital Public Display as an Interactive Media

Adrian Samuel Limanto and Yunli Lee

***Abstract*—**Interactive public displays give access as an innovative media to promote enhanced communication between people and information. However, digital public displays are subject to a few constraints, such as content presentation. Content presentation needs to be developed to be more interesting to attract people's attention and motivate people to interact with the display. In this paper, we proposed idea to implement contents with interaction elements for vision-based digital public display. Vision-based techniques are applied as a sensor to detect passers-by and theme contents are suggested to attract their attention for encouraging them to interact with the announcement content. Virtual object, gesture detection and projection installation are applied for attracting attention from passers-by. Preliminary study showed positive feedback of interactive content designing towards the public display. This new trend would be a valuable innovation as delivery of announcement content and information communication through this media is proven to be more engaging.

***Keywords*—**Digital announcement, digital public display, human-information interaction, interactive media.

I. Introduction

NOWADAYS, evolution of communication media occurs from times to times as the world of information and technology has developed rapidly every day. Slowly, most traditional media such as posters and notice boards will be vanished as Information Technology has been influence in our lifestyle. There is a major shift in public advertising where digital public display indirectly immersed and blended as part of us. The shift from traditional media to modern and digital public display has made positive impacts on information delivery. The reason is digital public display introduces new ways for people to interact and communicate with information.

Digital public display is a visual and physical system that acts as a media to transmit graphical information to the viewers. In this advanced technology, digital public display needs to serve more than just a read-only media. However, existing approaches of multimedia contents display the production of digital media on any Liquid Crystal Display (LCD) screen, plasma screen or glass storefront window that only involves one-way communication to the application user. Therefore, digital public display developer needs to focus on how the display interacts or communicates with human users. Users feel more engaged with a media or public display when they are able to communicate and control the content by themselves. The reason is users are motivated to explore the interactive function of the display [1]. When people feel engaged with the display, they are also more responsive to information. Users will be immersed with the display, if they are receiving clear feedback while interacting with the display. In one of the HII (Human-Information Interaction) principles, it is important for system to give feedback to the users in order to maintain users' attention level [2].

Our research is mainly focused on the development plan of vision-based digital public display announcement as an interactive media. The display will be integrated with more interactivity usability feature in order to ensure announcement delivers information to public effectively. Besides, people are more attracted to interactive contents that could help to stop the passers-by initial destination and grab their attention to read into the information. This method is more effective to trigger people attention and deliver the information, since interactivity in learning process is an essential instrument for knowledge acquisition [3]. In addition, the methodology for content implementation will be our contribution to develop a more effective digital public display. Idea of using themed display will help to bring more interesting content presentation to viewers. In this paper, we are also going to discuss how and where to apply our development plan for the digital public display.

II. Related Works

A. Existing Digital Public Display

Plasma Posters: Elizabeth F. Churcill et al. [4] presented Plasma Posters as plasma displays with interactive overlays, enable direct touch interaction, designed for placement in public spaces to facilitate multimedia information sharing. Plasma Posters are digital, large screen digital public display, intended to facilitate content sharing within people in communities. It has succeeded to gain positive response from its users within twenty months usage as web-based information sharing media. The screen detects human hands as input modal. The goal is to provide socially acceptable way to share multimedia content and to promote polite, non-intrusive information encountering. Plasma Poster interface has been designed to support numbers of engagement's form with content such as peripheral noticing, active reading, navigating and browsing through posted content and social connections. Plasma Posters cost is reasonable. Users are able to post and

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Adrian Samuel Limanto is with Sunway University's Faculty of Science and Technology, Sunway, Selangor, Malaysia (e-mail: adrian.limanto@gmail.com).

Yunli Lee is with Sunway University's Faculty of Science and Technology, Sunway, Selangor, Malaysia (corresponding author to provide phone: +603-7491-8622; fax: +603-5635-8633; e-mail: yunlil@sunway.edu.my).

share content with others, as well as view other people's post. Even though, it has succeeded to attract users to interact with the touch screen, people interact less frequently in more crowded places. In conclusion, Plasma Posters is able to attract attention and trigger users to interact by using the interactive feature. However, usage increased over the first few months of deployment and has reached a stable state.

Interactive Ambient Displays: Daniel Vogel and Ravin Balakrishnan [5] has developed an interaction framework for shareable, interactive public ambient displays that support the transition from implicit to explicit interaction with both public and personal information. Prototype of this system has been tested in public. The display recognizes body presence, hand gestures and direct touch screen input as explicit interaction from users. The prototype has been evaluated and receives good feedback. Though, it is not tested in real environment yet. This digital public display requires high-end hardware, like large display screen and motion sensors. On the other hand, the cost is inexpensive as claimed by the author. The content usability and visuals are able to attract users' attention and trigger further interaction.

B. Digital Public Display Interaction Phases

Interactive screens and digital public displays are deployed in public places like shopping malls, airports, bus stations and stadiums. They are transforming from traditional to digital with the new form of multimedia experiences and interactive feature. There are some requirements needed to describe a good and effective interactive digital public display.

Daniel Vogel and Ravin Balakrishnan [5] has developed interaction framework that covers the range from distant implicit public interaction to up-close explicit personal interaction, with four phases with fluid inter-phase transitions: Ambient Display, Implicit Interaction, Subtle Interaction and Personal Interaction. The framework is meant to be applied to give a fluid moves from implicit interaction with a digital public display to explicit interaction with their personal information in a more focused manner. The framework and design principles allow multiple-users to engage with the display, regardless of what phase each user is in.

Jörg Müller and Daniel Michelis [6] have proposed a diagram of different phases of interaction to display how human interacts with a display. This frame work helps to determine how we design our content and level of design, how to make people stay and interact with the display and communicate the information the users. People pass through different phases, where a threshold must be overcome for people to pass from one phase to another.

C. Content Design for Interaction Element

In terms of design space, Jörg Muller et al. [6] has come out with a taxonomy for digital public displays that categorized the mental models (the hardware of the display) and interaction modalities (tools to interact with the display) of a display. This taxonomy is a good resource to provide information and comparison of each mental models and interaction modalities.

Interactivity in learning is necessary and fundamental mechanism for knowledge acquisition and the development of cognitive and physical skills. Interactivity will engage the viewer more. The level and depth of content and the underlying information and presentation design is critical to the overall interactive experience. Anna Kämäräinen and Pertti Saariluoma [7] concentrate on the issue of participant's engagement, qualitative satisfaction and understanding of the digital public display. Therefore, interaction and content design is able to enhance the content of the media. The media itself must give feedback as part of the interaction design.

III. Proposed Works

In this paper, vision-based interactive public display announcement for posting the university's announcements is being developed. We are focused on implementation of HII in digital display media, implementation of face detection using image processing toolkit and design of user-centered digital display's interface and visual. By gathering information interactively with our public display, users will be able to receive information in more engaging way. The digital public display that we developed is used to post university's announcements on promotion of events and other awareness activities. This public display content is presented with a theme as a model design to grab user attention. The display's theme is designed based on the university calendar.

We detailed our development plan of vision-based interactive announcement display to explain how we tackle the limitations of traditional media. The digital display is mainly intended to attract people who pass by the display and motivate them to interact with it, thus practicing two-way communication between human and information. Since people are more attracted to interactive contents, the design and interactive feature of the display are able to stop the passers-by initial destination and grab their attention to read into the information. This method is effective to trigger people attention and to deliver information. Our implementation involves the framework for the digital public display, the interactive features, workflow of the system and the content implementations.

We developed a framework for the display to contribute on how to set up the physical digital public display. The projector will be mounted on the ceiling and projected to a mirror. The mirror then will reflect the projection and display it to the wall. The projection needs to be reflected to the higher part of the ceiling to avoid shadow caused by people's body or head that pass by the projection accidentally. Furthermore, the idea to put the projector above human height is to avoid the projection being distracted by people who walk and move around near the projector. The digital public display is placed in thoroughfare where most people hang out and pass by. The set-up of the digital display will help to attract passers-by to notice the display and hence, triggering interaction. The overall architecture of the digital public display can be seen in the Fig. 1.

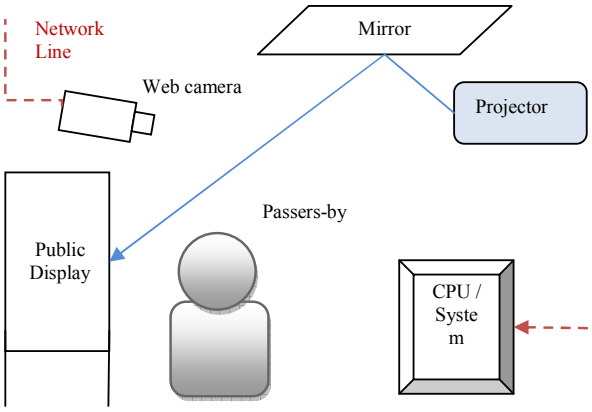


Fig. 1 Framework and set-up of PDA

As we propose interactivity between users and display as our goal in this research, therefore we have to make sure that two-way information flow is presented in the proposed display. The type of our proposed display is vision-based digital public display where users can just simply look at the display and interact with it using their own body parts, such as hands. Digital computer methods are being used to interpret content in visual or images, for the purpose to apply vision-based techniques in the research. The gesture available in this display is single-hand gesture. The reason is people usually are carrying some sorts of thing such as bags, hand phones, and other items. The viewers of the display are able to interact with the display by applying single-hand movement to swap the content from one to another. The display set up needs to determine where the user will stand as distance between user and display is important. By determining the region where user is allowed to interact with the display, the camera would be able to decide the particular person who owns the control of display at that time. Markerless system approach of motion capture will be applied so users do not need to wear special equipment for motion detection. This technique will involve camera-based by using image processing and computer vision methods in order to achieve desired result.

The system in the digital public display will follow certain workflow where in each step the system holds different responsibilities. Most of the workflow that we develop, involves body presence detection and hand movement detection. When the system is idle and users entered the area of detection, the camera will detect user's presence and starts displaying the virtual object in user's face. The visual will aid users to give information that users are able to interact with the display using hand gestures. The camera then detect users' hand and interpret the movement to help navigates the announcements. When the users are done reading from this media, they will leave the display and the system will be reset to the first state. The workflow is described in the Fig. 2.

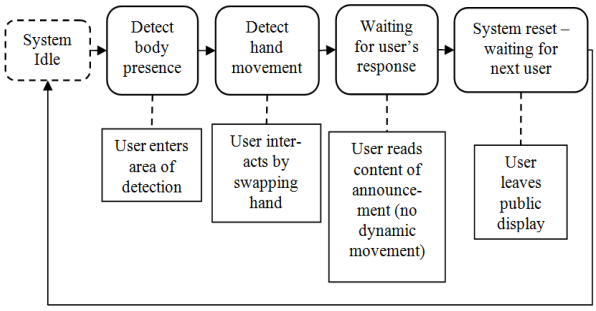


Fig. 2 PDA system workflow

In terms of content implementation, commonly traditional notice boards will have a lot of announcement inside and sometimes pretty messy. In our digital public display, we propose to show one digital contents at a time to avoid bombarding viewers with too many information. User needs to navigate from one announcement to another by applying hand movement gesture at the display. Swapping the content horizontally to navigate the announcements follows human's natural behavior to shift objects horizontally in order to move it. Usage of body gesture will promote the lightweight interaction, as users do not need extra effort to use devices to operate the interactivity features.

Design of the content such as the digital screen design and dynamic contents needs to be designed in such a way to attract people's attention and grab passers-by attention. We will apply multimedia features such as animation, digital screen, lighting, etc. to promote the usage of good user interface design in our display. Furthermore, we designed system interaction phases where we plan how users will starts noticing the display, triggering their curiosity, and then approach the display and results in interaction between human and information. The phases consist of 6 steps: Ambient Display, Implicit Interaction, Subtle Interaction, Direct Interaction, Multiple Interaction and Follow up Actions. Ambient Display phase occurs when users are still not aware of the display and have no interaction with the display. Ambient Display happens when users are in Participation Threshold. Implicit Interaction phase is the phase where users start to notice the display's set up and trying to figure out what is its function. Users start to enter the focal awareness threshold and may engage further interaction with the display. This phase will be followed by the next phase, Subtle Interaction. In Subtle Interaction, users are triggered to come nearer to the display. Users are motivated to pursue further interaction and use the display to fulfill their goal. Direct Interaction phase is where users attracted with the display, start to interact directly with the display and entered the Peripheral Awareness Threshold. In Multiple Interaction, users are engaged with the interactive features and use the display to see the latest announcements. Users interact with the display through the virtual object implementation and hand gesture recognition. Follow up Actions is the phase where the display has communicated the information and users have reached their goal to obtain information from the display.

Users will do follow up from the information they just received. Knowledge gathered from the literature review related to digital public display is used to develop our interaction phases in Fig. 3.

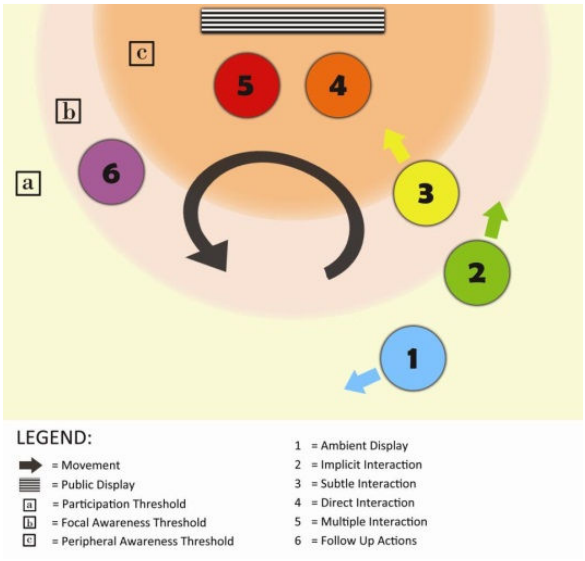


Fig. 3 Proposed PDA system interaction phases

As the purpose of the research is to explore how our development ideas for digital public display are being used in a public setting, the research method selected will be a case study. We choose university as the case study for our research. The display will act as university's interactive news portal where students can refer for university's announcements. As a new media application, the display will be able to attract students and promote a more effective and fun way to view announcement compared to traditional notice board. The interactive digital public display will be placed at indoor and open area, within the university compound.

Digital public display's theme is intended as a model design to present the contents in more appealing way. The theme will change based on university calendar, for example Christmas theme, Chinese New Year theme, etc., to let users know that the display is up to date. The theme will change periodically, probably every two or three months to keep users' excitement towards the display. Example usage of the theme is explained in Fig. 4.

Fig. 4 Digital public display imply one user to engage interaction with the display

First, for example we use the 'secret agent' theme. The display will imply one user to come closer and stand in particular position where the camera could capture their presence. Once the camera recognize the user and gives control to him/her, the system will show virtual objects on that particular user with some features of 'secret agent' such as black spectacles, hat and moustache (1). Next, user needs to do hand movement to drag a box and 'accept mission' which is actually the university announcements. These virtual objects are designed to attract attention of each user. User is triggered when they see their reflection on the wall with the black spectacles, hat and moustache (3). Once user is familiar with the display, he/she will drag the box and go the further part of the system. User now is able to view the announcements and he/she is able to browse through the announcements by doing swap hand movement. The camera will recognize the movement and interpret it, then send request to the system to navigate the announcement whether to the left or right (5). Once user is done, he can leave immediately and the system will be reset to the idle state. Fig. 5 explains the visual.

A system to organize and manage university's announcement will be developed to introduce more efficient and 'easy to manage' method to post announcements. Administrator will help to maintain and control the workflow of the system. Administrator is responsible to accept announcements, post it and take announcements off. University departments are given access and may log in to request announcement contents to be posted by administrator. Upon accepting request of announcement's contents, administrator needs to make the digital version of announcement that is synchronized with the digital public display theme.

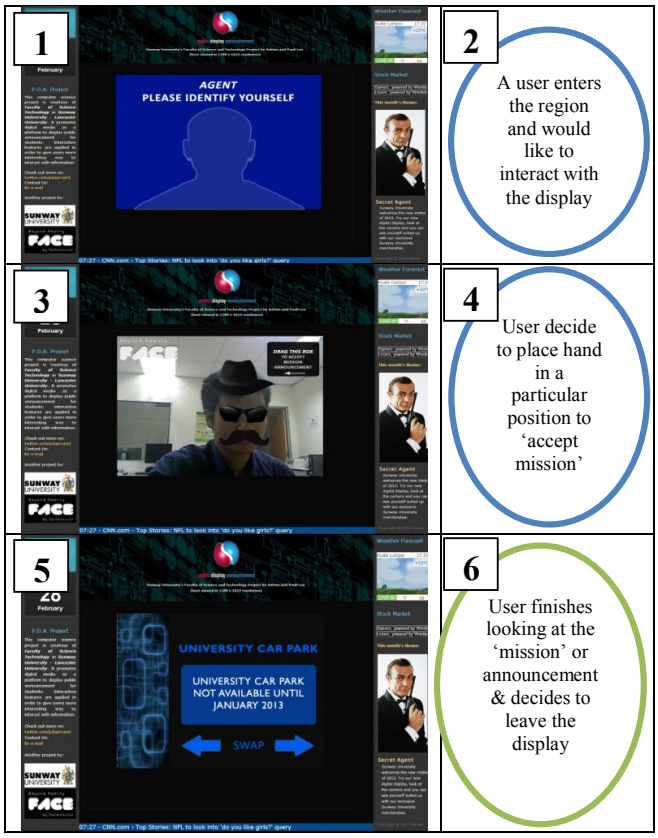


Fig. 5 Visuals for secret agent theme in the digital public display

The virtual object implemented in this digital display is an enhancement of Beyond Reality Face Software Development Kit [12] which is available to download in the internet (http://www.beyond-reality-face.com). This application is Flash-based application which is compatible with any operating software and web browsers that support Adobe Flash Player 11. We combined this SDK and virtual object library with our proposed framework in order to develop the application that we plan. The SDK is editable and flexible as we can alter the parameter and the presentation in the FLA file (Flash file) and the AS file (Flash Action Script file). We are using Adobe Flash CS6 and FDT as our authoring tools to compile the application. Table I below list down the software specifications needed for this augmented reality application.

TABLE I
SOFTWARE REQUIREMENTS

Flash Player	Adobe Flash Player 11.5.502.146 Web Plugin
Web Browser	Google Chrome, Mozilla Firefox 4.0 or later, Internet Explorer 7.0 or later, Safari 5.0 or later, Opera 11
Operating System	Windows, Linux, Mac OS
RAM	512 MB

In terms of face detection method and framework, we are going to combine methods and algorithms that has been discussed in the literature review, such as Skin Color Detection, Viola-Jones' Haar Feature Detection and Optical Flow Algorithm. Xiao Gang Zhao and Yanbo Hui present proposed system to capture human's face and detect it [8]. By combining and improving Skin Color Model and Optical Flow Algorithm, rate of false positives is reduced, processing speed is increased and the performance is improved. However, to depend on Skin Color Filtering Method alone may result in some inaccurate detection. Several false detections might occur on Skin Color Detection based on the paper written by C.E. Erdem et al. [9]. Since the skin color filter is not perfect, it may fail to spot some skin colored pixels. Therefore, the accuracy of the face region might not be preserved if the skin color is used as the only pre-filter. By combining Viola-Jones algorithm and skin color detection method, the speed is increased and false detection rate is decreased, even in a higher percentage compared to the previous method. The skin color detection methods used are Bayesian Classifier with Histogram Technique and Explicitly Defined Skin Color Detector. In addition, Viola and Jones has developed an efficient method based on set of Haar-like features which are designed in scaled analysis windows. A variant of Ada Boost algorithm is used to select the best features and to train the classifier [10].

After color image that contains number of faces are prepared, the method will apply illumination compensation algorithm to reduce the effect of lighting in the input video. The color compensation selected for this method is based on the Gray World method as it has good and fast performance and simple to implement [11]. The image is passed through Viola-Jones and skin-pixel detector. Next, the face that has been detected by Viola-Jones algorithm is verified by skin-color based method. Pyramidal implementation of Lucas-Kanade feature tracker method will collaborate with Optical Flow in order to do the face tracking. For the Optical Flow algorithm in the next phase, skin color model segmentation and mathematical morphological operators are applied. Optical Flow will aid to develop multi-resolution layering algorithm to obtain final face regions. Hence, a hybrid of three main frameworks is used in this face detection method. They are Skin Color Detection Method, Viola-Jones' Haar Feature based Face Detector and Optical Flow algorithm. The diagram is presented in Fig. 6.

To compare the proposed method with other similar digital public display, we will analyze Plasma Posters and Interactive Ambient Displays which have been discussed in Section II, Related Works. When users are too familiar with the content presentation and visuals, usage of the proposed display may reach a stable state or even declining state. To avoid this, we prepare themed display that change periodically to keep the content fresh. The theme will change based on current occasions to keep the display up to date. Gesture detection is chosen among others because it is the very basic and simple way for users to interact with the display. It is natural and imitates human's behavior, unlike other interaction that requires users to engage with a device or hardware, like motion sensor for instance. It requires less effort from human to be involved with the display in social environment. We feel that this method will support the proposed display's immediate usability concept.

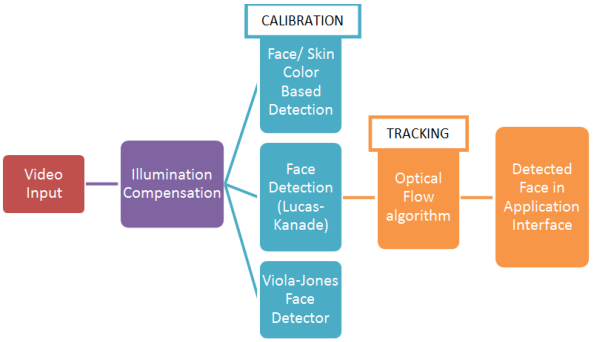


Fig. 6 The diagram of proposed face detection method

Surveys and observations of human's behavior towards digital public display are conducted as well as in-detail comparison between actual notice board in campus and digital public display announcement. Several sets of questionnaire, surveys and observations will be conducted during the research. The first set of data analysis on public's opinion about digital public display has been spread online to university students in Malaysia. Sample of the questionnaire is available in the appendix. We have collected responses from 30 male and 29 female respondents in the age range of seventeen to twenty-five years old. We are still waiting from other schools' students in Sunway University to participate in this survey. This data collection is expected to be done in March 2012. From the data that we have gathered, people check announcements in campus occasionally as seen in the Fig. 7 below.

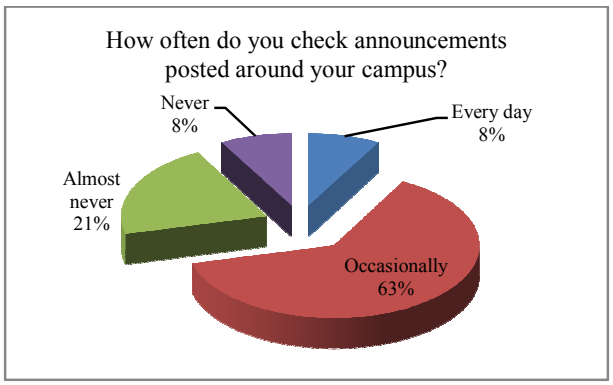
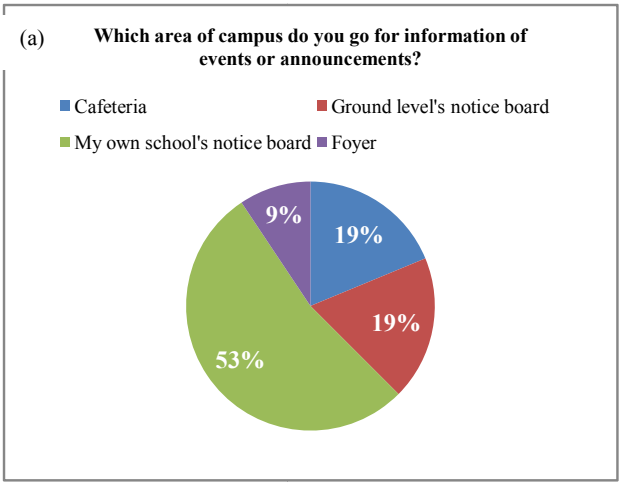


Fig. 7 Data collection result of how often do people check announcements in campus

Most students check the announcement in their own school's private notice board. They often check about education related topic such as seminar, internship, training and others. Most respondents agree that digital and interactive digital public display is more interesting and would like to try it out if it exists. Fig. 8 highlight results on: a) which area in the campus that people seek for announcement, b) the types of information people search the most in digital public display and lastly, c) whether the people wants to spend time and effort to interact with interactive digital public display announcement.



(b) **Please select *one* of the following types of information that you search THE MOST in a digital public display:**

On campus events (Club activities prom night sports carnival, etc.)	13	34.21 %
Education related (Seminar training internship class cancellation etc.)	20	52.63%
Products promotion	2	5.26%
Other (please specify)	3	7.89%

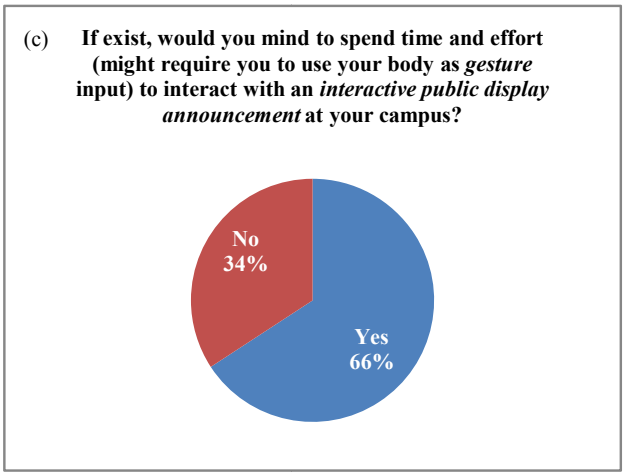


Fig. 8 Data collection results related to interactive digital public display announcement

IV. Discussion

The proposed display will act as media for people to refer for announcements. This research contributes how society and public places can adopt the idea of digital notice board to display announcement that does not required high cost budget. Currently, to adapt interactive usability features and multimedia aspect to a digital public display require expensive

hardware and tools, such as large touch screen display, motion sensor, and others. This project will be beneficial for public as they always looking out for good quality product with lowest price.

Another contribution will be the design of the theme and content presentation of the digital public display announcement. Attracting passers-by to have a look and interacting with the digital public display can be done by providing themed multimedia and visuals. We are designing the model of proposed interactive digital public display announcement to also ensure the communication delivery method is effective and clear.

The digital public display that we proposed will be the new platform for students to refer for information regarding university's events and other awareness. Moreover, we are proposing a system to help managing university announcements. The system can be used to post, manage and store digital announcements in university. By applying this system, it will be easier to manage the contents and posting of announcements. Moreover, it promotes to save environment by reducing paper usage.

The limitation is the proposed display supports a single-user only. People may need to queue in order to use the proposed display's function. The digital public display will be placed in university's foyer where most students hang around. When the digital public display is launched, there are possibilities that users need to wait to use the digital public display and view the announcements. Even though a small number of features in our digital public display support group usage, the main digital public display announcement usability feature is limited for one person only. Some users may find the queuing time too long, hence will leave the digital public display announcement.

V. Conclusion

In conclusion, we have presented the development plan for vision-based announcement digital public display that has interactive features integration. Besides the benefit and contribution, this paper also points out the limitations of digital public display such as not attractive enough to grab attention and poor communication flow between the system and users.

In particular, our experiments tackle limitations related to digital public display. The main objective of the research is to create attractive communication media based on visual perception that able to grab people's attention and trigger viewers to come closer and interact with the display. Moreover, our digital public display announcement will take a role as a solution in new media application that allows two-way communication flow. A digital system and workflow to post, view and manage announcements will be applied in order to efficiently the announcements. In the future, we will propose to engage more interactivity feature to enhance interesting experience with digital public display.

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