Study on design and implementation of web-based audience measurement platform for digital signage service

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***Abstract*—Digital signage service provides advertisement and information to users using electronic displays with network capabilities. Compared to traditional DID (Digital Information Device) that just provides contents one-way, digital signage service can provide more advanced functionalities such as user interaction and audience measurements. By measuring audience behavior, it is possible to provide appropriate contents to user and increases advertisement effects. In this paper, we present implementations of audience measurement using Kinect camera since Kinect camera can track a human objects, distance calculation and gesture recognitions, and web-based analysis platform for audience measurement information.**

***Keyword*— audience measurement, digital signage, Kinect, AM, Web-based analysis platform, big data**

I. INTRODUCTION

DIGITAL signage service provides advertisements and useful information using terminal equipped with electronic displays, and it is also possible to aggregate information using various kinds of sensors including camera. Nowadays, digital signage services are evolving for providing interaction and more intelligence services. Especially, since digital signage terminals are installed in public space like bus stops, hallways, shopping mall, it is useful for gathering audience and ambient information. This information can be used for analysis of customer's behavior and venue characteristics.

When it comes to analyses the effectiveness of advertisement and provides interactive contents switching, it needs to extract audience behavior information. ITU-T SG16 is under standardization for audience measurement in digital signage. Different from audience measurements in IPTV that service providers already knows subscriber's information, digital signage service are targeting anonymous audience. Furthermore, it is forbidden to identify audience for privacy reason. In general, digital service providers use cameras to extract audience information, and there are several products that extract basic audience information such as ages and gender. In order to extract advanced attribute of audience's behavior, we uses Kinect[1] to extract height, distance, direction and staying duration, and OpenCV[2] for gender detection and deciding whether audience is watching or not. Each digital signage terminal downloads policies for audience measurement from preference server that resides in service provider's domain. Since audience information is reported periodically from massive number of digital signage terminals continuously, the information need to be stored into big data systems rather than using file systems for further analysis. We have surveyed several candidates for storing these log messages, and we have used mongoDB for this.

In this paper, we present brief surveys of standardization on audience measurement in digital signage services and related products regarding audience measurement in chapter 2, architectural service model for web-based audience measurement platform of our digital signage service in chapter 3, audience metrics and implementation of audience measurement functionalities using Kinect and OpenCV in chapter 4 and 5, and implementations of web-based audience measure platform in chapter 6. We conclude in chapter 7.

II. RELATED WORKS

In ITU-T Q14/SG16, the standard for audience measurement in digital signage is under development. Figure 1 shows a generic digital signage architecture including audience measurement. Terminal device can have audience measurement (AM) client, and the measured information will be delivered to AM aggregation in service provider's domain.

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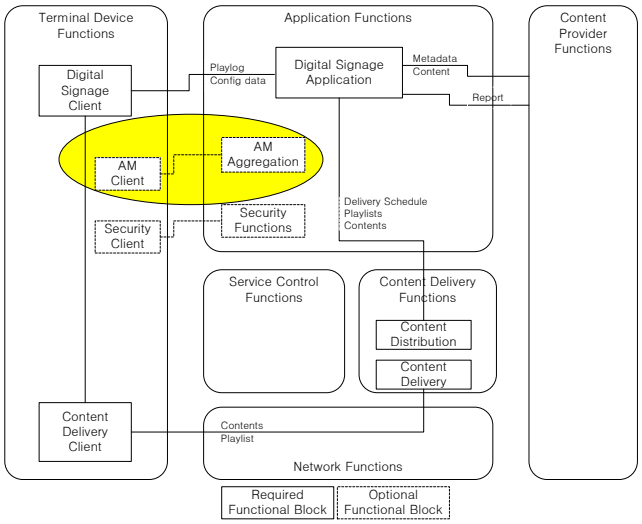

Figure 1. Generic digital signage architecture with audience measurement[3]

The audience measurement functionality of our implementation will be embedded into AM client of terminal device. It gathers audience and ambient information using various sensors, and report to AM aggregation functions. In this paper, we use Kinect 3D camera to extract related metrics.

As well as standardization, there are several prototypes that extract audience metrics such as gender and ages using generic 2D camera.

Figure 2. Prototypes supporting audience measurement in Digital Signage Expo 2013[4] and Digital Signage Japan 2013[5]

Figure 2 shows several products regarding audience measurement. As shown in Figure 2, most prototypes provide detections for gender and ages since these are most important factors for evaluation of advertisement. In this paper, we have used Kinect 3D camera, since Kinect camera trace human objects, distance calculation, moving directions of audience and gesture recognitions.

III. Architectural Model for Web-based Audience Measurement Platform within Digital Signage Systems

We designed digital signage server and terminal systems to be implemented as a web application using Tomcat 6.0[7].

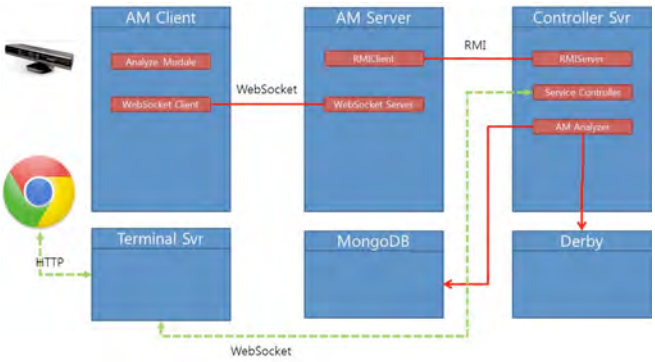

Figure 3. Architectrual model for audience measurement in digital signage system

As shown in Figure 3, the digital signage terminal is consists of AM client application and terminal server. The terminal server is a web application that is running on WAS platform, and it is implemented *Java*. The AM client application is implemented *C++* since it must use *Kinect* SDK library and *OpenCV* library. When digital signage application boots up, it retrieves operation policy from remote controller signage server. The policy includes play schedule, configuration of terminal that contains AM configuration and log server address. Whenever it generates AM report message, it sends it by using *WebSocket* to AM server that will be located in digital signage service operator

A. Audience Measurement Client Module

This module receives video stream from Kinect camera, and extracts audience metrics using Kinect SDK and OpenCV library. When it extracts audience information, it sends the record to remote digital signage server by use of WebSocket [8].

B. Local Terminal Server

Since digital signage terminal is designed to use generic web browser, it needs to build local web application server that prepares contents prior to play. As well as contents repository, it also acts as agency that receives configuration regarding audience measurement policies such as resolution, reporting frequency, reporting destination, etc.

C. Audience Measurement server

Unlike previous version of AM server [10], we have re-implemented it to use socket server, since the AM server does not need to be implemented as a web application server. When it receives AM report message, it just stores it to mongoDB for further analysis. When it needs to interact with controller server, it uses RMI (Remote Method Invocation), since those servers are tends to be located within service provider's domain.

D. Service Controller server

The service controller server manages overall digital signage services, and it provides web-based advertisement effect analysis. In this paper, an advertiser or administrator can take measures of effectiveness of advertisements or terminals by use of web browser. This server is designed to run as Web application server on top of tomcat server.

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In order to provide web-based analysis of the AM information, we have designed user interface as shown in figure 4.

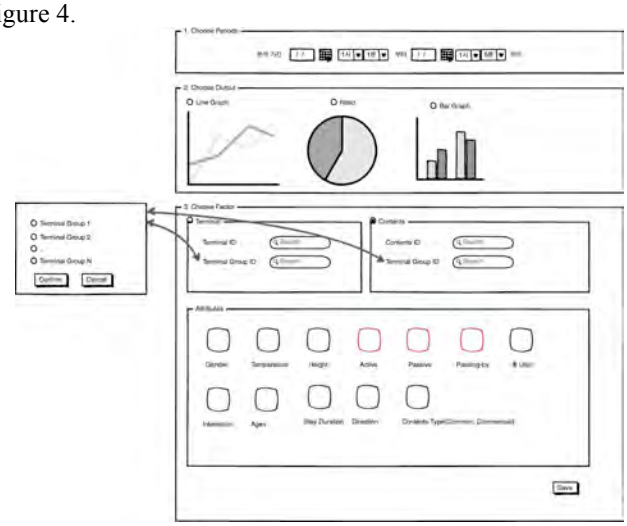

Figure 4. Design of web-based analysis user interface

It is designed to provide three types of graph; line graph, ratio graph and bar graph. An user can select the type of output for visual analysis of the result. In order to simplify the procedure, the analysis can be performed on one terminal group or one terminal. Since digital signage terminals are turned on during the service, it will accumulate huge volume of information; hence, it uses *MongoDB* [9] for storing the audience measurement information.

This platform can provide followings, but not limited;

- The number of audience as per time
- The number of audience as per temperature
- Stay duration for a specific content
- The moving pattern of audience as per time

Since our AM client does not support temperature sensor, it fetches the information from 3rd party open API services with the location information of the terminal. It is also possible to complex analysis by composing multiple conditional attributes, since this platform supports multiple selections of attributes for analysis.

IV. AUDIENCE METRICS DERIVED FROM AM CLIENT APPLICATION

Table 1 shows audience metrics that will be embedded into log message. When it comes to report log message, it should contain terminal identifier since terminal is installed in various location. This information is used for analysis of venue characteristics.

TABLE 1. METRICS FOR AUDIENCE MEASUREMENT

Element	*Attribute*	*Description*
TerminalId		Terminal identifier
ContentId		Content identifier that has been played
DateTime		Date and time for the log
Noise		Ambient noise (dB)
AudioVolume		Audio Volume (dB)
MoveInfo		Moving information of audience
	Direction	Direction (L2R, R2L)
	InTime	The time that audience come into the sight of camera
	OutTime	The time that audience go out from the sight of camera
Presence		Presence Detection Value
Audience	Count	Total number of audience
Person	Id	Identifier for differentiating each human object
Gender		Gender
Age		Rough Age
Distance		Distance between camera and audience
Height		Height of audience
Watching		Watching/Not watching

As well as venue characteristics, it is also possible to analyse the relevance with content that had been played at the time. This is useful for evaluating advertisement effect. Since we have used 3D camera, it is possible to extract moving direction, stayed duration, height and distance. Other metrics are derived from *OpenCV* library.

```
<audience-measurement>
    <terminal-id>terminal-1</terminal-id>
    <content-id>content-3</content-id>
    <date-time>2012/09/23 11:30:34</date-time>
    <noise>80</noise>
    <volume>60</volume>
    <movement-list>
        <movement direction="Left"
              enter-time="2012/09/23 11:30:40"
              exit-time="2012/09/23 11:30:50"/>
        <movement direction="Right"
              enter-time="2012/09/23 11:30:43"
              exit-time="2012/09/23 11:30:55"/>
    </movement-list>
    <presence>True</presence>
    <audience-list count="2">
        <audience>
            <gender>Male</gender>
            <age>20</age>
            <distance>100</distance>
            <height>170</height>
            <watching>True</watching>
        </audience>
        <audience>
            <gender>Female</gender>
            <age>40</age>
            <distance>150</distance>
            <height>150</height>
            <watching>True</watching>
        </audience>
    </audience-list>
</audience-measurement>
```

Figure 5. Example log message for measured audience metrics

Especially, moving direction of audience can be used for analyzing traffic pattern in accordance with time. This can be used for authoring content for effective advertisements, and advertisement strategy.

Figure 5 shows an example log message expressed using XML.

V. IMPLEMENTATION OF AUDIENCE MEASUREMENT USING KINECT CAMERA

In this chapter, we describe implementation details. We have implemented AM client in Windows OS environment, and used *OpenCV* for image processing in order to acquire gender and eye detection as shown in table 2.

TABLE 2. DEVELOPMENT ENVIRONMENT

OS	*Windows 7/Visual Studio 10*
Library	*Kinect SDK 1.6* *OpenCV*

A. Audience measurement procedure

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When the AM client boots up, it initializes two modules as shown in Figure 5 after retrieving the configuration from local WAS. In order to construct internal model (*Initialize_openCV*) for analysing face, eye and gender detection, it loads pre-configured image for training. It also initializes and registers call back function (*KinectProc*) for controlling Kinect camera.

The call back function *KinectProc* takes event and streams from camera and performs main analysis.

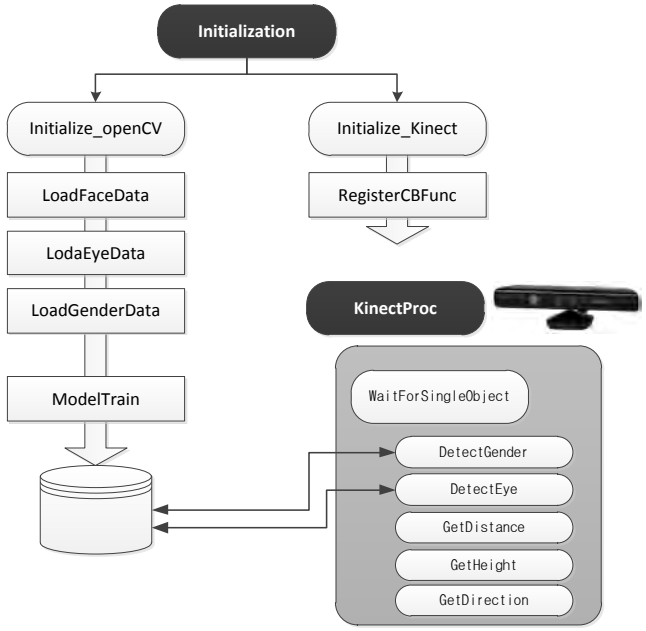


Figure 6. Example log message for measured audience metrics

When it comes to analyze gender and eye detection, it passes the vector data and images into model analyzer constructed within *openCV* library. The distance, height and direction data are coming from Kinect SDK. When the analysis is completed, it construct log message as shown in Figure 4, and sends it to remote log server using *WebSocket*.

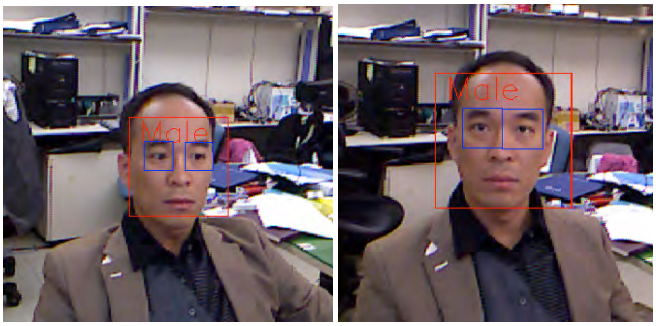
B. Acquisition mode of AM data

Since it takes time to analyse acquired image from camera depends on the size of crop area effects the performance, we have defined four level of analysis as shown in table 3.

TABLE 3. PARAMETERS AND IT'S VALUES FOR FACE DETECTION

Mode	Parameters	Value
Fastest	LogTick	50ms
	FaceDetectSize	180pixel
	EyeDetectSize	50pixel
Fast	LogTick	200ms
	FaceDetectSize	120pixel
	EyeDetectSize	30pixel
Normal	LogTick	500ms
	FaceDetectSize	80pixel
	EyeDetectSize	20pixel
Slow	LogTick	1000ms
	FaceDetectSize	30pixel
	EyeDetectSize	5pixel

In case of *fastest* mode, it generates a log every 50ms. Hence, it generates 200 messages in a second, but it has some limits on producing accurate data due to lack of time for analysis. When we used *slow* mode, it can extract most of metrics what we want. By the way, since Kinect SDK can support tracking of maximum four number of person simultaneously, metrics derived from Kinect is constrained. However, some metrics from *openCV,* such as number of person, gender and eye detection, are not limited since it just extracts those metrics by using image processing engine of *openCV* rather than using Kinect SDK. In this case, Kinect is just used as a source of image.



(a) Normal mode (b) Fast mode

(c) Height and distance detection using Kinect in *normal* mode

Figure 7. Extraction of audience metrics using AM client

Figure 6(a) shows a face detection using *normal* mode, and (b) shows in *fast* mode. The size of crop region in Figure 6(b) is slightly larger than Figure 6(a) as configured in table 3. The lower column of Figure(c) shows extracted metrics including gender, height, distance and eye detections.

C. Report of AM data

The AM information is delivered to AM server by using WebSocket with XML format like Figure 4. This report will be transformed into JSON format for storing into MongoDB.

VI. IMPLEMETATION OF WEB-BASED AUDIENCE MEASUREMENT PLATFORM

In this chapter, we describe procedures of web-based audience measurement platform briefly.

A. Audience measurement server operation

When AM server boots up, it establish RMI connection with controller server for retrieving preference information such

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as port number that AM server should listen through step1~3. When it is ready, AM client sends report message to this server using WebSocket as shown in step 4. The AM server converts XML data into JSON format to insert mongoDB systems.

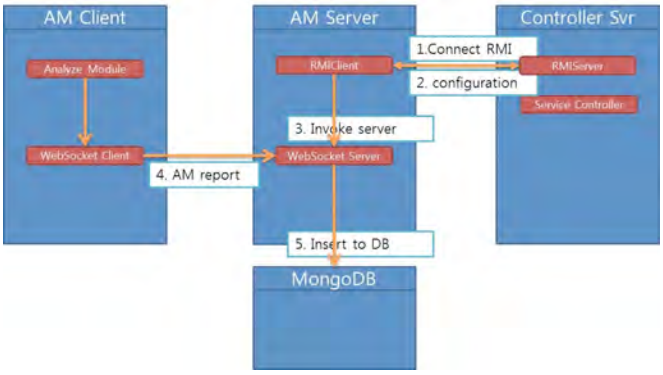

Figure 8. Procedures for audience measurement server

B. Analysis of advertisement effect procedures

When a customer or operator wants to take an analysis on the effect of advertisement, it is needed to specify period, output format, target terminals, attributes to be analyzed as shown in step 1 of Figure 9. When it submits the analysis profiles to controller server, it gives an order to pull data from *mongoDB* for specified criteria as shown in step 2. The result record will be stored into derby database for showing the result as a format of graph. When the analysis is completed, the platform notifies it to user for checking out the result.

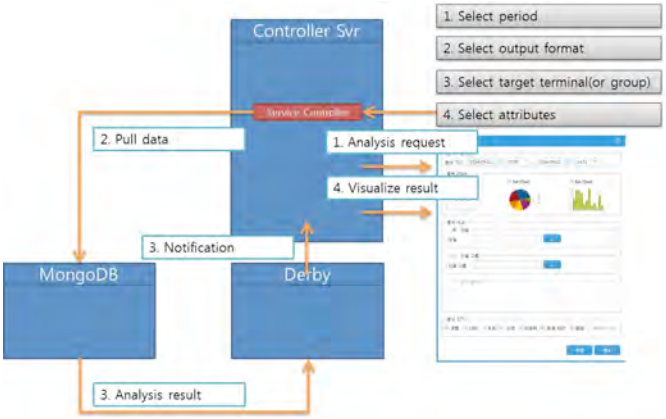

Figure 9. Procedures for measuring advertisement effect

The Figure 10 shows an interface of composing analysis request. As shown in the figure, it can express the result with three types of graph; line, bar and pie chart. It is possible to analize for one terminal, and it is also possible to do it for serveral terminals within a same group. These analysis can be used for installation strategy and setting up charing policy for an advertisement. It is also possible to make a advertisement plan based on the types of users and their behaviors on a specific terminal or terminal group.

This implementation supports of analysis on of gender, height, stayed duration and moving direction, and those attributes are gathered from *Kinect* devices.

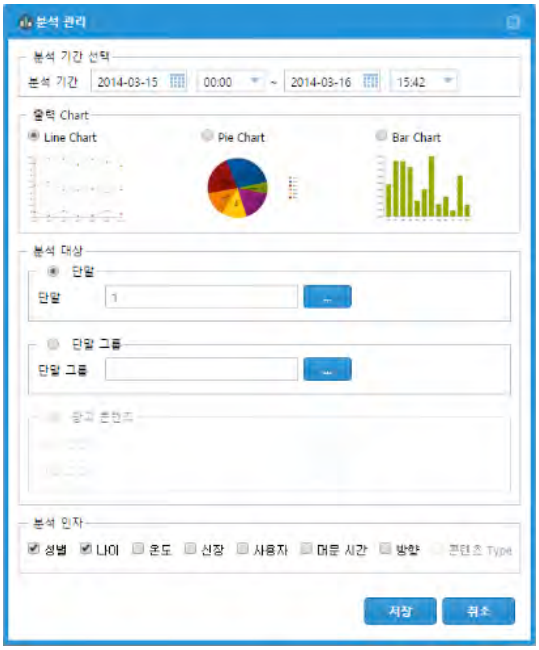

Figure 10. Web-based analysis of audience measurement data

Some attributes such as ages, temperature are not fully supported at this time, since those attributes are not gathered.

VII. CONCLUSIONS

In this paper, we have presented architectural model for web-based audience measurement platform for digital signage systems, and details regarding implementation of audience measurement functionalities collaborated with web technologies. By use of 3D camera, we can get more attributes of audience, such as distance, height, directions, etc. These metrics can be used for better marketing strategy with additional analysis on aggregated audience measurement data. For storing and analysing audience measurement information, we have used MongoDB, since there are lots of information would be stored. By use of this platform, it is possible to compose basic analysis on effect of advertisement by advertiser without any help of digital signage service provider by their own.

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