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AROUND: An Interactive and Context-Aware Mobile Exhibition Guidance System

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***Abstract*—With the increasing demand for exhibition/museum guidance services, more and more information technologies and devices have been applied in building intelligent exhibition guidance systems to enrich the understanding and enjoyment of exhibition. In view of this, this study aims to propose and develop such a mobile exhibition guidance system. The proposed system, named AROUND, is designed with the focus on exploiting the context-awareness of mobile devices to achieve high-quality interaction for exhibition visitors and organizers. To this end, we propose a trigger-and-response interaction methodology. The trigger refers to the data obtained from mobile sensors/interfaces, such as camera, NFC reader, recorder and GPS sensor; the response (to visitors) relies on a validation process performed by the AROUND back-end. Under this context, an organizer can easily orchestrate interactive and creative activities for visitors to encourage exhibition participation. On the other hand, we design a set of easy-to-use web/app interfaces and introduce a card-based data model with extensibility support. We also present a real application of AROUND, as a proof-of-concept, to demonstrate the potential and feasibility.**

***Keywords*—Exhibition guidance, interaction technology, sensor integration, context-awareness, mobile computing**

I. Introduction

Mobile technology has now evolved to the point where building a real context-aware architecture and application, such as a smart home or smart museum/exhibition guidance system, becomes more feasible. Such an intelligent environment normally requires an extensive integration of various information technologies and context aware devices [1, 2]. This study is aimed at proposing a mobile exhibition guidance system, with the focus on better exploiting the context-awareness of mobile devices to achieve high-quality interaction between exhibition visitors and organizers.

In recent years, with the increasing popularity of mobile devices (especially smartphones and tablets), more and more researchers and developers have begun deploying exhibition guidance systems on exhibition visitors' mobile devices [4, 5, 6, 7]. These systems differ from traditional guidance methods in that they collect data, such as location and time, from sensors on the visitors' mobile devices, analyze these data, and recommend exhibition information appropriate for the visitors. Most of these studies are devoted to devising better information selection and presentation approaches for individual visitors.

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This technically involves a context-sensitive information system that requires complicated context models and/or hardware deployment (e.g. ZigBee) [6] for identifying the needs of visitors and presenting appropriate information automatically. Such designs enable user status monitoring and real-time recommendation, but are often costly and not user-friendly for exhibition visitors and organizers.

In this study, we propose a mobile exhibition guidance system, named AROUND (implying that exhibitions/exhibits are all around). We attempt to address some key issues on building an exhibition guidance service, with the focus on achieving high-quality interaction between exhibition visitors and organizers. The design of the system is based on the following criteria.

First, the system is highly interactive. Some related study has indicated that providing a high-quality interaction is one of the key requirements for mobile exhibition guidance systems [5]. In our system, a diversity of "sense-and-react" mobile interactions are designed and implemented for this purpose. Organizers can pre-configure interactive tasks/activities that are then allowed to be triggered by visitors' mobile devices. The supported interaction triggers include NFC tags, QR codes/barcodes, check-ins, photographs, audio clips and manual text inputs.

Second, the system should be equipped with extensibility. We approach this by introducing an extensible card-based data model and a card-based mobile UI to, respectively, describe and present the entities of AROUND-enabled exhibitions. In addition, an extensible back-end is conducted to support further integration with new services for new applications.

Third, the system must be simple to use. To this end, our system includes a set of easy-to-use interfaces, including web and app interfaces, for different types of AROUND end-users. Since the system deployment only involves software and network connections, the cost and complexity of deploying an exhibition guidance service can be reduced. Moreover, our system integrates social networks and location-based services, thus enabling the social interaction for visitors.

We also present a real application of the proposed system. A prototype of AROUND has been implemented and applied to one famous annual design exhibition in Taiwan [3]. In particular, a treasure hunt-style activity with achievement support is conducted based on our interaction methodology. By following the instructions from an AROUND-enabled app, visitors can complete treasure hunt missions/quests on their personal mobile devices. After solving specific quests, visitors earn achievement awards and trophies that can be exchanged for prizes after the exhibition. The results show the potential and demonstrate the feasibility and effectiveness of the proposed system.

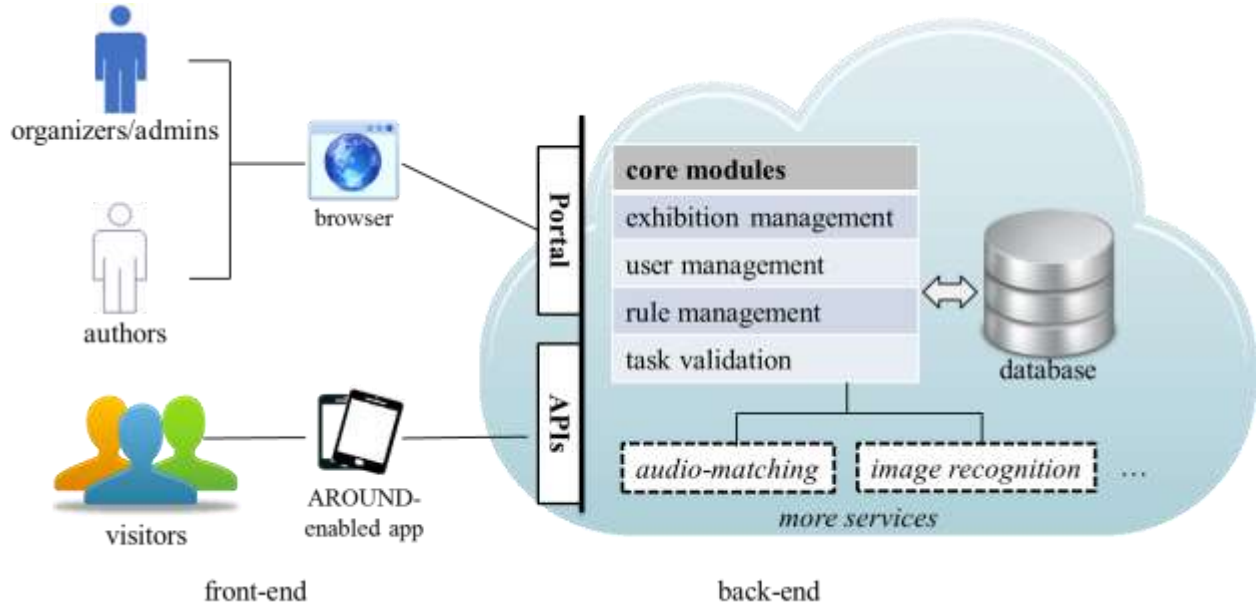

Figure 1. AROUND system overview.

The rest of this paper is organized as follows. Section II presents our system architecture and design concepts, including the details of how to support context-aware interaction and the AROUND data model. Section III describes our prototype implementation and demonstration, followed by our conclusions.

II. System Architecture and Design

This section gives an overview of the proposed system (AROUND) and highlights some of the design concepts. The whole system, as illustrated in Fig. 1, can be divided into front-end and back-end.

The front-end serves as the user interface that enables the end-users of AROUND to be virtually connected to a specific exhibition. The participant roles include organizers, authors and visitors. An organizer is normally an exhibition planner and administrator who initiates and maintains the exhibition-related information through the AROUND web-based portal interface. An author/exhibitor logically refers to an exhibit booth that is supposed to be displayed in an exhibition; each author is allowed to orchestrate their own exhibit/booth information after logging in to the AROUND web portal. The AROUND visitors are simply the exhibition visitors who have an AROUND-enabled app installed on their smartphones (including Android and iOS devices). With this app, visitors can navigate, receive and share general exhibition contents, location-aware maps and exhibition tour planning in a friendly manner.

To increase the degree of user participation and to enrich the understanding and enjoyment of exhibits, AROUND provides a diversity of interaction methods which organizers/authors can use to arrange interactive activities for visitors. For example, an organizer can encourage exhibition participation by offering awards to the visitors who have finished one or more predefined tasks by using their smartphones, such as taking photos of posters, recording audio clips, scanning QR codes on explanation boards and touching near field communication (NFC) tags behind direction signs. Each of these tasks requires a specific data entered by visitors or sensed by smartphones; the data is then sent to the AROUND back-end for task validation.

The AROUND back-end is a centralized information server that comprises a number of software components. In addition to the interfaces for the front-end and the database for storing all the information of the AROUND-enabled exhibitions, several core modules and services are designed/integrated to realize the requirements of the proposed mobile exhibition guidance system.

There are two management modules: the user management module and the exhibition management module. The former, as it is called, is used for account management and authentication purpose. The latter helps maintain and deliver the exhibition-related contents (e.g., textual information, meta-information, images and videos) for the AROUND end-users; most of the contents are structured data and can be accessed online through our web-based portal interface. Also included are the relationships between exhibitions and booths. The structures and data model for the entities specific to AROUND system is detailed later in this section.

On the other hand, both the task validation and the rule management modules are dedicated to carrying out the high-quality interaction functionality required by our system. Each interactive task sent from a visitor to the AROUND back-end, as just mentioned, involves a validation test process; different validation rules and functional services may be applied to ensure that each finished task satisfies some predefined requirements.

For example, given a task associated with an audio-matching action (i.e. task requirement) that has been triggered by a visitor, an audio feature extracted by the visitor's smartphone would be considered as the input of the validation process. In this case, a functional service (either internal or external) equipped with audio-matching feature would be invoked to examine if the audio is valid. The similar procedure goes for the other types of task, depending on the input data.

A. Supporting Context-Aware Interaction

Mobile devices, especially smartphones and tablets, are known to have many built-in sensors and have the property of context-awareness, thus facilitating the development of mobile applications based on sensing and reacting context information [1, 2].

In the proposed system, visitors' smartphones and tablets are the only context-aware devices. By installing an AROUND-enabled app, each visitor can interact with the exhibition guidance system in pull mode, push mode or interaction mode. The pull mode simply means that the visitor can choose what available information to read, just like browsing a website. In contrast, the push mode indicates that the visitor is allowed to receive push messages sent by an exhibition organizer through the AROUND back-end. This can also be configured to be location-aware, in which the location is a zone and the push action is triggered by the location context obtained from the GPS sensor.

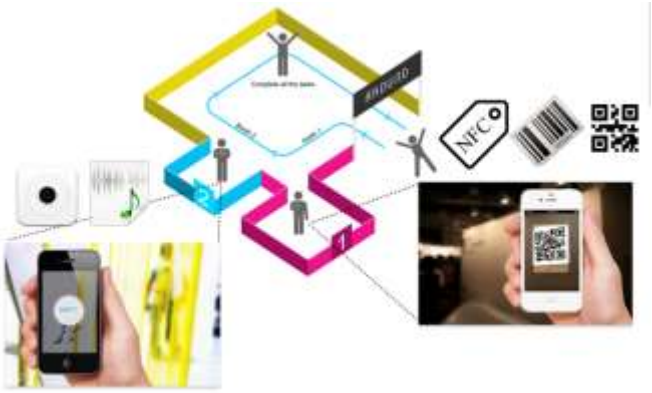

Figure 2. Example of mobile context-aware interaction.

The interaction mode, as mentioned earlier, refers to that each visitor can use a smartphone to join those interactive tasks prearranged by organizers. Fig. 2 shows an example of how a visitor can tour an AROUND-enabled exhibition with a smartphone. Suppose the visitor carries a smartphone with an AROUND-enabled app installed. He/she can participate in one or more of the following types of tasks: (1) QR codes/barcodes validation, which relies on a phone camera interface; (2) NFC tag validation, which needs a NFC-enabled smartphone; (3) check-in validation, which is based on GPS-based location services and/or social network integrations; (4) image validation, which requires a phone camera as well as an image recognition service; and (5) audio validation, which needs a phone recorder and an audio-matching service.

B. AROUND Data Model

To better describe the relevant entities in an exhibition context, AROUND employs a card-based data model. Most of the information presented to the end-users, including exhibition and booth information, interactive activities for visitors (e.g., game-like tasks), and extended information (e.g., value-added rewards), are represented with cards.

An abstraction of the data model is depicted in Fig. 3. It is easy to see that an exhibition entity is logically composed of a set of cards. Each of these cards has its own data layout and/or meta-data, depending on the card type. There are two main types of cards developed for this system; that is, data card and quest card.

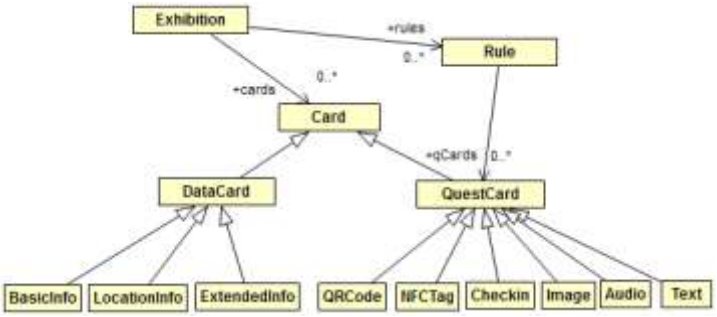

Figure 3. AROUND data model.

Each data card is an instance that normally reflects general or location-based information for individual exhibit or booth. By producing a collection of these data cards, an organizer can easily deploy an online guidebook for exhibition.

The quest cards here correspond to the tasks configured for the interaction mode. Each type of quest card defines a specific input, output and validation process. Also included are interactive instructions that inform users (1) where to perform a task (e.g., a booth), (2) what types of tasks are required (e.g., touching an NFC tag), and (3) how to complete a quest and obtain rewards (e.g., earn achievements). At the current stage, our system supports the following quest cards: NFC tags, QR codes/barcodes, check-ins, photographs, audio clips and manual text inputs. In addition, an exhibition can be associated with task rules; each rule stipulates how to determine if a task or an activity (involving a group of tasks) is completed.

From the perspective of the exhibition organizer, the key aspect of implementing a highly interactive exhibition guidance service is establishing related quest cards and rules. Consider the process of planning a tour of the booths in an exhibition. The first step involves creating quest cards featuring related missions (i.e., activity targets) for individual booths. The second step is to specify the rules on those cards according to the tour plan. The AROUND system determines whether the tour plan has been completed according to the rules. For example, suppose a tour plan comprises 10 booths. The rules may state that the tour is considered completed if at

Figure 4. User interface of AROUND game card:
a-Card list, b-Information card, c-Quest card ,d-booth location information, e-Finished a quest, f-Get a reward coupon.

least 5 of the 10 booths are visited (and the associated targets are collected), or if the booths are visited in a specific sequence.

To facilitate the implementation of AROUND-enabled exhibitions, we provide exhibition organizers with a web-based portal that enables full access to exhibition cards. Exhibition organizers can tailor AROUND to their exhibition by creating and modifying the required cards and quest details online (based on the card-based data model presented in this study).

In addition, each booth included in the exhibition can be instructed (by the exhibition organizer) to setup the cards specific to the booth to reduce the load placed on the exhibition organizer. Because the tasks and activities are configurable and adaptive to dynamic changes, the flexibility and practicality are enhanced.

III. Demonstration

To demonstrate the feasibility of the proposed approach, we have implemented a prototype of AROUND and have applied it to the Taiwan Designers' Week (TWDW), one famous annual design exhibition organized by non-governmental sector in Taiwan [3].

The design and deployment of the system is similar to that in Fig. 1. In addition to the AROUND back-end server that implements/integrates those modules/services needed by the system, we also developed two mobile exhibition guidance apps (i.e., the front-end apps), respectively, for Android and iOS device. Both of these two apps are AROUND-enabled and are designed to have the same look-and-feel (UI) for better consistency and user experience, where a fancy card-based UI design is implemented. Fig. 4 shows screenshots of the user interface.

Moreover, to increase visitors' engagement with this exhibition, the TWDW organizer implemented a treasure hunt-style game/activity by arranging various quests and game rules for individual exhibitors (e.g., booths and design stores), as shown in Fig. 5. Such a game transforms the experience of attending exhibitions into an activity similar to a treasure hunt game. Visitors can earn achievement awards and trophies by solving quests throughout the exhibition.

As a proof-of-concept, this prototype shows that the proposed system is feasible and effective. The results are encouraging for both organizers and visitors. For organizers, the user-friendly interfaces significantly reduce the complexity of deploying an exhibition guidance service. For visitors, the only requirements are to install the exhibition guidance app on their mobile device, carry the device when moving through the exhibition/booths, navigate the exhibition/booth information provided on the cards, and perform some interactive tasks (like playing games or collecting cards) for awards. Furthermore, visitors can post their achievements on social network sites (e.g., Facebook) to compete with friends who also attend the exhibition.

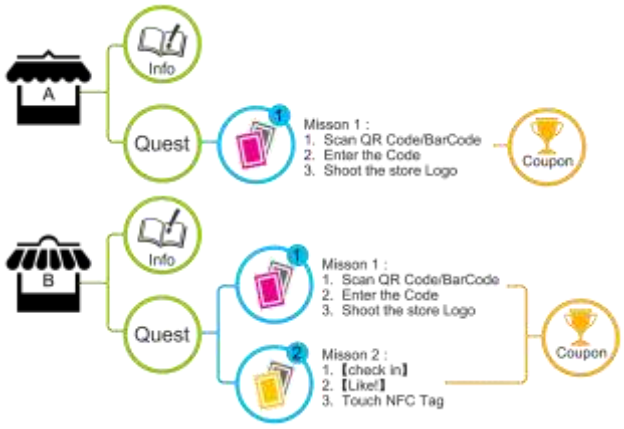

Figure 5. Quests and rules for treasure hunt-style activity.

IV. Conclusions

In this study, a highly interactive, extensible, easy-to-use and context-aware mobile exhibition guidance system, named AROUND, has been proposed and implemented. The key to this work is a mobile-based interaction methodology that enables the possibility to connect visitors and exhibitions with a diversity of mobile interfaces/sensors. The proposed approach also deals with the issues of extensibility, simplicity, reusability and social integration in terms of technical aspects. Furthermore, a prototype of the proposed system has been deployed and tested in one famous annual design exhibition in Taiwan. The results are encouraging and show that AROUND

has the potential to enrich the current mobile exhibition guidance experience.

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