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개인화된 도움을 위한 증강현실기반 메시지 주석시스템

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요 약

본 연구에서는 특정개인에 맞춘 정황정보를 제공할 수 있는 개인화 메세지 주석시스템을 제안한다. 본 시스템에서 컨텍스트는 사용자의 신분, 위치, 시간등을 포함하는 실체로 정의하며 사용자의 정체는 개인화된 메세지 생성의 주된 데이터이다. 컨텍스트를 감지하기 위해 증강현실 기술이 사용되며, 사용자의 위치를 추적하기 위해 실제 물체에 마커가 부착된다. 증강현실 기술은 인간의 지각과 상호작용을 강화시키는 아주 효과적인 주석 방법으로 사용될 수있다. 메시지는 가상 문자메세지 또는 3차원 가상물체일 수 있다. 실험결과는 제안된 시스템이 실시간으로 효과적으로 작동됨을 보여주며 또한 개인화 메시지를 제공하는 모바일 서비스로 사용될 수 있음을 보였다.

키워드 : 증강현실, 상황인식 컴퓨팅, 모바일 서비스, 개인화 메세지

AR-based Message Annotation System for Personalized Assistance

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ABSTRACT

We propose an annotation system, which allows users moving on an environment to receive personalized messages that are generated by exploiting contextual information. In the system, the context is defined as an entity including user's identity, location and time. Identity of user is a key data to enable personal aspect of generated message. For sensing the context, the proposed system uses AR(augmented reality) technology. Markers are attached to real objects for tracking user's location. AR can provide an effective annotating method to enhance human's perception and interaction abilities. The received message can be a virtual post-it or three-dimensional virtual model of object overlaid onto the real-world view. Experimental results show that the proposed system works well in real-time with high performance and it can be used as a mobile service for personalized messaging.

Keywords : Augmented Reality, Context-aware Computing, Mobile Service, Personalized Messaging

1. Introduction

Context-aware computing has been a hot research topic and it greatly contributes to the enhancement of our life's quality. Many context-aware applications and systems have been developed to make our life more convenient and comfortable[1]. Examples are travel information while travelling[12], local shopping guide[11], the nearest parking lot when needed to stop your car, up-to-date local news, etc. Those applications are developed by taking advantage of contextual information such as location, time, user's activity, etc. However, most of them provide helpful information in public way and also they do not exploit user's profile that is considered as an important data for the present business. With the rapid development of mobile devices such as wearable computer, personal digital assistant (PDA) or cell phone, data services tend to be personalized. Research and development for mobile services focus on the personal aspect of mobile devices. CHIP (Cultural Heritage Information Personalization) project [4] provides personalized access to combined cultural heritage content. In CHIP, the personalization that is based on a user model containing the interests, goals, background and knowledge of the user, improves museum website usability by supporting user navigation and assisting them in finding appropriate and interesting information. A context-based information sharing system, *cPost-it*, allows users to share various types of media data by exploiting context such as the user's identity

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(ID), location, time, etc[5]. In order to offer personalized services in a consistent manner, a *Personal Service Environment*[6] is presented that besides profile management, provides generic service discovery, content adaptation and service adaptation functionality. Jorstad et al.[7] present an analysis of the requirements for service personalization and proposes a generic service architecture that supports personalization. Mechanisms for efficient synchronization of profiles based on semantic distinctions are introduced in[8].

In this paper, we focus on the personal aspect of information retrieving on mobile devices. The proposed annotation system allows users to see not only general information in public places, but also private messages according to the user's identity. For example, a big university has many buildings and departments so that a lot of public bulletin boards are available. Most information in these boards is too general or may be not specific to users. Also the information may be degraded due to environmental effects. In order to give more information (private messages, comments, virtual models, etc) to a specific user, an annotation system is proposed. A user can take his PDA or mobile computer equipped a camera to go anywhere around the university. Annotation system will track user's location using markers which have been attached to bulletin boards for place definition. For each board, not only information written on the board can be perceived, the user also can see private message in terms of text or thee-dimensional (3-D) virtual objects overlaid on board's marker. For unknown(or outside) user of a department, a general message can be created and displayed such as "Welcome to the exhibition of our department at room 317" or "A new model of car has just been created. Please see this demo" with a 3-D virtual model of car shown over the marker. Users of the department can get private messages like "We have meeting at room 7-314" or "Please meet Mr. Kim at 2pm" that is made according to user's position (manager of department, professor, student).

In such annotation systems, Augmented Reality (AR) is an effective means to enhance human's perception and interaction abilities. AR refers to a field of computer research which deals with the combination of real world and computer generated data. Most AR research is concerned with the use of live video imagery which is digitally processed and "augmented" by the addition of computer generated graphics. For annotation applications, AR is normally used to provide users with helpful information overlaid onto the real-world view.

The paper is structured as follows. In section II, we introduce context-aware mobile computing, AR technology, and their related works. Section III presents detailed design of the proposed system. Experimental results will be shown in section IV. Finally, we conclude this paper and discuss future works in section V.

2. Related Works

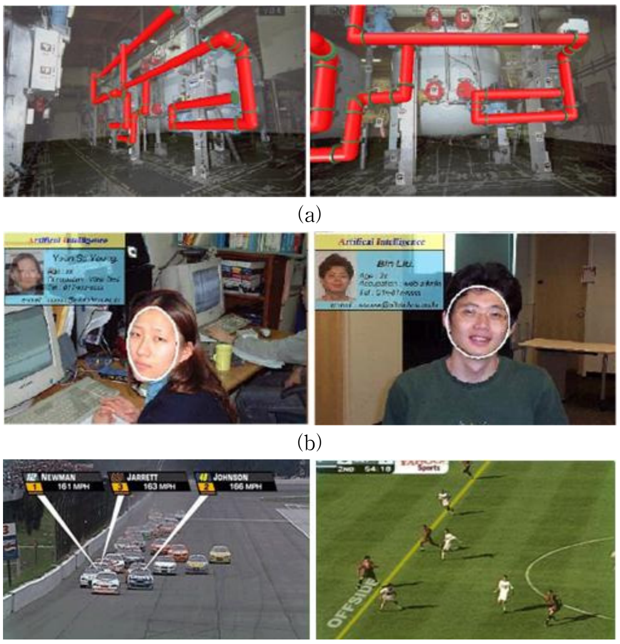
2.1 Context-aware mobile computing

Context-aware mobile computing aims to discover and take advantage of contextual information. Many researchers have studied this topic and built several context-aware applications to demonstrate the usefulness of this new technology. The *Active Badge*[9] system is generally considered to be one of the first context-aware applications. With the system persons could be located in an office and calls forwarded to the closest phone. The office personnel wore badges that transmitted IR-signals (so-called active badges). A network of sensors placed around the office building picked up the signals and a central location server polled these sensors. The telephone receptionist could find out where a person was and direct the call to an appropriate phone. Based on *Active Badge*, *Teleporting*[10] is built as a tool to dynamically map the user interface onto the resources of the surrounding computer and communication facilities. The *Shopping Assistant*[11] can guide the shoppers through the store, provide details of items, help locate items, point out items on sale, and so forth. *Cyberguide*[12] is a tourist guide system which provides information services to a tourist about his current location. The *Conference Assistant* helps conference attendees by using a variety of context information[13]. It examines the conference schedule, topics of presentations, user's location and user's research interests to suggest the presentations to attend. The *Office Assistant*[14] is an agent that interacts with visitors at the office door and manages the office owner's schedule. The *ComMotion* project[15] provides a service that each reminder message is created with a location and it is delivered via voice synthesis when the intended recipient arrives at that location.

As mentioned at the previous section, those applications are not personalized. Helpful information is mainly based on user's location which can be sensed by using several techniques. One location-tracking technique is the Global Positioning System (GPS). However, GPS cannot work in an indoor environment due to building's obstructive affect on GPS signal strength. Thus, other techniques based on infrared (IR)[12] or radio frequency (RF)[11] have been proposed. To reduce the cost of system and to adapt with AR environment, the proposed system is based on image processing for tracking user's location.

2.2 Augmented Reality

AR refers to the real-time insertion of computer-generated graphical content into a real scene. The AR environment is a real-world based environment where physical entities and computer-generated entities coexist. R. T. Azuma[1] has classified applications for which AR is applied. In medical applications, an AR system can support general medical visualization tasks in the surgical theater[16-17]. For annotation and visualization, information helpful to the user can be overlaid onto the real-world view[18-19]. In manufacturing and repair, AR can be used to support the assembly, maintenance, and repair tasks of complex machinery[20-21]. Moreover, AR can aids user in testing the visual robot's action and using the real robots. Entertainment and military aircraft also are suited areas of AR applications which can place user into environments with intelligent virtual creatures[22] or provide soldiers with simple task-specific systems by the "smart clothing" method[23]. AR applications including mobile, collaborative, and commercial are discussed in a survey paper[2]. The *Touring Machine* is a tour guide system using wearable devices which presents information about Columbia University's campus[24]. The *Déjà vu*[25] is a navigation system in the indoor environment using a mobile computer to take current position with GPS sensor and a CCD camera. Billinghurst's *Shared Space* work showed how AR can be used to seamlessly enhance face to face collaboration[26]. Henrysson et al.[27] demonstrate the first face to face collaborative game running on a mobile phone. For commercial applications, AR has been used for real-time augmentation of broadcast video to enhance sporting events and to insert or replace advertisements in a scene[28]. The Fig. 1 shows some examples of AR applications. In the first picture, a virtual pre-display of the pipes on the screen of an AR system could help a plumber to install the pipe in the most efficient way. Next, a virtual post-it is displayed to provide detailed information of a person while a user is moving in unknown environment. For car racing, AR systems are used for providing fans "not at the track" with graphic effects and relevant data enabling them to follow the action of their favorite drivers more easily. In soccer games, virtual offside line created by an AR system enables the viewer see exactly when and how the foul was committed.



(a)
(b)
(c)

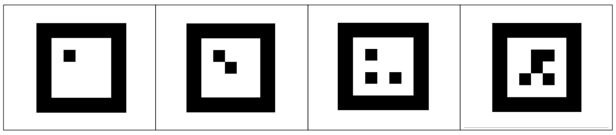
(Fig. 1) Examples of AR applications. (a) Industrial AR application (Siemens Corporate Research[29]). (b) Annotation application (Personal Identity System[19]). (c) Consumer AR application[28]

3. Proposed System

3.1 System Overview

The proposed system is designed in client-server architecture. It consists of a portable computer (a PDA or a mobile PC with a wearable camera) connected to server via wireless network. The system uses camera to capture image sequences of real world. Portable computer process those images as input to detect, track and recognize markers attached to real objects. Afterwards, the data including user ID and marker ID will be sent to application server. At server, marker ID is mapped to user's location. Then, messages will be retrieved from database based on user context: ID, location, time. Messages can be texts or 3-D graphic objects defined in VRML. Portable computer displays text message to the user in the form of virtual post-it attached to the top-left corner of live video screen whereas 3-D virtual symbol can be overlaid on the marker.

As mentioned above, the system uses marker to track user's location (e.g. which department or bulletin board). In such real-time distributed application, a challenge is to maintain high performance due to the expensive computation of image processing and the delay of client-server data transmission. Hence, simple markers are employed to reduce the cost of computation in detection, tracking and recognition processes. Markers consist of the black and white squares as shown in Fig. 2. The predefined patterns make the difference of markers.



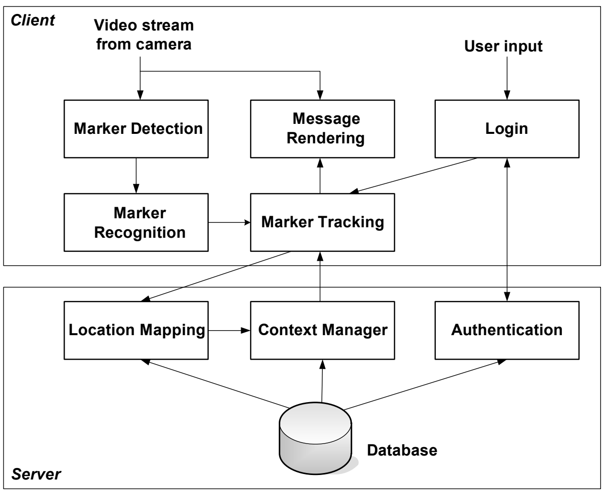
(Fig. 2) Four examples of marker used in the system

3.2 Annotation system

A process diagram of the system is shown in Fig. 3. Given an image sequence as input, the system generates personalized messages and shows them to the user. The proposed system comprises eight processes: the marker detection, tracking, recognition, message rendering, login, on the client and authentication, location mapping, context manager on the server.

Authentication is to obtain personal property of message. A user having his own profile data such as name, job, position can get a specific message upon his current situation like standing location or current time. Each person can be uniquely determined by a user's identity that is easily attained via registration process provided by service provider. In the beginning, a user enters his ID and password. The data will be sent to server and be processed for checking validity. Then, the user's identity is given to other processes as input and this information is frequently used during data transmission between client and server for personalizing data.

Computer vision algorithms are applied in marker detection and marker recognition process[30]. Marker detection process is to detect potential markers in image sequences taken from camera. It is based on a contour detection technique to find objects having shapes similar to a marker whereas marker recognition is based on corner detection and template matching to identify a marker. The detailed steps are shown in Fig. 4.

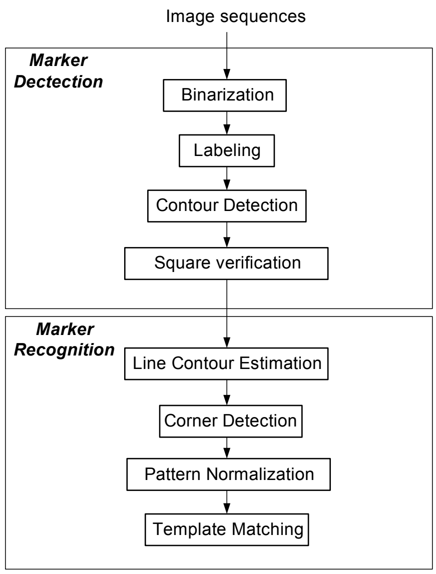


(Fig. 3) Process diagram of the system

The system performs the image binarization and then detects the contour of objects in the image. Gray-level images are converted to black and white images by binarization. The binarized image is processed by labeling algorithm which helps to distinguish separated objects. After labeling, contour following is performed to extract contours of objects. For each contour, the system uses square verification method to check the similarity of their shapes and a rectangle.

Marker recognition uses template matching technique to recognize markers. First, line contour estimation is applied and then the process detects sub-pixel corners of the found contour. Afterward, the region of marker-considered object is extracted using detected corners. The extracted image is then normalized to the predefined size of pattern. Finally, the system uses a correlation matching method to evaluate the marker similarity. The detected marker is compared with all predefined patterns, and a matching score computed through the correlation is returned. The detected marker is then recognized as the one giving the highest cumulative score.

Whenever a marker is recognized, its information will be sent to marker tracking. This process is to keep track of detected marker with its information including ID number, position, size and direction. When the camera is rotated or moved, the marker information is frequently



(Fig. 4) The Flow diagram of marker detection and recognition processes updated. In order to make functionality of annotation properly, marker tracking also have to manage personalized messages which are stored on a remote database. Each time a marker is identified, the process determines the corresponding message of the marker and then sends those data to message rendering for annotation. For getting messages at remote database, marker tracking need to make a request to application server by sending information including marker ID and user's identity. A problem occurring in this process is that consecutive data transmission between client and server affects the performance of the system. To solve that problem, the payload of client-server communication need to be decreased and the client sends requests to server only if needed. To do this, message tracking is implemented. Not only current marker is monitored but also previous detected markers and their corresponding messages are tracked. Once a relevant message of a marker has been retrieved, it can be reused for that marker during the user's session. The system checks the current detected marker's appearance and if this is not the first time, previous received message will be used.

Getting data from client as input, location mapping connects to remote database for determining location. The relationship between marker and location is predefined and is stored in database in term of relation of tables. One marker is mapped to one location uniquely. All data is passed to context manager for next processing.

The purpose of context manager is to extract personalized messages upon received data. The system uses 3W (Who, Where, When) as a context to provide the proper service[31]. "Who" is a user's identity which represents the name of the user or group the user belongs. The system classifies messages based on identity. "Where" represents the location of user and "When" is information about the current time of message request. Given "Who", "Where" and "When" as input, Context Manager connects to the database for messages retrieving. More detail of data organization and management is explained in next section.

3.3 Data Management

As mentioned above, data is mainly stored in a remote database. The data includes information about user, marker, location, and message. User-related data consists of user profile (name, job, work place, position, etc) and account (ID, password, role). User account is necessary for authentication and data management.

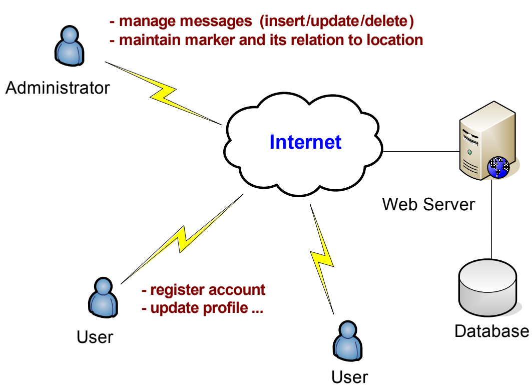
A marker has its own ID, name and pattern file used for recognition. To improve the performance, marker recognition needs to be designed as a client process. Pattern files of marker are stored not only in the database, but also in the client. Thus, a synchronization mechanism is demanded for matching pattern files between client and database. A client automatically updates new patterns from database after successful login. Because pattern file is ASCII file containing pixel values of normalized image of marker template, the size of file is normally small. Moreover, the number and model of marker used in system is generally stable. Hence, the task of synchronization does not take much time for updating and also does not affect the system performance.

In the system, location means the place where user is standing. It is "Where" playing important role in message extraction. User location is determined and tracked by marker. The system assigns a marker to one location so that each detected marker in client will be mapped to a corresponding location. This relationship can be defined in linked table on the database.

Stored message is personalized information created to inform user an event or provide more detail about objects. The content of message varies frequently according to user situation such as who he is, where he is standing and what time is. Message can be a string that provides information to user or a 3-D virtual object defined by VRML. It is easy to model a real object or an animation of world by VRML. Therefore it can enhance user's perception and interaction ability. Message will be displayed to user in term of virtual post-it in case of its string format. Otherwise, a virtual model of object will be overlaid on marker.

To manage data, a web-based remote control service is provided. User of this service can be classified into two groups: administrator and normal user. Fig. 5 depicts a general view of remote data management.

A normal user needs the service to register an account



(Fig 5) Diagram of remote data manage

and update information of his profile as well. An administrator has a more complicated task. He initiates messages then assigns them to each user in relation with location and time. A message can be assigned a start time and an expired time for limited access. If the time of request is within this period, the message will be provided to user. Otherwise, user cannot receive the message. Another important mission of administrator is to manage information of location, marker and maintain their relation. Location data is created for each real place(e.g. building, department, floor, etc). Also, marker data is made and handled in relation with each location.

4. Experimental Results

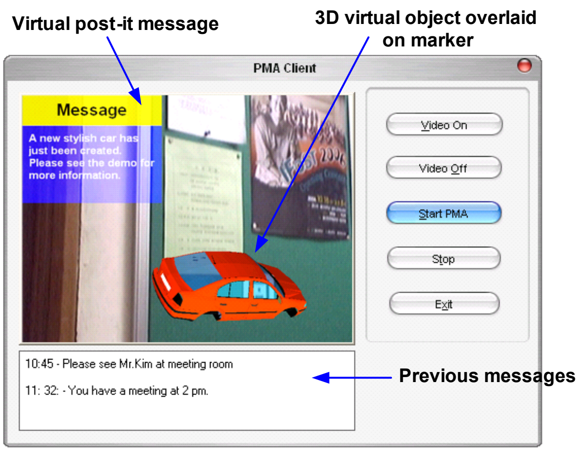
A test version of the proposed system has been built using Visual C++ 6.0 mostly based on ARToolkit open source library[30]. The interface of Personalized Messaging Assistant (PMA) client is shown in Fig. 6.

With login form, users input their information including user name and password for authentication. The data is known in advance for each person via registration process. The main view form contains a window of live video that shows image sequences continuously captured from real world. In addition, a historical message board is available that enables user to see previous received messages. A virtual post-it is displayed on the top-left corner of live video window for a text message whereas a 3D virtual model of car is overlaid on a marker.

In order to evaluate the performance, the system has been tested in our university. The client program has been installed in notebook with a USB digital camera and a wireless LAN card. For location tracking, markers have been attached in several places such as bulletin board, room door, wall, etc. A user taking the mobile PC with camera walks around the floor. The image sequences are captured continuously by the camera. Once a marker is detected and then recognized, the predefined relevant message is displayed to the user. Fig. 7 shows examples of personalized messaging assistance. Four persons using PMA system stand in front of a bulletin board and direct their camera to the same marker attached on the board. The captured screens on their PMA client are shown in the figure respectively. The first person got no message. The second person received a virtual post-it notice. The third person saw a 3D virtual arm of robot whereas the last person observed 3D virtual car and an explanation.

The problem encountered in the test is the occurrence of delay of video stream. In the two first cases, the messages were displayed to the users immediately. However, last two persons have observed the delay of video stream when the marker is recognized at the first time. This problem is caused by the transmission time of files between server and client. In case of text message, the small amount of data needed to transfer makes the time of data retrieving very short. Since text message can be transferred very quickly, there is no delay. But the transferring VRML files needs more time due to the noticeable size of file. Consequently, retrieving process makes the delay problem with respect of 3D virtual object message. Table I lists the tested VRML files with their sizes and corresponding delay times.

However, the proposed system uses message tracking mechanism so that the delay only occurs at the first recognition time of each marker. Hence, the performance



(Fig. 6) Implemented PMA client - main view form with example of augmented messages

(Fig. 7) The result of personalized messaging assistance: (top-left-no message, top-right-virtual post-it notice, bottom-left-3D object, bottom-right-3D object and explanation)

File name	Size (KB)	Time delay (ms)
Ufo.wrl	359	1243
Car.wrl	264	863
GrayPipe.wrl	163	521
Snowman.wrl	5.66	34

〈TABLE 1〉 VRML Files and Time Delay

of the system is not affected by the delay problem.

5. Conclusion

In this paper, an annotation system for personalized messaging is proposed. The key contribution of this work is to design a system which is a combination of context-aware based mobile computing, private messages and augmented reality. The experimental results demonstrate the possibility of real-time processing. Thus, the system suggests a realizable mobile service for personalized messaging. In the future, we will implement the system on PDA for further evaluation of performance.

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