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AN EVENT-DRIVEN NAVIGATION SYSTEM FOR CONTENTS REUTILIZATION

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ABSTRACT

Our research group is creating navigation contents for Expo'70 Commemoration Park in Japan, and is developing navigation systems that will use these contents. Since it costs a lot of money and requires a lot of human resources to create useful and interesting navigation contents, it is difficult to create high-quality contents for a single small-scale system. Therefore, we propose a framework for constructing multiple navigation systems, without needing to make drastic modifications to the contents and systems, using our proposed event-driven platform. We constructed four navigation systems using the proposed framework with the navigation contents we created for Expo'70: a wearable navigation system, an AR navigation system, a kiosk-style navigation system, and a streaming navigation system. The two implemented systems received high praise from users in experimental demonstrations.

KEYWORDS

Navigation System, Contents Reutilization, Wearable Computing

1. INTRODUCTION

Advances in multimedia technologies mean that navigation systems with multimedia contents are now used in various places such as museums, art galleries, and amusement parks [1,2]. One of most important factors in users' evaluations of navigation systems is the quality of the navigation contents. However, the creation of high quality contents costs a lot of money and requires a lot of human resources. Therefore, it is difficult to create very high-quality contents for a single small-scale system, such as an experimental navigation system used for research. A solution to this problem is our proposed framework, which cuts the cost of creating new contents for each new application by using the same contents for various applications, such as other navigation systems, handbills, and web sites.

We used the Expo'70 Commemoration Park in Osaka, Japan, as the target for our navigation contents, and we developed a framework for constructing various navigation systems using the same navigation contents. The proposed system framework uses the Event-Condition-Action mechanism for navigation applications. Therefore, since we can separate the trigger for playing the navigation contents, the conditions for playing them, and the execution of the contents being played, we can easily construct navigation applications with the same contents. We developed four navigation applications, and some of them are used in the park.

We explain the navigation contents in Section 2, and the proposed navigation framework and developed applications in Section 3. Section 4 explains the evaluation of applications and Section 5 presents our conclusions and future work.

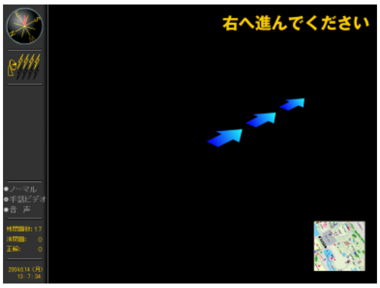
2. NAVIGATION CONTENTS FOR USE AT EXPO'70 PARK

Expo’70 (Nihon Banpaku Hakuran-kai) was a World Fair held in Suita, Osaka, Japan in 1970 [3]. The theme of the Expo was “Progress and Harmony for Mankind.” 77 countries attended the event and there were 76 pavilions. There were 64,210,000 visitors. This fair was one of the largest and best-attended expositions in history. The site of Expo’70 is now the Expo Memorial Park. Almost all the pavilions were demolished, with memorial stones set in their place, as shown in Figure 1.

Many young people do not know that the fair took place, and it is difficult to imagine the details of the circumstances at the time, with only the memorial stones with engraved names of the pavilions to remind us.

Figure 1. A memorial stone where a pavilion once stood

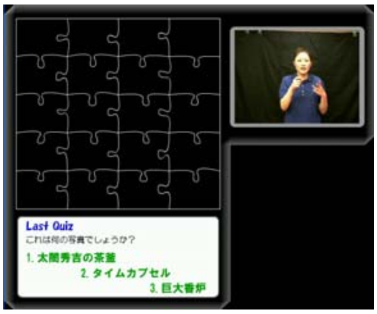
(1) Map



(2) Arrow for navigation

(3) Contents in hand-language

(4) Quizz



(5) Puzzle

Figure 2. Navigation contents

Therefore, we started a project to construct navigation contents that will remind people of the fair as it used to be. There were several requirements for the contents:

- The navigation style must vary according to the systems that the contents are applied to, such as streaming video for displaying the contents at kiosk terminals or mobile phones. The contents should not need to be modified when changing applications.
- The contents must be barrier-free, enabling all people, including the developmentally challenged, to enjoy the contents.
- Contents should be easy to add or delete for use at seasonal events.

With these requirements in mind, we created navigation contents, including 23 animations for explaining pavilions and attractions, 18 quizzes about pavilions and attractions, 1 puzzle, maps, and 19 arrow animations for navigation, all using Macromedia Flash MX. For each animation, we created three types of animations; normal animation, normal animation with sign language animation for the hearing impaired, and sound streaming for the visually impaired. We created the contents in multiple individual small pieces because such small pieces are more flexible when constructing navigation applications. Screen shots of the contents are shown in Figure 2.

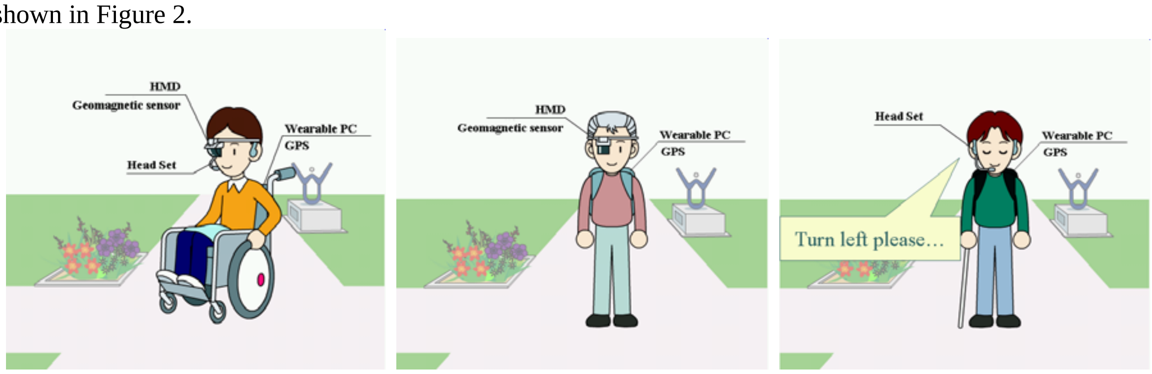


Figure 3. Device configurations for different users

3. NAVIGATION FRAMEWORK AND APPLICATION

As described in the previous section, the navigation contents are flexible. If the functions of a navigation engine (system) are fixed, it costs a lot more to reuse the contents in other applications. Therefore, we employed an event-driven rule processing engine already in use in the “Wearable Toolkit” that we developed [4,5,6]. This engine’s behavior is determined by a set of ECA rules. Each ECA rule consists of three parts: Event, Condition, and Action. Event describes the event that is occurring in the system, Condition describes the conditions for executing the actions, and Action describes the operations to be carried out. When constructing navigation applications, we only have to write some rules, in which events that occur trigger which contents to play and actions determine which contents will be played. We can create a new application by simply changing events in the rules, and the system’s functional flexibility is achieved by adding or deleting rules to or from the system.

Examples of navigation systems that use our system are a wearable navigation system, a navigation system for use in a kiosk terminal, an augmented reality navigation system, and a video streaming navigation system. Although these navigation applications are different types of applications, we can construct them simply by making a few changes in the rules.

3.1 Wearable Navigation System

The wearable navigation system is a system in which the user wears a wearable computer and sees the contents on a head mounted display. The user wears a computer, headphones, HMD, GPS locator, and a geomagnetic sensor to determine the user’s direction. He or she walks around in the park using the navigation system. When approaching an intersection, arrows are displayed to guide the user. When he or she approaches an area where a pavilion used to exist during the EXPO, the system automatically plays an introduction movie and quizzes the user about it. The contents that are played are selected automatically according to the device configuration of the wearable computer. As shown in Figure 3, The system plays normal contents if both the HMD and headphones are attached to the wearable computer, sound contents if only an audio output device is attached (for visually impaired people), and movie contents in sign language if only an HMD is attached (for hearing impaired people). The criterion used for determining that the user is approaching a specific point is shown in Figure 4. The system monitors the objects in the user’s field of vision and, on the basis of what the user can see, determines the user’s latitude, longitude, direction, range, and radius. If the user is in the object area, the system determines whether the user is approaching the object.

The total number of rules in the application is 30, and the rules used for determining the playing contents are shown in Figure 5. The *OnRotate* and *OnMove* rules retrieve scenes near the user when the user's direction or position changes. The *CheckPosition* rule chooses an appropriate object from among those retrieved, and the *DoNavigation* rule displays the contents.

We demonstrated these navigation contents at Cyber Communication 2004 [7] held at Expo'70 Commemoration Park on March 25th, 2004. Cyber Communication 2004 was a symposium on barrier-free navigation systems for the park. 20 handicapped persons and 60 other visitors used our system for about an hour, and we evaluated the system for six hours. In this experiment, we used four small customized computers, four Sony PCG-U3s as wearable computers, and a SHIMADZU DataGlass2 for the HMD of the

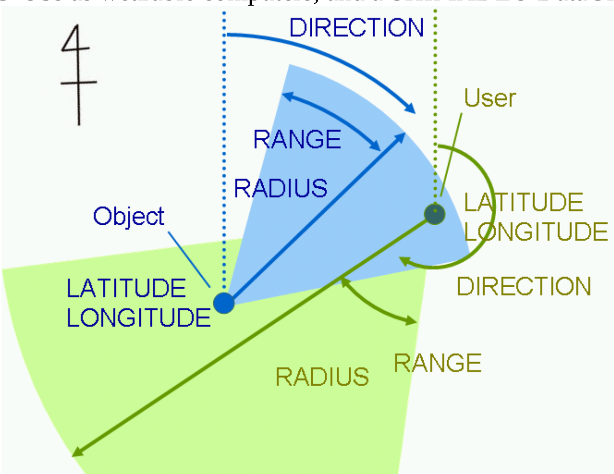


Figure 4. Criterion used to determine whether a user is approaching an object

```
DEFINE OnRotate
WHEN ROTATE
IF !CMN.IS_IN_BOUND[NEW.DIR, OLD.DIR, 10]
THEN DO DB_QUERY('SELECT * FROM PositionTable WHERE
  LATITUDE > %GPS.LATITUDE% - RADIUS
  AND LATITUDE < %GPS.LATITUDE% + RADIUS AND
  LONGITUDE > %GPS.LONGITUDE% - RADIUS
  AND LONGITUDE < %GPS.LONGITUDE% + RADIUS')

DEFINE OnMove
WHEN MOVE
IF !CMN.IS_IN_BOUND[NEW.LONGITUDE, OLD.LONGITUDE, .001]
  OR !CMN.IS_IN_BOUND[NEW.LATITUDE, OLD.LATITUDE, .001]
THEN DO DB_QUERY('SELECT * FROM PositionTable WHERE
  LATITUDE > %NEW.LATITUDE% - RADIUS
  AND LATITUDE < %NEW.LATITUDE% + RADIUS AND
  LONGITUDE > %NEW.LONGITUDE% - RADIUS
  AND LONGITUDE < %NEW.LONGITUDE% + RADIUS')
```

```
DEFINE CheckPosition
WHEN DB_SELECT(PositionTable)
IF ?CMN.IS_OBJECT_VISIBLE(GPS.LONGITUDE, GPS.LATITUDE,
  0.05, DIR.ALPHA NORTH,60,NEW.LONGITUDE,NEW.LATITUDE,
  NEW.RADIUS, NEW.DIRECTION, NEW.RANGE)
THEN DO DB_QUERY('SELECT * FROM SceneTable
  WHERE POS = %NEW.ID%')

DEFINE DoNavigation
  WHEN DB_SELECT(SceneTable)
  THEN DO CALL VIEWER(NEW.XML)
```

Figure 5. Rules for playing contents

wearable computer. We also used RIGHT STUFF GPS-USB-RA as a GPS and Sensation Vector Cube (VC-03) as a geomagnetic sensor. Figure 6 shows snapshots of people using our system.

3.2 Navigation System in Kiosk Terminal

The navigation system described in Section 3.1 is an advanced navigation system for a user wearing a computer. On the other hand, for visitors enjoying the park casually, it is more practical to provide information to them through kiosk terminals with touch panels, which are located around the park. Therefore, we constructed a navigation system for use in kiosk terminals, as shown in Figure 7. A user can browse navigation contents by touching certain points on the map.

This application was also developed using our navigation framework. We changed only the rules that trigger contents, as shown in the upper left of Figure 8.

3.3 AR Navigation System

The previous two applications were intended for actual use at Expo'70 park. However, the navigation contents are also useful for exploring the park virtually from elsewhere. We constructed an augmented reality (AR) navigation system that uses visual markers of the AR toolkit [7] to experience the park virtually. The constructed system consists of a room decorated with photos of the park that represent it virtually, as shown in Figure 9, and wearable computers equipped with cameras and HMDs. When a user wearing a computer looks at a photo panel, the wearable camera recognizes a visual marker and the system show the navigation

Figure 6. Snapshot of a user using the wearable navigation system

Figure 7. A snapshot of the navigation system for kiosk terminals

```
DEFINE DetectPosition
  VAR str AS BSTR
WHEN CLICK_SCREEN
THEN DO DB_QUERY('SELECT * FROM PositionTable WHERE
  X > %NEW.X% - MGN AND X < %NEW.X% + MGN AND
  Y > %NEW.Y% - MGN AND Y < %NEW.Y% + MGN')
```

Navigation system for kiosk terminals

```
DEFINE DetectMarker
  VAR str AS BSTR
WHEN AR_MARKER
THEN DO DB_QUERY('SELECT * FROM SceneTable
  WHERE ID = %NEW.MARKER%')
```

AR navigation system

```
DEFINE PlayNext
WHEN END_PLAY
THEN DO DB_QUERY('SELECT * FROM SceneTable
  WHERE ID = %GLOBAL.ID%')
  DO GLOBAL.ID = MOD(CMN_SET_I4(#GLOBAL.ID + 1#))
```

Streaming navigation system

Figure 8. Rules modified for other systems

contents associated with the detected marker. The rules are modified only to trigger different contents, as shown in the upper right of Figure 8.

This system was actually used in an event for high-school students called Playing with Wearable Computers. Over a hundred people enjoyed our system, as shown in Figure 10.

3.4 Streaming Navigation System

When a user experiences the park virtually from elsewhere, it is most effective to show streaming navigation contents, like TV programs, without any interaction. Therefore, we constructed the rule shown at the bottom

Figure 9. A room decollated with photo panels and visual markers

Figure 10. Snapshots of a person using the AR navigation system

Figure 11. A snapshot of a user using the streaming navigation application

of Figure 8, which shows the recommended touring course by playing a series of navigation contents continuously. Figure 11 shows a snapshot of a person using this application.

4. EVALUATION

In our experiments with the wearable navigation system and the AR navigation system, we handed out questionnaires to 39 people and 80 people, respectively. Each participant was encouraged to rank (1: worst, 5: best) every question and to write honest comments. Table 1 shows the aggregate statistics of the questionnaires (we used the same questionnaires in both experiments). In the table, WE means the wearable navigation system described in Section 3.1, and AR means the AR navigation system described in Section 3.3. We got high marks for the effectiveness of the automatic information presentation and interestingness

Table 1. Statistics of questionnaire

Questions		Average		Standard deviation	
		WE	AR	WE	AR
Wearable computer					
Q1	I have been to EXPO'70 park	70%	49%	-	-
Q2	I usually use a computer	4.0	3.7	1.2	1.3
Q3	It was comfortable to wear the computer	3.4	3.0	1.3	1.3
Q4	I could see information cleary on HMD	2.1	2.5	1.3	1.0
Q5	I expect HMDs to become popular	3.2	3.6	1.1	1.0
Q6	Displaying information on the HMD automatically is helpful	3.8	4.0	1.2	1.0
Q7	People wearing HMD look good	2.8	3.3	1.2	1.2
Q8	Cables were not a problem	2.5	2.3	1.6	1.3
Q9	What would you like to do with the wearable computer? (free form)	-	-	-	-
Navigation service					
Q10	The system helps visitors to learn the details of the park	3.5	3.7	1.3	1.1
Q11	The system is more helpful than guidebooks	3.6	4.0	1.4	1.1
Q12	The system is more interesting than guidebooks	4.0	4.2	1.3	1.0
Q13	I was able to clearly watch contents	2.3	2.6	1.3	1.2
Q14	It was easy to operate the system	3.1	-	1.2	-
Q15	The amount of guide information is adequate	3.2	3.3	1.1	1.1
Q16	What kind of functions do you want? (free form)	-	-	-	-
Q17	Any comment? (free form)	-	-	-	-

factor of the services and contents (Q6, 10, 11, 12). On the other hand, we can see that wearable devices (Q4, 8, 13) are uncomfortable. As for the free comments, although there were many positive comments on the helpfulness and novelty of our system such as "fabulously effective and useful" and "I'm very pleased to see a new service that will become very popular," there were also negative comments about the devices such as "It is difficult to see information on the HMD in bright-lighted areas." We can deduce from the questionnaires that the contents and services of the models are acceptable to users but that the present designs of the wearable devices themselves are not acceptable. Therefore, when we construct the next navigation application, we will have to consider using PDAs for visibility, or using mobile phones as wearable devices. Such changes in devices and service styles usually cost so much, but our system enables easy modification of services and easy adaptation of other devices, by simply changing a few rules. Suggestions from people included using the system in a shopping center, controlling the system by voice, chatting with other people using the system, and sharing information with their friends. Requests for additional features can be easily incorporated into our system, and in future versions, we plan to take the points made by users in our experiments into account.

The coefficient of correlation between the results from the WE navigation system questionnaires and those of the AR navigation system questionnaires is extremely high (0.99). We can see from this that the most important matter that determines whether people have a good impression of a navigation system is not the system configuration but the quality of the navigation contents, because these two navigation systems are very different in terms of the places they can be used and the system configurations. Therefore, using our mechanism, a developer can concentrate on creating high-quality contents, because once they have created good contents, they can use them in various applications.

At the same time, we were unable to gather experimental results about the navigation system for kiosk terminals and the streaming navigation system. In future, we intend to modify our mechanism on the basis of information gained from the user evaluations of these two navigation systems.

5. CONCLUSION

We have proposed a method for developing navigation systems in which the contents can be reused in other systems. We implemented four navigation systems using the same navigation contents. Results of the questionnaire we conducted in our experimental study show that our systems are highly effective and useful despite the fact that our navigation contents are used in two different systems. Moreover, we showed that the creation of new navigation systems can be performed easily by changing a part of the event-driven rules. Using our method and systems, we can construct various navigation systems with the same contents easily and rapidly. In future, we plan to apply our method to other navigation contents.

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