A Wearable System for Supporting Audiences and Motorbike Racing Teams

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Abstract:
Motorbike racing is one of the most famous motorsports and a lot of people visit circuit places to watch races. However, since audiences and pit crew can get only limited information, it is difficult for them to get information about teams except for high rank teams and few popular teams. In this paper, to solve this problem, we have presented and implemented an information browsing system for pit crew and audiences. Since our system can provide various information such as detailed ranking table and favorite teams, our system can make the supporting team advantageous and entertain audiences much more.

1 Introduction

Motorbike racing is one of the most famous motorsports. In most case, more than seventy thousand people visit the circuit place and they enjoy watching motorbikes in high-speed. By watching a race in the circuit place, audiences can feel a sense of togetherness with riders, pit crew, and other people, unlike the case of watching the race on television. On the other hand, they cannot get information enough to grasp the current race situation in the circuit, because it provides information about only a few teams, which are high rank teams and very popular teams. Therefore, there is an increasing demand on the information supplement systems providing the information which they want to know.

Pit crew who participate in the race have also the same problem. Figure 1 shows a television monitor which provides the current race information to pit crew. As the figure shows, since the monitor presents information of only top-10 teams, they cannot grasp the race condition when they want. In response to this problem, we have proposed a information browsing system for pit crew and a team manager by utilizing wearable computers, and applied the system for Suzuka 8 hours Endurance Race in 2003[1]. Figure 2 shows a team manager and a pit crew who are wearing our system. Since our system employs wearable computers, it provides various information without interfering their work.

Figure 1: A television monitor showing race information

Figure 2: The use of wearable computers

Through the previous practical use, since we have gotten some knowledge from the team manager and the pit crew, to improve our system for supporting their winning of races. In this research, we clarify the requirements for our system, improve the system, and use it in an actual motorbike race. Moreover, since audiences in the circuit place need the race information to enjoy the race, we also enhance our system for entertaining audiences by presenting various information. The key point of the enhancement is the function to post/share photographs among audiences. Using this function, they can post photographs taken by their digital camera with their comments, and they can browse them broadcast from the server in their wearable computers. These photographs enable audiences to know various situations such as a crush at the opposite side of the circuit, and a rider taking a rest at the pit.

The remainder of this paper is organized as follows. Section 2 explains the environmental assumptions and system requirements, and Section 3 describes the design of our system. Section 4 explains the implementation and the practical considerations, and Section 5 presents a conclusion and future work.

2 Assumptions and requirements

2.1 Environmental assumptions

Our system is designed for the FIM World Endurance Championship Series, Round 5 "Coca-Cola" Suzuka 8 hours Endurance Race, which is one of the most famous motorbike races held in Japan in July. In this race, motorbikes are not allowed to have any communication devices to pit crew except a transmitter that sends a motorbike ID to a receiver placed at the control line across the race track. The circuit control tower collects the information from the receiver and broadcasts it via radio waves. This means every time a motorbike passes the control line, the control tower broadcasts the motorbike information, which includes the motorbike ID, the rider ID, the number of laps, and the elapsed time. On the other hand, the other important information to win races is not provided officially, such as the ranking information, distance

between two specific teams, and detailed position of a motorbike.

Suzuka Circuit has a 6km race-track, and motorbikes run through approximately 200 laps in the 8 hours. It has one control line at the goal line.

2.2 Requirements from pit crew

In our previous work[1], we designed and implemented the system for supporting the team manager and pit crew, especially considering the following three requirements: (1) **No interference** means that wearable computer does not interfere with the work of a pit crew, (2) **Continuous information** means that a wearable computer provides the latest information immediately whenever a pit crew wants to check, and (3) **Notification of incidental information** means that a wearable computer offers immediate information when an incident has occurred.

After the practical use, we have gotten the following requirements from users of our system.

- Environmental information: the condition of road surface is sensitively influenced by surrounding situation. Especially, the change of weather has potential to change the race condition drastically. Therefore, the system should provide information about weather forecast, temperature, and humidity.

- Ranking table: users sometimes want to check all teams to grasp the whole of race.

- Information of following/ahead two teams: to improve their rank, the team manager observes these teams carefully. Therefore, they want to check this information anytime.

- Positions of motorbikes: the team manager wants to know the approximate positions of motorbikes to devise a rough strategy.

- Road surface after an accident: the team manager wants to check the condition of road surface after an accident because there is a possibility of changes in the condition.

To fulfill these requests, we have to enhance our system drastically. In this research, we design and implement the system for the team manager and pit crew, which has the above functions.

2.3 Requirements from audience

The audiences in Suzuka Circuit acquire information only from one large main display monitor and announcement via public address system. This monitor displays top-5 team numbers which do not include even team names, thus it is difficult for audiences to grasp the race situation. Moreover, this monitor is located in front of the main stand. Since many audiences

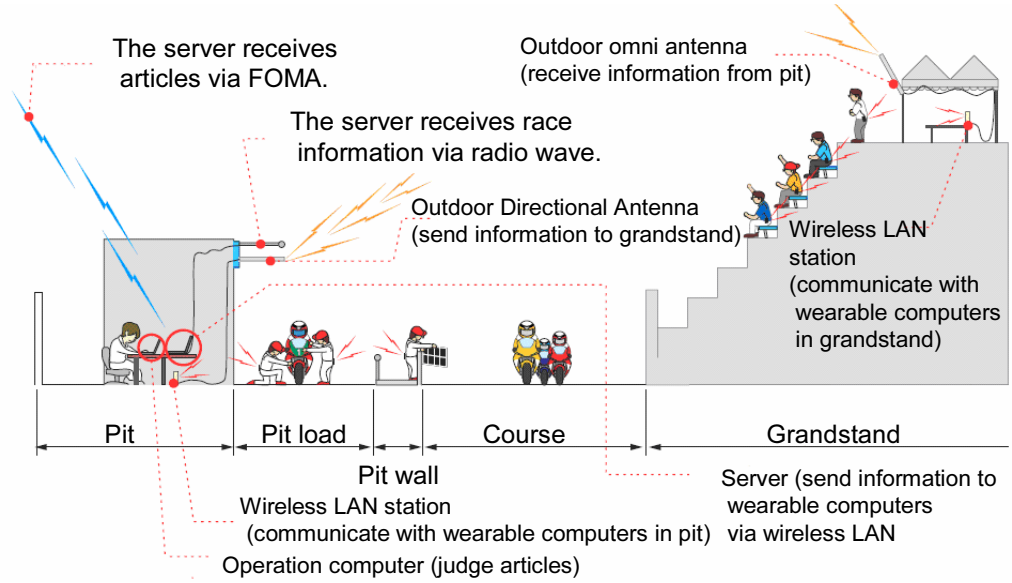

Figure 3: System image

watch a race in places of the circuit, they cannot get even such poor information from the monitor.

For bringing solutions to these problems and entertaining audiences much more, we also provide a wearable system that provides various information to users and enables users to participate the race actively. Since this system also employs a wearable computer, users can walk around the circuit freely on using our system. The system has the following functions:

1. Browsing race information: the system provides information about races such as ranking table, team and rider names, lap time of the team they want to know, approximate position of all motorbikes.

2. Sharing photographs: to create opportunities for audiences to participate the race actively, the system provides the function to share photographs taken by their digital camera with their comments. They can browse them broadcast from the server in their wearable computers. These photographs enable audiences to know various situations such as a crush at the opposite side of the circuit, and a rider taking a rest at the pit.

3 Design of the system

Figure 3 shows our system image. Since the control tower disseminates only lap information for each motorbike via radio waves, we place a server that receives and accumulates information from the control tower, calculates the ranking information, and broadcasts the information to wearable computers via wireless LAN. Moreover, the server plays a role of www and mail

Table 1: Functions provided by plug-ins

Common Plug-in

Type	Name	Content
EVENT	CMN_START	Initialize System
	CMN_TIMER	Timer expires
ACTION	COMM_EVENT	Generate specific event
	CMN_ADD_RULE	Insert rules

Race specific plug-in

Type	Name	Content
EVENT	RACE_RANK_INFO	Ranking updates
ACTION	INIT_RACE	Initialize

Network Plug-in

Type	Name	Content
EVENT	NET_RECEIVE	Receive data
	NET_FILE_RECEIVED	Finished receiving file
	NET_FILE_SENT	Finished sending file
ACTION	NET_UNICAST_SEND	Send data
	NET_BROADCAST_SEND	Broadcast data
	NET_BROADCAST_SEND	Broadcast data
	NET_FILE_SEND	Send file

server for the photograph sharing function. The server receives article including photographs via an email and a www page. Operators in a pit judge whether the posted article is suitable for delivering to users. Audiences receive information from the wireless LAN station placed at the grandstand.

3.1 A-WEAR

We employ an event-driven system called A-WEAR[2] as a platform of the proposed system. A-WEAR is a middleware for wearable computers, which runs between OS and wearable services. In A-WEAR, we describe system behaviors with event-driven rules and use plug-ins to extend system functions. Service developers can easily construct various services by combining plug-ins and describing rules. We can add, delete, or customize those services while the system is running by adding, deleting, or modifying the rules.

All services are represented as a set of ECA rules, which were originally a behavior description language in an active database system that is a database technology. An active database processes the prescribed actions in response to an event arising inside or outside the database[5]. Each ECA rule consists of three parts: *Event*, *Condition*, and *Action*. The event part describes an event that occurs in the system, the condition part describes the conditions for executing actions, and the action part describes the operations to be carried out. Events and actions that we can use are specified by plug-ins. Table 1 shows the functions of some implemented plug-ins. EVENT and ACTION describe events and actions that the plug-in provides.

When we constructed the previous system for supporting the motorbike racing team, we implemented only one race specific plug-in, since we could use many conventional plug-ins. All functions of the system were described as several ECA rules. In this way, A-WEAR enables us to construct services for wearable computing easily and rapidly.

3.2 System design

The detailed structure of our system is shown in Figure 4. We achieve the services by adding new functions to the race specific plug-in and describing ECA rules to provide services. The

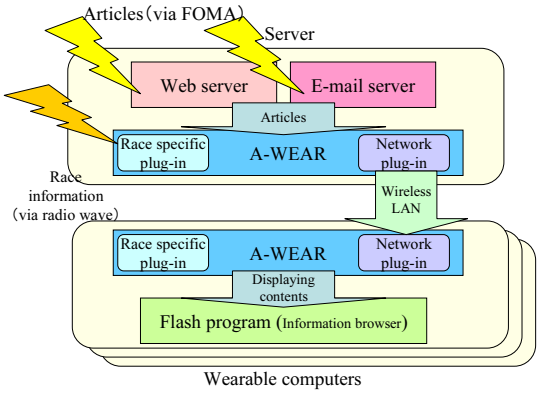

Figure 4: Detailed system structure

server has functions of WWW server and email server to receive articles. The user interaction part in a wearable computer is constructed by flash to realize rich visual animations. The server broadcasts only differences of information with revision number for reducing the network load. When a wearable computer detects the lack of information by referring the revision number, it requests the lost data via HTTP connection. In this way, our system achieves the robustness.

The race specific plug-in on the server receives the information from the control tower via radio waves, calculates the ranking, and generates a ranking update event and a pit stop event. When a ranking update event occurs, the server broadcasts the ranking information to wearable computers. Moreover, when the server receives a submitted article via email or the www page for submitting articles, the network plug-in generates data receiving event. The A-WEAR on the server sends the notification of a new article to the computers for operators, and these computers updates the list of article candidates for broadcast. When the server receives a request to deliver the specific article, it sends the article to wearable computers. When A-WEAR on the wearable computer receives rank update information from the server, the A-WEAR processes the information using the race specific plug-in to generate ranking table and update information on its screen. When it receives other information such as an article and a message from another wearable computer, it also updates the information on the screen. In addition, the race specific plug-in periodically predicts locations of motorbikes according to the previous lap times, and displays them.

3.3 Interface design

We have decided the displaying information and the interface design based on the requirements. Figure 5, 6, 7, and 8 show snapshots of each window of the system. Figure 5 shows the strategy window which displays estimated times of pit stops. Figure 6 illustrates the course window which displays current predicted locations of motorbikes. The upper part of the strategy window and the course window displays information of specific team that in-

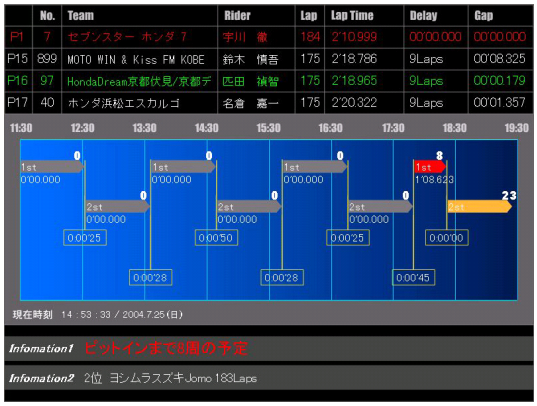

Figure 5: Strategy window

Figure 6: Course window

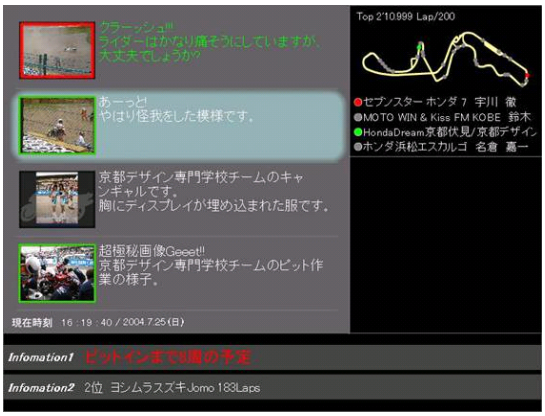

Figure 7: Board window

Figure 8: Detailed article

cludes ranking, lap-time, team name, and the rider name. Figure 7 shows a board window for audiences, which displays posted articles. Users can operate the system by at least three buttons for changing window, scroll, and select. When a user selects an article, the system shows the detailed information of the article as shown in Figure 8.

4 Implementation and practical use

We have implemented the prototype system. We developed new functions in the race specific plug-in, and described 22 rules for the server, 19 rules for the operation computers, and 60 rules for wearable computers. Figure 9 shows an example of rule for the server. When this rule receives the pit-stop information correctly, the rule updates the ranking information and the strategy window. Figure 10 shows an example of rules for weather forecast at wearable computers. When the computer receives an information on weather forecast, *ReceiveWeather* stores it. *ShowWeatherForecast* is activated when the user pushes the select button, then the rule shows the weather forecast.

```
DEFINE ReceivePitin
WHEN NET_RECEIVE
IF NEW.TYPE == 'PITIN'
  AND NEW.REVISION == GLOBAL.REVISION
THEN
  DO RACE_CLIENT_PITIN(NEW.RANK)
  DO CMN_EVENT('UPDATE_STRATEGY','RANK',NEW.RANK)
```

Figure 9: The ECA rule for pit stop

```
DEFINE ReceiveWeather
  VAR Xml AS BSTR
WHEN NET_RECEIVE
IF NEW.TYPE == 'WEATHER'
THEN
  DO GLOBAL.WEATHER_XML = STR('<Weather><Visible>
   True</Visible><Picture>http://%NEW.ADDRESS%
   %NEW.LARGE_PHOTO_URL%</Picture></Weather>')
  DO GLOBAL.WEATHER_FORECAST = BOOL(1)

DEFINE ShowWeatherForecast
WHEN SELECT_ITEM
IF GLOBAL.CURRENT_PAGE != 3
  AND !GLOBAL.WEATHER_FORECAST
THEN
  DO NET_XMLSOCK_SEND(GLOBAL.WEATHER_XML)
  DO GLOBAL.WEATHER_FORECAST = BOOL(1)
```

Figure 10: The ECA rule for weather forecast

(a) The team manager

(b) A reporter

(c) Hardware

Figure 11: Using the system

We have used Microsoft Visual C++ .NET 2003 Enterprise Architect for implementing the system and Macromedia Flash MX for the information browser. The system was actually used by the team in the Suzuka 8 hours World Endurance Championship Race held in Japan in July, 2004[4]. We also demonstrated our system for audiences, and approximately 100 audiences experienced our system. We have allocated several reporters to post photographs, and 70 articles are posted during the race.

Figure 11 shows the snapshots in the actual use of our system; (a) the team manager using the system, (b) a reporter, and (c) the wearable devices. We have used Sony VAIO Type-U as wearable computers, which were covered with our handmade carry-bag and fixed to users' waist. We employed SHIMADZU Data Glass 2[3] as HMD, Sony VAIO R505R/DK for the server, and IBM ThinkPad X31 for the operation computer. As for input devices, we provided three types of devices for user's operation, hand-made small input devices that has two buttons, Sony Jog-dial controller, and Mevael Keiboard for users who need to input texts for chat.

In total, we have used 30 computers, 17 HMDs, and 20 digital cameras. The wireless LAN network was composed by IEEE 802.11b devices. We achieve the long-distance wireless com-

Table 2: The results of questionnaire

Question	Avg.
1. How many times have you come to see the endurance race?	4.80
2. Does HMD look sophisticated?	3.69
3. Are you interested in showing information on HMD?	4.50
4. Do you think that HMD is useful?	2.88
5. Did you enjoy our system?	4.63
6. Does information our system provides fulfill your needs?	4.34

munication by using Buffalo outdoor directional antenna WLE-HG-DYG and outdoor omni antenna WLE-HG-NDC. The reporters have posted articles via wireless LAN and PHS networks.

4.1 Experiences

We have demonstrated our system for audiences to approximately 100 people. In conjunction with the demonstration, we sent out questionnaires about the system and got 33 answers. This questionnaire has 6 questions and a space for free comments. The result is shown in Table 2, which question 2-5 request the answer in the scale of 1 to 5 (1: worst, 5: best).

From the result, most answerers have attended this race several times, and they are interested in our system and feel that the system is useful. This result means that even the experienced audiences feel the information provided by the circuit is not enough and our system can resolve this problem. They enjoy using wearable computers feel HMD and wearable computers are sophisticated although it is hard for nearly half of them to watch information on HMD. More than 90% of them felt that our system fulfills their needs and several answerers said that they want to rent this system even if it costs dozens dollar per a day. This result shows the effectiveness of our system is available for business use in the circuit places.

The free comments in the questionnaire include that "I want to watch real-time movies from in-vehicle camera," "I want to know riders' profiles," "the system should provide local information such as stores, lavatories, and maps." Since these comments are valuable for improvement of our system, we will enhance the system based on them.

4.2 Durability

Since the circuit place is very large, sometimes wireless LAN, cellular phone network, and PHS network lost their connection for submitting photographs. On the other hand, the servers and PCs for operators have worked well for 8 hours without any problem. However, the laptop located in the pit wall became runaway in fifteen minutes after the start of the race because of high-tempareture. We have to adopt measures to avoid the rise of temperature and the

direct sunlight.

The team manager had used our system for almost 8 hours without any big trouble and as a result the team reached a record a 18th ranking, in spite of 43rd start.

5 Conclusions

In this research, we built an event-driven system for supporting audiences and racing teams in motorbike races. Moreover, we performed a practical test in the Suzuka 8 hours Endurance Race. Since our system employs an event-driven system called A-WEAR, it can provide various information on the race with enough immediacy. The system also enables audiences to post/share/browse photographs with their comments. Using these functions, audiences can easily grasp the race situation at any time.

We acquired valuable knowledge from the practical use, which help us to improve the system further. In the future, we apply the knowledge to our system for better support, and we have a plan to apply this system to other races, such as auto races and motocross races.

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