Development of a Context-Aware Information System for Baseball Service

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***Abstract*—A context-awareness is one of the important issues for developing an intelligent information service system in order to provide the information most useful for the users. In this paper, a context-aware information service system for baseball game is described. To recognize the context of baseball play, a contextual knowledge model is suggested. An 'observation point' concept is also introduced to provide baseball information effectively and proactively. A proto-type context-aware information service system has been implemented on smart phone, and evaluated in the aspects of usefulness and appropriateness. The system was appreciated in understanding over the progress and immersion of the match.**

Keywords-context-awareness; contextual knowledge model; information service; observation point

I. INTRODUCTION

Rapid and remarkable progresses in computing environment such as World Wide Web and powerful yet affordable server systems enable the application programs to provide more intelligent and proactive information services. Software agent is usually the kernel of those information services, and intelligent agents for information services have been developed to satisfy user's requirement and to provide practical services in many different domains such as finance, traffic, e-health [6][7][8]. Among those agents, the agent for context-aware information service is supposed to recognize not only the current situation of the information content and user, but also the changes of their situation, in order to supply the information most useful for the user at the contextual aspect. The recognition of the situation is based on the overall assessment about all the related factors such as context of content, user location, surrounding objects, environmental conditions, and their semantic relations. As a consequence, for the recognition of the situation, contextual knowledge models and reasoning techniques based on ontology concept have drawn many attentions, and reported as highly effective [5][10][11]. For the representation of situation, the changes over time should be considered as one of the important factors since the agent needs to adapt to the dynamically changing situation and corrects its behavior [3][4]. These changes are even more significant in the case of the context-aware information service for baseball game.

Baseball game continues couple of hours, and the situation consisted of many factors like pitcher, batter, runner, inning, out count, ball count, etc. keeps changing. At every change, game audience might be interested in specific information through which the progress of the game is predicted. For the simplicity, in the rest of this article we refer to these kind of information as 'observation points (OP)'. There can be many observation points relevant to the specific situation of the baseball game. In addition, each audience might be interested in different observation points according to his or her knowledge of baseball game. For instance, the record on the stolen base of a runner might be more interesting than the hitting average of a batter if the runner is on the first base with out-count one at late inning while both team scored nil. In the broadcasting of baseball game, even though some observation points are usually provided by commentator, these information are only the commentator's observation points, so that likely to fail to satisfy every TV audience. Moreover, the commentator's observation points are very limited as the commentator should prepare the observation points before the specific situation take place. Currently, several mobile information services for baseball game have been developed and commercialized [9][12]. These services, however, focused on providing the current status of a game and live video clips.

In this paper, we investigate the use of a software agent which can systematically provide the observation points at the specific situation of baseball play in order to address the above-mentioned problem. The agent was regarded as the kernel of artifact being capable of playing the role of commentator and recommending proactively the observation points suitable for the context of game as shown in Figure 1.

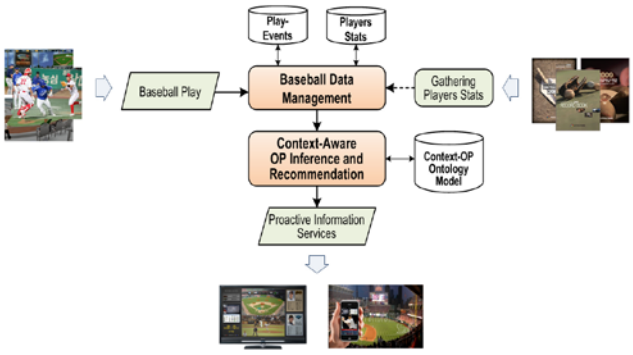

Figure 1. Conceptual diagram of the intended information service.

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For the inference of the observation points at the specific situation of baseball play, a contextual knowledge model ('Context-OP Ontology Model' in Figure 1) representing the relations between contextual factors and observation points of baseball play is suggested. All the possible observation points at the specific situation of baseball play are collected from the interviews with baseball experts. Also, the records of players are gathered manually, and statistically managed to be linked with the observation points in the contextual knowledge model. Each situation of baseball play is entered by game recorder as a play event defined with situation factors. The agent has been implemented as a context-aware information service on a smart phone, which becomes the powerful platform for mobile internet services and the most useful personal assistant for watching baseball game.

The rest of this paper is organized as follows. Section 2 describes the context-awareness and functional requirement for information services. Section 3 illustrates the functional structure and its role of the proposed context–aware information service for baseball game. Section 4 explains the contextual knowledge model used for recognition of situation and inferring observation points. Section 5 discusses the service platform and a proto-type mobile application of the developed information service system. Section 6 sums up the work and concludes the paper.

II. CONTEXT-AWARE INFORMATION SERVICE

As the agent needs to recognize current situation and recommend information appropriate for the context, it requires number of functionalities such as context-awareness, inference of matching items, information retrieval, and priority indexing (see Figure 2) [1][2]. For the context-awareness, the formalization of the contextual factors defining the situation of the target content is necessary. The recognized contextual factors can be represented in a formalized context model by applying ontology technology. The function to recognize and assess current context by analyzing the model is identified as context recognition. Clear definition on the contextual elements is necessary for context-awareness. Moreover, grouping of the elements and converting them into knowledge are also necessary. Once current context is recognized, the agent refers to the knowledge model and infers the information appropriate for the context. The knowledge model defines context element and information element for generating the relations between two elements in knowledge map. Then, the agent retrieves the specific information relevant to the context from the database and supplies it to the user.

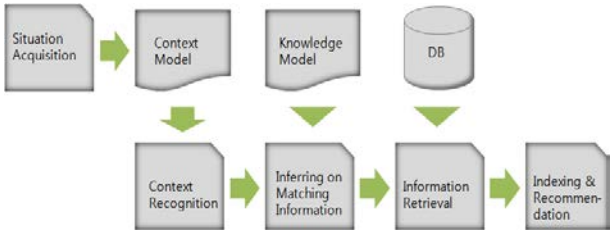

Figure 2. Functions required for a context-aware information service.

III. CONTEXT-AWARE INFORMATION SERVICE FOR WATCHING BASEBALL GAME

There are various records in baseball game as often referred as the game of data. They are commonly provided by caster or commentator. However, inevitably the service is uni-directional and limited in quality and quantity in many cases. Introduction of the 'observation point', and proactively providing the observation point and relevant statistics in suitable timing by the system would improve the service and add the zest to watching the game. The observation point means the group of the player's record and interesting information relevant to the current context of baseball play, which attracts audience's interest. The system structure of the context-aware information service applied to the baseball game watching is depicted in Figure 3. The role of each module on the structure diagram is introduced, and the flow from context recognition to providing observation points is explained in this section.

Provisioning of observation points starts when a play-event occurs, that means the change of the situation in baseball game. The event is recorded by game recorder through the interface as shown on Figure 4, and analyzed to match to the context model, which is then stored in the 'Play-Event DB'. The server process (i.e. agent) regularly checks the change of content in the 'Play-Event DB'. In case of any changes detected, the agent recognizes the current context through the 'Context Recognition Module', and extracts observation points relevant to the context. Then, the observation points are served through the user interface. The extraction of the observation points is carried out in the 'Observation Point Inference Module' by inferring the 'Context-Observation Point Ontology Model' representing the relations between context and observation points. The agent extracts all the instances of observation points matched to the context. Then, detail information of each extracted observation points are retrieved from the 'Observation Point DB'. As shown in Figure 5, the instance of the observation point has the name of the related database table, name of column, searching constraints, etc. as the 'Related Data' properties. The details of each observation points are stored in the database through 'Player Stats Analysis Module' when the players' records are imported.

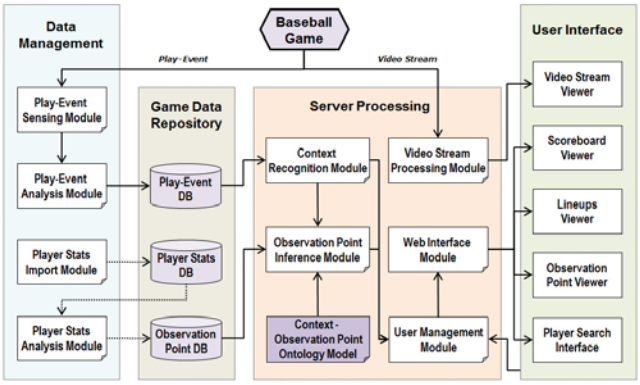

Figure 3. System structure of the context-aware information service for watching baseball game.

Figure 4. User interface for recording play event.

Also, a weight value is given to each observation point instance in order for comparing the importance of the observation points. The inferred observation points are sorted in the order of weight values given to the observation points. Finally, the derived observation points are changed into XML files, and provided to user in the 'Web Interface Module'. Through this integrated process, the agent proactively provides users with situation relevant observation points of baseball game, and users are able to get interesting information.

IV. CONTEXTUAL KNOWLEDGE MODEL FOR INFERENCE OF OBSERVATION POINTS

The structure of the contextual knowledge model for the representation of the relations between context and observation points is shown in Figure 5. The model consists of 2 classes for representing the change of context, and 2 classes for representing the relation between observation points. Also, the relation between context and observation point is represented in order to infer the observation point relevant to the current context. This relation is one-to-many relation as the one observation point might be relevant to many contexts. Moreover, an additional class, 'Additional OP', is introduced to represent the related multiple observation points. The context class is defined with contextual factors of baseball play, and the observation point class has a weight value and properties used for retrieval of detail information. In the context class, contextual factors are grouped to be recognized according to the data type property. Inning, runner, count, score difference, etc. are groups in high level. Inning has inning number and top/bottom as lower elements. This ontology model has been modeled in the way of contexts that can be specifically represented with these grouping elements by using Protégé as shown in Figure 6. The context with a series of events can be represented since the context class contains the relation with the previous context. The change in context along with the progress of events can be expressed as the sequence, which is controlled with 'previous context number'. The agent can identify the contextual change over time according to the representation defined in the model. Variety of the observation points might have been derived since the change of context over time can be expressed and the agent is able to recognize the contextual changes.

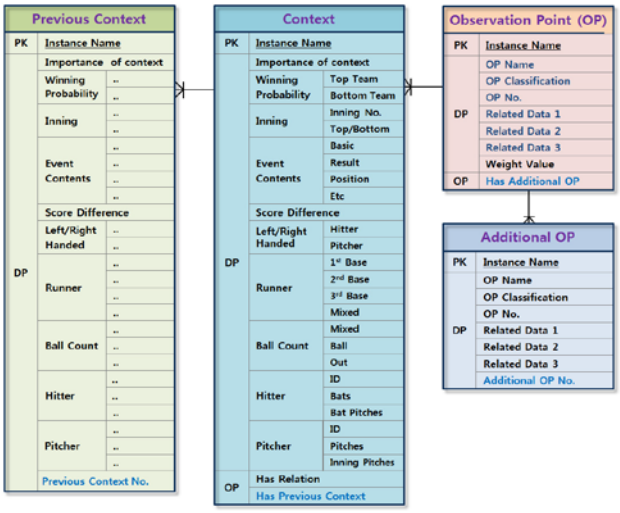

Figure 5. Structure of the Contextual Knowledge Model.

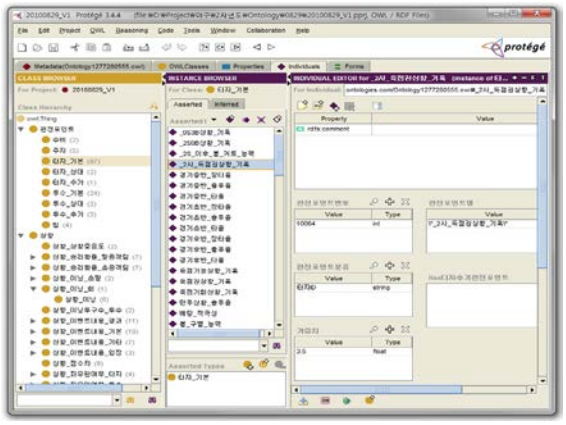

Figure 6. Ontology Modeling of Knowledge Model using Protégé.

V. IMPLEMENTATION

A proto-type information service system for providing observation points and the relevant information during the baseball play has been realized in order to assess the usability of the context based information agent. The system has been implemented in the server/client structure based on internet as shown on Figure 7. The near real-time play event on a game in progress and the video stream of the game are supplied to the server at the ball park. The observation points related to current situation are derived and indexed by the agent according to the level of relevance. The observation points and related statistics are stored along with the current video stream, and these are supplied to the client on request.

As an example, iPhone has been used as the client device for mobile service. A client App has been developed, which can supply video stream of the baseball game, observation points, game progress information, player information, etc. through the user interface as shown on Figure 8. The App regularly requests the server for the observation points along with the timing of the video streaming of a game. The game situation and the player information are supplied only on demand from user.

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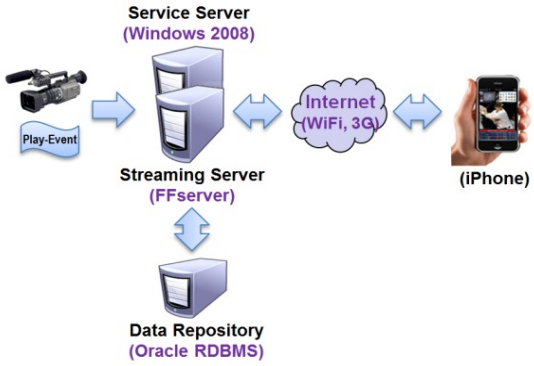

Figure 7. Implementation platform for the proto-type information service system.

Figure 8. Examples of baseball information service on the client App.

Only top three of the suggested observation points are displayed at the bottom considering screen size of smart phone. Once any of the observation points is selected by the user, the relevant data are displayed on the top of the screen. The information is overlaid on the video streaming of the ball game.

The system has been applied to the baseball games of Korean Series 2010, and evaluated in the aspects of usefulness of the service and appropriateness of the suggested observation points. The evaluation was carried out by using questionnaire survey from 70 university students after watching a baseball game through the system. They liked baseball game and known baseball knowledge quite well. Figure 9 shows the result of evaluation. Almost 90% users expressed positive opinions in the usefulness, and over 80% users thought the suggested observation points were helpful to understand the progress of the game. Therefore, it is enough to suggest that the information service might be enhance the understanding over the progress of the match, and increase the interest and immersion in the game.

However, some users mentioned the lack of the variety of observation points, caused by the interface of the proto-type application. The interface is designed for display only top three observation points because of the small screen of the device. Therefore, this issue might be resolved by modifying the interface through which the user can search the suggested observation points. Personalization of the observation points might be another resolution of the issue.

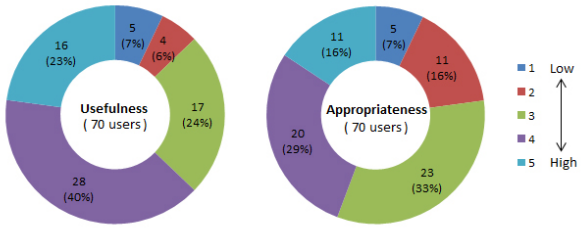

Figure 9. Evaluation results of the proto-type information service system

VI. SUMMARY AND DISCUSSION

In this work, an intelligent information service system for baseball game has been implemented as a context based information service agent. Recording interface for the acquisition of the progress information of baseball game and for the context modeling has also been designed. An ontology model has been structured for being aware of contextual change over time. The ontology is also designed for parsing data to knowledge and extracting observation points. The observation points which is the representation of groups of the information appealing to the user at a certain context are listed in the order of the relative importance and displayed on the mobile device as shown on Figure 8.

The implemented proto-type system satisfactorily offered information at every change of the situation while the system was applied to the real match of Korean Baseball League. In an actual situation, when runners on the first and third base at the out count one, for instance, the system suggested the possibility of hit, base steal, and double play. Once the possibility of double play was selected, the record of the batter on double play against the pitcher during the season was displayed with some other information. As the observation points were listed first, and the record information in detail was supplied only when the observation point was selected, the service was appreciated non-invasive and timely. The scope of this agent can be expanded to other domains like tourism, e-learning, and e-health since the ontology can be modified and expanded as required.

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