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3D virtual viewer on mobile device for wireless sensor network-based RSSI indoor tracking system☆

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ABSTRACT

Most of recent research on indoor location sensing information has been presented in dull and unpleasant 2D image standard. This paper focuses on high precision three-dimensional received signal strength indication (RSSI)-based location information in an interactive virtual reality on PDA. The developed system operates by capturing and extracting signal strength information at multiple pre-defined reference nodes to provide information in the area of interest, thus updating user's location in 3D indoor virtual map. Virtual Reality Modeling Language (VRML), which specifically developed for 3D objects modeling is utilized to design 3D indoor environment. To shorten the rendering time in low-power processing PDA, culling algorithm is introduced to render only essential 3D objects needed for navigation. Meanwhile, RSSI accuracy refinement algorithm introduced reduces noises in signal strength mainly caused by the effect of reflecting and attenuating objects in the indoor environment. PDA user's position is computed with respect to VRML specification, synchronized with real indoor environment. Moreover, interpolating of digital magnetic compass shows real-time dynamic orientation processing, generated projected 3D view to be displayed on PDA screen.

1. Introduction

Recently indoor tracking system had gained its trust as new application for development of services for object location identification especially on mobile handheld. Various indoor tracking methods had been discovered and improved through different researches and experiments nowadays. Popular indoor tracking methods include Active Badge and Cricket. Cricket used ultrasonic technology while Active Badge utilized the infrared technology. Meanwhile, received signal strength indicator (RSSI) identifies user or object location based on radio frequency (RF) method. Due to its low cost implementation, many researchers focus on incrementing the accuracy of the location sensing with RSSI method. Furthermore, representation of location sensing information is a critical issue in presenting user an understanding view of his current position. Therefore, three-dimensional virtual reality was utilized to provide user with interactive view, represent location sensing information in more systematic way, replaced traditional and dull 2D image standard [1–3].

Virtual reality had gained its trust as a representation of different spatial information in academic or industry areas recently. Visualization of 3D graphics on low processing, limited memory and resources constraint PDA presents a critical issue in modeling of 3D objects. Key technical elements for the realization of this vision are the model construction and organization, and rendering processes of 3D databases to 3D pipeline to increase the visualization speed. Numbers of pioneers had started to exploit 3D in this area, but mostly are concentrated only on outdoor activities [2,3].

VRML offers faster high-level abstraction prior to its platform independent definition [4]. Therefore, 3D indoor maps modeling on PDA by VRML might be a good choice.

The increasing miniaturization of electronic components leads to the development of extreme low-power and small sensor nodes for indoor tracking application with RF-based signals method. RSSI exhibits favorable properties with respect to battery lifetime, cost and size, eliminates the requirement of additional hardware. RSSI is able to estimate the distance between the transmitter and receiver and therefore predict the location of unknown device. Radiolocation device (CC2431 [5], Norway) is capable of estimating user location via RSSI. User relative position was estimated by using trilateration method, based on continuous range measurements from at least three known pre-defined position reference nodes.

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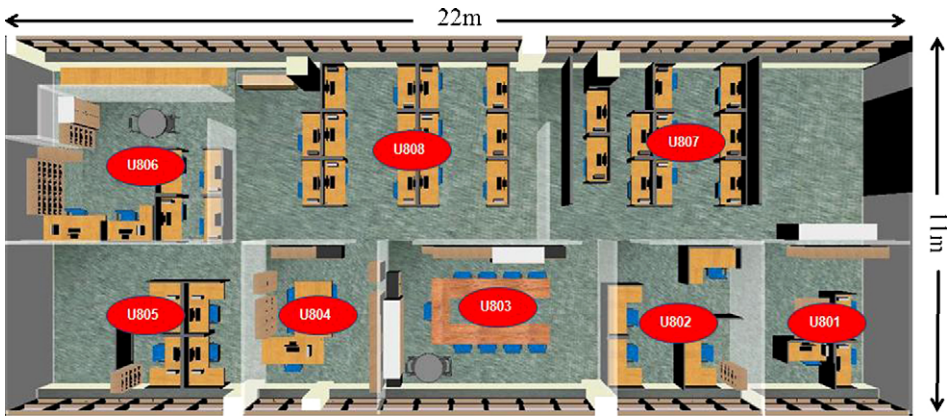

Fig. 1. Top view of a virtual indoor environment modeled in VRML.

Fig. 2. Indoor virtual reality model designed on PDA.

The RSSI coordinate data is used to give location of the object; meanwhile, user's orientation plays an important role in deciding which 3D objects are to be viewed based on current direction faced by PDA user. Digital magnetic compass manufactured by OPCEL [6] was used to determine orientation, produce an output in digital format. TIP710GM sensor node (MAXFOR Technology Inc., Korea) is combined with the digital magnetic compass device for sending compass packets to base station via wireless communication where digital compass magnetic is interpolating on it.

2. Indoor virtual reality

This study focused on the development of indoor tracking system by RSSI method using wireless sensor nodes and digital magne

```
Culling_Algorithm (Cell, Pos)
    If IsCellVisible (Cell, Pos)
        LoadCell (Cell)
        For each (Child in Cell.Node)
            If IsObjectVisible (Cell.Node.Bbox, Pos)
                LoadNode (Node)
        End for
    Endif
```

Fig. 3. Psuedocode script for portal culling algorithm.

tic compass device, and the implementation of three-dimensional virtual viewers on PDA using the location and orientation data.

To give virtual reality in location tracking map, the VRML was used. VRML is an international standard for describing 3D objects and scenery on various applications [1]. VRML's technology has very broad applicability, extended to 3D collaborative environments, 3D user interfaces to remote web resources, distributed visualization, and more. VRML had different features that distinguish it from other 3D graphic tools including availability to access through Internet at anytime, possibility to animate inside virtual scene at any viewpoint, and ability to interact with objects, move or change their state.

VRML could be constructed by using text editor or world builder application. VRMLPad [7] is used as an editor for VRML programming that used to model 3D indoor virtual environment in our experimented.

Indoor virtual reality is designed and modeled based on Ubiquitous Sensor Network Laboratory located at UIT-8 Floor in Dongseo University in limited the space of 27 m × 11 m. In order to ease the process of modeling, the laboratory was divided into eight spaces (cells). Each room number of the space is denoted by a red circle as shown in Fig. 1.

2.1. VRML browser

Before outlining specifies of particular application developed, indoor virtual reality is to be stressed on for first priority in our