반응형 가상 URS 서비스를 위한 실내 기하구조 및 환경 센서 모델링

Modeling of Indoor Geometry and Environment Sensor for Responsive Virtual URS Service

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Abstract This paper presents URS (Ubiquitous Robotic Space) Modeling and service technique for the robotic security service while bridging between virtual space and physical space. First, this paper introduces a concept of virtual URS and responsive virtual URS. Second, this paper addresses modeling of URS which covers modeling of indoor geometry and environment sensor. Third, this paper describes virtual URS services including interactive virual-physical bridging service.

Keywords : 3D modeling, Indoor geometry, Environment sensor, Virtual ubiquitous robotic space

1. Introduction

VR (Virtual Reality) technology can provide several advantages in view of intuitive understanding, real-time interactivity and virtual experience based on simulation model. This paper aims to achieve the technology fusion between VR and robot technologies. The research goal includes intuitive interaction between user and robot based on virtual robotic space that corresponds to physical space and robot.

This paper introduces the concept of virtual URS (Ubiquitous Robotic Space) and its application to human – robot interaction. Here, URS means ubiquitous robotic space where robot can communicate with sensors of USN (Ubiquitous Sensor Network). The virtual URS can provide virtual model of physical space and status of robot and salient objects for intuitive and interactive service. There are many possibilities of new applications by combining VR, robot and USN technologies.

This paper focuses on bridging between virtual URS and physical URS and visualization service based on virtual model. The service can be applied in robotic service with USN (Ubiquitous Sensor Network) environment. For example, in large scale environments like airport, museum, large warehouse and department store, autonomous mobile robots with USN will play an important role in security and surveillance tasks. In this service, it should be noted that virtual model with sensor and robot status information are needed for intuitive understanding of environment.

The virtual URS plays two roles. The first one is the virtual model of physical space, which provides 3D geometry and textures of physical space. The virtual model gives us intuitive and detail environment information from which human can understand the situation of the environment intuitively. Especially the 3D model can give more information. In view of visualization of information and human robot interface, a 3D model can give much more useful information than the typical 2D models used in many robotic applications. It is true that people could interact with robot more naturally in a remote circumstance with 3D model than 2D model. It should be also noted that windows and doors are opened or closed can be rendered with 3D model, while 2D model specifies only the location of window or door. This paper introduces our simple and easy to use method to build both of 2D map and 3D textured model using 2D LRF (Laser Range Finder) and camera. Our

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researches on the virtual indoor geometry modeling can be used for the application of remote surveillance, game contents, museum indoor modeling and so on [1-6].

The other one is that virtual URS provides interactive service between human and robot. Interactive service can make it possible virtual robot path navigation on the virtual space. Human can simulate the virtual robot path and position on the virtual space and understand the whole environment that user wants to see. The user can see the robot status like present position in the 2D/3D model and control it using the environment model. For human – robot interaction application, we will present web service and mobile phone service for remote access[4-7].

This paper also addresses modeling of environment sensors of URS in addition to the indoor geometry. According to the sensor status change, robot responds and provides various kinds of services. This paper aims to introduce the concept of responsive virtual URS in which the status of virtual environment model is also changed according to sensor status of physical space. For this purpose, this paper describes our approaches on environment sensor modeling and bridging method between physical space and virtual space. Experimental results on visualization of responsive virtual URS are also shown .

2. Virtual URS

The virtual URS is a virtual space for intuitive human-URS (or robot) interface, which provides geometry and texture information of the corresponding physical space. Fig. 1 shows the concept of virtual URS which is an intuitive interface between human and physical URS. In physical URS, there may be robot and ubiquitous sensor network (USN) which are real things in our close indoor environment. For example, the robot can perform the security duty and sensor network information is updated to be used as a decision ground

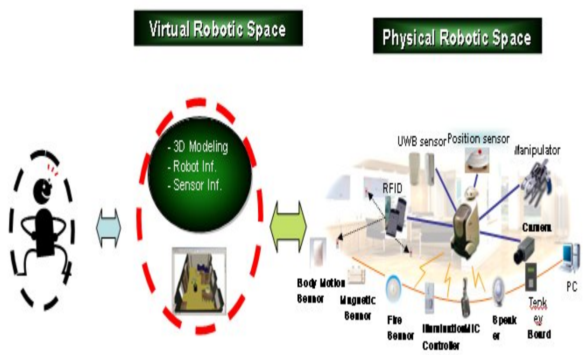

Fig. 1. Concept of physical and virtual URS

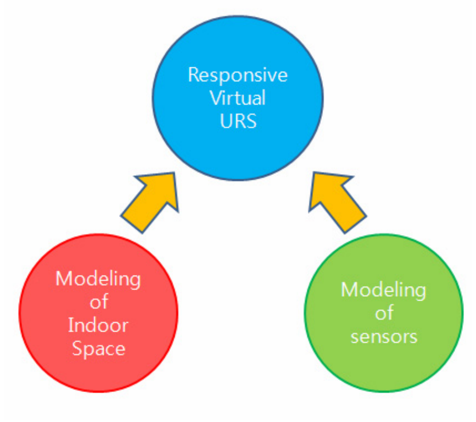

Fig. 2. Concept of responsive virtual URS

of whole devices' operation. The virtual URS is the intermediate between the real robot space and human. It can represent the status of physical URS, e.g., robot position and sensor position/status based on 2D/3D indoor model.

The virtual URS can be responded according to the sensor status. As a simple example, the light rendering can be changed according to the light sensor information in physical space. This is a concept of responsive virtual URS which provides similar environment model to the corresponding physical URS status. In other words, when event happens in physical URS, the virtual URS responds. Fig.2 shows the concept of responsive virtual URS.

3. Indoor Geometry Modeling

This section gives an overview of our method to build a 3D model of an indoor environment. In case of 2D model & 3D model, the geometry data is acquired with 2D laser scanner manually. Based on these geometry data, TMM (Table Metric Map), GMM (Graphic Metric Map) and 3D EM (Environment Map) is generated automatically. It is also possible to apply same procedure

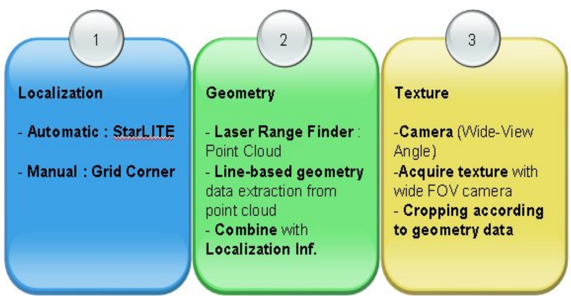

Fig. 3. Indoor geometry modeling process

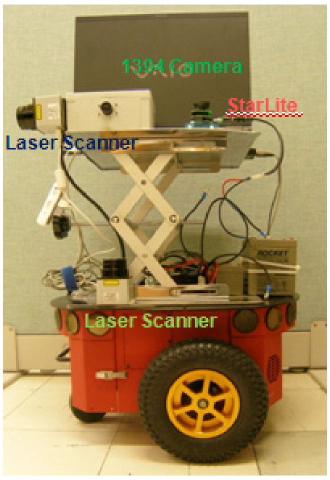

Fig. 4. Indoor geometry modeling platform

if there is a metric flat drawing. In this case, the data acquisition with laser scanner is not needed. Fig. 3 shows the presented method for building 2D and 3D model for virtual indoor environment.

The localization information is used for building the overall indoor model. In our research, we use two approaches. One is using IR landmark-based localization device, named as starLITE [6], the other is using dimension of floor square tile (DFST) manually. The starLITE approach can be used automatic localization. The DFST approach is applied when starLITE is not installed. The DFST method can be used easily in the environment that have reference dimension without the additional cost for the localization device, although it takes times due to the manual localization.

Fig. 4 shows our indoor modeling platform using two Hokuyo URG laser range finder (LRF) and one IEEE-1394 camera. One scans indoor environment horizontally and another scans indoor environment vertically. From each LRF, We can generate 2D geometry data by gathering and merging point clouds data. Then, we can get 3D geometry information by merging two LRF 2D geometry data.

For texture, the aligned camera is used to capture texture images. Image warping, stitching and cropping operations are applied to texture images.

4. Environment Sensor Modeling

4.1 XML-based sensor modeling

We implement XML based environment sensor modeling. Especially we design sensor XML GUI and develop XML sensor file generator according to the input data from GUI. As an example, the sensors we use are light, fire and gas sensor. We design the model data of sensors with sensor id, type, location and status. Using our sensor XML GUI as shown in Fig. 5, user can create the XML file for each sensor. In other words, user can input sensor id, type, location and status using GUI and then the corresponding XML sensor file is generated. For same sensor type, we can describe many sensors of which id, location and status are different. Fig. 5 shows sensor XML GUI and generated XML.

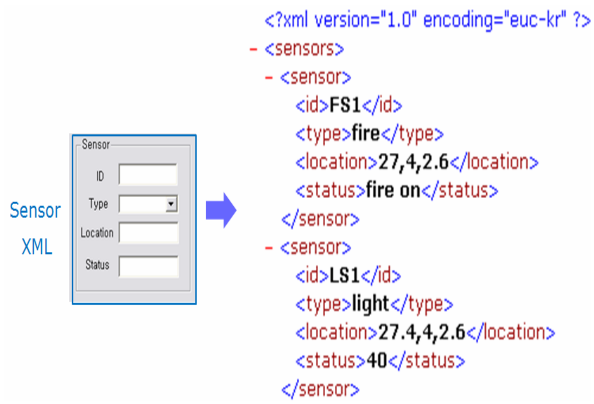

Fig. 5. Sensor XML GUI and generated XML data

4.2 Automatic acquisition of sensor information

We can acquire sensor information automatically. The sensor network is based on zigbee network. Sensor base

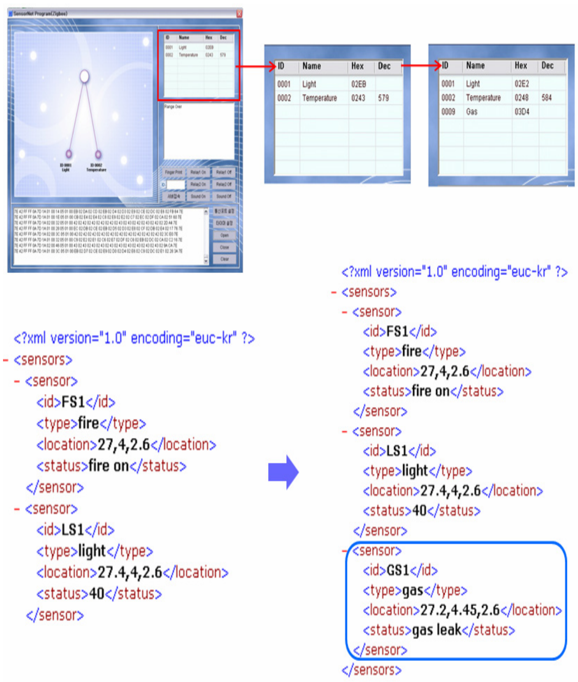

Fig. 6. Detection of sensor module and automatic addition of sensor data in XML file

station detects sensor which is now working and sensor information (sensor id, sensor type, sensor status etc.) based on data logging. So user is able to confirm the sensors that are working and know their id, name and value. All information is saved and managed by XML. Fig. 6 shows automatic detection of newly installed sensor and addition of new sensor XML data into the previous XML sensor file.

5. Responsive Virtual URS Service

We provide virtual URS interactive robot service through bridging between physical and virtual URS. We implement XML based on sensor status update. When an event happens in physical space, the sensor catches the event. Then the sensor id, sensor status is delivered to the web server through Zigbee network. Upon receiving sensor status change, the XML data is also updated automatically. In case of robot position, the position is continuously detected by sensor and the XML robot data is updated. The XML robot data is reflected to robot in virtual URS. Here, the XML file acts like a virtual sensor in virtual URS. Then, the virtual URS also responds according to the virtual sensor status. Fig. 7 shows an overview of physical-virtual bridging service.

Fig. 8 shows sensor distribution and locations in 3D virtual indoor space. Fig. 9 shows light sensor assisted

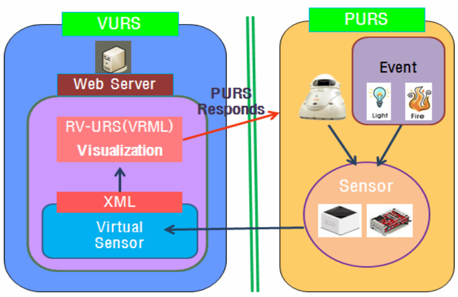

Fig. 7. Overview of physical-virtual bridging service

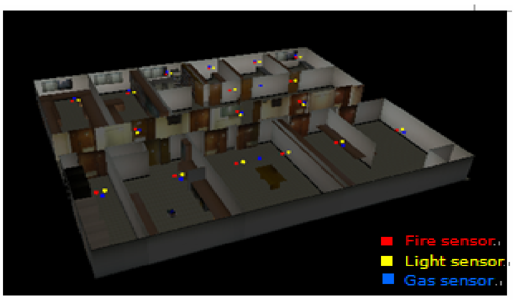

Fig. 8. 3D Responsive Virtual URS – 3D visualization of sensor distribution

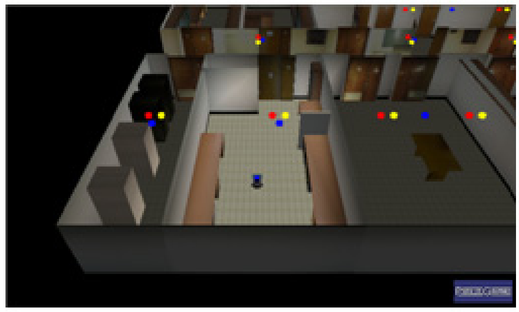

Fig. 9. Light sensor-based responsive VURS visualization

responsive VURS visualization. When event happens, robot view visualization service is also possible according to robot movement. If fire happens, fire sensor detects fire and transfers the information to robot. And then, robot moves to the location where fire happens.

6. Conclusion

This paper presents modeling of indoor space and XML-based environment sensor and robot service while bridging between virtual space and physical space. This paper describes our approaches of indoor space and environment sensor modeling. Our sensor modeling system provides sensor XML GUI, sensor XML file generation, zigbee based detection of sensor module and automatic addition of sensor model data into XML file. The bridging system b/w physical and virtual URS is also implemented using web server while sensor status is reflected into XML file automatically. Sensors detect the robot position and situation and the information is reflected to virtual URS. This paper also shows sensor-assisted responsive virtual URS service.

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