Crime scene robot and sensor simulation

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Abstract

Virtual reality has been proposed as a training regime for a large number of tasks from surgery rehearsal (cf. [Robb et al. 1996], to combat simulation (cf. [U. S. Congress, Office of Technology Assessment 1994]) to assisting in basic design (cf. [Fa et al. 1992]). Virtual reality provides a novel and effective training medium for applications in which training “in the real world” is dangerous or expensive. Here we describe the C2SM simulator system – a virtual reality-based training system that provides an accurate simulation of the CBRNE Crime Scene Modeller System (see [Topol et al. 2008]). The training system provides a simulation of both the underlying robotic platform and the C2SM sensor suite, and allows training of the system to take place without physically deploying the robot or the simulation of chemical and radiological agents that might be present. This paper describes the basic structure of the C2SM simulator and the software components that were used to construct it.

CR Categories: H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities — Virtual Simulation

Keywords: bomb disposal simulation, crime scene simulation, virtual reality

1 Introduction

Crime scene investigation is an essential component of modern police work. A critical requirement in the investigation of any crime scene is to ensure the safety of the personnel involved in the investigation. Crime scenes may occur in environments that are unsafe due to various environmental factors, and the nature of the event itself may introduce contaminants into the crime scene that can be hazardous to investigators. The extreme version of this problem occurs in crime scenes which have been contaminated by Chemical, Biological, Radiological-Nuclear or Explosive (CBRNE) contaminants. In such environments it may be necessary to perform any evaluation and remediation of the scene using remotely controlled systems and sensors.

Figure 1 illustrates some of the problems faced by the operator of such a system. The operator is presented with a range of different onboard camera and sensor systems. Some sensors are tasked to drive the robot and operate its on-board manipulators (the “Operator’s View” in Figure 1), while other sensors are targeted towards obtaining specific sensor readings (radiation, chemical concentrations), and even towards obtaining dense surface maps of the environment (as illustrated by the C2SM operator’s console shown in Figure 1). Operating the robot and its sensors effectively involves learning how to operate the vehicle using the onboard camera systems and at the same time learning how to deploy onboard sensors in an effective manner. This can be a very difficult skill set to acquire.

Traditional training regimes involve staging simulated crime scenes and then having trainees operate real vehicles under supervision. Such an approach can be very effective but it incurs significant cost, requires appropriate scenes to be staged, leads to wear and tear on the vehicles and in some cases can lead to significant vehicle damage.

Training becomes even more complicated when complex sensor suites such as the C2SM sensor are integrated with the robot. The operator must learn how to utilize the various sensors and how these sensors integrate with the vehicle. The C2SM sensor package includes sensors capable of constructing 3D surface models of the local environment as well as chemical and radiological sensors. Properly simulating these sensors in a field trial of the vehicle involves deploying appropriate chemical and radiological elements into the environment. The deployment of such elements in the test environment poses its own risks and can greatly complicate field trials.

Given the complexities associated with conducting real field trials with robots designed to operate in these types of environments there is considerable interest in the development of simulations that can aid in training. Here we describe a distributed training system for telerobotic sensor platforms operating in potentially contaminated crime scenes. Using the C2SM sensor package and its robot platform as a basis, a simulation system has been developed that can be used to train robot operators without the expense and complexities associated with physical system deployment.

2 System design

The robot simulation system must provide an accurate physical simulation of the robot and its environment and must also provide an accurate simulation of the sensing capabilities of the robot’s sensors. This necessitates the development of a virtual environment within which the environment, the robot(s), and the sensor(s) can be properly simulated. The need to support multiple actors within a common virtual space mandated a system structure within which remote connections (operator consoles, C2SM consoles, supervisor consoles, etc.) could connect to a common system that maintains and simulates an appropriate virtual space. The basic structure of

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Figure 1: C2SM system and robot operator consoles. An operator must learn how to use the two very different user interfaces to drive the vehicle and sensors around a contaminated environment.

(a) Operator’s view
(b) C2SM operator’s View
Figure 2: Basic system design. Multiple robots (mobile bases and onboard sensor packages) operate within a common simulation.

the system is shown in Figure 2. A central server connects multiple robots with a physics engine and scenario simulator. Multiple servervisor consoles are also supported in order to allow ongoing monitoring of the scenario being simulated. Each simulated robot actually provides two different connections to the server, one associated with simulating the robot the other associated with simulating the on-board sensor package. A common world model is maintained by the agents operating within the system with the physics engine module being responsible for ensuring that the world model is properly updated by actions taken by the active agents within the system. A scenario simulator directs the overall structure of the current scenario.

The C2SM sensor package can be mated to a range of different robot platforms. This has a number of implications for overall system design. The first is that the user interface for the teleoperated vehicle including the placement of cameras and vehicle control and dynamics. Following the design of the physical C2SM system, the simulation implements the vehicle and sensor as separate applications (potentially running on different machines). As in the real system coordination between the two systems operating on the platform must be performed by the operator.

The entire C2SM simulator leverages a number of open source/easily licensed software toolkits. This includes

- The Ogre3D rendering system [Junker 2006] is used to provide a basic scene graph structure and rendering.
- The Newton Physics Engine [Jarez and Suero 2008] is used to provide basic physics simulation.
- A Python interpreter to provide scenario control.

The use of these large open source/easily licensed components permitted quick system prototyping and the development of a software system that operates on a range of different operating systems including Windows, OSX and Linux.

3 Summary

Training responders to operate complex remotely operated vehicles coupled with a range of sensing technologies is a daunting task. The development of virtual systems that enable much of this training to be conducted in simulation allows for training to be conducted in a more controlled manner and at a significant saving. The simulation system described here runs on consumer hardware and can be operated in a distributed manner permitting responders at disparate locations to be engaged in a common training scenario. Ongoing work includes the development of a number of realistic training scenarios. Field testing of the system is planned for late 2009.

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References


