Demo: The extended VSNsim for Hybrid Camera Systems

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ABSTRACT

This paper presents the extension of the simulator VSNsim to enable the simulation of hybrid camera networks in the field of coordination and control algorithms. A hybrid camera network combines mobile and static cameras. Thus, mobile cameras in form of autonomously moving robots are added to the existing static cameras of VSNsim. Furthermore, priorities can be assigned to rooms in the simulated environment in order to focus monitoring to dedicated areas.

Categories and Subject Descriptors

Computer systems organization [**Embedded and cyber-physical systems**]: Sensor Networks; Computer systems organization [**Architectures**]: Other architectures—*Self-organizing autonomic computing*; Software and its engineering [**Software organization and properties**]: Contextual software domains—*Virtual worlds software*

Keywords

Visual sensor networks, Virtual worlds, Distributed systems

1. INTRODUCTION

A major task of researchers is to simulate their approaches before implementing them into a physical system. Therefore, a number of digital tools are available that can be used for evaluating VSNs. Nevertheless, there exists no tool covering all relevant aspects for the evaluation of VSNs. The tools can be categorized into three groups. The first group focuses on simulating image processing algorithms, as presented by Qureshi[1], the second group on networking aspects, such as OMNeT++[2], and the third group on coordination and control algorithms, as proposed by Schranz and Rinner in [1].

[1]https://youtu.be/b067HAGQgOQ?list=PL637927A6D91CB3A5
[2]http://www.omnetpp.org/

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This paper describes a major extension to VSNsim which comprises the integration of mobile robots and priority assignments to the rooms in the simulated environment.
Through the active interaction between static and mobile cameras a hybrid camera network is realized. Static cameras are typically implemented to monitor a given environment and track moving targets. Nevertheless, the environment itself or a turned-off static camera can produce gaps—areas not observed by any camera. Thus, mobile cameras allow the observation of targets in such gaps. Mobile cameras—in the scope of the paper denoted as mobile robots—have the aim of supporting the static camera network in its monitoring task. Furthermore, mobile cameras can achieve an observation in shorter distance at higher resolution. The combination of mobile and static cameras forms a hybrid camera network combining the advantages of both types of cameras.

The remainder of this paper is organized as follows: Section 2 describes the basics of VSNsim and the implementation of the extension. Section 3 deals with evaluation data of the VSNsim. Furthermore, Section 4 describes the presentation at the ICDSC conference.

2. THE VSNSIM SIMULATOR

VSNsim was designed for evaluating coordination and control algorithms for VSNs [1]. It abstracts the physical layer, networking protocols and image processing tasks of the camera nodes. The VSNsim can be reconfigured by the user defining the number of static cameras, rooms and targets to track—further denoted as non-player characters (NPCs). The task of VSNsim is to evaluate multi-camera algorithms running on a VSN. The simulated cameras provide the NPC's ID and position if it is in its FOV. This and more information can be used by researchers to evaluate their individual algorithms.

The extension of the VSNsim deals with the same implementation tool as already applied in [1]. The game development platform Unity 4.0[3] is used, additionally with the tool-kit Playmaker 4.0[4]. The respective processes, such as physical activity or memory acquisition were handled with native C# scripts, state machine design in PlayMaker and other Unity tools. As result, the goals of this project, namely integration of mobile robot units and assigning of priorities to rooms, are realized with these tools. Figure 1 provides a graphical impression of the refined VSNsim showing the existing static cameras and the newly deployed mobile robots.

[3]http://docs.unity3d.com/Manual/index.html
[4]http://www.hutonggames.com/

2.1 Mobile Robots

To realize a hybrid camera network in VSNsim, the mobile robots need to be deployed additionally to the existing static camera network. As the static cameras, the mobile robots are realized as so-called prefab objects. A prefab is a reference object where clones can be built from. The prefab is equipped with simple appearance and textures through Unity function materials. The graphical realization of the mobile robots within Unity 4D is shown in Figure 1. The name or ID of the robot together with its status in form of a colored sphere are displayed on the top of each robot. The status expresses that the mobile robot is available to tracking tasks with a green sphere, where the red sphere indicates occupied or out-of-power robots. Special moving routines were adopted from the NPCs prefab and amended to avoid collisions with the NPCs moving on the floor. The camera functionalities correspond to the ones used by the already existing static cameras in the VSNsim. The Unity 4.0 internal camera module placed onto the mobile robot is oriented to the robot's direction.

2.2 Room Priorities

Another important extension was created by different priorities assigned to the rooms of VSNsim. For example, a broom closet will have a lower priority than a server room. The rooms of the simulation scene are divided into sections and a priority is assigned in color codes. Up to now, priority assignment is static. The hybrid camera network performs the coordination and control tasks influenced by these priorities. For example, the hybrid camera network detects, if a NPC stays longer in a place with a high priority level. Thus, it classifies this behavior as suspicious and provides another mobile robot for the tracking of the NPC.

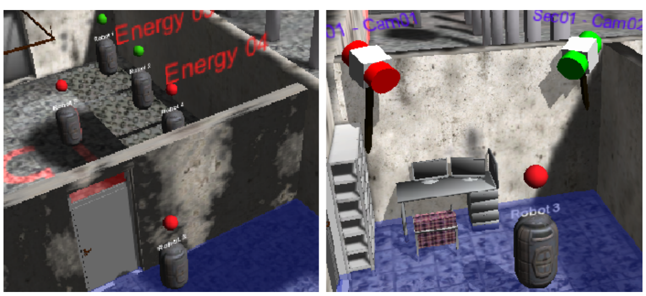

Figure 1: The left figure depicts the mobile robots in their charging station, the right figure the mobile robots together with the already existing static cameras.

3. SIMULATION EXAMPLE

As an application, a coordination and control algorithm for hybrid camera networks is designed and evaluated with the presented extension of VSNsim. The protocol for resource-aware self-coordination of VSNs [2] is expanded for mobile cameras. The main idea is to handle gaps and failures of a static camera network by incorporating mobile cameras. The assignment of static or mobile cameras is a local task that needs to be decided by the participating cameras themselves in a resource-aware way. Moreover, the areas of interest have priorities assigned. These priorities together with the distribution of mobile cameras give a unique challenge to the resource-aware dynamic clustering protocol with the aim of object state optimization through estimation algorithms in a market-based manner. For the evaluation VSNsim is used with 14 rooms, 22 smart cameras, 3 mobile cameras and 4 targets to be tracked. A preliminary result is given in Figure 2, illustrating the resources consumed by a set of selected static cameras c_1, c_3, c_5, c_7 and the mobile cameras r_1, r_2, r_3 supporting the tracking task. The recorded resource consumption is normalized to make them comparable. If a static camera reached a resource limit of 0.3 it is turned-off. The same holds for the mobile robots at 0.1. As we can see in this figure, the mobile robots are increasingly used, when the static cameras are turned-off.

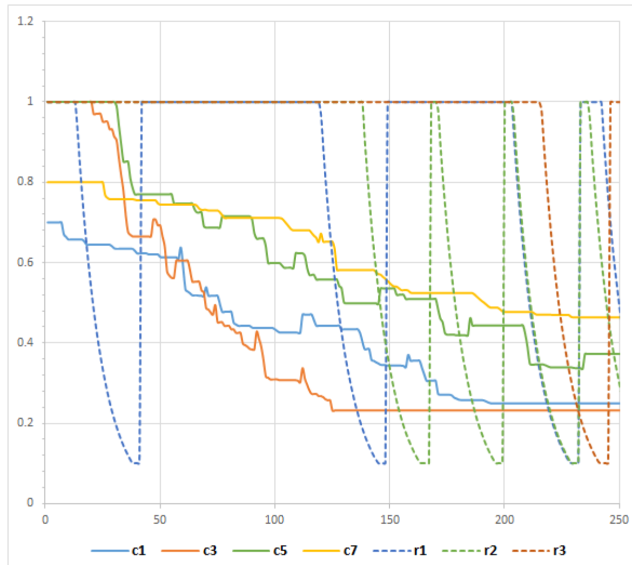

Figure 2: Preliminary result comparing the resource consumption of static and mobile cameras.

4. ICDSC DEMO

During the presentation at the conference, we would like to present the extensions to VSNsim gradually. It starts with the explanation of the technical details to the simulator and followed by an exact description of the mobile robots and the principal of priority assignment. Finally, the integration of the mobile robots and the priorities to the simulation process is shown. A short video about the VSNsim and the proposed extensions is presented under:
www.youtube.com/watch?v=Ek6Xr2rlsZU.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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[2] ——, "Resource-Aware State Estimation in Visual Sensor Networks with Dynamic Clustering," in *Proceedings of International Conference on Sensor Networks*, 2015, p. 10.