Video-Based Multi-Camera Automated Surveillance of High Value Assets in Nuclear Facilities

C.-H. Chen, Y. Yao, D. Page, B. Abidi, A. Koschan, and M. Abidi

Imaging Robotics, and Intelligent Systems Laboratory, The University of Tennessee, 1508 Middle Drive, Knoxville, TN 37996
{cchen10, yyao1,dpage,besma,akoschan,abidi}@utk.edu

INTRODUCTION

In a nuclear facility, asset monitoring and chain-of-custody protocols are essential to maintain safety and security. Most existing surveillance systems require human interaction where security guards watch the monitor wall and manually trigger alarms when they detect security violations. Due to fatigue, the possibility of missing alarms is high, even for well-trained security personnel. These issues lead to the need for a multi-camera surveillance system that automatically detects, tracks, and records security violations in nuclear facilities.

In the literature, one popular choice for such a surveillance system is the combination of an omni-directional and a pan-tilt-zoom (PTZ) camera, referred to as dual-camera system. Omni-directional cameras, equipped with a field of view (FOV) of 180°×360°, are promising candidates for monitoring latent activities in an area of interest. However, omni-directional cameras have non-uniform resolution and are unable to provide close observations of particular targets. The PTZ cameras are more suited for this role. With high mobility and zoom ability, PTZ cameras compensate for the deficiencies of omni-directional cameras.

Considering the scale and complexity in monitoring a nuclear facility, it is almost impossible for a single set of dual cameras to fulfill both the detection and tracking tasks with an acceptable degree of continuity and reasonable accuracy. Systems with multiple sets of dual cameras require research into consistent labeling [1] and camera handover [2] not only between the omni-directional and PTZ cameras but also among the dual-camera sets.

SYSTEM ARCHITEUTURE

This paper presents a dual-camera system architecture that has been developed. The omni-directional camera fulfills target detection, pan-tilt angle estimation, and target tracking. The PTZ camera uses information from the omni-directional camera to track the target of interest. The PTZ has two tracking modes: passive and active. In the passive tracking mode, the PTZ camera receives the estimated pan/tilt angles from the omni-directional camera and then directs its gaze to the object of interest.

In a surveillance system with multiple dual-camera sets, camera handover and consistent labeling between adjacent omni-directional cameras should be executed before the object of interest leaves the FOV of an observing camera. Therefore, sufficient overlapped area between adjacent omni-directional cameras should be reserved to ensure enough computation time for executing camera handover and consistent labeling successfully.

EXPERIMENTAL RESULTS

Figure 1 shows image frames of a video sequence from a real-time dual-camera system. These images show the PTZ camera tracking a person moving a cart for chain-of-custody monitoring.

Fig. 1. Video sequences of the real-time dual-camera system showing an image sequences from a PTZ camera.

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