# CamInSens - Demonstration of a Distributed Smart Camera System for In-Situ Threat Detection

Carsten Grenz, Uwe Jänen, and Jörg Hähner
Universität Augsburg
Organic Computing
Germany

Colin Kuntzsch[*], and Moritz Menze[†]
Leibniz Universität Hannover
[*]Kartographie und Geoinformatik
[†]Photogrammetrie und GeoInformation
Germany

David d'Angelo[‡], Manfred Bogen[‡], and Eduardo Monari[§]
[‡]Fraunhofer IAIS
[§]Fraunhofer IOSB
Germany

***Abstract*—The CamInSens system is a next-generation self-organizing video surveillance system that combines research being done in the fields of person-tracking, trajectory analysis, visual analytics, and self-organizing system management algorithms. Its purpose is the online threat detection by analysing anomalies in persons' trajectories. Therefore, robust multi-camera multi-person tracking is combined with a flexible analysis module, which uses online learning classification algorithms as well as user-generated filters to process the persons' trajectories in the surveillance space.**

## I. Introduction

This demo presents a huge step forward letting the 'Tale of the 1000 cameras' becoming true. As Lambert Spaanenburg outlined in last year's keynote for the ICDSC '11, one of the major challenges in the field of distributed smart camera systems is applicability of the developed algorithms w.r.t. scalability and management. Furthermore, current video surveillance systems are mostly presenting raw live images of the cameras to the user and are collecting those images to be used as evidence after an incident happened.

The CamInSens system is a demonstrator of a third-generation video surveillance system (following the classification of Velastin et al. [1]), presenting solutions for large self-organizing Smart Camera deployments. Its main goal is the in-situ threat detection in public spaces, e.g. railway stations. It aims at threats that are induced by persons that are moving through the surveillance space. Therefore, the Smart Cameras acquire the persons' trajectories while also being responsive to various surveillance tasks which are induced by the security personnel. While performing its automatic tasks, the system does not interfere with the users' actions in the control room, who can use the system for all kinds of manual surveillance tasks, simultaneously. Therefore, the Smart Cameras take care of the all active surveillance tasks with the help of self-organizing distributed task-ressource-allocation algorithms. The trajectories are analysed to recognize potential threats in real-time. Finally, the system incorporates new visualization and interaction techniques for the security control room and mobile personnel, too. One of the major requirements is scalability. All components are developed w.r.t. high scalability, e.g. trajectory analysis works with incremental models.

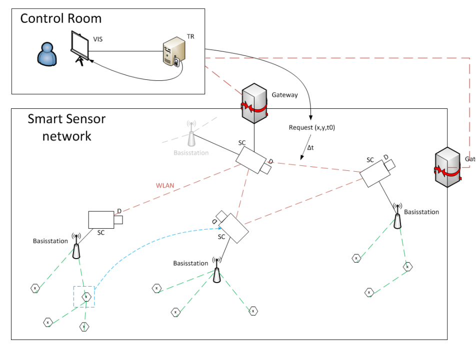


Fig. 1. CamInSens - System Architecture

## II. The CamInSens system

### A. Overview

The CamInSens system consists of three major components: A self-organizing distributed Smart Sensor Network, trajectory analysis modules and databases, and new visualisation and interaction components for the central control room as well as mobile personnel (see Figure 1). The system's design addresses requirements of surveillance systems for public spaces using the example of a bigger railway station. One main aspect of implementation is a legal framework for intelligent video surveillance systems [2]. The system is capable of processing all kinds of surveillance tasks, e.g. tracking of individual people across many field-of-views (FOVs), focusing on prioritized areas, and 3D reconstruction of single persons.

### B. Smart Sensor Network

The Smart Sensor Network consists of a mixture of Smart Cameras (SCs) and additional small sensors (Sensor Motes). The SCs consist of an Axis 214 PTZ IP-camera combined with local processing and networking power of a PC ([3]). The Sensor Motes are based on a MicaMote platform and can, therefore, be connected to all kinds of additional sensors, e.g. brightness, temperature, glass breakage detectors. All of those sensors organize themselves in one large ad-hoc sensor network with the Smart Cameras acting as in-network base-stations for the Sensor Motes ([6], [7]). The Smart Cameras are able to perform various tasks and organize themselves in a distributed fashion. The directional characteristic of their photo sensor makes it necessary to use their pan, tilt and zoom capabilities to cover all regions of interest in the surveillance space over the time. Therefore, a distributed agent-based ressource management system is implemented, that enables the cameras to work on all current surveillance tasks simultaneously. The main goal is to process the tasks, which have been induced into the system by the user, in the most effective way possible. Its applicability and performance has been proved recently ([4], [5]).

### *C. Trajectory Analysis and Alarm Management*

The trajectory module performs automated recognition of safety critical behaviour of observed persons in the output data of the multi-camera multi-person tracker component. It offers different analysis techniques: On the one hand, it implements an online learning module to incrementally build spatio-temporal models of typical trajectory behaviour. Detected anomalies in trajectories are signalled to the user, who can identify real threats by informed security personnel. This way, the user triggers automatic reconfigurations because of a raised attention work mode in the Smart Camera system, as well as giving feedback towards the learning components. On the other hand, the system offers a single trajectory analysis module. This enables the user to specify a certain spatio-temporal movement behaviour in different areas, e.g. one-way movement, forbidden areas, short-time resting areas. Depending on its configuration, these detectors may raise alarms with different severities. The output data of the trajectory analysis is mainly used in two ways: The security control room gets a detailed picture of the current activities and (classified) trajectories. Moreover, the detection of anomalies in movementment behaviour leads to a feedback towards the Smart Camera network, that represents an increased priority for certain trajectories. These priorities are used by the Smart Camera network to effectively reconfigure themselves to meet the required degree of attention for prioritized persons while covering the region of surveillance, too.

### *D. Visualization and Interaction*

New methods of visualizaton and interaction have been researched for the security personnel. The control room consists of a 56" multi-touch enabled quad HD display. This display shows a large 3D map view of the surveillance space accompanied by different system control panels. The user is supported to view and interact with large-scale trajectory by offering her an intuitive way of interaction. The different information panels give a comprehensive overview of current activities in the surveillance space, active alarms, and instantiated trajectory filters.

The interaction concept incorporated TabletPCs for mobile security personnel. The *Mobile Control System (MCS)* provides a customised view of the monitored area containing relevant trajectories, events, alarms, and positions of (other) mobile personnel. Of course, the camera streams can be shown on demand as well.

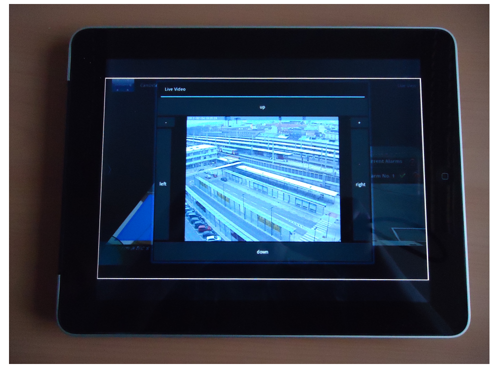

Fig. 2. Mobile Control System

## III. Demonstrator setup

The authors are going to present a fully functional demonstrator that performs all of the described tasks. To meet the challenge of incorporating many different sensors and proving the applicability for huge spaces, the demo is going to incorporate local sensors as well as a remotely connected surveillance space that is located in a camera lab in Augsburg, Germany. The surveillance space contains six mounted Axis 214 PTZ cameras and additional small sensors. During the presentation, there will be live action taking place in the surveillance space. This enables us to show a working system under real-world constraints. The visitor will be able to use the MCS on a multi-touch enabled TabletPC. To get a better insight in the different self-organiziation and analysis algorithms, additional technical views will be offered. The demo will be accompanied by posters explaining the theoretical background of the system.


## Acknowledgment

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