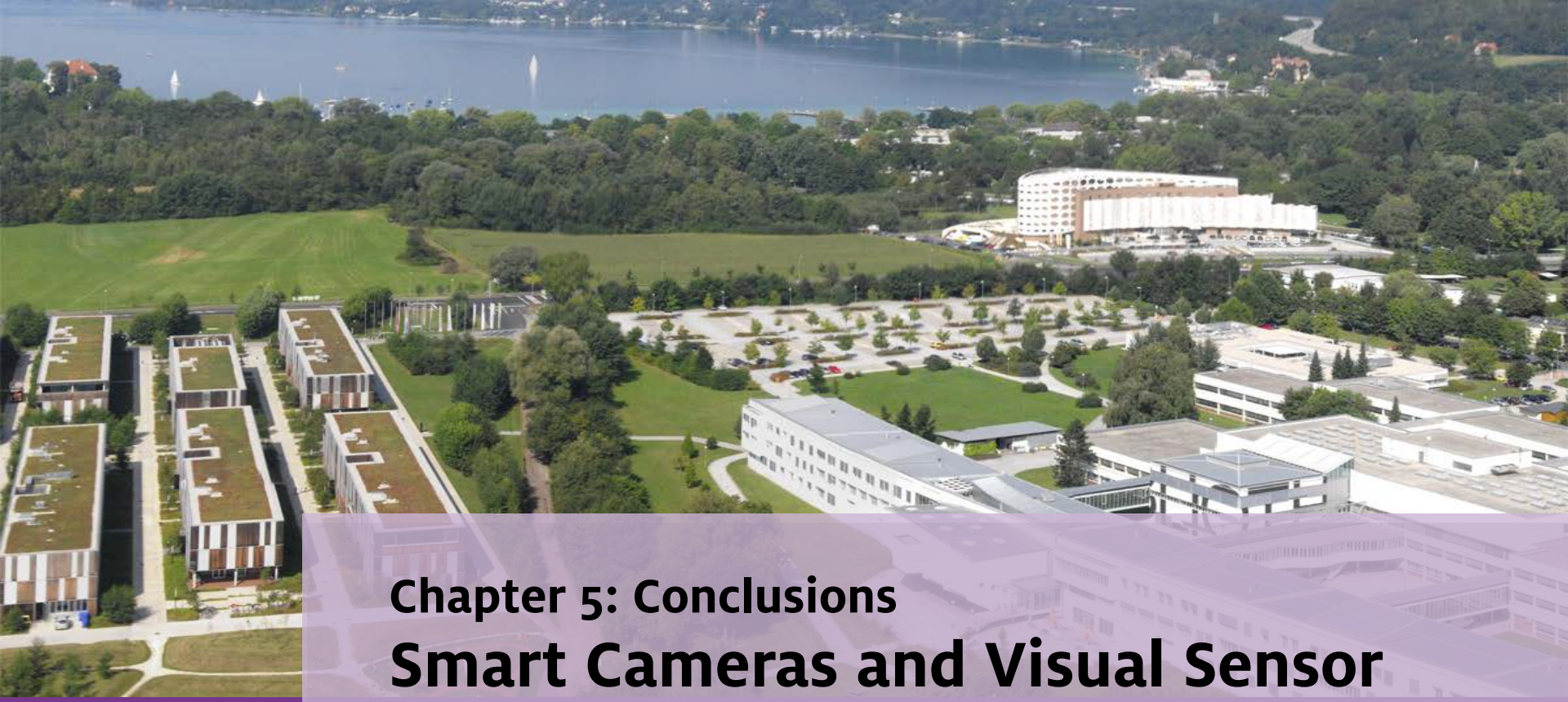


Chapter 5: Conclusions

Smart Cameras and Visual Sensor Networks

ALPEN-ADRIA UNIVERSITÄT
KLAGENFURT | WIEN GRAZ

Bernhard Rinner

FAKULTÄT FÜR TECHNISCHE WISSENSCHAFTEN

Institut für Vernetzte und Eingebettete Systeme

Agenda

Chapter 5: Conclusion

- Research Challenges
- Summary
- Further information

Research Challenges

#1: Architecture

How to design resource-aware nodes and networks

- Low-power (high performance) camera nodes
  - Dedicated platforms: vision processors, PCBs, systems
  - Many examples: CITRIC, NXP
- Visual/Multimedia Sensor Networks
  - Topology and (multi-tier) architecture
  - Multi-radio communication
- Dynamic Power Management
  - For sensing, processing and communication

#2: Networking

How to process and transfer data in the network

- Ad hoc, p2p communication over wireless channels
  - Providing RT and QoS
  - Eventing and/or streaming
- Dynamic resource management
  - (local) computation, compression, communication, etc.
  - Degree of autonomy: dynamic, adaptive, self-organizing
  - Fault tolerance, scalability
  - Network-level software, middleware

#3: Deployment, Operation, Maintenance

Consider the entire life cycle of the camera network

- Development support for applications
  - Model/simulate the application (function, resources, QoS)
  - Reuse/exchange of software/libraries
  - Software updates, debugging etc.
- Autonomous calibration and scene adaption
  - Avoid manual procedures
  - Adapt to different scenes and settings
- Network configuration

#4: Distributed Sensing & Processing

Where to place sensors and analyze the data

- Sensor placement, calibration & selection
  - Optimization problem
  - Distributed approaches eg., consensus, game theory, multi-agent systems
- Compressive Sensing
- Collaborative data analysis
  - Multi-view, multi-temporal, multi-modal
  - Sensor fusion
- Online/real-time processing
  - Can not effort to store large amounts of data

#5: Mobility

How to exploit networks of mobile cameras

- Mobile cameras are ubiquitous
  - PTZ, vehicles, robotics etc.
  - Mobile phones
- Advanced vision algorithms
  - Ego motion, online calibration
  - Closed-loop control, active vision

#6: Usability

How to provide useful services to people

- Ease of deployment, maintenance
  - Self-* functionality
  - “Smart cameras for dumb people”
- Privacy and Security
  - Trust of the user
  - Control the privacy setting
- Interaction with the camera network

#7: Applications

What applications can (only) be solved by DSC

- Demonstrations
  - Large scale networks eg., for surveillance
  - Small scale networks eg., for entertainment, home environments
  - Only single camera application?
- Market opportunities
- Killer Application

(Potential) further Applications

- Entertainment (computer games)
  - in 3D environments
- „Smart Rooms / Smart Environments
  - detection gestures, sign language, room occupancy …
- Environmental monitoring
  - sensor fusion, habitat monitoring
- Security
  - Safety enhancement (trains, cars), access control, surveillance
- „Virtual Reality“
  - augment real world with digital information
- …

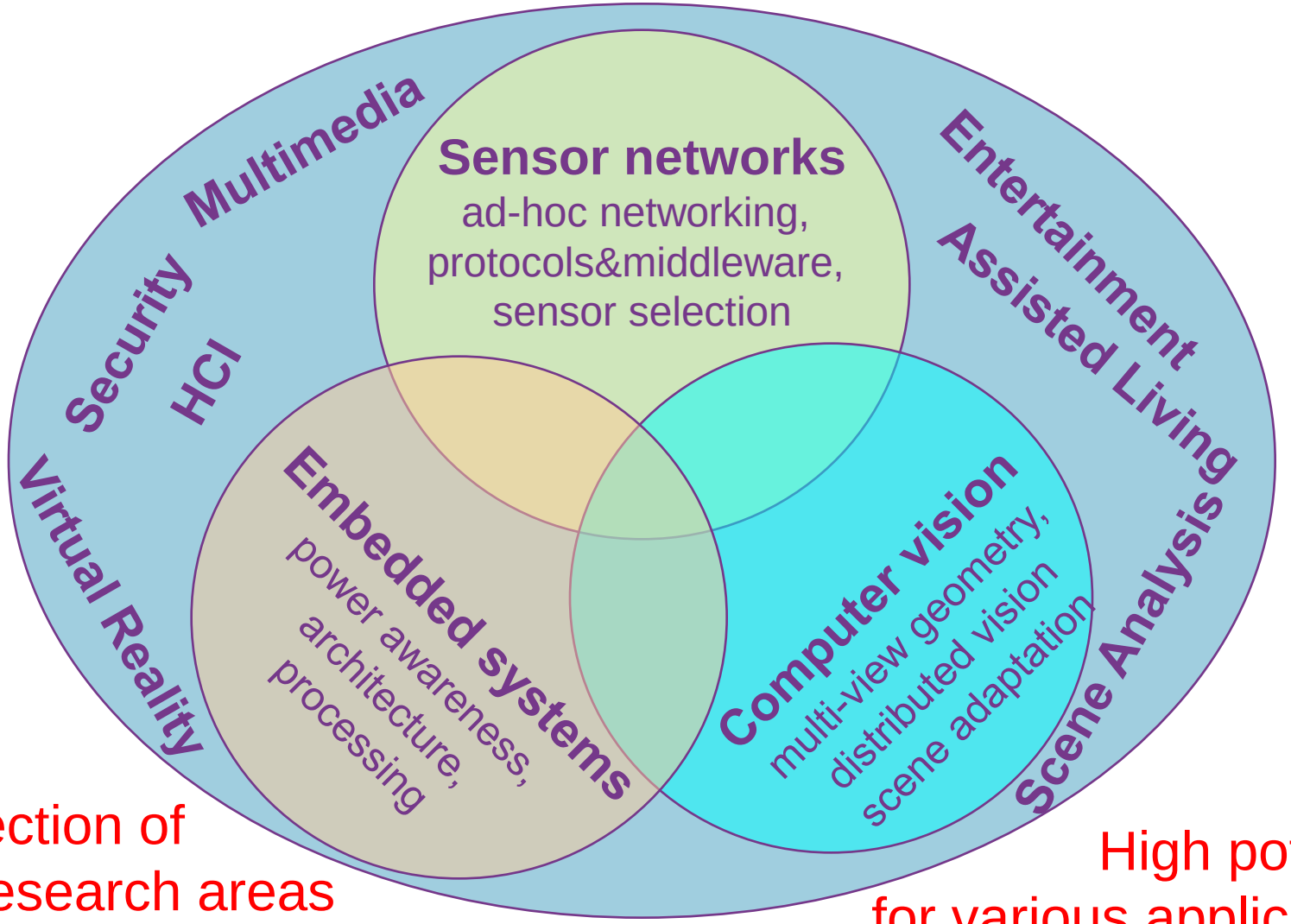
Smart Cameras

- combine
  - sensing,
  - processing and
  - communication

  in a single embedded device

- perform image and video analysis in real-time closely located at the sensor and transfer only the results
- collaborate with other cameras in the network (multi-camera system)

Interdisciplinary Research



Intersection of
"hot" research areas

High potential
for various applications

Further Information

- Tutorial Site
  http://pervasive.aau.at/S5-tutorial

Literature

- Introduction, Surveys etc.
  1. Rinner, Wolf. Introduction to Distributed Smart Cameras. Proceedings of the IEEE, 96(10):1565–1575, October 2008
  2. Rinner et al. The Evolution from Single to Pervasive Smart Cameras. In Proc. ICDSC-2008, pp 1-10 , September 2008,
  3. Soro, Heinzelman. A Survey of Visual Sensor Networks. Advances in Multimedia, pp 21, 2009
  4. Akyildiz, Melodia, Chowdhury. A survey on wireless multimedia sensor networks. Computer Networks, 51:921–960, 2007
  5. Aghajan, Cavallaro (Eds.). Multi-Camera Networks. Elsevier 2009
  6. Belhabir (Eds.) Smart Cameras. Springer 2010
  7. Kisacanin et al. (Eds.) Embedded Computer Vision. Springer 2009
  8. Bhanu et al. (Eds.) Distributed Video Sensor Networks. Springer 2010

Selected Journals & Conferences

- Journals
  - ACM Transactions on Sensor Networks
  - IEEE Transactions on Image Processing
  - Machine Vision and Applications
  - IEEE Transactions Circuits and Systems for Video Technology
  - …
- Conferences, Workshops
  - ACM/IEEE Intern. Conference on Distributed Smart Cameras
  - IEEE Workshop on Embedded Computer Vision
  - ACM/IEEE Intern. Conf. on Information Processing in Sensor Networks
  - …
  - Various dedicated workshops at major conferences

References

- Baumgartner et al. Benchmarks of low-level vision algorithms for DSP, FPGA, and mobile PC processors. in Embedded Computer Vision, Springer, 2009, pp. 101–120
- Bramberger et al., Distributed embedded smart cameras for surveillance applications, Computer, vol. 39, no. 2, pp. 68–75, Feb. 2006.
- Ding et al. Collaborative Sensing in a Distributed PTZ Camera Network. IEEE Trans. on Image Processing, 2012
- Esterle et al. Socio-Economic Vision Graph Generation and Handover in Distributed Smart Camera Networks. ACM Transactions on Sensor Networks, ACM, pages 24, 2013 (to appear).
- Dieber et al. Resource-Aware Coverage and Task Assignment in Visual Sensor Networks IEEE Transactions on Circuits and Systems for Video Technology, Aug 2011
- Karakaya, Qi. Distributed target localization using a progressive certainty map in visual sensor networks. Ad hoc Networks. 2010.
- Mersheeva et al. Routing for Continuous Monitoring by Multiple Micro UAVs in Disaster Scenarios. In Proc. ECAI. 2012
- Quaritsch et al. Networked UAVs as Aerial Sensor Network for Disaster Management Applications. e&i, March 2010.
- Regazzoni et al. SI on Video Communications, Processing and Understanding for Third Generation Surveillance Systems. Proceedings of the IEEE. October 2001
- Rithe et al. Reconfigurable processor for energy-scalable computational photography. Proc. IEEE ISSCC 2013

References (2)

- Rinner, Wolf. Introduction to Distributed Smart Cameras. Proceedings of the IEEE, 96(10):1565–1575, October 2008
- Rinner et al. The Evolution from Single to Pervasive Smart Cameras. In Proc. ICDSC-2008, pp 1-10 , September 2008
- Song et al. Tracking and Activity Recognition Through Consensus in Distributed Camera Networks. IEEE Trans. on Image Processing, 2010
- Wagner et al. Real-Time Detection and Tracking for Augmented Reality on Mobile Phones. IEEE TVCG 16(3), 2010
- Winkler, Rinner. Securing Embedded Smart Cameras with Trusted Computing. EURASIP Journal on Wireless Communications and Networking, 2011
- Winkler, Rinner. TrustCAM: Security and Privacy-Protection for an Embedded Smart Camera based on Trusted Computing. In Proc. AVSS. pages 593-600, Boston, MA., USA. 2010.
- Winkler, Rinner. A Systematic Approach Towards User-Centric Privacy and Security for Smart Camera Networks. In Proc. ICDSC. Atlanta, GA., USA. September 2010.
- Winkler, Rinner. User-Based Attestation for Trustworthy Visual Sensor Networks. In Proc. SUTC. pages 74-81, Newport Beach, CA., USA. June 2010
- Yahyanejad et al. Incremental Mosaicking of Images from Autonomous, Small-Scale UAVs. IEEE AVSS, Sept. 2010
- Yanmaz et al. Area Coverage with Unmanned Vehicles: A Belief-based Approach In Proc. VTC. 2010