Distributed Smart Cameras and Long-Term Care of Special Needs People

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Outline

- Long-term care of special needs adults.
- Technical motivation:
  - Embedded computer vision and smart cameras.
  - Distributed smart cameras.
- Velipasalar, Schlessman, Chen, Wolf: Tracking with distributed cameras.
- Lin, Verilipasalar, Wolf: Temporal calibration.
- Kim, Romberg, Wolf: Long-term tracking with non-overlapping views.

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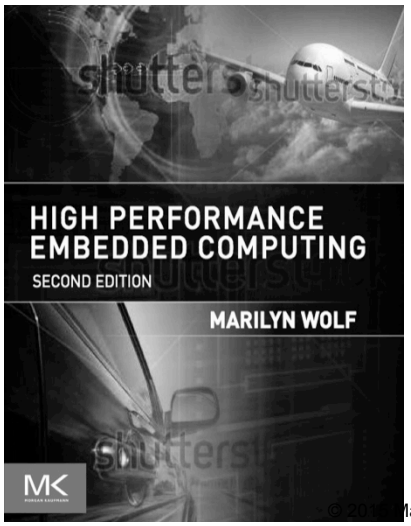
Shameless Plug Dept.



- High-Performance Embedded Computing, 2nd ed. out now!
- Check out my YouTube channel!

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Special needs people and long-term care

- Special needs is a blanket term for a wide variety of disabilities:
  - Cognitive.
  - Physical.
  - Multiple involvements.
- Special needs care is more involved than elder care:
  - No single trajectory of condition.
- Use the tools from cyber-physical systems, computer vision, and big data to improve the lives of special needs people.
- Goals:
  - Provide meaningful lives.
  - Maximize retention and productivity of caregivers.
- This is not medical model.
  - No cure.
  - What happens in between doctor visits.

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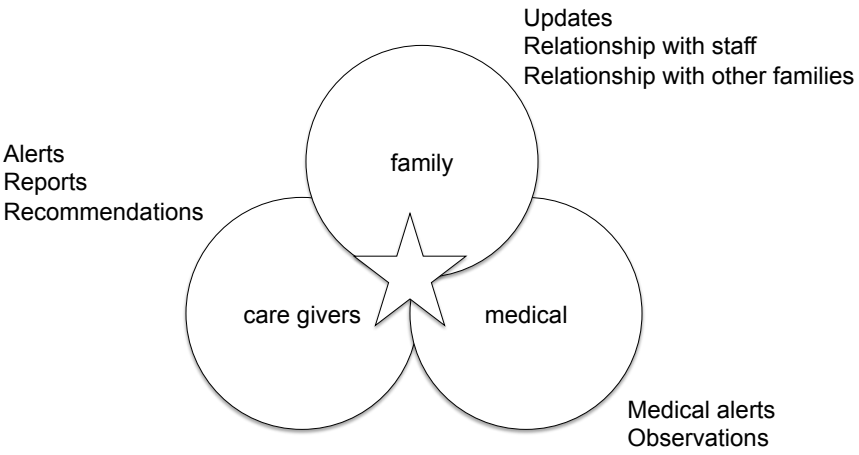
Circles of care



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Challenges

- Caregivers should be allowed to maximize time with their residents and minimize paperwork.
  - Caregivers are drawn to the work by the opportunity to work with people.
- The family should be kept in the loop with reports on their loved one.
- Medicaid requires an individualized plan:
  - Written yearly with specific goals.
  - Progress toward the goals must be monitored and documented.

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Smart homes for special needs adults

- Imagine! Is a Colorado Medicaid service provider that operates two smart homes for special needs adults.
  - About 10 years of experiments.
  - Extensive data collection: cameras, tags, electricity, water, computer terminals.
- Rutgers has announced an instrumented set of apartments for autistic people.
  - Allows opportunities to work with Rutgers faculty in the treatment of autism.
  - Individuals will live in the apartments for extended periods.

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Sample problems for activity analysis

- Tracking the activity of people over long periods:
  - How few sensors do we need?
  - How much can we infer from movement that is not attributed to an individual?
- How do we identify patterns of activity?
  - Typical behavior.
  - Unusual behavior.
  - May vary with a variety of factors.
- How do we identify activity and relate it to the Individualized Plan?

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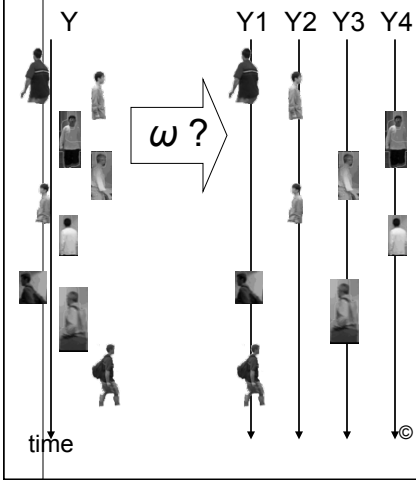
Tracking from non-overlapping fields of view

Given ***N* observations** from *M* nonoverlapping cameras,

partition the observations into tracks.



- How can we define a "likely partition"?
  (1) A new motion model
  (2) Posterior probability (objective function)
- How can we find the most likely partition?
  (3) Combinatorial optimization methods

- Does it work for huge *N* and *M*?
  (4) A distributed algorithm

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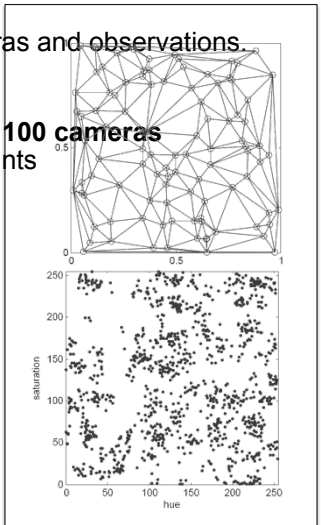
Experiment II

- Objective
  - Performance on a large number of cameras and observations.
- Simulated transition model for a system with **100 cameras**
  - Delaunay triangulation of 100 random points
  - Random transition probability
  - Travel time ~ Normal
- Targets
  - **200 targets** walking on the graph
  - **Color** (hue and saturation)
    ~ Unif[0, 255] for each target
- Observations
  - Noise in color measurements ~ Normal
  - **1,067 observations**



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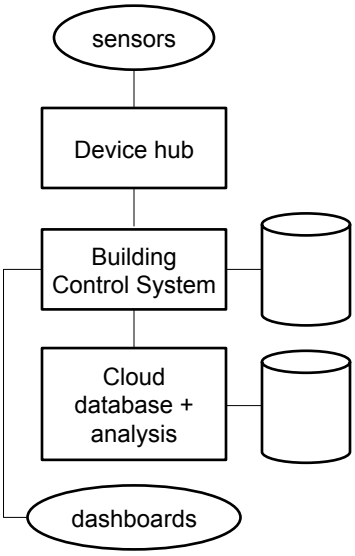
Experiment II

- Results
  - accurate but not scalable

	computation time	# tracks	# correct **tracks**	precision (fidelity)	recall (complete-ness)
MCMC	4 min	206	169 (86%)	0.98	0.96
	7 min	208	174 (87%)	0.98	0.92
Hungarian	6 min	200	177 (88%)	0.98	0.93

IoT architecture

- Many legacy devices are not designed for wireless, IoT style connections.
- Building Control System manages local devices and dashboards.
- Crunch data in the cloud.



Summary

- Long-term care requires streaming analysis of data at multiple time scales:
  - Minutes, days, weeks, years.
- Sophisticated analysis can help us make the best use of cheap, sparse sensors.
- IoT system architecture must balance needs:
  - Legacy and long-lived components.
  - Bandwidth and energy.
  - Matching computing capacity to data analysis.
  - Maintainability.

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