



Sensor Network Research Overview

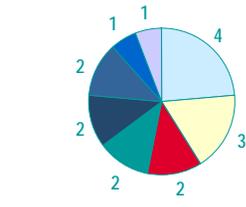
November 2004

Azer Bestavros
Chairman

Faculty: By Areas



- Theory
- Networks
- Systems
- Security
- Software
- Vision
- Database
- Other



- Azer Bestavros
- Margrit Betke
- John Byers
- Mark Crovella
- Peter Gacs
- Steve Homer
- Gene Itkis
- Assaf Kfrouny
- George Kollios
- Leonid Levin
- Ibrahim Matta
- Leo Reyzin
- Stan Sclaroff
- Wayne Snyder
- Shang-Hua Teng
- Richard West
- Hongwei Xi

Funding ~ \$285K / fac / year

Example: Sensorium Research

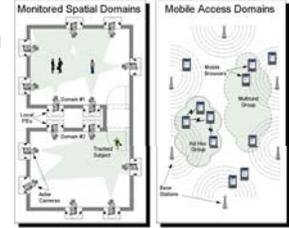


Sensorium:

A common space equipped with video sensors for ubiquitous recognition and tracking of activities therein

Applications:

- Assistive environments
- Homeland security
- Hospitals
- Parking lots
- ...



HCI for the Severely Disabled



- Investigators**
- Betke
 - Gips
 - DiMattia

American Sign Language



- Goals:**
- (1) Collect/annotate video DB of simultaneous ASL streams
 - (2) Automatic annotation of head, face, body and hand gestures
 - (3) Algorithms for indexing/retrieval of ASL video
 - (4) Linguistic research regarding non-manual cues in ASL

- Investigators**
- Sclaroff
 - Metaxas
 - Neidle

Environmental monitoring



- Investigators**
- Betke
 - Kunz
 - ...

Bats: Tracking and Census

Optimal Sensor Placement

Investigators

- Sclaroff
- Erdem

Produce a camera network layout such that every point is visible within a given number of views (including "hot spots"), at desired resolution, with acceptable focus, in a given time interval, with minimum cost.

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Sensor Field "Sketching"

Density Inference and Control

- Used as a building block for many services (e.g., routing, power mgmt, etc.)
- Used to compute unbiased functions of the sensor field data
- Use "caricatures" to infer structure of sensor field to enable structure cognizant applications

Distributed Fault-Tolerant Aggregation

- Use *counting sketches* to handle "sum" (and mean, variance, ...): $N \rightarrow \log(N)$
- Use "smart" flooding; if any path works, data is included in aggregate function

Investigators

- Bestavros
- Byers
- Kollios
- Matta

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Real-Time Scheduling

Task	Time
Searching for potential cars	1-32 ms
Feature search in window	2-22 ms
Cropping template online	1-4 ms
Template match	2-34 ms
Lane Detection	15-23 ms

Investigators

- Bestavros
- Betke
- West

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QoS-aware Network Control

Streams Classes Resources

How to adjust network controls to manage QoS while ensuring efficiency and stability?

Model sharing of PID controllers

$$w_i^k = w_i^{k-1} + \alpha(B - q^k) + \beta_i[(B - q^k) - (B - q^{k-1})]$$

$$q^k = q^{k-1} + \sum_{i=1}^N w_i^{k-1} - C$$

Use Control theory to evaluate stability/QoS

$$\alpha + 2\beta < \frac{4}{N} \quad (w_i)_t = w_i^0 + (C - \sum_{j=1}^N w_j^0) / N$$

N : #competing flows, C : allocated capacity, B : allocated buffers
 $\alpha = \max_i(\alpha_i), \beta = \max_i(\beta_i)$

Investigators

- Bestavros
- Matta
- Kfoury

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snBench

The Sensorium is the computer...

Design/implement the programming and run-time infrastructure necessary for developers to specify and deploy truly distributed applications over a heterogeneous network of Sensing Elements (SEs) and of Computing Elements (CEs)

Investigators

- Bestavros
- Kfoury
- Matta
- West
- Xi

What sensors could I use and what functionality do I get from them?

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Safety and Security Issues

Safe programming and composition

- Is your sensor network stable? Convergent?
- Will I break my system if I upgrade one element?
- Could you establish all that in time to recover?

Biometric/Physical security

- Use noisy sensory data as crypto keys
- Physical cryptography: account for *physical attacks*

Containing security breaches

- Time/space intrusion resilience: small intrusions are ok
- Tamper evidence: detect breaches *cryptographically*
- Define and protect exploits of sensor field dynamics
- Intrusion detection

Investigators

- Bestavros
- Crovella
- Kfoury
- Matta
- Reyzin
- Xi
- West

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Technology Transfer



Technology Transfer

- Three successful startups in past 5 years + two companies currently in incubation
- 30+ invention disclosures since 1997 and many licensing deals through [CIE](#)
- Involvement in key startups/fabs (AKAM, Quarry, NTAP, MS, Sprint, INTC, NSA, MOT, AT&T, CSCO, HP, IBM, NDS, Sun)
- Influence on standards bodies (e.g., ADSL, IETF, W3C)