iWatch: BIG Data Management and Analytics for Intelligent Surveillance

Farnoush Banaei-Kashani, Ph.D.
Research Associate, Computer Science Department
Associate Director, IMSC
Viterbi School of Engineering
University of Southern California
Los Angeles, CA 90089-0781
banaeika@usc.edu
Outline

• An Overview of the iWatch Project

• Vertical Cuts: Application-Specific Prototypes
  – iWatch for Safety and Security (i4S)
  – iWatch for Health (i4H)
  – iWatch for Energy (i4E)
Project Objectives

• A Multi-purpose System for Intelligent Geoimmersive Surveillance
• An End-to-End System!
• A Research Showcase
• A Technology Showcase
GeolImmersive Surveillance

- **Sense**
  - Multi-modal sensing
  - Deep sensing
  - Active sensing

- **Detect Events**
  - Forensic analysis
  - Real-time monitoring
  - Prediction of potential expected (and unexpected!) events

- **Act**
  - Visualization
  - Recommendation
  - Actuation
iWatch System Architecture

Data Acquisition

Active Sensing

Incident Detection

Efficient Incident Retrieval

Real-time Event Detection and Prediction from Incident Stream

Incident Archive

Each Incident is an object with spatial, temporal, and textual attributes
Research Showcase

1. Active Sensing
2. Inferred Archival
3. Dynamic Integration
4. Scale-up

Each Incident is an object with spatial, temporal, and textual attributes.
Technology Showcase

Event Detection

- Microsoft: StreamInsight CEP Engine
- IBM: IBM InfoSphere Streams
- Oracle: DBMS 11g
- Lockheed Martin/Rocket Software: AeorText (?)
- NEC?
- HP?

Sense

- VideoIQ (through DPS): Smart PTZ Cameras
- Qualcomm/HTC: Evo 3D Smartphones
- USC: KNOWME Network (BAN)
- OSIsoft (through Chevron): SCADA/PI
- Verizon (through AIL)?
- Intel?

Act

- Qualcomm/HTC: Evo 3D Smartphones
- Verizon (through AIL)?
- Samsung?
- ESRI?
## Project Timeline

### January 2011

<table>
<thead>
<tr>
<th>Applications</th>
<th>Sponsors</th>
<th>Technologies</th>
<th>Funding</th>
<th>Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety and Security</td>
<td>IMSC</td>
<td>Oracle 11g</td>
<td>~20K</td>
<td>IMSC Researchers (4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IMSC Students (2)</td>
</tr>
</tbody>
</table>
## Project Timeline (cont’d)

### January 2012

<table>
<thead>
<tr>
<th>Applications</th>
<th>Sponsors</th>
<th>Technologies</th>
<th>Funding</th>
<th>Team</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety and Security</td>
<td>IMSC, NIJ, NGC, CREATE (DHS), USC (DPS), CIA?</td>
<td>Oracle 11g, IBM, Microsoft, Qualcomm</td>
<td>1.2M+</td>
<td>USC Public Safety, USC Doctors (3), CHLA Doctors (1), Reservoir Engineers, Sponsors’ PMs, IMSC Researchers (4), IMSC Postdocs (4), IMSC Students (15), Industry Partners, USC AMI</td>
</tr>
<tr>
<td>Public Health</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Related Projects:**
- IMSC
- NIJ
- NGC
- CREATE (DHS)
- USC (DPS)
- CIA?
- NGA?
- CTSI?
- NIH?
- LA County?
- Oracle?
- CiSoft (Chevron)
Outline

• An Overview of the iWatch Project

• Vertical Cuts: Application-Specific Prototypes
  – iWatch for Safety and Security (i4S)
  – iWatch for Health (i4H)
  – iWatch for Energy (i4E)
iWatch for Safety and Security (i4S)

- **Purpose:** Forensic and Real-time Criminal Activity Detection from Multi-Source Multi-Modal Data
- **Sponsors:** NIJ, NGC, CREATE, DPS
- **Team:**
  - Law Enforcement and Security/Intelligence Experts: Mark Greene (NIJ), Ed Tse (NGC), Carol Hayes (DPS)
  - Risk Analysis: Isaac Maya (CREATE)
  - Incident Detection from Video: Ram Nevatia (Tracking), Gerard Medioni (Face detection)
  - Geo-keyword Incident Indexing: Cyrus Shahabi
  - Spatiotemporal Event Detection: Farnoush Banaei-Kashani
  - Mobile Video Search: Seon Ho Kim
Approach

• **Motivation:**
  Multi-modal integration enables more effective surveillance systems for criminal activity detection

• **Challenge:**
  Data overload in detecting events in large environments over long time intervals

• **Proposed Approach:**
  Utilize state-of-the-art content analysis techniques to extract *incidents* from input data streams, while integrating the incidents in the *spatiotemporal domain* (rather than content domain) to detect *events*
**Approach (cont’d)**

- **Advantage:** Allows for event detection in large spatial and temporal scales
Last Year’s Demonstration

• Mode: Forensic Analysis
• Input: Video feed from 25 PTZ cameras
i4S Prototype: System Architecture

Data Acquisition

Active Sensing for Face Capture

Incident Detection from Video, Text, Sensor

Efficient Incident Retrieval

Real-time Event Detection from Incident Stream

Incident Archive

Act

Sense

Event Detection

Incident Stream

72 PTZ Cameras, Crowdsourced Mobile Video (TB/day)

1100 ACR (KB/day)

45 LPRs (KB/day)

Police Reports, Tweets (GB/day)
i4S Prototype: Research Showcase

Data Acquisition

1. Incident Detection from Video, Text, Sensor
2. Real-time Event Detection from Incident Stream
3. Efficient Incident Archive
4. Efficient Incident Retrieval
5. Incident Detection from Video, Text, Sensor
6. Dynamic Risk Analysis (CREATE: Maya)
7. Dynamic Event Detection (NIJ: Banaei-Kashani)
8. Event Detection Supporting Data Uncertainty (NGC: Medioni, Shahabi, Banaei-Kashani)
9. Online Tracking (NIJ: Nevatia)
10. Active Face Tracking (NIJ: Medioni)
11. Active Sensing for Face Capture

Act

Sense

Event Detection

- 72 PTZ Cameras, Crowdsourced Mobile Video (TB/day)
- 45 LPRs (KB/day)
- Police Reports, Tweets (GB/day)
- 1100 ACR (KB/day)
**i4S Prototype: Technology Showcase**

**Sense**

- VideoIQ PTZ Cameras
- IBM Streams
  - Text Analytics Toolkit, Video Analytics Toolkit (iMARS, OpenCV 2.0)
  - AeorText

**Event Detection**

- Efficient Incident Retrieval
- Real-time Event Detection from Incident Stream
- Oracle 11g

**Act**

- Qualcomm/HTC Smartphones
- VideoIQ PTZ Cameras
- 72 PTZ Cameras, Crowdsourced Mobile Video (TB/day)
- 45 LPRs (KB/day)
- Police Reports, Tweets (GB/day)
- 1100 ACR (KB/day)

**Data Acquisition**

- IBM Streams
Sample Demonstration

Server-side User Interface

Mobile Client

Create
Update
Monitor

Search for “Geofence Demo” on Youtube
Outline

• An Overview of the iWatch Project

• Vertical Cuts: Application-Specific Prototypes
  – iWatch for Safety and Security (i4S)
  – iWatch for Health (i4H)
  – iWatch for Energy (i4E)
iWatch for Health (i4H)

- Special-Purpose Prototypes
  - Prototype I: Contact Investigation
  - Prototype II: Understanding Geography of Diabetes
  - Prototype III: Point-of-Care Mobility Monitoring
i4H-Prototype I: Contact Investigation

- **Purpose:** Retrospective and Real-time Contact Investigation
- **Sponsor:** NIH?
- **Team:**
  - Contact Investigation: Dr. Brenda Jones (TB), Dr. Pia Pannaraj (Flu)
  - Tracking and Face Detection: Gerard Medioni
  - Spatiotemporal Contact Analysis: Farnoush Banaei-Kashani, Cyrus Shahabi
Step I: Data Collection
Step II: Reachability Analysis

**Input**

A graph $G$ which is:
- Large scale (Huge number of edges and vertices)
- Temporal (Edges are added and deleted over time)
- Geospatial (Nodes are moving in space)

**Queries**

Within a time interval $[a,b]$, find:
- Whether $u$ is reachable from $v$?
- The individuals reachable from $v$?
- The individuals that can reach $v$?
i4H-Prototype I: System Architecture

- Data Acquisition
- Active Sensing for Face Capture
- Incident Detection from Video

Efficient Incident Retrieval

Incident Archive
i4H-Prototype I: Research Showcase

Data Acquisition

Incident Detection from Video

Incident Archive

Incident Stream

Active Sensing for Face Capture

Active Face Tracking (Medioni)

Efficient Incident Retrieval

Efficient Reachability Analysis (Banaei-Kashani, Shahabi)

Online Tracking (Medioni)

Incident Detection from Video

Online Tracking (Medioni)
i4H-Prototype I: Technology Showcase

Data Acquisition

Incident Detection from Video

Incident Stream

Efficient Incident Retrieval

Oracle 11g

Active Sensing for Face Capture

PTZ Cameras

Incident Detection from Video

Incident Stream
i4H-Prototype II: Understanding Geography of Diabetes

- **Purpose:** Spatial Analysis and Mining of Diabetes Patient Data to Understand Spatial Causative pathways, Processes, and Patterns
- **Sponsor:** Verizon?, Oracle?
- **Team:**
  - Diabetes: Dr. Andy Lee
  - Use-case and Market Analysis: Nathalie Gosset (AMI)
  - Body Area Sensor Network: Murali Annavaram
  - Spatial Data Analysis and Mining: Farnoush Banaei-Kashani, Cyrus Shahabi
Analytics

• Categories:
  – Patient Analytics vs. Expert Analytics
  – Trajectory Analytics vs. Spatial Analytics
  – Individual Analytics vs. Collective Analytics

• Exemplary Analytics:
  – Spatial outlier detection to distinguish “good signatures”
  – Spatial co-location rules to identify causative processes
i4H-Prototype II: System Architecture

Data Acquisition

Incident Detection from BAN Data

Efficient Incident Retrieval

Real-time Event Detection from Incident Stream

Incident Archive

Active Sensing for Energy Efficient Data Collection

Incident Detection from BAN Data

Sense Event Detection

Act Event Detection
i4H-Prototype II: Research Showcase

Data Acquisition

- Incident Archive
- Incident Stream
- Efficient Incident Retrieval
- Real-time Event Detection from Incident Stream
- Spatial BAN Data Analytics (Banaei-Kashani, Shahabi)
- Incident Detection from BAN Data
- Active Sensing for Energy Efficient Data Collection

Efficient Incident Retrieval

Energy Efficient BAN Data Collection (Murali)

Real-time Event Detection from Incident Stream

Incident Archive

Incident Stream
i4H-Prototype II: Technology Showcase

Data Acquisition

Active Sensing for Energy Efficient Data Collection

Incident Detection from BAN Data

Efficient Incident Retrieval

Real-time Event Detection from Incident Stream

Event Archive

Oracle?

KNOWME Network

Qualcomm/HTC Smartphones

Qualcomm/HTC Smartphones
i4H-Prototype III: Point-of-Care Mobility Monitoring

- **Purpose**: Real-time Mobility Monitoring for 1) Rehabilitation of Stroke-induced Mobility Limitations, and 2) Optimization of Pharmacologic Interventions for Parkinson’s Disease

- **Sponsor**: CTSI?, Oracle?

- **Team**:
  - Rehabilitation: Dr. Carolee Winstein et al.
  - Use-case and Market Analysis: Cesar Blanco (AMI)
  - Video Data Analysis: Gerard Medioni
  - Sensor Data Analytics: Farnoush Banaei-Kashani, Cyrus Shahabi
Vision

PoCM-MS

1. Data Acquisition Module
2. Data Management and Analysis Module
3. Recommendation Module

Physician Recommendation → Data Interpretation

Data → Recommendations

Recommendations
Outline

• An Overview of the iWatch Project

• Vertical Cuts: Application-Specific Prototypes
  – iWatch for Safety and Security (i4S)
  – iWatch for Health (i4H)
  – iWatch for Energy (i4E)
iWatch for Energy (i4E)

- **Purpose:** On-the-Fly Decision-Making based on Real-Time Stream Data to Enhanced Oil Recovery
- **Sponsor:** Chevron/CiSoft?
- **Team:**
  - Stream Data Analytics: Farnoush Banaei-Kashani, Cyrus Shahabi
Vision

1. With GPS data from all moving objects in the field (vehicles, field workers, and perhaps robots that are monitoring and operating the field, etc.)
   - A Safety Application: Fire Announcement
   - Work order optimization application
   - A Security application: GeoFence

2. With sensor data from all wells in the field (e.g., production/injection rate detectors, bottom hole pressure and temperature readers, smoke and hazard detectors, vibration detectors)
   - Waterflood monitoring and optimization (WMO) application
   - A Safety and incident detection application: Fire Detection

3. With sensor data from the equipment in the field (RFID readers, vibration detectors, status sensors)
   - Inventory application
   - A Facility management application as well as safety application: Failure Detection
Q & A