CRUE

Center for Research on Unexpected Events

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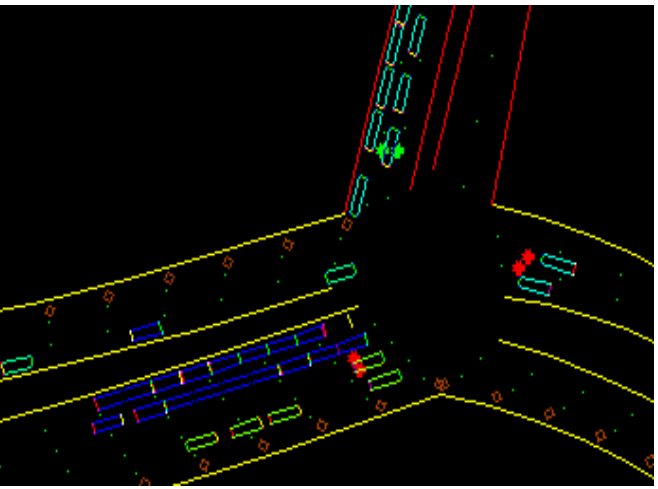
Visionary Project: The Virtual City

- Dynamic 3D model/simulation of major urban areas
  - Such as Los Angeles, New York or Washington, DC
  - Integrating existing and models of a wide range of key phenomena
    - Subsurface, surface and atmospheric, including utilities, transportation, weather, and more
    - Natural and man-made structures, processes, and behaviors
    - Physical, behavioral, social, economic and cultural phenomena
    - At varying levels of fidelity and granularity
- “Live” representations of area status
  - Link to real-time sensor/monitoring capabilities
  - Provide unified situation understanding
  - Starting point for what-if simulations

Some Building Blocks Exist – We Do Need to Learn to Assemble Them!



MIT

+

UCLA

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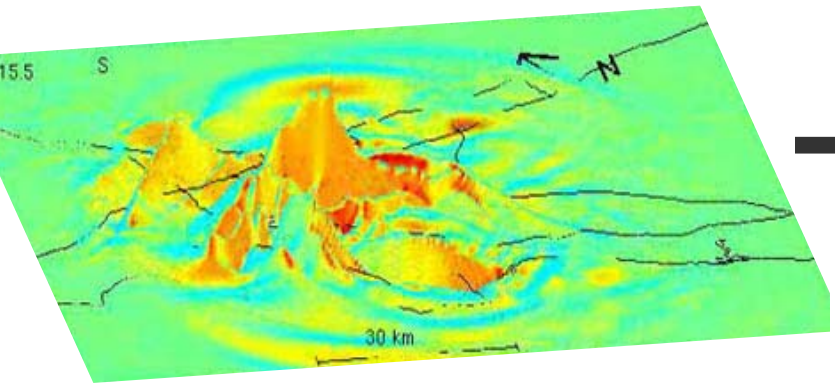


SCEC

+É → **Virtual City**

CRUE

Additional Building Blocks

- Relevant technologies: Geospatial information fusion, million-entity simulation methods, agent programming languages, traffic modeling, 3D modeling

The JFCOM JNTC vision is a virtual World-Wide training and mission rehearsal capability.

How the Virtual City Can Change Emergency Response

- Before an event
  - Urban design for reduced vulnerability
  - Study normal and suspicious patterns of events and behavior
  - Non-disruptive training for response
- During an event
  - Situation visualization and assessment
  - Anticipate effects on infrastructure and population
  - Anticipate needs and cascades of events
  - Test effectiveness of potential responses

Visionary Project: The Virtual City Wide-Ranging Utility

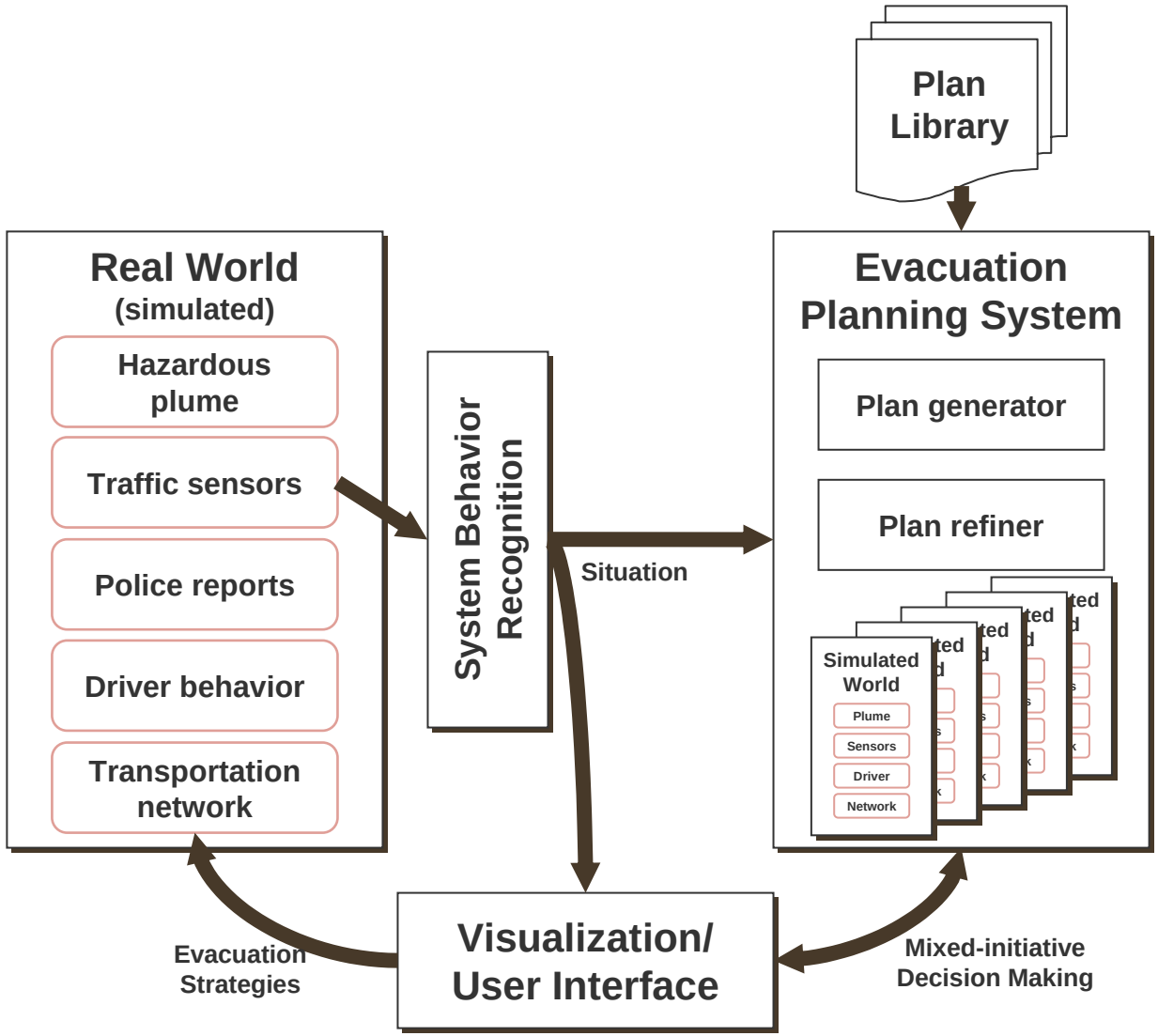
- Applicable to multiple unexpected event scenarios, for example:
  - Evacuation, chem/bio attack, earthquake, …
- Has varied aspects and many potential users
  - Unexpected event simulation and training
  - Basic research on new phenomena and interactions
  - Vulnerability and risk analysis
  - Urban planning and urban policy development
  - Regulation evaluation and technology testing
  - A testbed for in silico social science research
  - Military operations in urban terrain
  - Effects-based operations planning

Short-Term Example: Unplanned Urban Evacuation

- Problem
  - Evacuation plans exist only for anticipated events (e.g., hurricanes)
  - It is not realistically possible to identify all potential causes, routes
- Solution: Dynamic evacuation planning
  - Model transportation network, use artificial intelligence to support evacuation planning and management
- Dynamic response elements
  - Model complete transportation network of sizable urban region
  - Incorporate model of the spread of a toxic plume in the atmosphere
  - Develop support system for devising traffic management plan
  - Visualization tools for situation and effects of management decisions
  - Enable response managers to act as a virtual organization
  - Record events, activities for after-action review

$4M NSF ITR Proposal, February 2004, Caltrans collaboration

Urban Evacuation: Outline of System Use

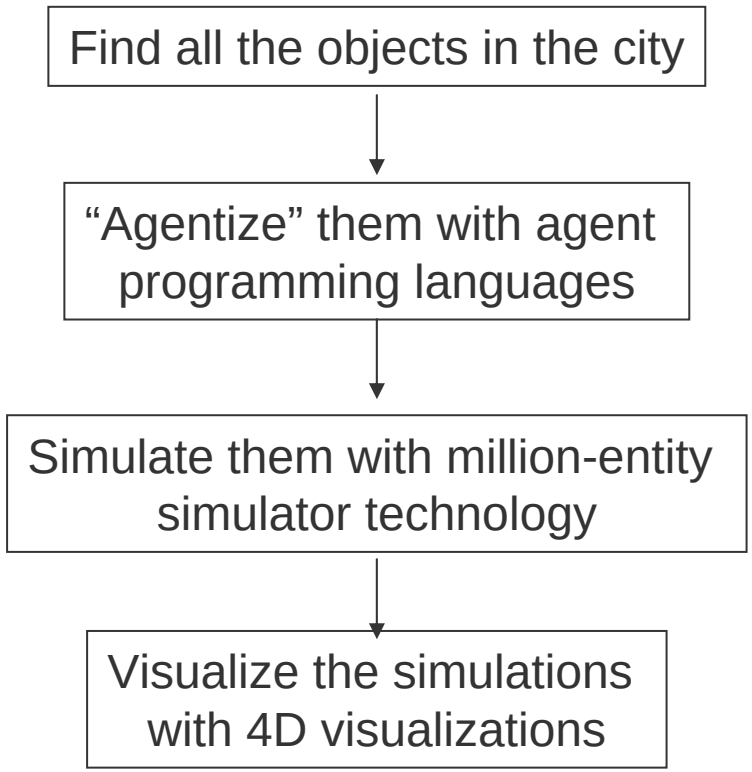


Rapid Construction of City Simulator

Goal: A Large City Simulator in Hours

The Idea

- All these parts exist, but have never been integrated



Summary: Rapid Construction of City Simulators

- Technologies: Geospatial information integration; agent programming languages; million-entity simulation; n-dimensional information management
- Capabilities: Populate battlespace simulators given satellite imagery and other intelligence; parameterize simulations of traffic flows in cities by counting cars on images of roads; 3D models of real buildings for training simulations for urban warfare…

- The component technologies exist—
  they need to be integrated

Integrating Online and Geospatial Information Sources

- Geospatial data sources have become widely available
- Huge amount of data available online that can be related to these geospatial sources
- Challenge is to support the dynamic integration of these two types of sources

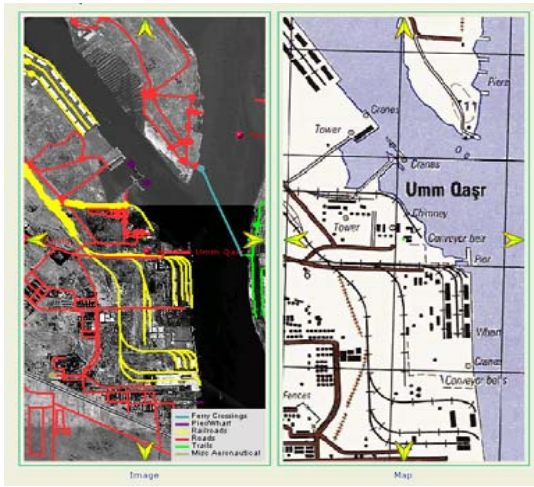
From Knoblock, Shahabi, et al.

Sources

Imagery

Maps

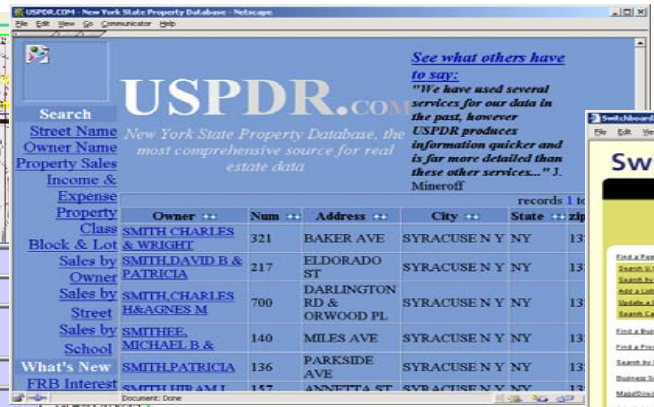
Vectors



Points and cultural features

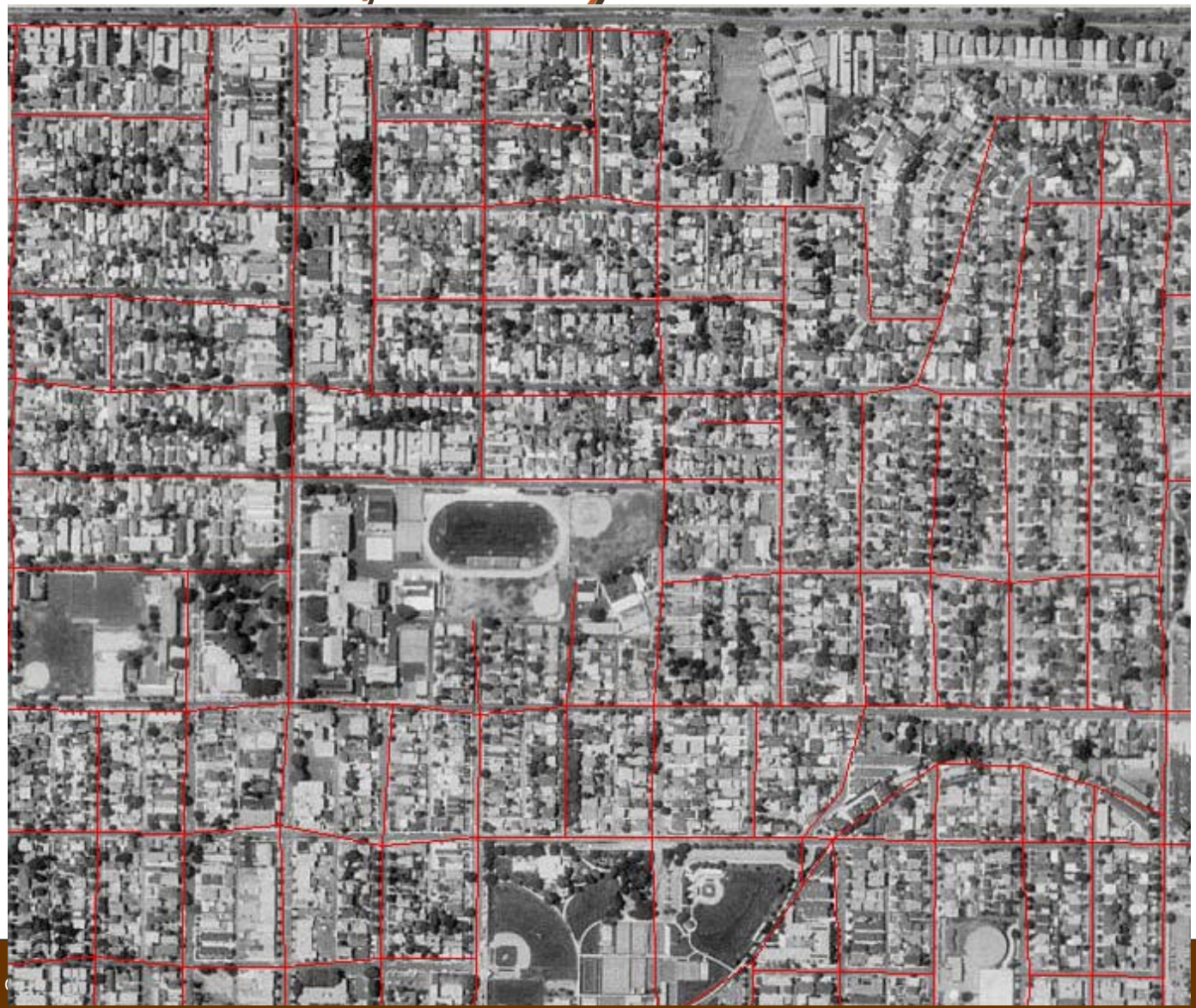
Name	YAKHCHALSAZIYEZ
Type	MFG
Feature Class	Spot Feature
Short Desc	factory
Long Desc	one or more buildings where goods are manufactured, processed or fabricated
Lat/Lon	35.7061 N, 51.2744 E
Data Source	NIMA

Tax records

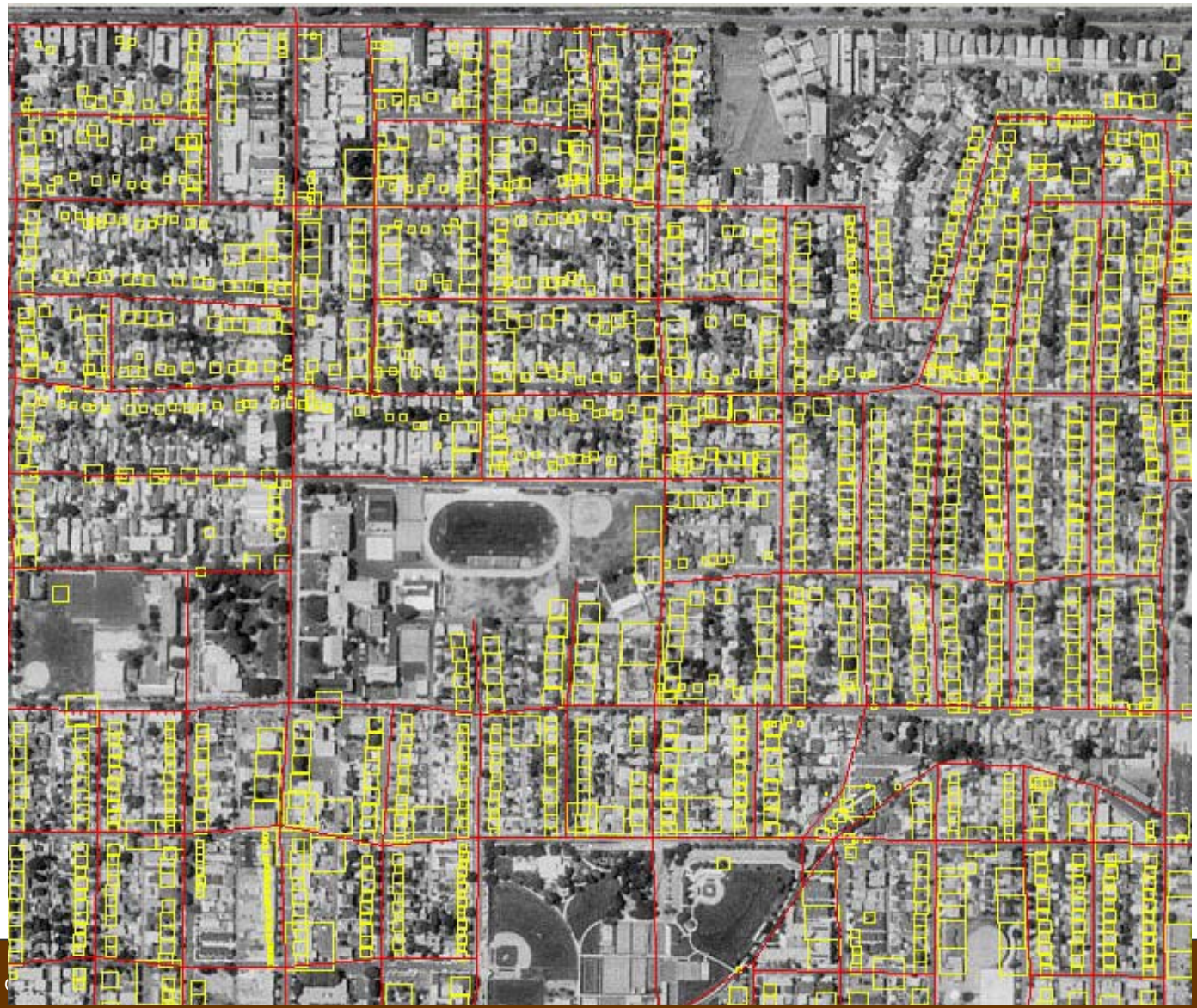


Telephone numbers

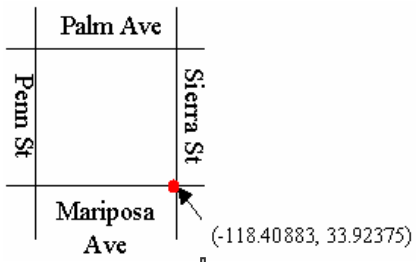
Locate Roads in the Satellite Image (Chen et al., 2003)



Locate Structures in the Image

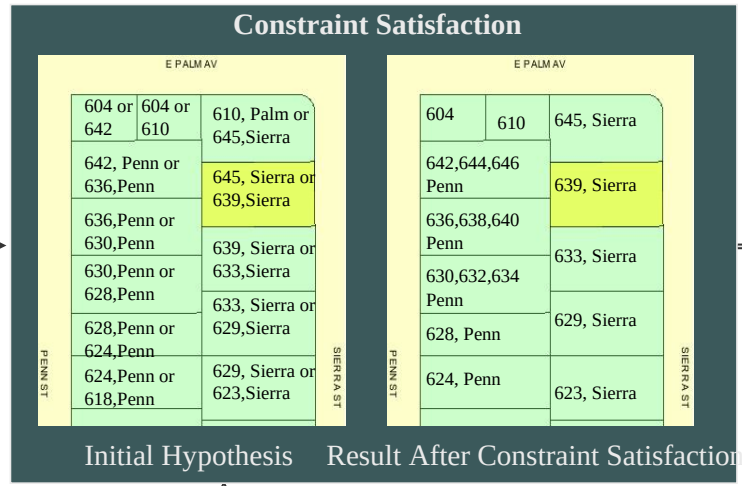


Exploiting Online Sources to Accurately Identify Structures in Imagery



Street Vector Data
Corrected Tiger Line Files

Satellite Image
Terraserver



Address	Latitude	Longitude
642 Penn St	33.923413	-118.409809
640 Penn St	33.923412	-118.409809
636 Penn St	33.923412	-118.409809
604 Palm Ave	33.923414	-118.409809
610 Palm Ave	33.923414	-118.409810
645 Sierra St	33.923413	-118.409810
639 Sierra St	33.923412	-118.409810

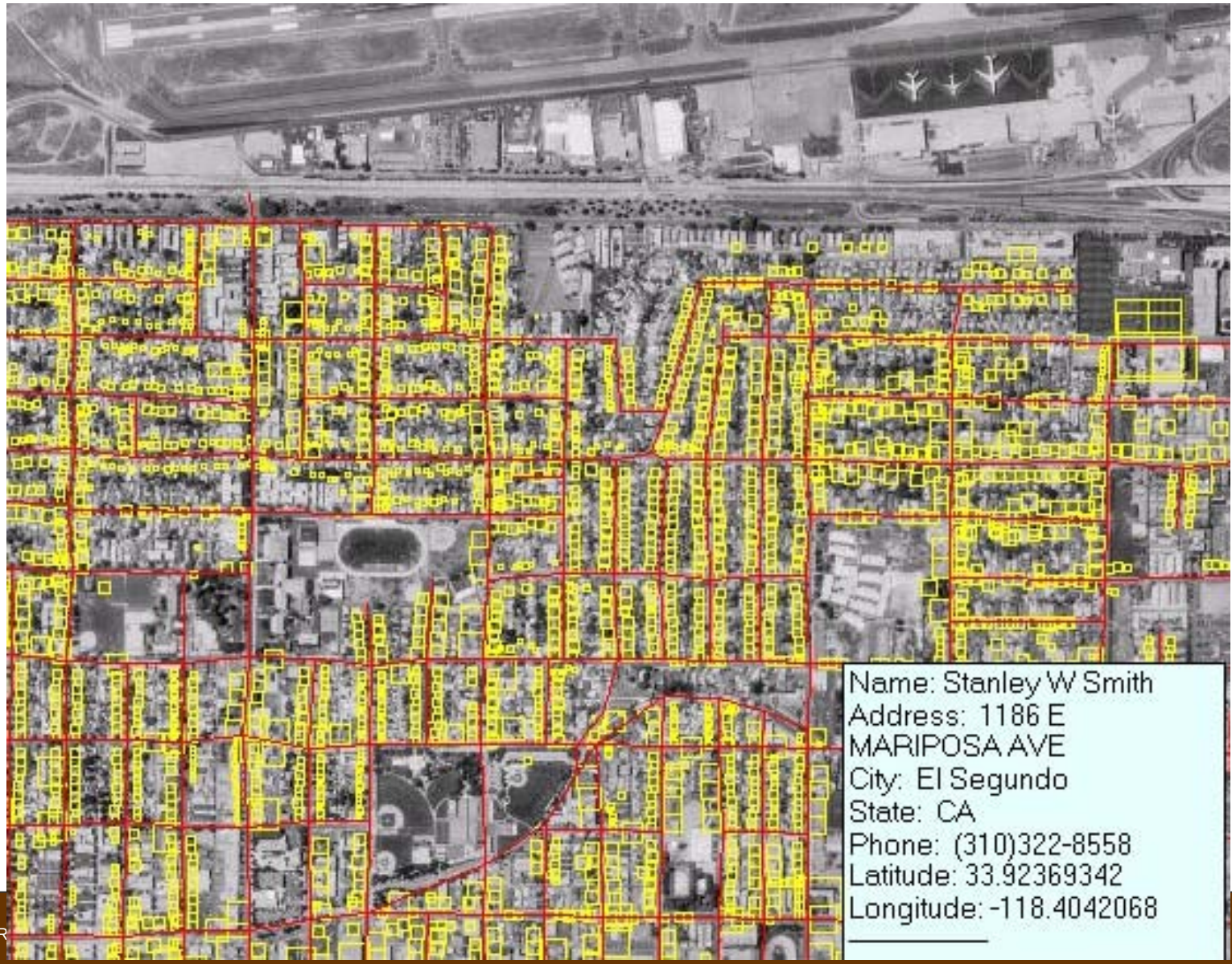
Geocoded Houses

Los Angeles County Assessor's Site
Property Tax Records

Address	# units	Area(sq ft)	Lot size
642 Penn St	3	1793	135.72 * 53.33
604 Palm Ave	1	884	69 * 42
610 Palm Ave	1	756	66 * 42
645 Sierra St	1	1337	120 * 62
639 Sierra St	1	1408	121*53.5

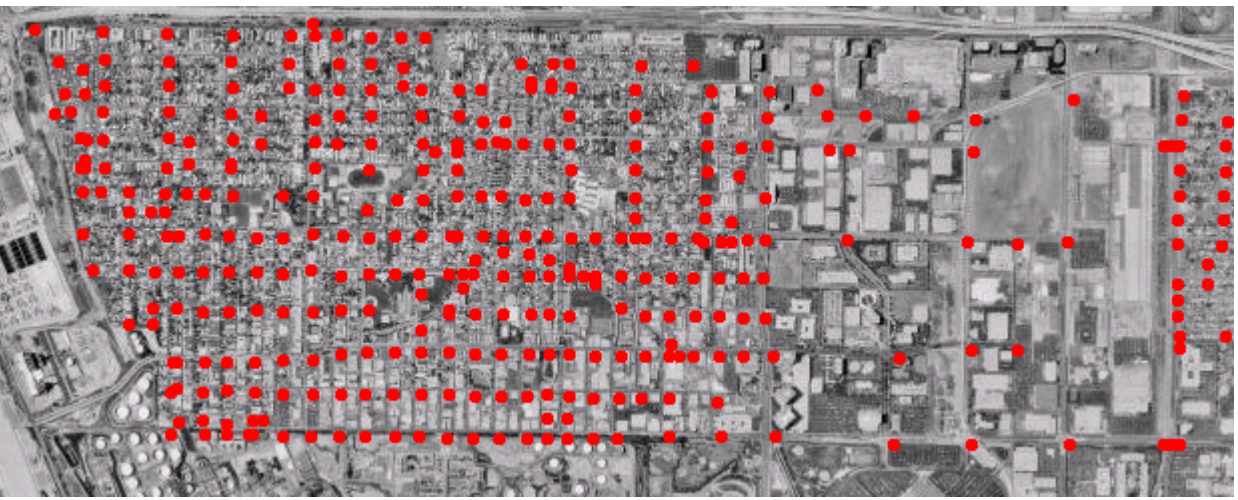
Data Extracted from Online Site

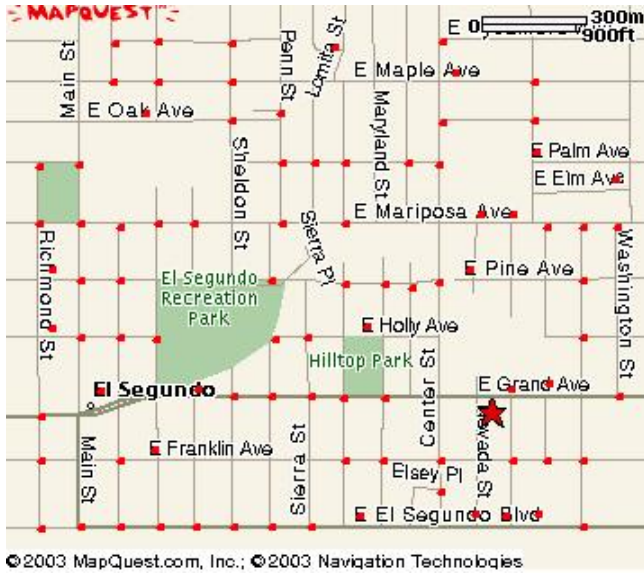
Labeling Structures in the Image



Recent results

- 281 road intersection points extracted from imagery
- 65% to 95% precision for identifying road intersections on various maps
- 90% of our tested maps accurately aligned their intersection point set with the corresponding point pattern on the image
  - 10% of the maps mis-aligned with the image by shift west (or east) one to two street blocks away.





Million-Entity Simulation
(Lucas, Yao, Wagenbreth)

Joint Experimentation on Scalable Parallel Processors (JESPP) runs large-scale, artificial intelligence agent simulations for JFCOM. Simulations field up to a million of agents, with complex models of vehicles demonstrating sophisticated behaviors and different capabilities based on vehicle driver fatigue, training levels, and environmental effects.

The simulations run on USC's 500-node scalable super computer. Each node has two IBM processors, and high-bandwidth, low latency inter-node communications.

Rapid Construction of City Simulator, in A Nutshell

- Technologies: Geospatial information integration; agent programming languages; million-entity simulation; n-dimensional information management
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Appendix

NSF Workshop on Responding to the Unexpected

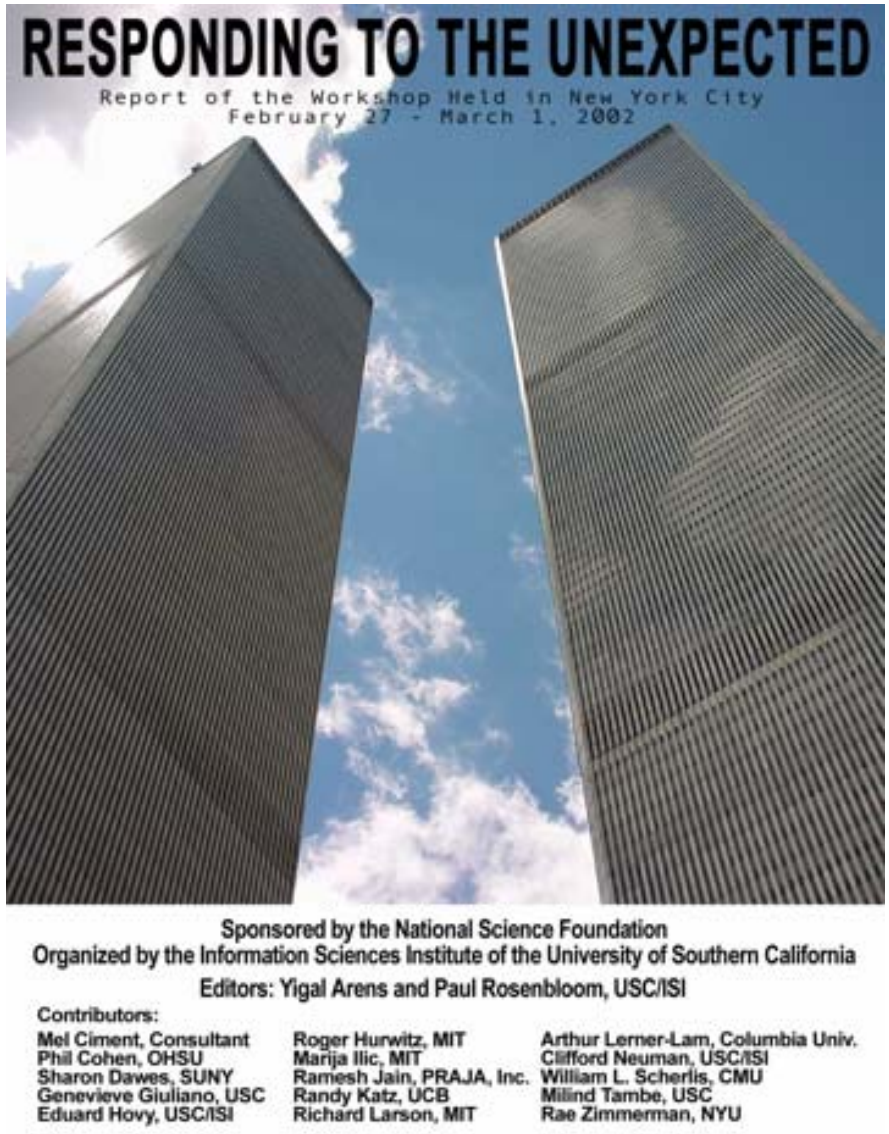
February 27-March 1, 2002

New York City

Organized NSF Workshop Feb/Mar 2002

- Report:
  - crue.isi.edu

A follow-on workshop just held



Participants

- Researchers (42)
  - Information Technology
  - Engineering
  - Social Science
- Responders and Practitioners (21)
  - Federal: FEMA, DOJ/NIJ, USCG, EPA, …
  - State: California Office of Emergency Services
  - Local: NYC DOITT, DC Emergency Management
  - Industry: Con Edison, Urban Logic, HP, …
- NSF Representatives (10)

Goals

- Examine diversity of unexpected events
  - Natural: Earthquakes
  - Accidental: Three Mile Island and other complex technological system failures
  - Intentional: 9/11
- Begin to understand and develop
  - New technical, social and policy requirements
  - Research agenda
  - The mechanisms for establishing an adequate research program

Recommended Research Areas

- Infrastructure and its protection
  - Monitoring technologies, critical infrastructure, transportation infrastructure, performance and response outcomes
- Risk analysis
  - Randomized strategies, regulatory structure, decision-theoretic data analysis, cascading causality, decentralized decision making
- Organizational response, support and integration
  - Formation, structure, operation, multi-agent collaboration, distributed resource allocation, pedagogical agents
- Policy, jurisdiction and regulation
  - Standardized case analysis, meta-model development
- Information management
  - Fusion, validation, presentation, access, exploitation, tailoring, metadata representation, economic and policy implications
- Networking and communication
  - Resilience, sensor networks, rule-based systems security, emergency response, Grid technologies, heterogeneous and ad hoc wireless infrastructure

Recommended Support Levels

- Grants
  - Individual: 100 at $100K-$300K per year
  - Group: 40 at $300K-$1M per year
- Centers
  - Focused: 20-30 at $5M-$10M per year
  - National: 2-3 at $20M-$30M per year
- **Total Funding: ~$300M per year**