Overview

1. Research Goals
2. Completed Work
3. Status of Completed and Proposed Goals
4. Publications
Original Research Goals

- Network Understanding / Anomaly Detection System
- Creation of Simulations from Streaming Data
- Updating Simulations from Streaming Data
- Online Validation Against Streaming Data
- Sensor Steering
Original Research Goals

» Network Understanding / Anomaly Detection System Removed
» Creation of Simulations from Streaming Data
» Updating Simulations from Streaming Data
» Online Validation Against Streaming Data
» Sensor Steering Removed
Research goals have been revised to reflect the priority of the WIPER project

- GIS for Data Analysis, Visualization and Simulation
- Data Curation
- WIPER: Simulation Prediction System
- Design and Implementation of WIPER Simulation
- Movement and Activity Models
Research goals have been revised to reflect the priority of the WIPER project

- GIS for Data Analysis, Visualization and Simulation
- Data Curation
- WIPER: Simulation Prediction System (System description, published in [1, 2, 3])
- Design and Implementation of WIPER Simulation
- Movement and Activity Models
Creation of Simulations from Streaming Data - Mostly Complete
Updating of Simulations from Streaming Data - In Progress
Online Validation Against Streaming Data - Offline Implementation. Working Towards Online Implementation
Revised Research Goal Status

- GIS for Visualization and Simulation - Complete
- Data Curation - Complete
- Design and Implementation of WIPER Simulation Prediction System - Mostly complete
- Design and Implementation of WIPER Simulation - Mostly Complete
- Movement and Activity Models - Taxonomy and Implementation of several movement models complete.
Creation of Simulations from Streaming Data

Figure: Graphical Explanation of Process for Generating Simulations from Streaming Data
Creation of Simulations from Streaming Data

**Procedure**

- **Offline:** Develop Movement and Activity Models
- **Offline:** Build GIS files describing area
- **Online:** Receive “snapshot” of activity in tower cell and region from DAS
- **Online:** Apply Movement and Activity Models to generate distribution of agents over cell

Tim Schoenharl (Notre Dame CSE)  
Dissertation Progress Report  
February 27, 2007
Validation of Simulations

**Call Activity Data Validation**

- **Activity Model** uses Empirical Data to Generate Activity
- **Passes** Kolmogorov-Smirnov test, $D = 0.0903$, $p=0.6003$, two-sided test at $\alpha = 0.05$

**Figure**: Plot of actual and simulated activity data.
Validation of Simulations

**Figure:** Empirical Data Plotted against data normally distributed around the points.

- Data generated by normally distributing points around empirical data
- Generated with mean = empirical data, sd = 1
- Fails Kolmogorov-Smirnov test, $D = 0.1389, p = 0.1243$, two-sided test at $\alpha = 0.05$
Several issues remain when validating simulations online vs streaming data

- Valid against empirical data? Distribution? Model? Currently using KS test against empirical data, with poor results
- KS test unable to distinguish normally distributed data generated from empirical distribution
- Idea: Utilize the prior probability of anomaly from MMPP model for validation.
- Implement in a per cell fashion, need to be cautious with time intervals
GIS for Visualization and Simulation

Figure: GIS Image from a WIPER Simulation

GIS Uses:

- Visualizing tower locations, relationship to urban areas, etc
- Simulations: agent and tower locations can be initialized from data, agents can interact with real world geography
**Figure:** Cell phone activity overlaid on a satellite image.

**Figure:** 3D View of Tower Activity
Data Curation

Overview of the Data Curation Workflow

- Created workflow to curate privacy-sensitive data
- Manage tradeoff between access to data and protection of cell customer privacy
- Implemented cryptographic hashing scheme to protect customer privacy

Figure: The Data Curation Workflow
The WIPER Scenario

Figure: The WIPER Scenario

- Detect Anomalies from streaming data
- Run simulations to understand crisis events
- Output results to web console
Overview of the WIPER System

The WIPER System Components

- Real Time Data Source
- Detection and Alert System
- Simulation Prediction System
- Decision Support System

Figure: The WIPER system
Design and Implementation of WIPER Simulation

Figure: The WIPER Simulation
Crisis Behavior Taxonomy

Figure: A Taxonomy of Crisis Scenarios.
As shown in the previous figure, movement models for crisis scenarios can be arranged in a taxonomy. This taxonomy allows rapid development of models due to shared components.

The class hierarchy mirrors the crisis taxonomy and uses code re-use to reduce development time and increase model validity.
Agent's Movement: 83.3 m/min
Direction away from Disturbance
Agent's Movement
Agent
Disturbance

Movement Model Explanation

- Agent calculates new location based on direction to disturbance

Figure: Basic Flee Action
Activity Models

Activity Model Explanation

- Simulation Reads in Empirical Distribution of Call Activity for the Day of Week
- Simulation schedules an appropriate number of calls for the time period based on the empirical distribution

Figure: Empirical Distribution of Call Activity
