ETRI Electronics and Telecommunications Research Institute

Predictive Policing 101

Preventing Crime with Data and Analytics

3 April 2014

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Data Management Research Section

ETRI


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Depth of Knowledge (DoK) Level of the Seminar

Outline

- Why is the Predictive Policing Important?
- Background
- Mathematical Frameworks
- Data Used in Predictive Policing
- Predictive Methodologies for Predictive Policing
- Summary

Why is the Predictive Policing Important?

Why is the Predictive Policing Important?

- **What is Crime Analysis?**
  - **Administrative, Tactical and Strategic Problem Solving**
  - **Forecasting and predictive analysis**

August Vollmer
Source: LAPD Web Site

1909

- **Principles of *problem-oriented* policing**
- ***Evidence-based* policing**
- ***Real-time* crime analysis**
- ***Intelligence-led* policing and other proven policing models**

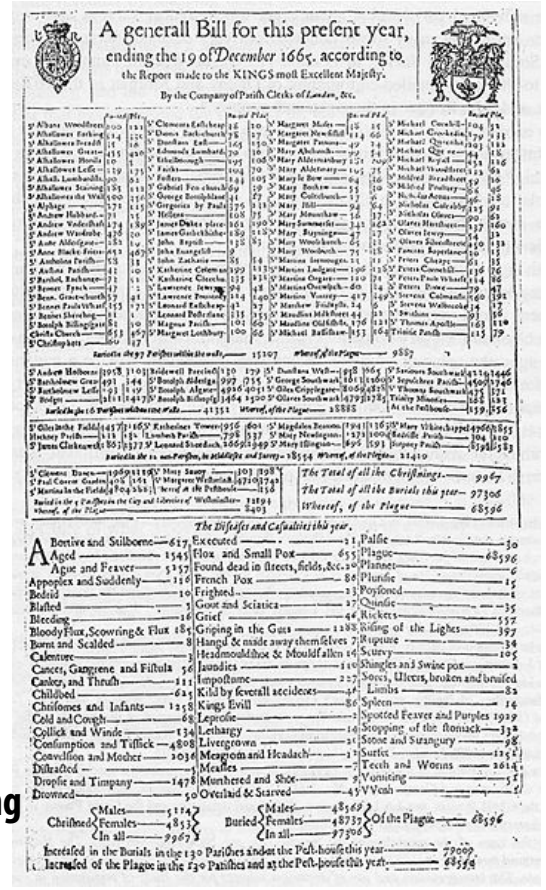
Orlando W. Wilson

1950

History

- *Origin of Crime Analysis*
  - Crime Mapping: 1829, Italian geographer and French Statistician
  - Crime Analysis: 1842, London's Metropolitan Police

- *First Data Miner*
  - John Graunt [Amateur Scientist]
  - Bill of Mortality (1st: 21 December 1592)
    - essentially *random* set of information
    - the study of the patterns causes and effects of *disease*
    - *Plague*
      - caused by person-to-person contact
      - tended to increase during the first year of the reign of a new king
    - gold mining



A generall Bill for this present year, ending the 19 of *December* 1665. according to the Report made to the KINGS most Excellent Majesty.

By the Company of Parish Clerks of *London*, &c.

The Diseases and Casualties this year.

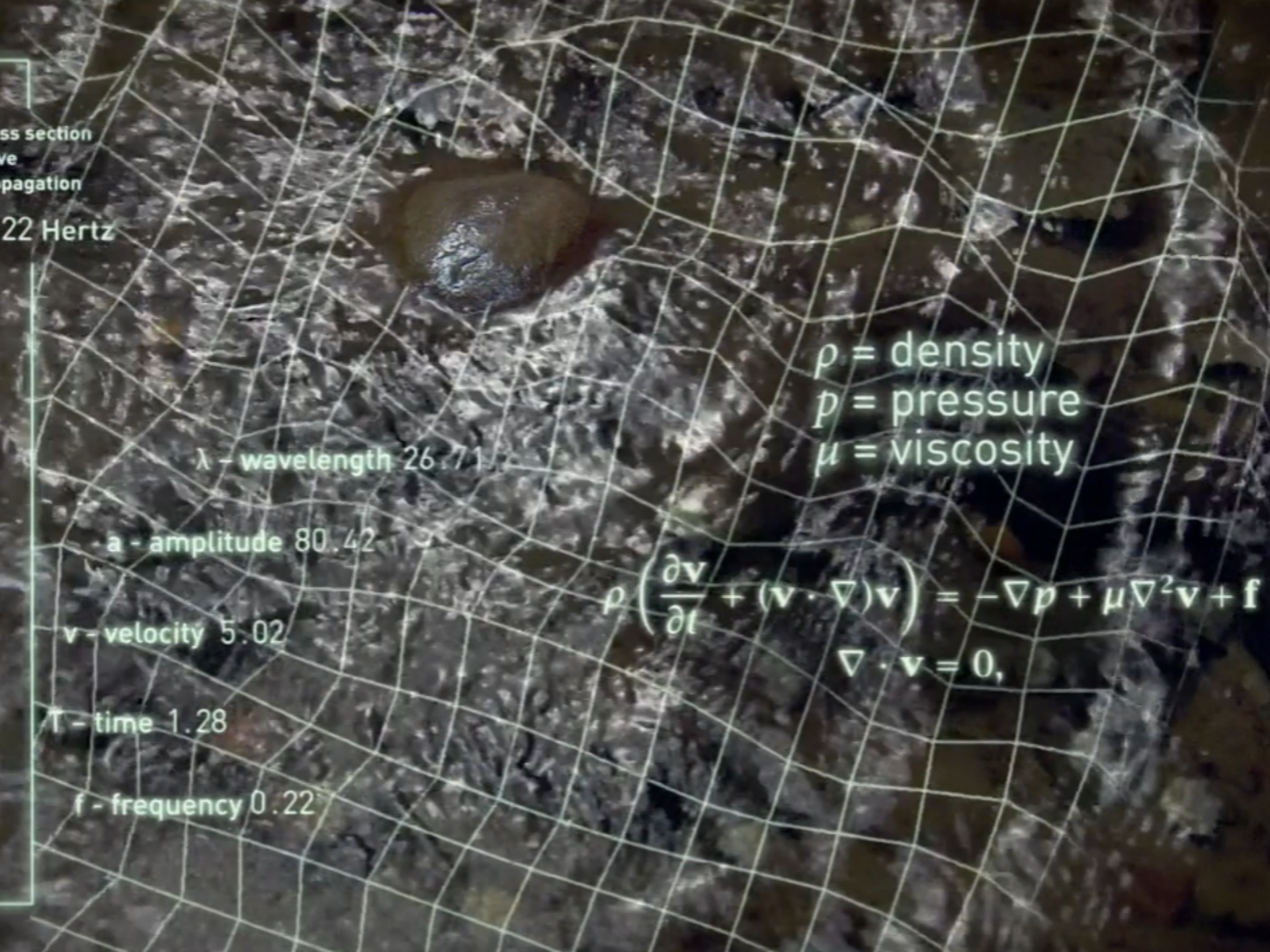
Abortive and Stillborne	617	Executed	21	Palsie	30
Aged	1545	Flox and Small Pox	655	Plague	68596
Ague and Feaver	5257	Found dead in streets, fields, &c.	20	Planet	6
Appoplex and Suddenly	116	French Pox	86	Plurisie	15
Bedrid	10	Frighted	13	Poysoned	1
Blasted	5	Gout and Sciatica	17	Quinsie	35
Bleeding	16	Grief	46	Rickets	557
Bloody Flux, Scowring & Flux	185	Griping in the Guts	1288	Riding of the Lights	397
Burnt and Scalded	8	Hangd & made away themselves	7	Rupture	34
Calenture	3	Headmouldshot & Mouldfallen	14	Scurvy	105
Cancer, Gangrene and Fistula	56	Jaundice	110	Shingles and Swine pox	2
Canker, and Thrush	211	Imposthume	227	Sores, Ulcers, broken and bruised	
Childbed	625	Kild by severall accidents	54	Limbs	82
Chrisomes and Infants	1258	Kings Evill	86	Spleen	14
Cold and Cough	68	Leprosie	2	Spotted Feaver and Purples	1929
Collick and Winde	134	Lethargy	14	Stopping of the Stomack	332
Consumption and Tissick	4808	Livergrown	31	Stone and Strangury	98
Convulsion and Mother	2036	Megrom and Headach	3	Surfet	1251
Distracted	4	Measles	7	Teeth and Worms	2614
Dropsie and Timpany	1478	Murthered and Shot	9	Vomiting	51
Drowned	50	Overlaid & Starved	45	Worms	27

Christned	Males	5114	Buried	Males	48569
	Females	4853		Females	48737
	In all	9967		In all	97306

Of the Plague 68596

Increased in the Burials in the 130 Parishes and at the Pest-house this year 79009

Increased of the Plague in the 130 Parishes and at the Pest-house this year 68558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22 Hertz
λ - wavelength 26.71
a - amplitude 80.42
v - velocity 5.02
T - time 1.28
f - frequency 0.22
ρ = density
p = pressure
μ = viscosity
$\rho\left(\frac{\partial \mathbf{v}}{\partial t} + (\mathbf{v}\cdot\nabla)\mathbf{v}\right) = -\nabla p + \mu\nabla^2\mathbf{v} + \mathbf{f}$
$\nabla \cdot \mathbf{v} = 0,$

Clustering Patterns

- Loma Prieta Earthquake (1989)
  - Earthquake analysis
  - Clustering patterns

- MASC Project
  - Clustering patterns are also seen in *crime data*
  - Future events *nearby* in *space* and *time* after shocks of crime
  - Finding and clustering the *patterns* from chaos human behaviours
  - *Self-exciting point* process model *similar* to that used in earthquake analysis
  - Pilot Project : Los Angeles
    - Data: 13 million past crimes
    - Duration: past 80 years

UC MASC PROJECT
MATHEMATICAL AND SIMULATION MODELING OF CRIME

Mathematical and Simulation Modeling of Crime

UC MASC PROJECT
MATHEMATICAL AND SIMULATION MODELING OF CRIME

Jeff Brantingham
UCLA Anthropology

George Mohler
Santa Clara Mathematics

George Tita
UCI Criminology, Law and Society

Mathematical Framework [7]

- **The Hawkes Process Model (1974)**
  - **any given event, or collection events can be causally linked to a *background Poisson process* and *foreground self-exciting process*.**

Self-excitation

the distribution of crimes following an initial event

$$\lambda(t) = \mu + k_0 \sum_{t_k < t} g(t - t_k)$$

background rate of events
stationary Poisson process

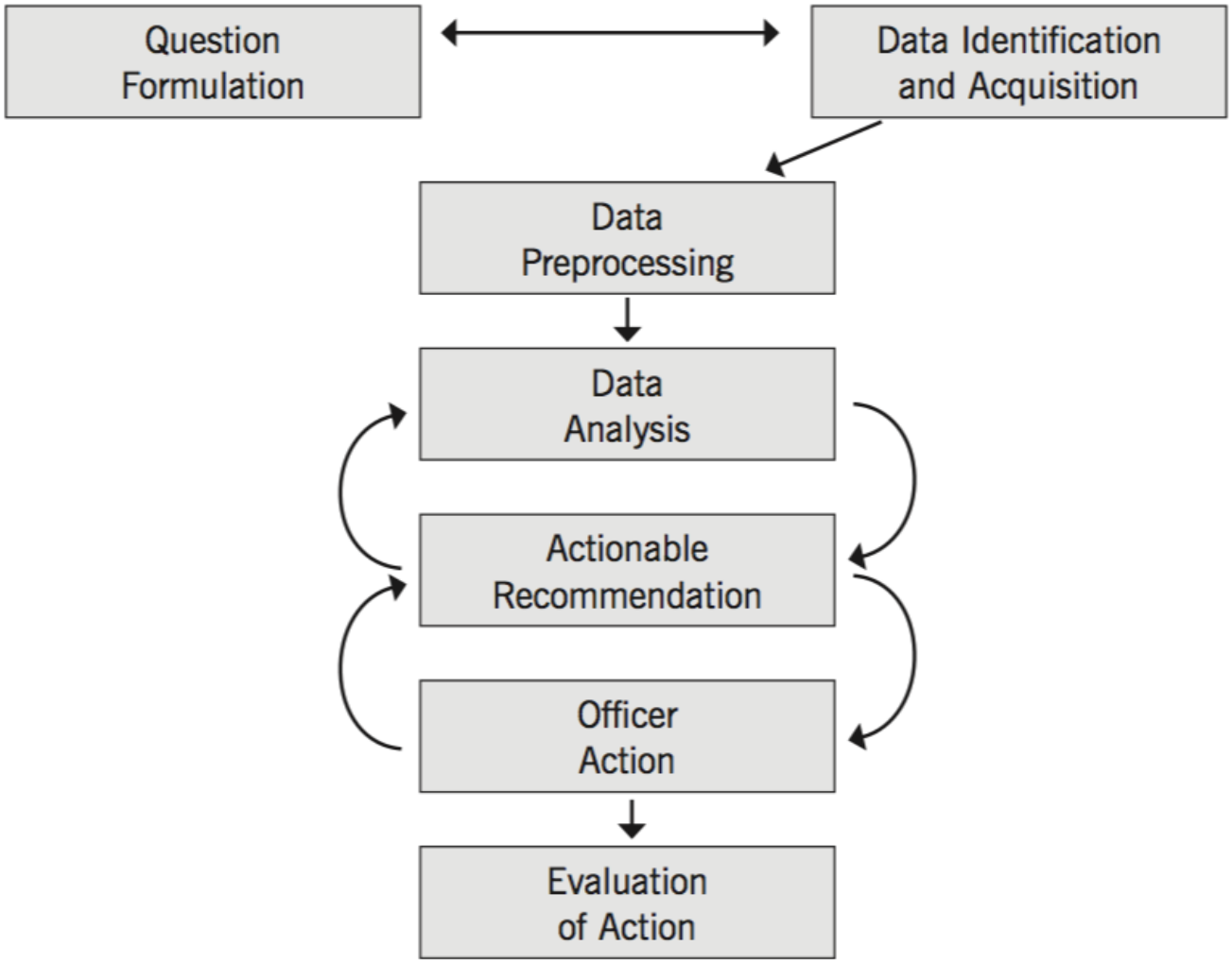
the density of prior events necessary to trigger excitation

how much excitation is generated by a collection of prior events

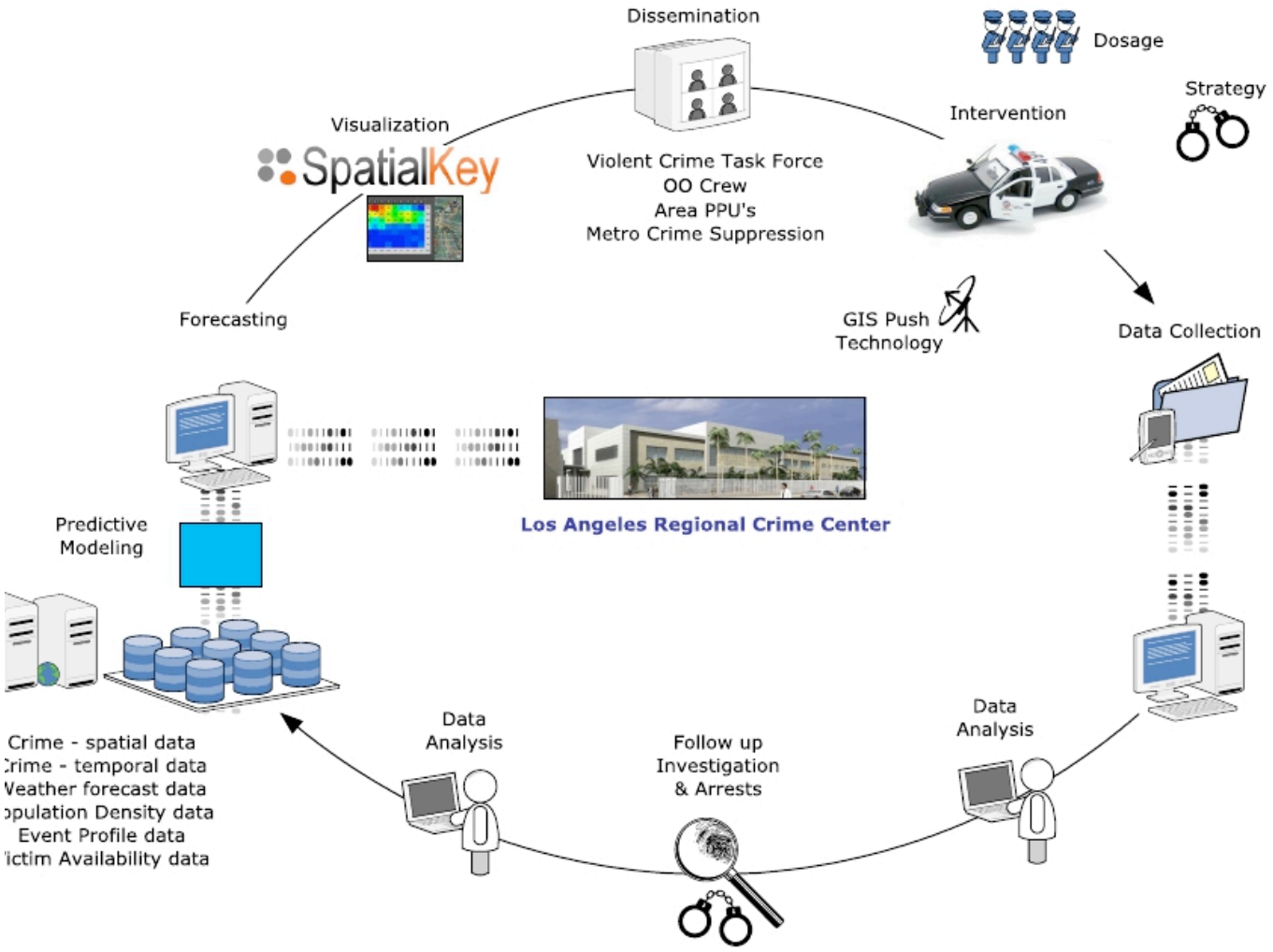
[7] Erik Lewis *et. al*, ***Self-exciting point process models of civilian deaths in Iraq***, *Security Journal*, 2011.


BURGLARY

Operational Challenges of Predictive Policing



Case Study: Los Angeles Regional Crime Center



Data Used in Predictive Policing

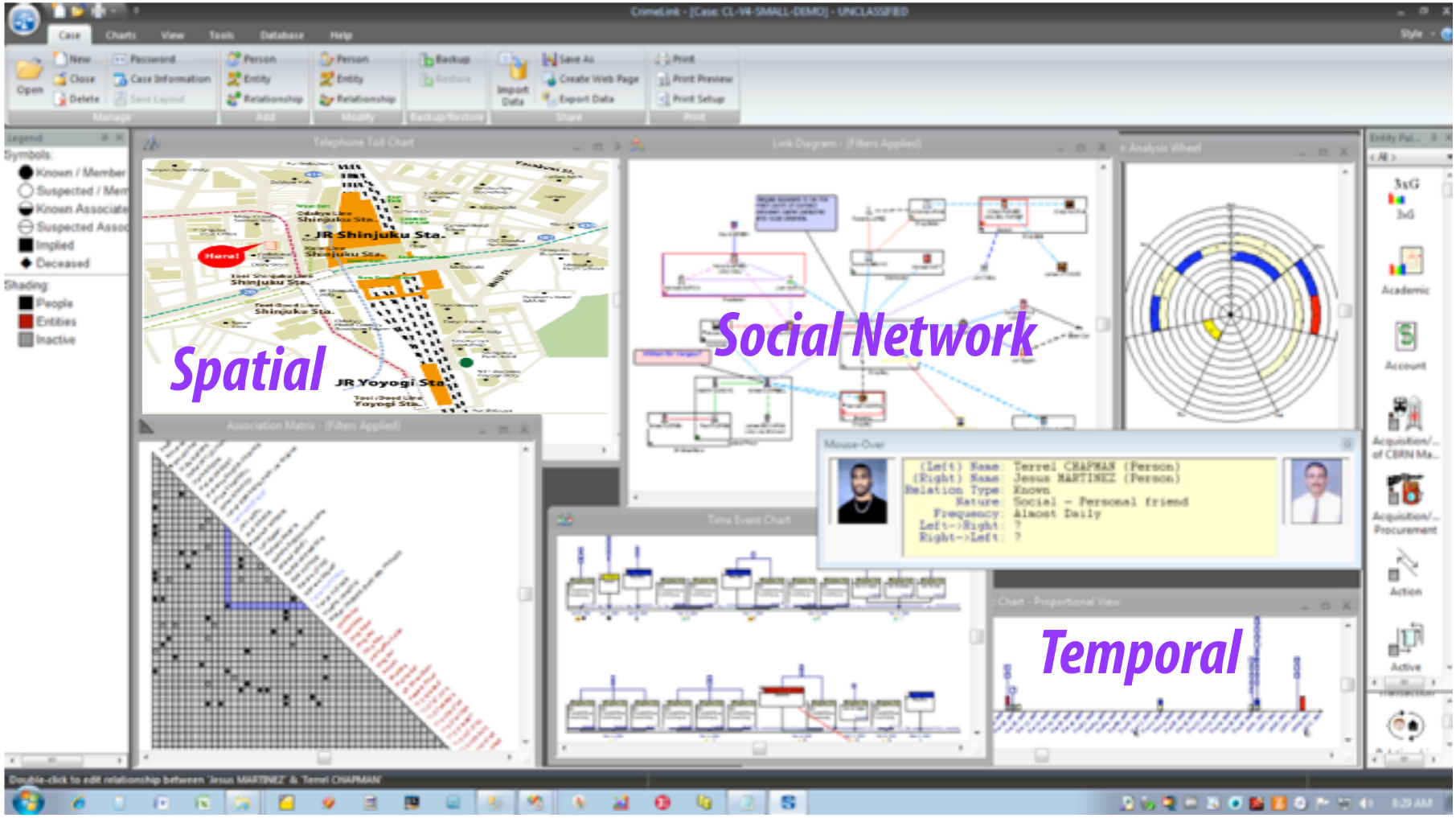
- **Three Categories**
  - **Spatial**
  - **Temporal**
  - **Social Network**

Spatial Variables	Temporal Variables	Social Network Variables
Indicators of Areas with Potential Victims/Targets • Shopping malls • Property values • Hotels • Area demographics • Population density • Residential instability **Indicators of Escape Routes** • Highways • Bridges • Tunnels • Public transportation • Railways • Dense foliage **Indicators of Criminal Residences** • Bars and liquor stores • Adult retail stores • Fast food restaurants • Bus stops • Public health information • Areas with physical decay	• Payday schedules • Time of day • Weekend vs. weekday • Seasonal weather (e.g., hot versus cold weather) • Weather disasters • Moon phases • Traffic patterns • Sporting and entertainment events	• Kinship • Friendship • Affiliation with an organization • Financial transaction • Offender/victim

The Transition from Data to Knowledge in a Police Agency

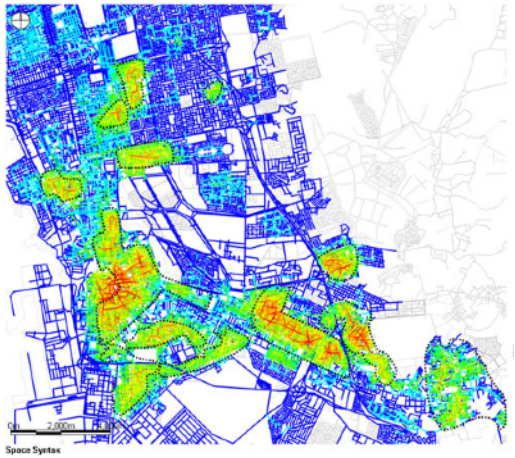
Data		Information		Knowledge		Result
Individual Incident Reports in a records management system	Analysis	Six of the reports are related in a series of robberies	Communication	Robbery series is prime topic of discussion in next detective's meeting	Strategy & Action	Robbery offender is apprehended
Statistics showing number of officers per capita throughout the state		Your police department has 20% fewer officers per capita than average		Chief has this information in mind when preparing his budget proposal		Agency is granted additional officers by city
Crime volume of current year compared to past years; individual records in RMS; jurisdictional information		Auto theft is up 20%, with most of the increase in Police Beat 5 on the midnight shift, probably influenced by new sports arena		Officers internalize this information and consider it when patrolling Beat 5		Auto theft is reduced

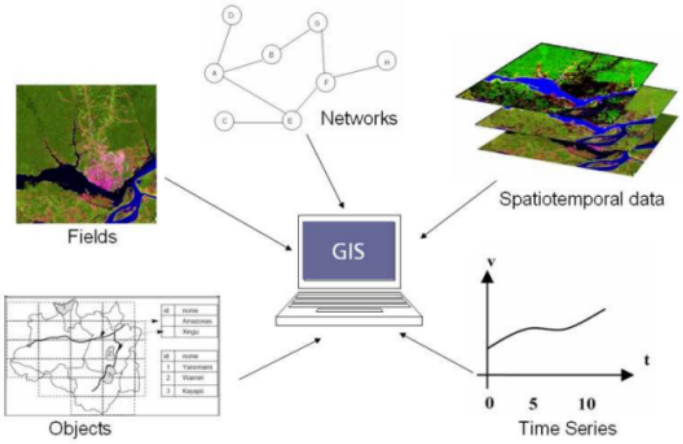
Full Scale Analysis

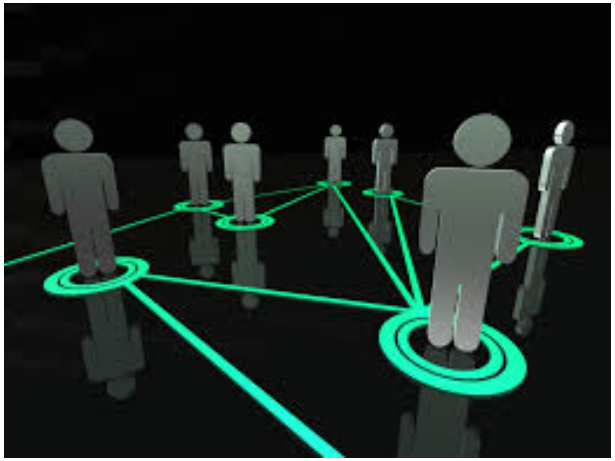


Predictive Methodologies

- Analysis of space
- Analysis of time and space
- Analysis of social networks

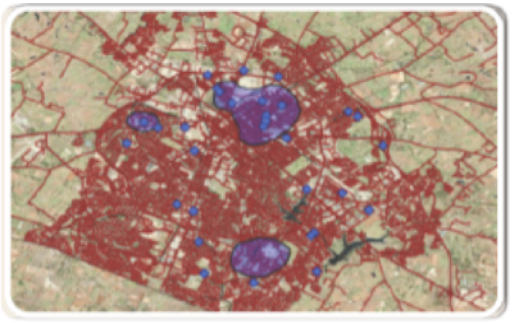


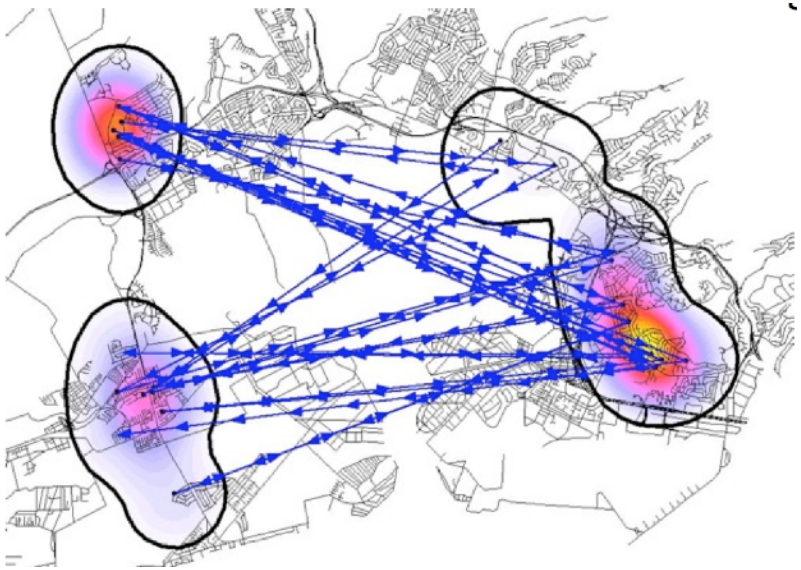


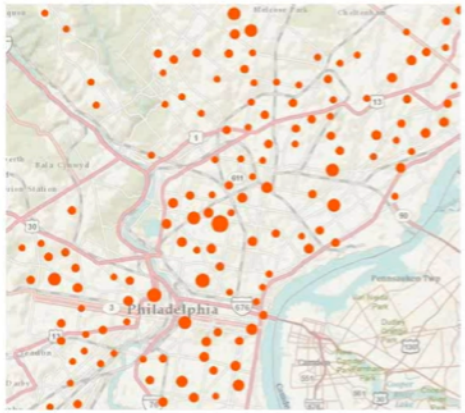


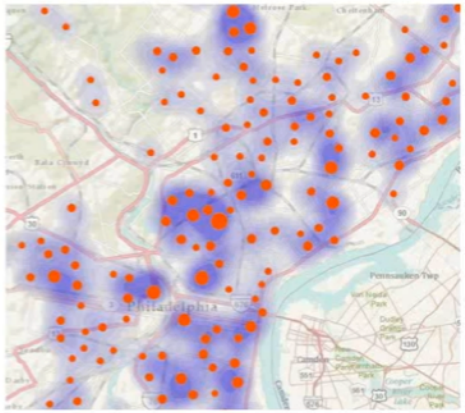
Predictive Methodology One: Analysis of Space

- Point (or offense) locations
- Hierarchical clusters
- Partitioned clusters
- Fuzzy clusters
- Density mapping
- Risk-terrain modeling (RTM) clusters









Predictive Methodology One: Analysis of Space

- **Point (or offense) locations**
  - ***Theory of repeat victimization, 500x500 feet*** **[PredPol Software]**
- **Hierarchical clusters**
  - **use a *nearest-neighbor technique* [display the clusters: *ellipses, convex hulls]***
- **Risk-terrain modeling (RTM) clusters**

Gun shootings example

Gun shootings example

Predictive Methodology Two: Analysis of Time and Space

Predictive Methodology Two: Analysis of Time and Space

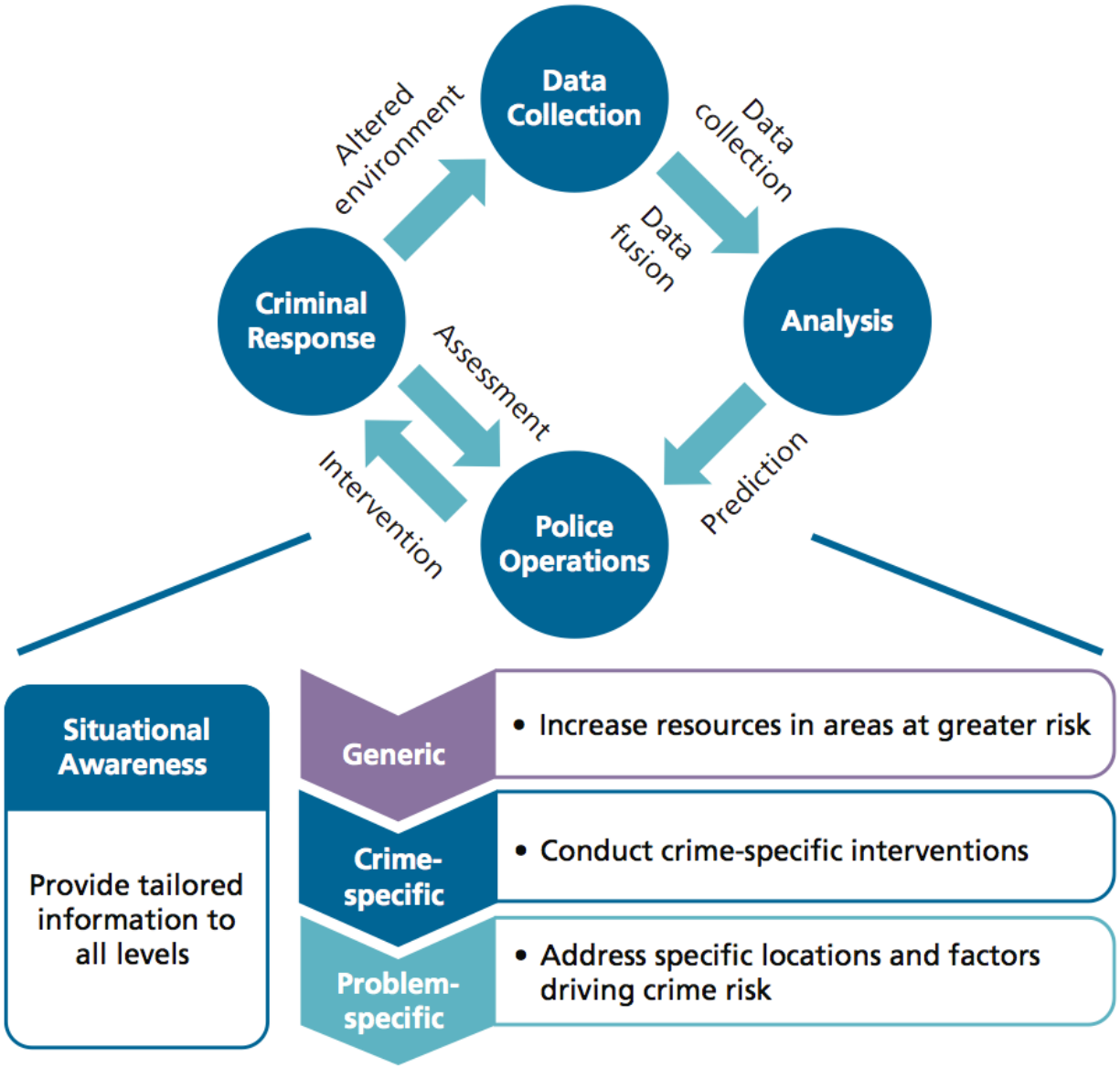
- **CrimStat III : a software program (sociologist + National Institute of Justice)**
  - **spatial-temporal moving average (STMA)**
    - **the *average time* and *location* for a subset of incidents**
  - **correlated walk analysis (CWA) : *temporal* and *spatial relationships* between incidents**
    - **computing the *correlation* between *intervals* [time, distance, direction between two events]**

Predictive Methodology Three: Analysis of Social Networks

- **Social Network Analysis (SNA) : *cutting edge* of crime analysis**
  - **detect *persons* of interest, as opposed to *locations* of interest**
  - **identify individuals that are central to criminal organizations (eg., gangs and drug networks)**

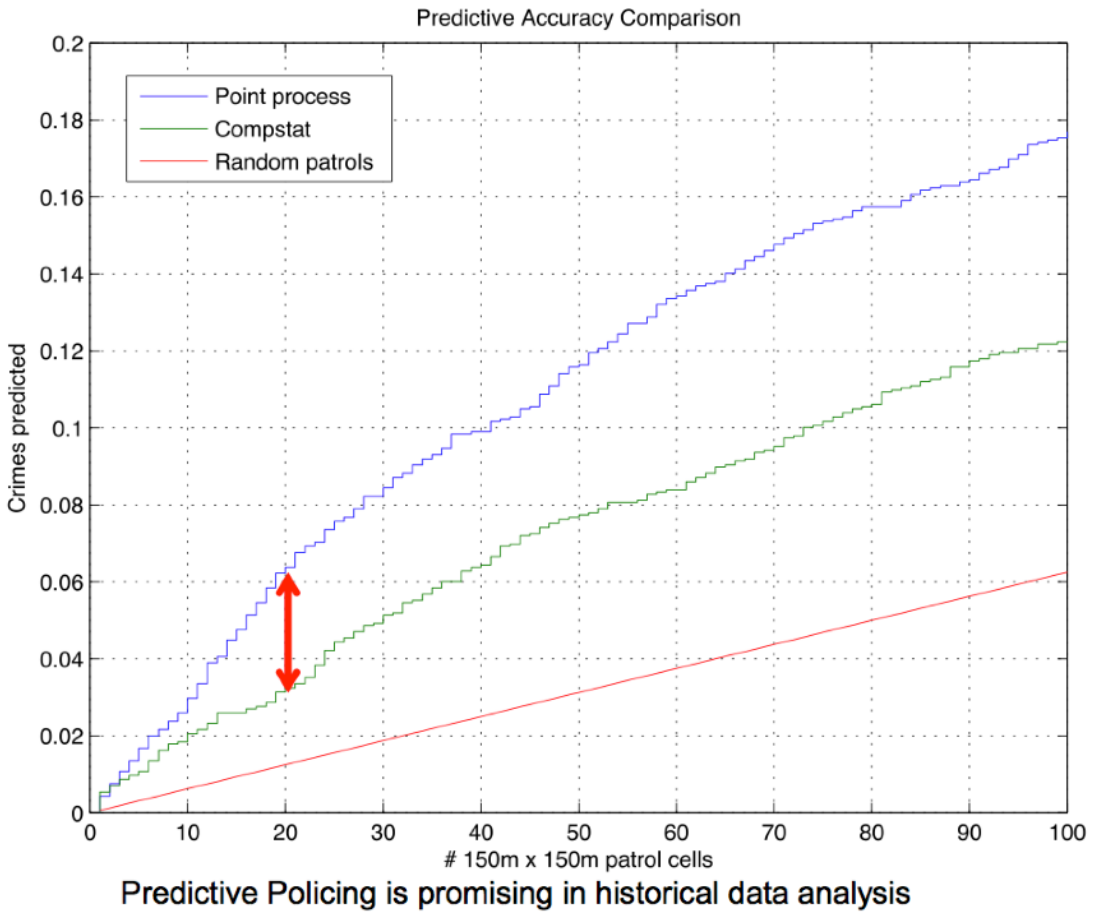
- **Building blocks of a social network: *relationships* between two actors**
- **In crime-fighting applications,**
  - **SNA is frequently used to identify *central nodes* [*high level of connectivity*]**
  - **Measures of *centrality***
    - ***degree* : *the number of links* possessed by a node**
      node's level of *connectedness*
    - ***closeness* : *the total distance* from a node to all other nodes in the network**
      ***ease* of obtaining information from the network**
    - ***betweenness* : *the number of instances* a given node appears in the shortest path between other nodes**
      ***relevance* to the passage of information within the network**

Review: Prediction-Led Policing Business Process [2]



Places on the Frontier of Predictive Policing in the United States

- *Los Angeles, California*
- Santa Cruz, California
- Baltimore Country, Maryland
- Richmond, Virginia
- Memphis, Tennessee



Predictive Policing is promising in historical data analysis

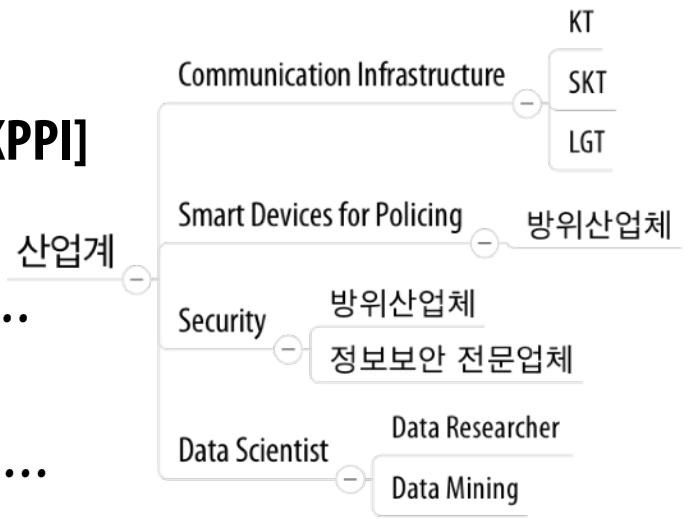
Summary

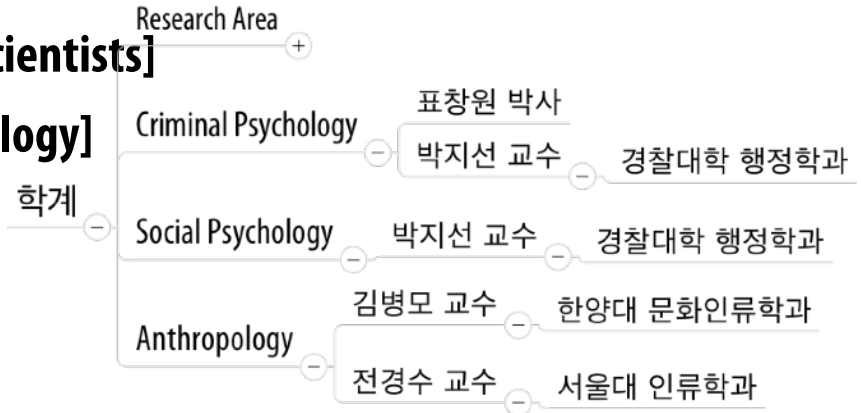
- Predictive Policing *Concept*
- *Mathematical Frameworks* for Predictive Policing
- *Data* Used in Predictive Policing
- *Predictive Methods* for Predictive Policing
- Predictive Policing *Business Process*


one more thing
or two...

Future Projects

- ^^ Starting from Fall 2018 ~
- 6 Years : *Korea Predictive Policing Infrastructure* [KPPI]
  - 1st phase (3 years) : Proof-of-concept Stage
    - *human dynamics, criminal analytics frameworks, . . .*
  - 2nd phase (3 years) : Experimental Stage
    - *Predictive Policing in Seoul and Daejeon, and more . . .*
- Candidate Research Collaborators
  - Industry [Communications, Systems, Data Scientists]
  - Academic [Criminology, Sociology, Anthropology]
  - Research Institutes [Nonprofits]






thank you
danke
謝謝
ngiyabonga
teşekkür ederim
gracias
merci
obrigado
dziękuję
bedankt
sukriya
kop khun krap
go raibh maith agat
mochchakkeram
grazie
arigatô
dakujem
terima kasih
감사합니다
ありがとう
спасибо
Баярлалаа
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