A close-up, slightly blurred image of yellow crime scene tape with the words "CRIME SCENE" printed in bold black letters. The tape is stretched across the frame, creating a sense of depth and focus on the text.

[Picture: Brandon Anderson, <https://flic.kr/p/7o8ffA>]

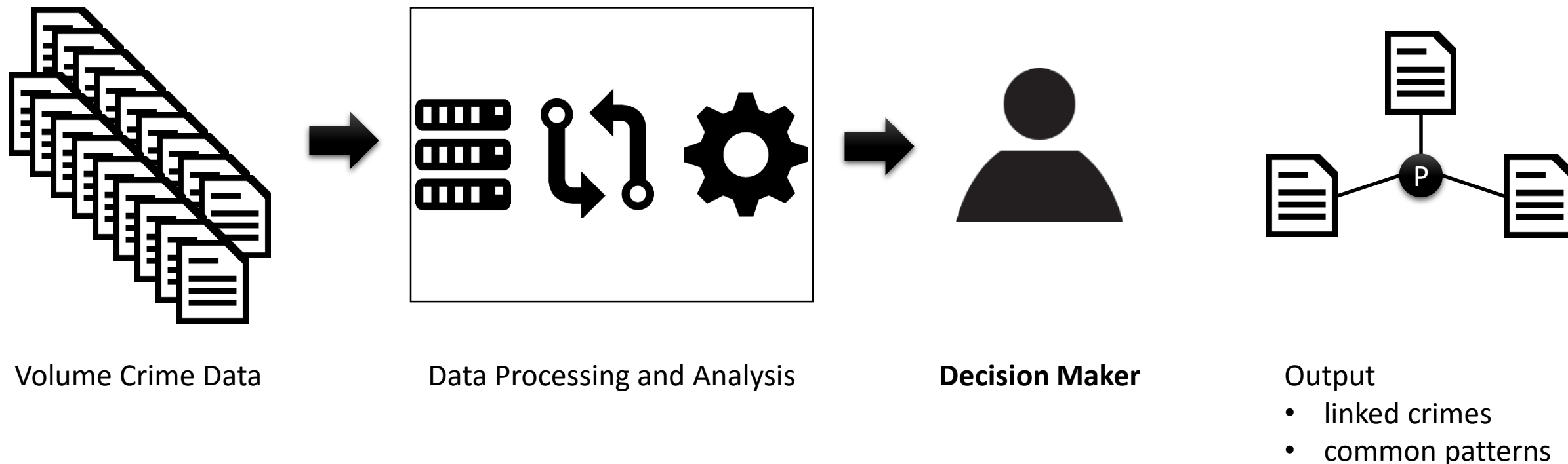
VAPD • A Visionary System for Uncertainty Aware Decision Making in Crime Analysis

Florian Stoffel, Dominik Sacha, Geoffrey Ellis, Daniel A. Keim

CCA – Comparative Case Analysis

„CCA aims to find patterns in incidents or crime events that will potentially link them.“

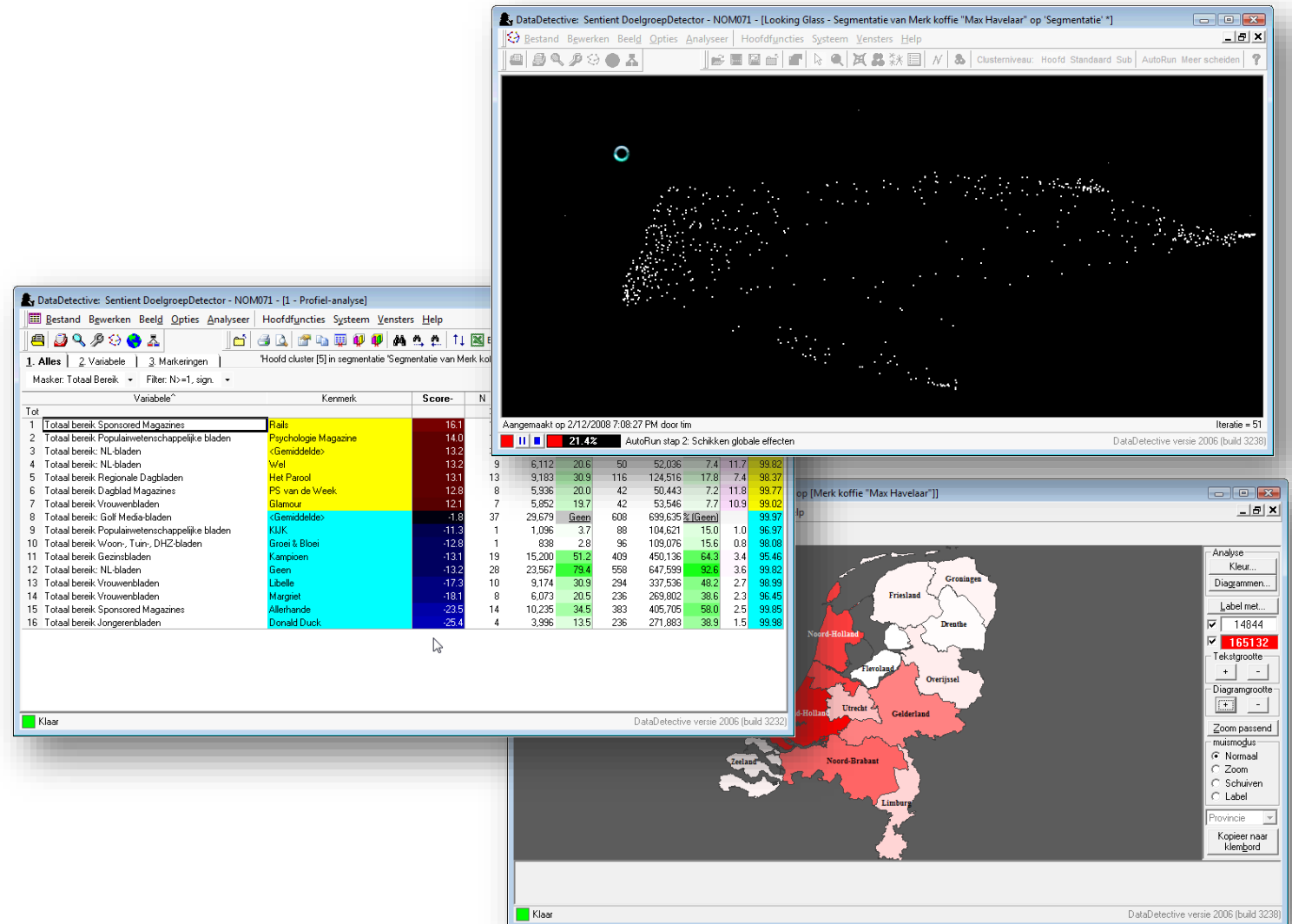
[Practice Advice on Analysis, NPIA]



Requires (fast), accurate, verifiable, and trustworthy information.

CCA – State of the Art Methods

- Network analysis
- Visual clustering
- Similarity measures
- Geo data analysis
- Text data analysis



Text Processing Pipeline – The Data



en

U/K OFFENDERS SMASHED KITCHEN WINDOW AT REAR OF PREMISES AND ENTERED THROUGH SAME TIDY SEARCH OF DOWNSTAIRS REMOVED TELEVISION AND MADE EXIT THROUGH REAR KITCHEN DOOR

[Source: Adderley 2013]

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Problems – Text Analytics

- Text data analysis is an active research area.
- Semantics, grammar, language use are problems for the analysis.

Sample Modus Operandi Text

U/K OFFENDERS SMASHED KITCHEN WINDOW AT REAR OF PREMISES AND ENTERED THROUGH SAME TIDY SEARCH OF DOWNSTAIRS REMOVED TELEVISION AND MADE EXIT THROUGH REAR KITCHEN DOOR

[Source: Adderley 2013]

Problems – Text Analytics - Basics

- Tokenization: ‘U/K’

U_/_K or UK?

- Determining POS Tags
 - Lib A: 58% tagged (20 of 34)
 - Lib B: 41% tagged (14 of 34)

 - Lib A: 30% incorrect (6 of 20)
 - Lib B: 14% incorrect (2 of 14)

Sample Modus Operandi Text

U/K OFFENDERS SMASHED KITCHEN WINDOW AT REAR OF PREMISES AND ENTERED THROUGH SAME TIDY SEARCH OF DOWNSTAIRS REMOVED TELEVISION AND MADE EXIT THROUGH REAR KITCHEN DOOR

[Source: Adderley 2013]

Problems – Text Analytics – Higher Level

Named entity detection

Organization: REAR OF
Organization: REMOVED
Organization: TELEVISION
Name: MADE
Location: U/_/_K

Sample Modus Operandi Text

U/K OFFENDERS SMASHED KITCHEN
 WINDOW AT REAR OF PREMISES AND
 ENTERED THROUGH SAME TIDY SEARCH
 OF DOWNSTAIRS REMOVED TELEVISION
 AND MADE EXIT THROUGH REAR
 KITCHEN DOOR

[Source: Adderley 2013]

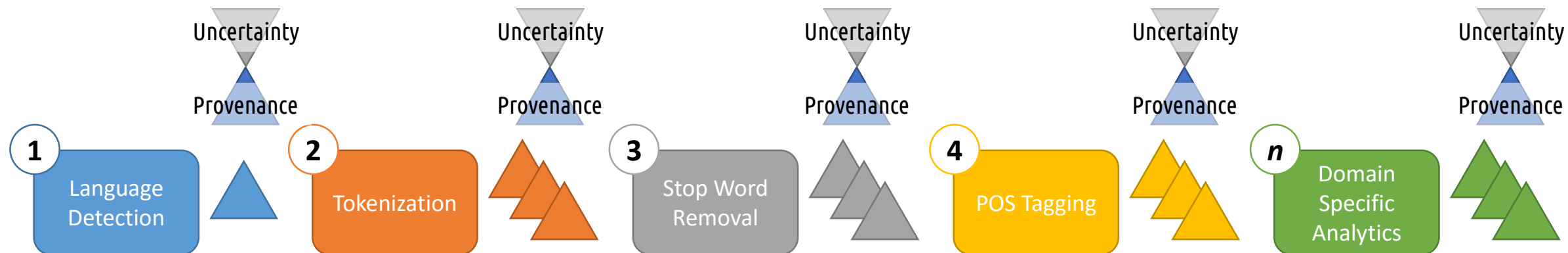
Text Processing Pipeline – “Real” Data

There are many different variants of analysis results!



[Picture: Anne Marie Peterson, <https://flic.kr/p/qhJBr2>]

Text Processing: Challenges for VAPD

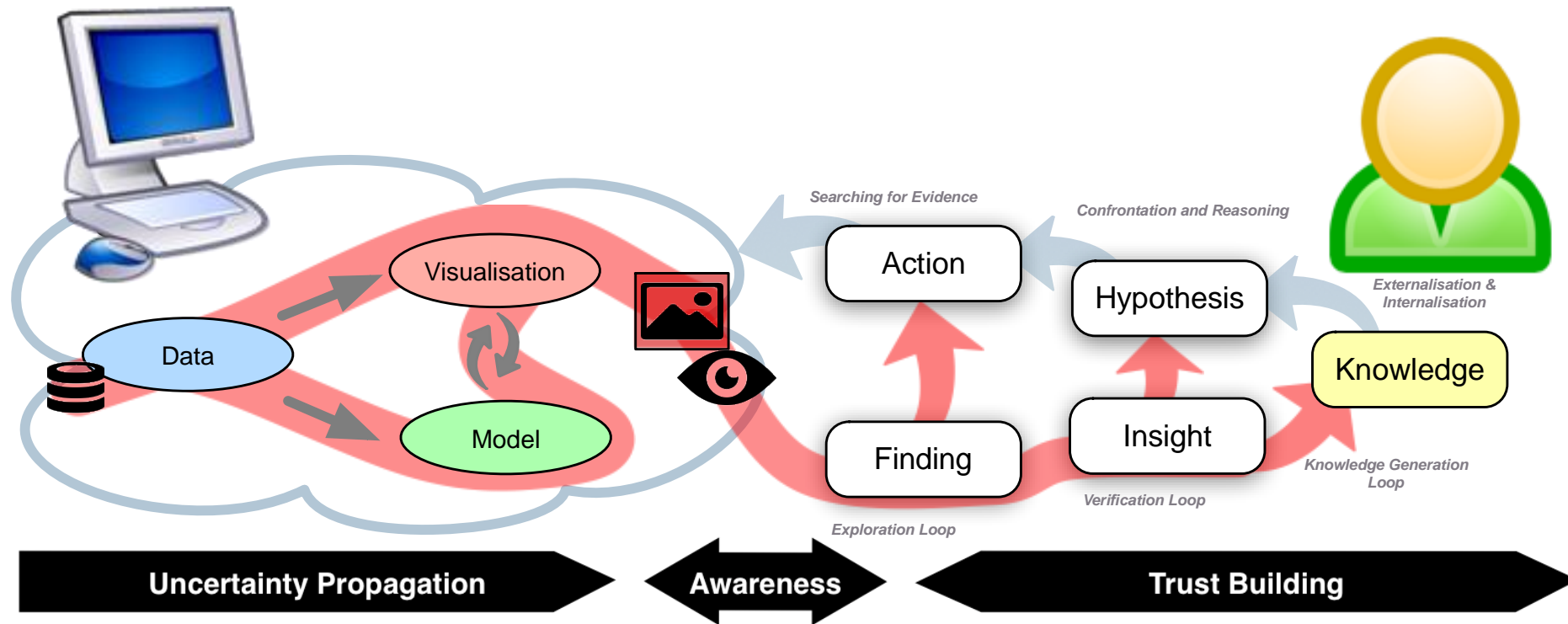


C1: Uncertainty quantification (C1.1) and propagation (C1.2) for each analysis step.

C2: Data provenance for each analysis step.

Uncertainty-enabled CCA

Part II – Raising Uncertainty Awareness and its Consequences



The Role of Uncertainty, Awareness, and Trust in Visual Analytics

Dominik Sacha, Hansi Senaratne, Bum Chul Kwon, *Member, IEEE*, Geoffrey Ellis, and Daniel A. Keim, *Member, IEEE*
 VAST 2015

Wednesday, October 28, 16:15-17:55, Room: Red

Guidelines for Handling Uncertainties – (More on Wednesday)

- **System**

- *G1: Quantify Uncertainty in Each Component*
- *G2: Propagate and Aggregate Uncertainties*
- *G3: Visualise Uncertainty Information*
- *G4: Enable Interactive Uncertainty Exploration*

Part I

Foundations

Part II

Exploring
Uncertainties

- **Human**

- *G5: Make the System Functions Accessible*
- *G6: Support the Analyst in Uncertainty Aware Sensemaking*
- *G7: Analyse Human Behaviour in order to Derive Hints on Problems*
- *G8: Enable Analysts to Track and Review their Analysis*

Human Issues -
Support Trust
Calibration

CCA Table View – Adding Uncertainty (Data Item Level)

Selected Crime

712	040XX W 16 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
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Similar Crimes

ID	Block	Primary Type	Description	Location
796	027XX W JACKSON BV	HOMICIDE	FIRST DEGREE MURDER	STREET
795	13XX S CENTRAL PARK AV	HOMICIDE	FIRST DEGREE MURDER	STREET
790	005XX N LECLAIRE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
789	028XX W HARRISON ST	HOMICIDE	FIRST DEGREE MURDER	STREET
785	013XX N KILDARE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
777	007XX N SPRINGFIELD AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
772	024XX N LAWNSDALE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
768	003XX E 63 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
759	016XX W NORTH AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
757	056XX S NORMAL AV	HOMICIDE	FIRST DEGREE MURDER	STREET
755	048XX W DEMING PL	HOMICIDE	FIRST DEGREE MURDER	STREET
753	001XX E 47 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
797	039XX S FEDERAL ST	HOMICIDE	FIRST DEGREE MURDER	STREET
730	034XX N HAMILTON AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
723	021XX S MARSHALL BLVD	HOMICIDE	FIRST DEGREE MURDER	STREET
721	031XX W 15 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
717	011XX N PARKSIDE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
713	041XX S ARTESIAN AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
712	040XX W 16 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
710	037XX S RHODES AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
706	024XX N LINDEN PL	HOMICIDE	FIRST DEGREE MURDER	STREET
701	007XX S KOSTNER AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
697	013XX W 48 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
692	047XX W NORTH AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
691	007XX N HAMLIN AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
684	030XX S KARLOV AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
677	078XX S SANGAMON ST	HOMICIDE	FIRST DEGREE MURDER	STREET

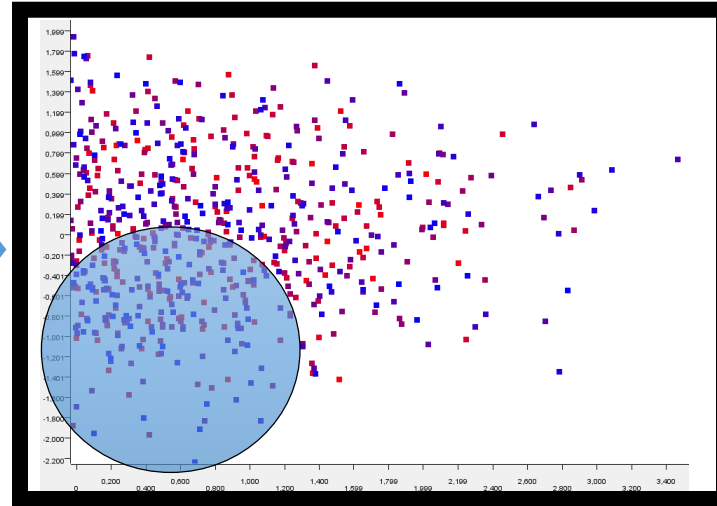
Uncertainty Exploration & Filtering



Explore Uncertainty Dimensions
Sensitivity Analysis
Weighting & Filtering

ID	Block	Primary type	Description	Location
796	027XX W JACKSON BV	HOMICIDE	FIRST DEGREE MURDER	STREET
795	13XX S CENTRAL PARK AV	HOMICIDE	FIRST DEGREE MURDER	STREET
790	005XX N LECLAIRE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
789	028XX W HARRISON ST	HOMICIDE	FIRST DEGREE MURDER	STREET
785	013XX N KILDARE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
777	007XX N SPRINGFIELD AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
772	024XX N LAWDALE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
768	003XX E 63 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
759	016XX W NORTH AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
757	056XX S NORMAL AV	HOMICIDE	FIRST DEGREE MURDER	STREET
755	048XX W DEMING PL	HOMICIDE	FIRST DEGREE MURDER	STREET
753	001XX E 47 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
797	039XX S FEDERAL ST	HOMICIDE	FIRST DEGREE MURDER	STREET
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721	031XX W 15 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
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713	041XX S ARTESIAN AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
712	040XX W 16 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
710	037XX S RHODES AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
706	024XX N LINDEN PL	HOMICIDE	FIRST DEGREE MURDER	STREET
701	007XX S KOSTNER AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
697	013XX W 48 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
692	047XX W NORTH AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
691	007XX N HAMLIN AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
684	030XX S KARLOV AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
677	078XX S SANGAMON ST	HOMICIDE	FIRST DEGREE MURDER	STREET

Crime Table



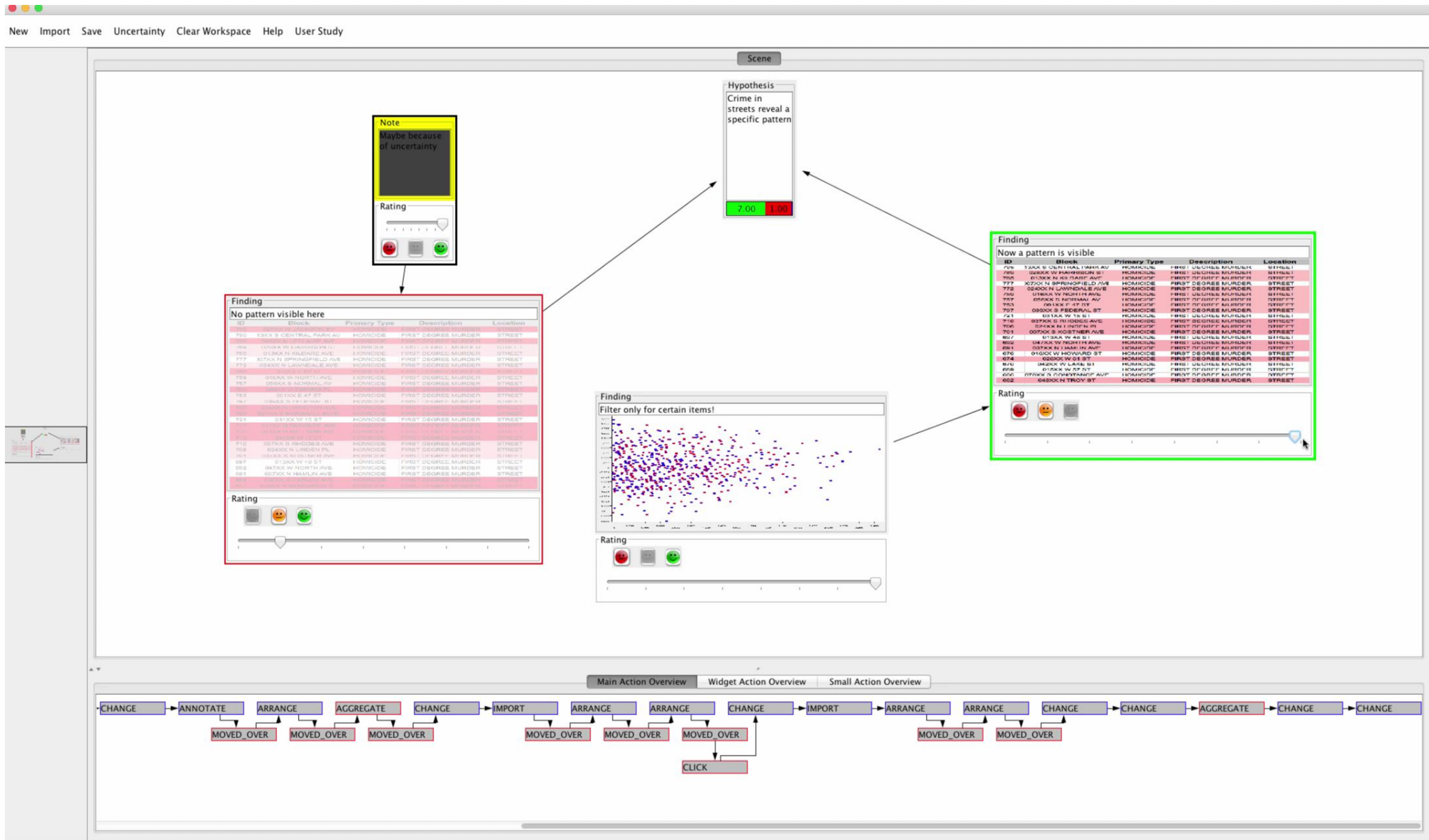
Uncertainty Exploration

ID	Block	Primary type	Description	Location
795	13XX S CENTRAL PARK AV	HOMICIDE	FIRST DEGREE MURDER	STREET
789	028XX W HARRISON ST	HOMICIDE	FIRST DEGREE MURDER	STREET
785	013XX N KILDARE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
777	007XX N SPRINGFIELD AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
772	024XX N LAWDALE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
759	016XX W NORTH AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
757	056XX S NORMAL AV	HOMICIDE	FIRST DEGREE MURDER	STREET
753	001XX E 47 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
797	039XX S FEDERAL ST	HOMICIDE	FIRST DEGREE MURDER	STREET
721	031XX W 15 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
710	037XX S RHODES AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
706	024XX N LINDEN PL	HOMICIDE	FIRST DEGREE MURDER	STREET
701	007XX S KOSTNER AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
697	013XX W 48 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
692	047XX W NORTH AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
691	007XX N HAMLIN AVE	HOMICIDE	FIRST DEGREE MURDER	STREET
676	016XX W HOWARD ST	HOMICIDE	FIRST DEGREE MURDER	STREET
674	025XX W 51 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
670	042XX W LAKE ST	HOMICIDE	FIRST DEGREE MURDER	STREET
669	015XX W 57 ST	HOMICIDE	FIRST DEGREE MURDER	STREET
666	078XX S CONSTANCE AVE	HOMICIDE	FIRST DEGREE MURDER	STREET

Filtered Crime Table

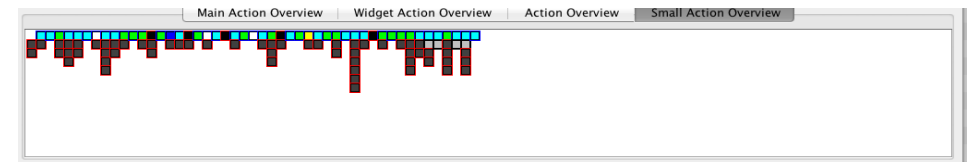
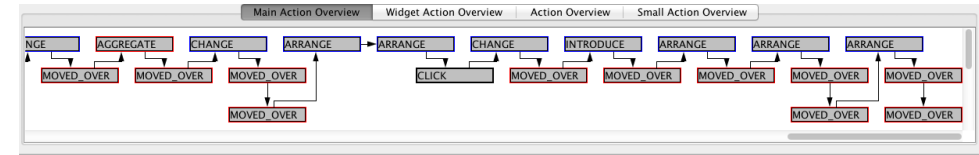
Analyze and Understand Uncertainties and its Impacts on the Data
"Back-Propagate" Changes

Reasoning Space - Uncertainty Aware Sensemaking



Analysing Human Behaviour – Interaction Capturing

- **VA-System/CCA-Table Interactions (Exploration)**
- **Uncertainty Exploration Interactions (Exploration)**
- **Reasoning Space Interactions (Verification)**
- **Widget/Element Interactions (Verification)**
- **Derived Measures**
 - Time (exploration vs. verification), switches, clicks, move overs/ “touches”, number of evidences, graph-complexity, etc...



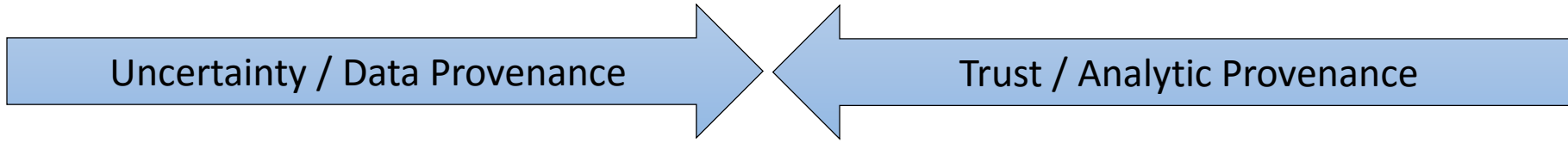
Summary & Future Work



Raising Uncertainty Awareness

Supporting CCA Analysis

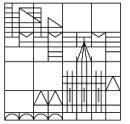
Human Issues – Trust Building



Develop/Create/Finalize a Prototype that can be Used by Crime Analysts

Lots of Challenges

- Combine, Integrate and Realize Ideas and Prototypes
- Uncertainty Quantification in NLP (Pipeline & Data Item Level)
- Uncertainty Aggregation and Interactive Exploration
- Visualizing and Communicating Uncertainties and Trust
- Inferring a Users Trust (from User Interaction & Observation)
- Bridging and Investigating Uncertainty and Trust Relations
 - Measure and Detect “Dangerous” Configurations
 - E.g., High Uncertainty and High Trust
 - Depends on Analysis Case
- ...



THANK YOU!

Questions?

For more information about our work please contact

Florian Stoffel

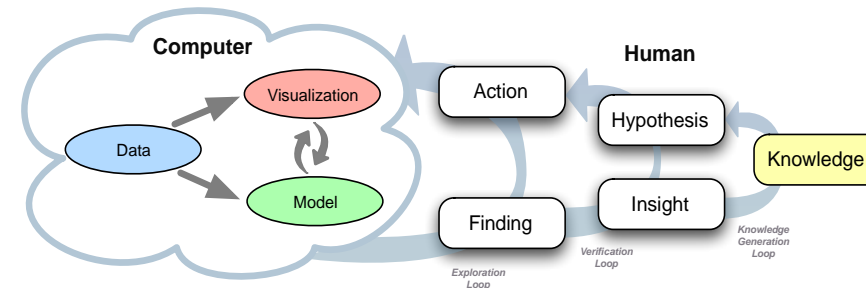
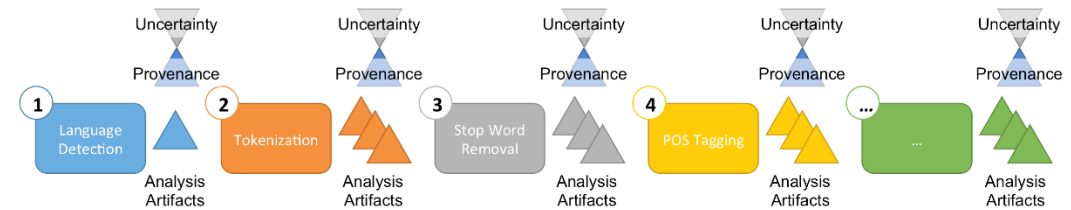
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- Adderley, Richard. “Exploring the differences between the cross industry process for data mining and the National Intelligence Model using a self organising map case study.” Business intelligence and performance management. Springer London, 2013. 91-105.
- National Policing Improvement Agency. “Practice Advice on Analysis.” Wyboston, 2008.

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