



Evaluating Visual Analytics Systems for Investigative Analysis: Deriving Design Principles from a Case Study

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Visual Analytics for Investigative Analysis

- Research focus on system building and techniques
- Challenges in evaluation

Related Work

- Utility evaluation for visual analytic tools (Bier et. al, 2008; Perer & Shneiderman, 2008)
- Qualitative study of intelligent analysis practices (Chin et. al, 2009; Robinson, 2008)
- Evaluation metrics and methodologies (Scholtz, 2006)



Goals

Can Visual Analytics assist investigative analysis

- How do people use systems?
- What characteristics matter?

Explore evaluation methods

- Utility evaluation
- What should we measure/observe?



Jigsaw

The screenshot displays the Jigsaw software interface, which is used for supporting investigative analysis through interactive visualization. The interface is divided into several panels:

- Top Left Panel:** Contains the application title "Jigsaw" and "StudyData" with "60 documents". It includes a "Color Legend" with categories: Person (red), Location (green), Organization (brown), Date (cyan), and Money (yellow). There is a search bar with the text "source" and a "Search" button. Checkboxes for "Entities" and "Documents" are also present.
- Top Middle Panel:** Titled "Document Cluster View", it shows a network of nodes and edges. Nodes are labeled with document IDs like "George W.: 2" and "colorado: 6".
- Top Right Panel:** Displays a text snippet: "Colorado driver found Georgia group identified known license person planned several source suspects their truck U-Haul U.S.". Below this, it shows "Source: Date: Oct 18, 2002" and "Source: doc_20021018_2 Date: Oct 18, 2002". A paragraph of text follows: "The driver's license provided by Arnold C. and Kamel J. to the truck rental agencies in Boulder, Colorado and Macon, Georgia are not authentic. The address shown on these licenses do not exist."
- Bottom Left Panel:** Titled "List View", it shows a list of entities under the "Person" category, including Arnold C., David W., George W., Harold W., Homer W., John H., Julio S., Kamel J., Muhammad J., and Ralph T. The "Date" category is also visible, showing a list of dates from 17 May to Wed Apr 10 2002.
- Bottom Right Panel:** A network graph showing connections between entities and documents. Nodes include "Kamel J.", "Arnold C.", "Colorado Boulder", "Macon", "Atlanta", "God's Aryan Militia", "George W.", "Ralph T.", "Georgia", "doc_20021015_1", "doc_20020715", "doc_20020415", "doc_20020810", "doc_20021018_2", "doc_20021018_2", "doc_20021026", "doc_20021027_1", and "doc_20021018_2".



J. Stasko, C. Görg, and Z. Liu. Jigsaw: supporting investigative analysis through interactive visualization. *Information Visualization*, 7(2):118–132, 2008. <http://www.cc.gatech.edu/gvu/ii/jigsaw>

Study Design

Task and dataset

- 50 simulated intelligence case reports
 - Each a few sentences long
 - 23 were relevant to plot
- Identify the threat & describe it in 90 minutes

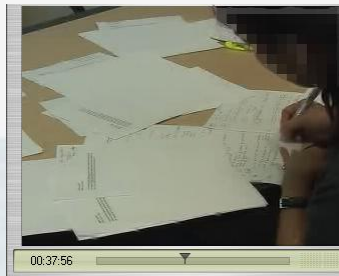
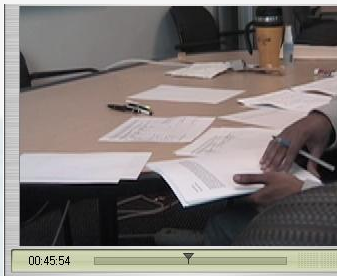
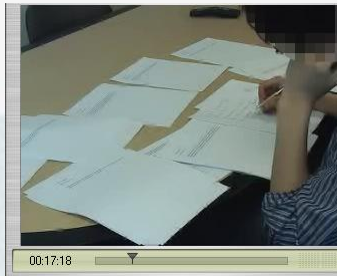
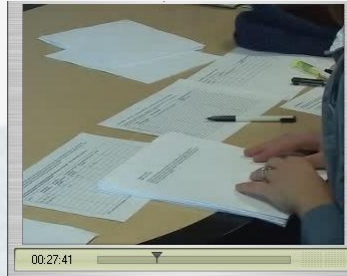
Source: doc017

Date: Oct 22, 2002

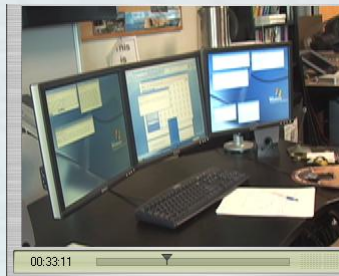
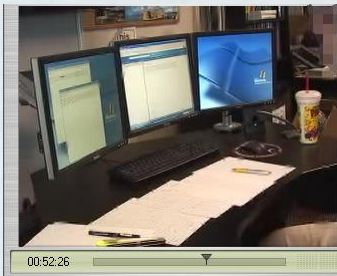
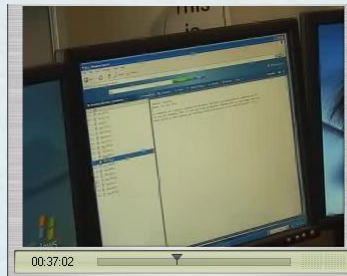
Abu H., who was released from custody after the September 11 incidents and whose fingerprints were found in the U-Haul truck rented by Arnold C. [see doc033] holds an Egyptian passport. He is now known to have spent six months in Afghanistan in the summer of 1999.

Study Design - Settings

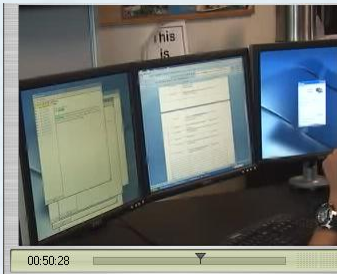
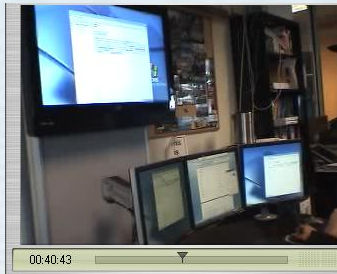
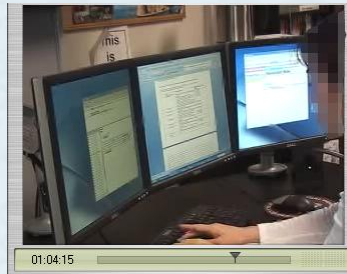
1: Paper



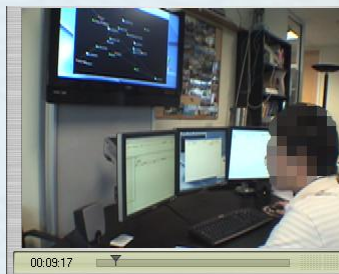
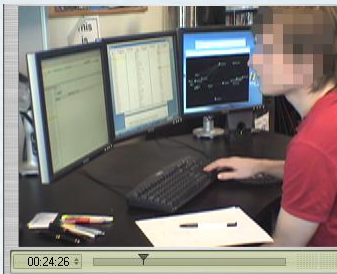
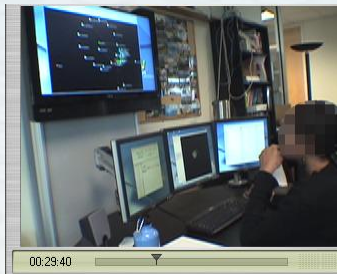
2: Desktop



3: Entity



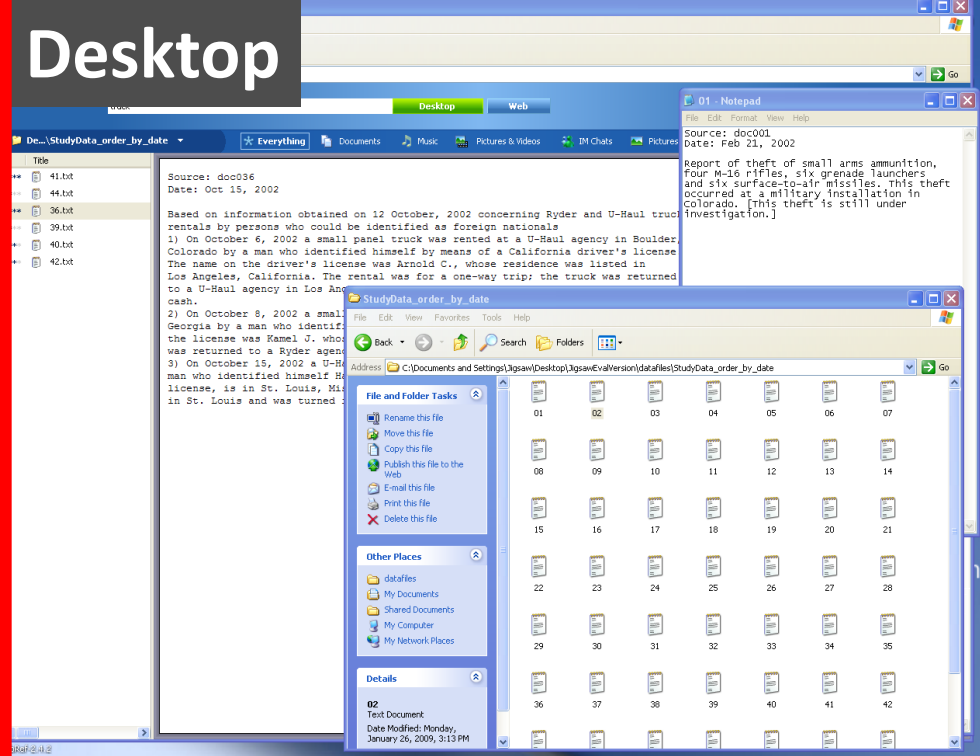
4: Jigsaw



Paper



Desktop



Entity

Source:
Date: Oct 15, 2002

Source: doc_20021015_1
Date: [Oct 15, 2002](#)

Based on information obtained on [12 October, 2002](#) concerning [Ryder](#) and [U-Haul](#) truck rental persons who could be identified as foreign nationals

1) On [October 6, 2002](#) a small panel truck was rented at a [U-Haul](#) agency in [Boulder, Colorado](#) who identified himself by means of a [California](#) driver's license. The name on the driver's license was [Arnold C.](#), whose residence was listed in [Los Angeles, California](#). The rental was for a one-way trip; the truck was returned to a [U-Haul](#) agency in [Los Angeles](#) on [9 October, 2002](#). Mr. C. paid for the cash.

2) On [October 8, 2002](#) a small panel truck was rented at a [Ryder](#) agency in [Macon, Georgia](#) by a man who identified himself by a [Minnesota](#) driver's license. The name on the license was [Kamel J.](#) whose address was listed in [St. Paul, Minnesota](#). This truck was returned to a [Ryder](#) agency in [St. Paul, Minnesota](#) on [10 October, 2002](#).

3) On [October 15, 2002](#) a [U-Haul](#) panel truck was rented in [Nashville, Tennessee](#) by a man who identified himself [Harold W.](#) whose address, given on his [Tennessee](#) driver's license, is in [St. Louis, Missouri](#). This truck was turned in to a [U-Haul](#) agency in [St. Louis](#) and was turned in on [17 October, 2002](#).

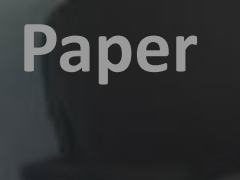
Jigsaw

Colorado driver found [Georgia](#) group identified known license person planned

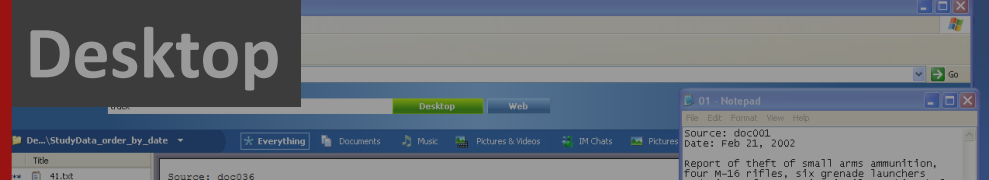
source suspects truck U-Haul U.S.

Source:
Date: Oct 18, 2002
Source: doc_20021018_2
Date: [Oct 18, 2002](#)

The driver's license provided by [Arnold C.](#) and [Kamel J.](#) to the truck rental agencies in [Boulder, Colorado](#) and [Macon, Georgia](#) are not authentic. The address shown on these licenses do not exist.



Paper



Desktop

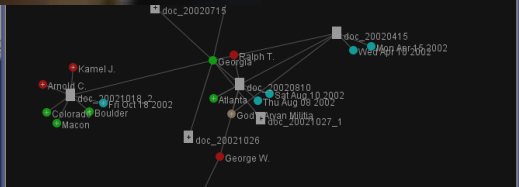


Paper

Entity

- 0 doc_20020617
- 0 doc_20020626
- 0 doc_20020703
- 0 doc_20020708
- 0 doc_20020715
- 0 doc_20020716
- 0 doc_20020723
- 0 doc_20020726
- 0 doc_20020729
- 0 doc_20020801
- 0 doc_20020808
- 0 doc_20020810
- 0 doc_20020820
- 0 doc_20020828
- 0 doc_20020906
- 0 doc_20020907
- 0 doc_20020913
- 0 doc_20020914
- 0 doc_20020915
- 0 doc_20020915
- 0 doc_20020920_1
- 0 doc_20020920_2
- 0 doc_20020928
- 0 doc_20021001
- 2 doc_20021015...
- 1 doc_20021015_2

| | |
|-------------|-----------------|
| Kamel J. | Mon Jul 15 2002 |
| Muhammad J. | Sat Aug 10 2002 |
| Rafiq T. | Sat Oct 12 2002 |
| | Sat Oct 26 2002 |
| | Sun Oct 06 2002 |
| | Sun Oct 27 2002 |
| | Sun Sep 15 2002 |
| | Sun Oct 08 2002 |
| | Thu Oct 17 2002 |
| | Thu Oct 24 2002 |
| | Tue Aug 20 2002 |
| | Tue Jul 16 2002 |
| | Tue Oct 08 2002 |
| | Tue Oct 15 2002 |
| | Tue Oct 15 2002 |
| | Wed Apr 10 2002 |



01 - Notepad

File Edit Format View Help

Source: doc001
Date: Feb 21, 2002

Report of theft of small arms ammunition, four M-16 rifles, six grenade launchers and six surface-to-air missiles. This theft occurred at a military installation in [redacted]. [This theft is still under investigation.]

Georgia group identified known license person planned

suspects their truck U-Haul U.S.

provided by Arnold C. and Kamel J. to the trucker Colorado and Macon, Georgia are not shown on these licenses do not exist.

Paper

Desktop

Desktop

Windows Search Results

truck

Desktop Web

De...\StudyData_order_by_date

| Title |
|------------|
| *** 41.txt |
| *** 44.txt |
| *** 36.txt |
| *** 39.txt |
| *** 40.txt |
| *** 42.txt |

Source: doc036
Date: Oct 15, 2002

Based on information obtained on 12 October, 2002 concerning Ryder and U-Haul truck rentals by persons who could be identified as foreign nationals

1) On October 6, 2002 a small panel truck was rented at a U-Haul agency in Boulder, Colorado by a man who identified himself by means of a California driver's license. The name on the driver's license was Arnold C., whose residence was listed in Los Angeles, California. The rental was for a one-way trip; the truck was returned to a U-Haul agency in Los Angeles, California.

2) On October 8, 2002 a small panel truck was rented at a U-Haul agency in Georgia by a man who identified himself by means of a Georgia driver's license. The license was Kamel J. who was returned to a Ryder agency in Atlanta, Georgia.

3) On October 15, 2002 a U-Haul truck was rented at a U-Haul agency in St. Louis, Missouri by a man who identified himself by means of a Missouri driver's license, is in St. Louis, Missouri. The rental was for a one-way trip; the truck was returned to a U-Haul agency in St. Louis and was turned over to a Ryder agency in St. Louis.

StudyData_order_by_date

File Edit View Favorites Tools Help

Back Forward Stop Search Folders

Address C:\Documents and Settings\jigsaw\Desktop\jigsawEval\Version\datafiles\StudyData_order_by_date

File and Folder Tasks

- Rename this file
- Move this file
- Copy this file
- Publish this file to the Web
- E-mail this file
- Print this file
- Delete this file

Other Places

- datafiles
- My Documents
- Shared Documents
- My Computer
- My Network Places

Details

02
Text Document
Date Modified: Monday, January 26, 2009, 3:13 PM

Source: doc001
Date: Feb 21, 2002

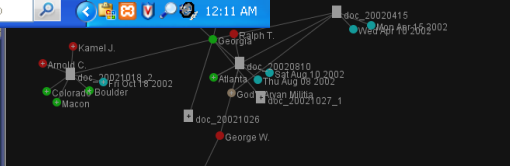
Report of theft of small arms ammunition, four M-16 rifles, six grenade launchers and six surface-to-air missiles. This theft occurred at a military installation in Colorado. [This theft is still under investigation.]

01 02 03 04 05 06 07
08 09 10 11 12 13 14
15 16 17 18 19 20 21
22 23 24 25 26 27 28
29 30 31 32 33 34 35
36 37 38 39 40 41 42

Start XAMPP Control P... StudyData_orde... truck - Windows ... Microsoft Power... 01 - Notepad 02 - Notepad Search Desktop 12:11 AM

Entity

- 0 doc_20020617
 - 0 doc_20020626
 - 0 doc_20020703
 - 0 doc_20020708
 - 0 doc_20020715
 - 0 doc_20020716
 - 0 doc_20020723
 - 0 doc_20020726
 - 0 doc_20020729
 - 0 doc_20020801
 - 0 doc_20020808
 - 0 doc_20020810
 - 0 doc_20020820
 - 0 doc_20020828
 - 0 doc_20020906
 - 0 doc_20020907
 - 0 doc_20020913
 - 0 doc_20020914
 - 0 doc_20020915
 - 0 doc_20020920_1
 - 0 doc_20020920_2
 - 0 doc_20020928
 - 0 doc_20021001
 - 2 doc_20021015...
 - 1 doc_20021015_2
- Add all



Paper

Desktop

Entity

- 0 doc_20020017
- 0 doc_20020626
- 0 doc_20020703
- 0 doc_20020708
- 0 doc_20020715
- 0 doc_20020716
- 0 doc_20020723
- 0 doc_20020726
- 0 doc_20020729
- 0 doc_20020801
- 0 doc_20020808
- 0 doc_20020810
- 0 doc_20020820
- 0 doc_20020828
- 0 doc_20020906
- 0 doc_20020907
- 0 doc_20020913
- 0 doc_20020914
- 0 doc_20020915
- 0 doc_20020920_1
- 0 doc_20020920_2
- 0 doc_20020928
- 0 doc_20021001
- 2 doc_20021015...**
- 1 doc_20021015_2

Add all

Source:
Date: Oct 15, 2002

Source: doc_20021015_1
 Date: Oct 15, 2002

Based on information obtained on 12 October, 2002 concerning Ryder and U-Haul truck rental agencies in Colorado and Georgia and persons who could be identified as foreign nationals

- 1) On October 6, 2002 a small panel truck was rented at a U-Haul agency in Boulder, Colorado, who identified himself by means of a California driver's license. The name on the driver's license was Arnold C., whose residence was listed in Los Angeles, California. The rental was for a small panel truck which was returned to a U-Haul agency in Los Angeles on 9 October, 2002. Mr. C. paid for the rental in cash.
- 2) On October 8, 2002 a small panel truck was rented at a Ryder agency in Macon, Georgia who identified himself by a Minnesota driver's license. The name on the license was Kamel J. whose address was listed in St. Paul, Minnesota. This truck was returned to a Ryder agency in Atlanta, Georgia on October, 2002.
- 3) On October 15, 2002 a U-Haul panel truck was rented in Nashville, Tennessee by a person who identified himself Harold W. whose address, given on his Tennessee driver's license, is in St. Louis, Missouri. This truck was to turned in to a U-Haul agency in St. Louis and was turned in on 17 October, 2002.

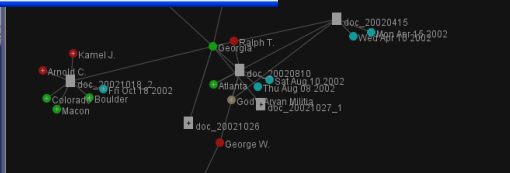
Entity

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- 0 doc_20020626
- 0 doc_20020703
- 0 doc_20020708
- 0 doc_20020715
- 0 doc_20020716
- 0 doc_20020723
- 0 doc_20020726
- 0 doc_20020729
- 0 doc_20020801
- 0 doc_20020808
- 0 doc_20020810
- 0 doc_20020820
- 0 doc_20020828
- 0 doc_20020906
- 0 doc_20020907
- 0 doc_20020913
- 0 doc_20020914
- 0 doc_20020915
- 0 doc_20020920_1
- 0 doc_20020920_2
- 0 doc_20020928
- 0 doc_20021001
- 2 doc_20021015...**
- 1 doc_20021015_2

Add all

Manimad J.
 Rahn T.

- Sat Aug 10 2002
- Sat Oct 12 2002
- Sat Oct 26 2002
- Sun Oct 06 2002
- Sun Oct 27 2002
- Sun Sep 15 2002
- Thu Aug 08 2002
- Thu Oct 17 2002
- Thu Oct 24 2002
- Tue Aug 20 2002
- Tue Jul 16 2002
- Tue Oct 08 2002
- Tue Oct 15 2002
- Tue Oct 15 2002
- Wed Apr 10 2002



Paper

Desktop

Jigsaw

StudyData
50 documents

- Color Legend:
- Person
 - Location
 - Organization
 - Date
 - Money

source

Entities Documents

Workspace: no active workspace

List View

Edit View Bookmarks Lists Options

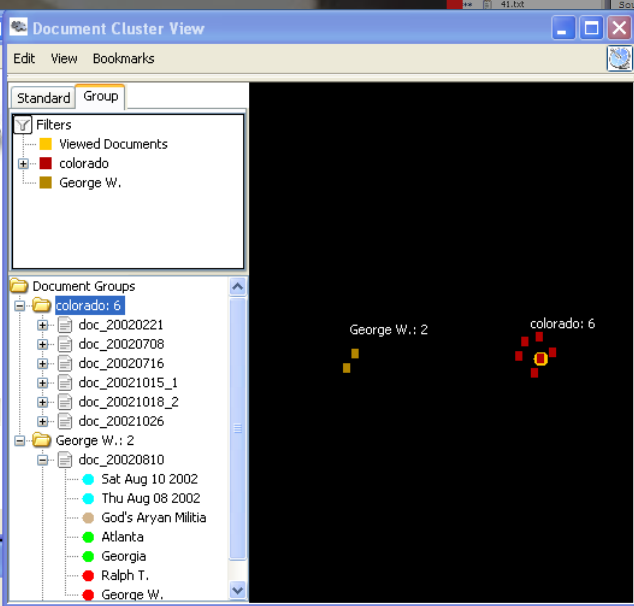
Person Add all Clear Show all connections

Date Add all Clear

- Arnold C.
- David W.
- George W.
- Harold W.
- Homer W.
- John H.
- Julio S.
- Kamel J.
- Muhammad J.
- Ralph T.

0 doc_2002101... Add all

- 17 May
- Fri Jul 12 2002
- Fri Oct 11 2002
- Fri Oct 18 2002
- Mon Apr 15 2002
- Mon Jul 01 2002
- Mon Jul 08 2002
- Mon Jul 15 2002
- Sat Aug 10 2002
- Sat Oct 12 2002
- Sat Oct 26 2002
- Sun Oct 06 2002
- Sun Oct 27 2002
- Sun Sep 15 2002
- Thu Aug 08 2002
- Thu Oct 17 2002
- Thu Oct 24 2002
- Tue Aug 20 2002
- Tue Jul 16 2002
- Tue Oct 08 2002
- Tue Oct 15 2002
- Tue Oct 15 2002
- Wed Apr 10 2002



Colorado driver found Georgia group identified known license person planned

several source suspects theft truck U-Haul U.S.

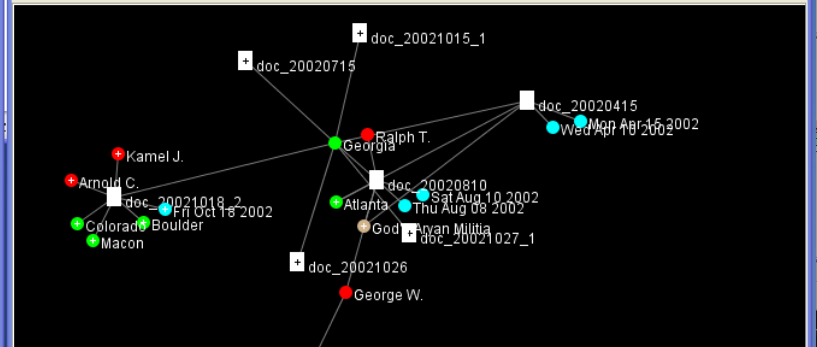
Source:
Date: Oct 18, 2002

Source: doc_20021018_2
Date: Oct 18, 2002

The driver's license provided by Arnold C. and Kamel J. to the truck rental agencies in Boulder, Colorado and Macon, Georgia are not authentic. The address shown on these licenses do not exist.

Edit View Bookmarks Filter Entities Options

Circular Layout Pan&Zoom to fit



Entit

- 0 doc_2002061
- 0 doc_2002062
- 0 doc_2002070
- 0 doc_2002070
- 0 doc_2002071
- 0 doc_2002071
- 0 doc_2002072
- 0 doc_2002072
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- 0 doc_2002081
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- 0 doc_2002090
- 0 doc_2002091
- 0 doc_2002091
- 0 doc_20020915
- 0 doc_20020920_1
- 0 doc_20020920_2
- 0 doc_20020928
- 0 doc_20021001
- 2 doc_20021015...
- 1 doc_20021015_2

01 - Notepad

Source: doc001
Date: Feb 21, 2002

Report of theft of small arms ammunition, four M-16 rifles, six grenade launchers, two-to-air missiles. This theft occurred at a military installation in Georgia. The theft is still under investigation.

Identified known license person planned

ts theft truck U-Haul U.S.

Arnold C. and Kamel J. to the truck rental agencies in Boulder, Colorado and Macon, Georgia are not authentic. The address shown on these licenses do not exist.

Performance Measures

- Task sheets (like VAST Contest)
 - Three components (relevant people, events, locations)
 - +1 for correct items, -1 for a misidentified items
- Summary narrative
 - Subjective grading from 1 (low) to 7 (high)

Two external raters

Normalized, each part equal, mapped to 100-point scale



Results

| | Paper | | | | Desktop | | | | Entity | | | | Jigsaw | | | |
|-------------------|-------|-----------|-------|-----------|-----------|-----------|-------|-------|--------|-------|-------|-----------|-----------|-------|-----------|-----------|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 |
| Final Score | 22.87 | 65.00 | 24.26 | 87.08 | 62.08 | 67.13 | 42.13 | 29.41 | 52.23 | 15.00 | 29.26 | 81.19 | 95.05 | 58.07 | 75.20 | 90.00 |
| Performance | Fair | Very good | Fair | Excellent | Very good | Very good | Good | Fair | Good | Poor | Fair | Excellent | Excellent | Good | Very good | Excellent |
| Average Score | 49.80 | | | | 50.19 | | | | 44.42 | | | | 79.59 | | | |
| Documents Viewed | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 49 | 31 | 45 | 50 | 31 | 50 | 46 | 23 |
| # of Queries | | | | | 19 | 18 | 48 | 8 | 23 | 61 | 59 | 91 | 44 | 4 | 26 | 8 |
| First Query | | | | | 40:49 | 19:55 | 2:47 | 12:41 | 1:31 | 0:29 | 0:59 | 3:12 | 0:18 | 5:35 | 25:37 | 4:18 |
| Amount of Notes | Many | None | Many | Some | Many | Some | Few | Some | Some | None | None | Few | Some | Few | Few | Few |
| First Note Taking | 0:07 | | 0:05 | 0:16 | 1:53 | 19:57 | 2:47 | 8:20 | 2:37 | | | 3:14 | 0:48 | 0:32 | 5:15 | 78:45 |
| First Task Sheet | 43:20 | 32:53 | 70:13 | 3:25 | 61:35 | 20:26 | 7:33 | 64:11 | 28:09 | 0:52 | 2:55 | 7:20 | 48:26 | 41:48 | 43:00 | 5:33 |



Results

| | Paper | | | | Desktop | | | | Entity | | | | Jigsaw | | | |
|-------------------|-------|-----------|-------|-----------|-----------|-----------|-------|-------|--------|-------|-------|-----------|-----------|-------|-----------|-----------|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 |
| Final Score | 22.87 | 65.00 | 24.26 | 87.08 | 62.08 | 67.13 | 42.13 | 29.41 | 52.23 | 15.00 | 29.26 | 81.19 | 95.05 | 58.07 | 75.20 | 90.00 |
| Performance | Fair | Very good | Fair | Excellent | Very good | Very good | Good | Fair | Good | Poor | Fair | Excellent | Excellent | Good | Very good | Excellent |
| Average Score | 49.80 | | | | 50.19 | | | | 44.42 | | | | 79.59 | | | |
| Documents Viewed | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 49 | 31 | 45 | 50 | 31 | 50 | 46 | 23 |
| # of Queries | | | | | 19 | 18 | 48 | 8 | 23 | 61 | 59 | 91 | 44 | 4 | 26 | 8 |
| First Query | | | | | 40:49 | 19:55 | 2:47 | 12:41 | 1:31 | 0:29 | 0:59 | 3:12 | 0:18 | 5:35 | 25:37 | 4:18 |
| Amount of Notes | Many | None | Many | Some | Many | Some | Few | Some | Some | None | None | Few | Some | Few | Few | Few |
| First Note Taking | 0:07 | | 0:05 | 0:16 | 1:53 | 19:57 | 2:47 | 8:20 | 2:37 | | | 3:14 | 0:48 | 0:32 | 5:15 | 78:45 |
| First Task Sheet | 43:20 | 32:53 | 70:13 | 3:25 | 61:35 | 20:26 | 7:33 | 64:11 | 28:09 | 0:52 | 2:55 | 7:20 | 48:26 | 41:48 | 43:00 | 5:33 |



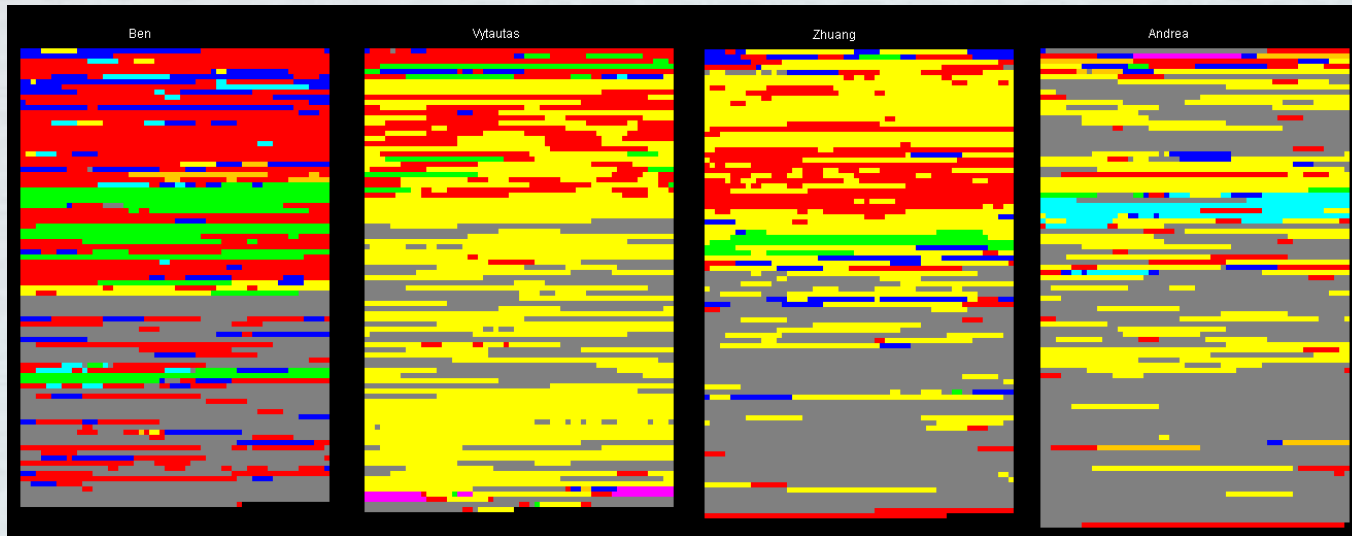
Jigsaw Usage Patterns

P13

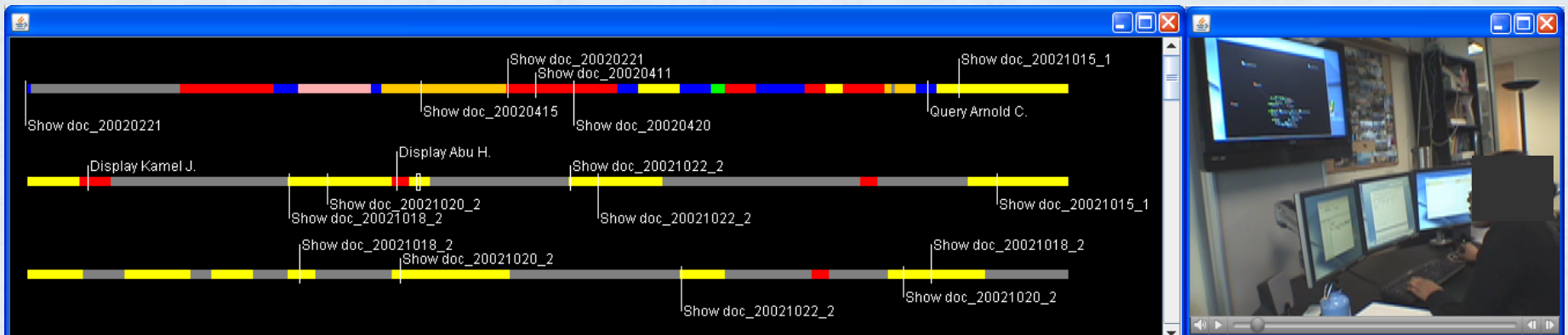
P14

P15

P16



- Main View
- Document View
- List View
- Graph View
- Calendar View
- Document Cluster View
- Timeline View
- Task Sheet



Investigative Analysis Strategies

1. Overview, filter and detail (OFD)
2. Build from detail (BFD)
3. Hit the keyword (HTK)
4. Find a clue, follow the trail (FCFT)

P16: *“I like this people-first approach. Once I identify key people, then things that are potentially important come up, too. I’m an impatient person and don’t want to read all documents chronologically.”*



Results by Strategy

| | Paper | | | | Desktop | | | | Entity | | | | Jigsaw | | | |
|------------------|-------|-----------|------|-----------|-----------|-----------|------|------|--------|------|------|-----------|-----------|------|-----------|-----------|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 |
| Strategy Used | OFD | OFD | BFD | OFD | OFD | OFD | FCFT | BFD | BFD | HTK | HTK | FCFT | FCFT | HTK | OFD | FCFT |
| Performance | Fair | Very good | Fair | Excellent | Very good | Very good | Good | Fair | Good | Poor | Fair | Excellent | Excellent | Good | Very good | Excellent |
| Documents Viewed | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 49 | 31 | 45 | 50 | 31 | 50 | 46 | 23 |

Results by Strategy

| | Paper | | | | Desktop | | | | Entity | | | | Jigsaw | | | |
|------------------|-------|-----------|------|-----------|-----------|-----------|------|------|--------|------|------|-----------|-----------|------|-----------|-----------|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 |
| Strategy Used | OFD | OFD | BFD | OFD | OFD | OFD | FCFT | BFD | BFD | HTK | HTK | FCFT | FCFT | HTK | OFD | FCFT |
| Performance | Fair | Very good | Fair | Excellent | Very good | Very good | Good | Fair | Good | Poor | Fair | Excellent | Excellent | Good | Very good | Excellent |
| Documents Viewed | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 49 | 31 | 45 | 50 | 31 | 50 | 46 | 23 |

Results by Strategy

| | Paper | | | | Desktop | | | | Entity | | | | Jigsaw | | | |
|------------------|-------|-----------|------|-----------|-----------|-----------|------|------|--------|------|------|-----------|-----------|------|-----------|-----------|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 |
| Strategy Used | OFD | OFD | BFD | OFD | OFD | OFD | FCFT | BFD | BFD | HTK | HTK | FCFT | FCFT | HTK | OFD | FCFT |
| Performance | Fair | Very good | Fair | Excellent | Very good | Very good | Good | Fair | Good | Poor | Fair | Excellent | Excellent | Good | Very good | Excellent |
| Documents Viewed | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 49 | 31 | 45 | 50 | 31 | 50 | 46 | 23 |

Results by Strategy

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|------------------|-------|-----------|------|-----------|-----------|-----------|------|------|--------|------|------|-----------|-----------|------|-----------|-----------|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 |
| Strategy Used | OFD | OFD | BFD | OFD | OFD | OFD | FCFT | BFD | BFD | HTK | HTK | FCFT | FCFT | HTK | OFD | FCFT |
| Performance | Fair | Very good | Fair | Excellent | Very good | Very good | Good | Fair | Good | Poor | Fair | Excellent | Excellent | Good | Very good | Excellent |
| Documents Viewed | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 49 | 31 | 45 | 50 | 31 | 50 | 46 | 23 |

Results by Strategy

| | Paper | | | | Desktop | | | | Entity | | | | Jigsaw | | | |
|------------------|-------|-----------|------|-----------|-----------|-----------|------|------|--------|------|------|-----------|-----------|------|-----------|-----------|
| | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 | P13 | P14 | P15 | P16 |
| Strategy Used | OFD | OFD | BFD | OFD | OFD | OFD | FCFT | BFD | BFD | HTK | HTK | FCFT | FCFT | HTK | OFD | FCFT |
| Performance | Fair | Very good | Fair | Excellent | Very good | Very good | Good | Fair | Good | Poor | Fair | Excellent | Excellent | Good | Very good | Excellent |
| Documents Viewed | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 49 | 31 | 45 | 50 | 31 | 50 | 46 | 23 |

Observations on Sensemaking

Diversity in the process

- In relation to Card & Pirolli's Think Loop Model of Sensemaking

Power of schematizing

P12: There were a couple of themes that kept popping up. And so I think I was more mentally taking notes about those and then once I started feeling there were too many references and things got intertwined in my head, I started using these task sheets to drop them down and organizing.

Insight acquisition



Design Implications for IA Tools

- Support finding starting points/clues
- Guide the analyst to follow the right trail
- Support different strategies of SM process
- Support smooth transition between SM stages
- Provide a workspace
- Allow flexibility in organizing
- Support to find next steps when dead-end
- Facilitate further exploration



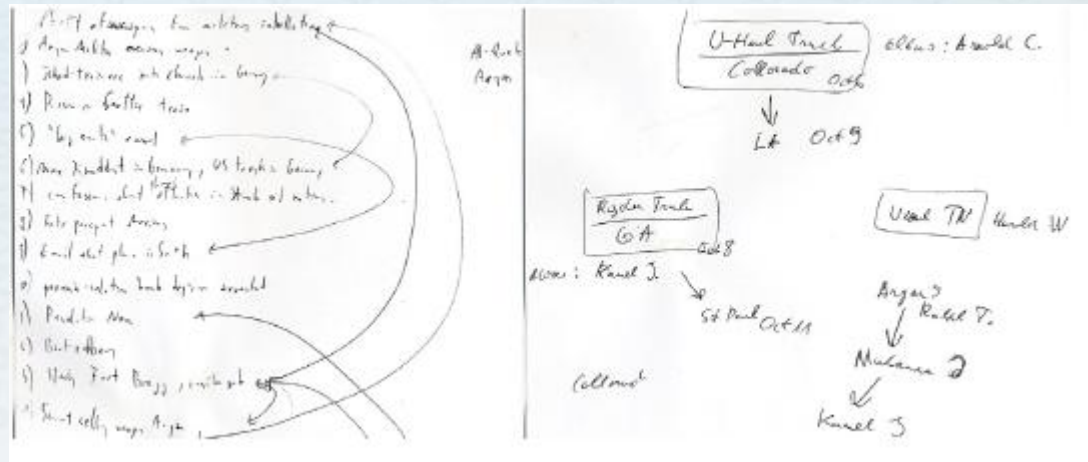
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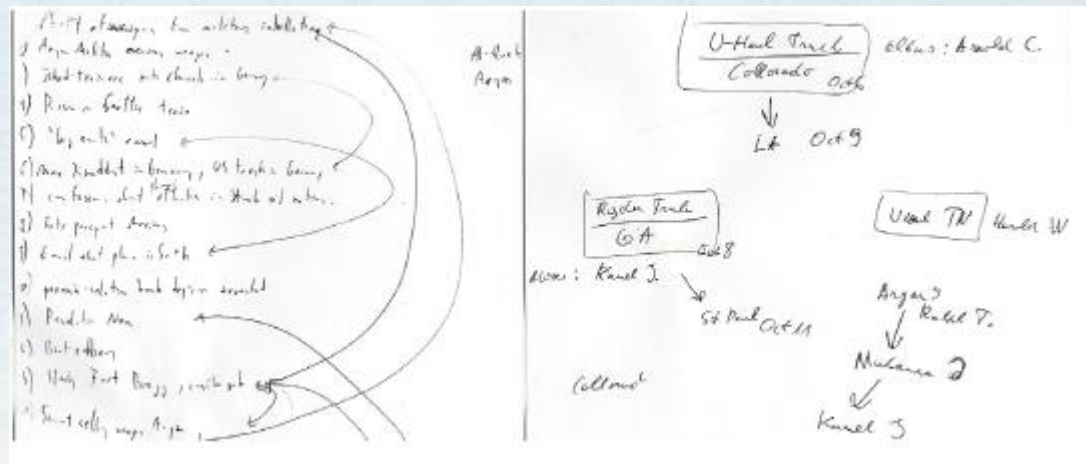
Jigsaw's Influence

- Supporting different strategies
- Showing connections between entities
- Helping users find the right clue
- Helping users focus on essential information
- Reviewing hypotheses
- Increasing motivation



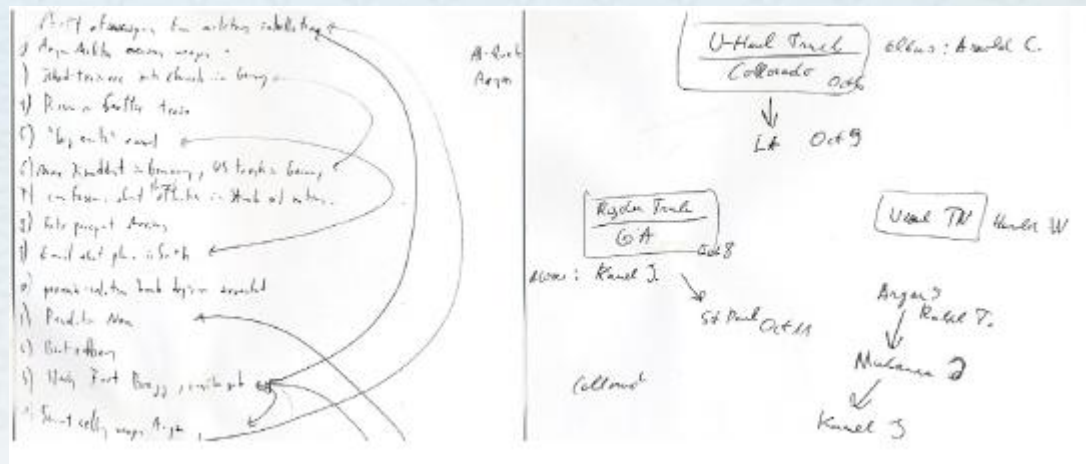
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Evaluation Implications for IA tools

- Compare system usage to traditional methods
- Collect qualitative data, support with quantitative data
- Consider questions to be answered
- Possible metrics
 - Number of documents viewed
 - When note-taking initiated
 - The quantity of representations created
 - Amount of time and effort in organizing
 - Time spent in reading/processing relevant information

Conclusion

Contribution

- Provides an experimental design and methodology
- Explains how visualization added analytic benefit
- Describes four analytic strategies employed
- Identifies design suggestions and capabilities
- Suggests evaluation metrics and qualitative factors

Future work

- Study with domain experts



Acknowledgements

- The National Visualization and Analytics Center (NVACTM), a U.S. Department of Homeland Security Program, under the auspices of the Southeast Regional Visualization and Analytics Center
- National Science Foundation under awards IIS-0915788 and CCF-0808863 (FODAVA lead)



Study Limitations

- Student analysts
- Small sample size
- Other systems not compared
- Small document collection
- Lack of experience and training
- Only a targeting scenario

Task Sheets

1. WHO: who are the players engaging in questionable activities in the plot(s)? When appropriate, specify the association/organization they are associated with...



| Name | Associated organization | Involved in illegal activities? (Yes/No) | Involved in terrorist activities? (Yes/No) | Most relevant source files (5 MAX) | Notes |
|-----------------|-------------------------|--|--|------------------------------------|-------|
| e.g. John doe | | Yes | Yes | FBI_1, FBI_2 | |
| e.g. Mary Smith | | Yes | No | | |
| | | | | | |
| | | | | | |

2. WHEN /WHAT: What events occurred during this time frame that are most relevant to the plot(s)?

Provide a text list of events following the sample layout. Use short description (i.e. one or 2 lines per event).
Provide what you think is the best subset of events (20 events MAX).



| | Date (Can be a range) | Event description | Most relevance source files (5 Max) |
|----|-----------------------|--|-------------------------------------|
| 1. | e.g. 11/4/1789 | e.g. Citizens take control of the Bastille | CIA_4, Image 2 |
| 2. | | | |
| 3. | | | |
| 4. | | | |