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Applied Research Laboratory: Visualization, Information and Imaging Programs

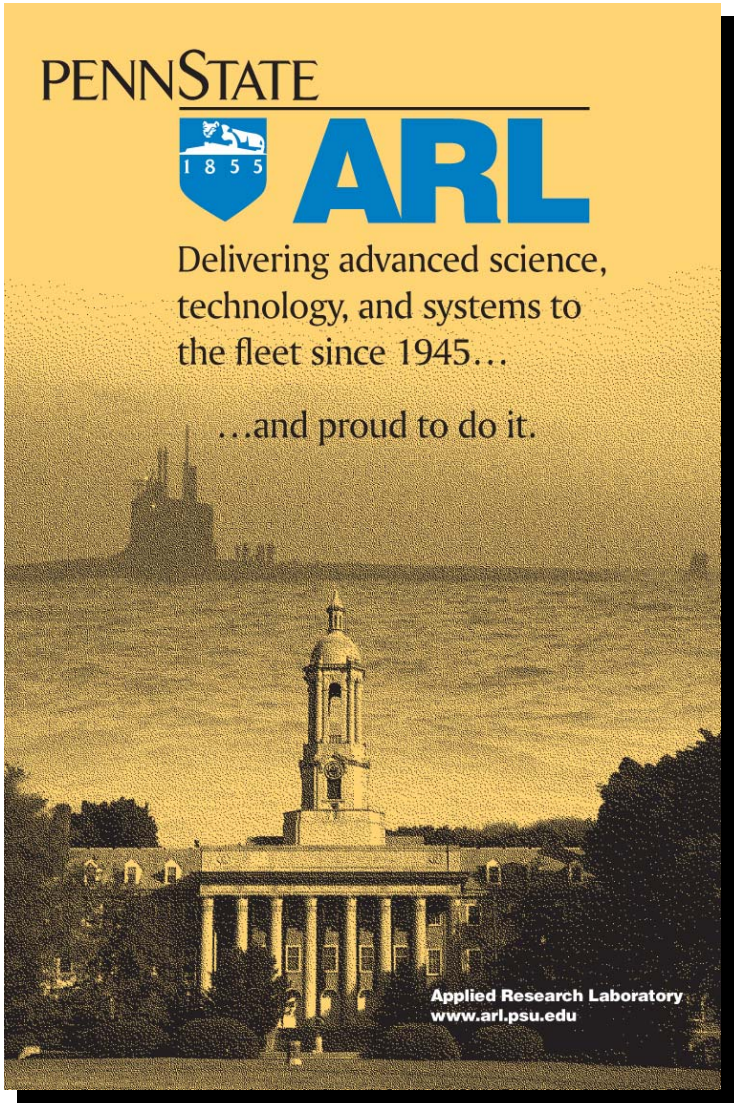
Dr. Christopher Griffin

Applied Research Laboratory

Penn State University

Applied Research Laboratory

- DoD Designated UARC



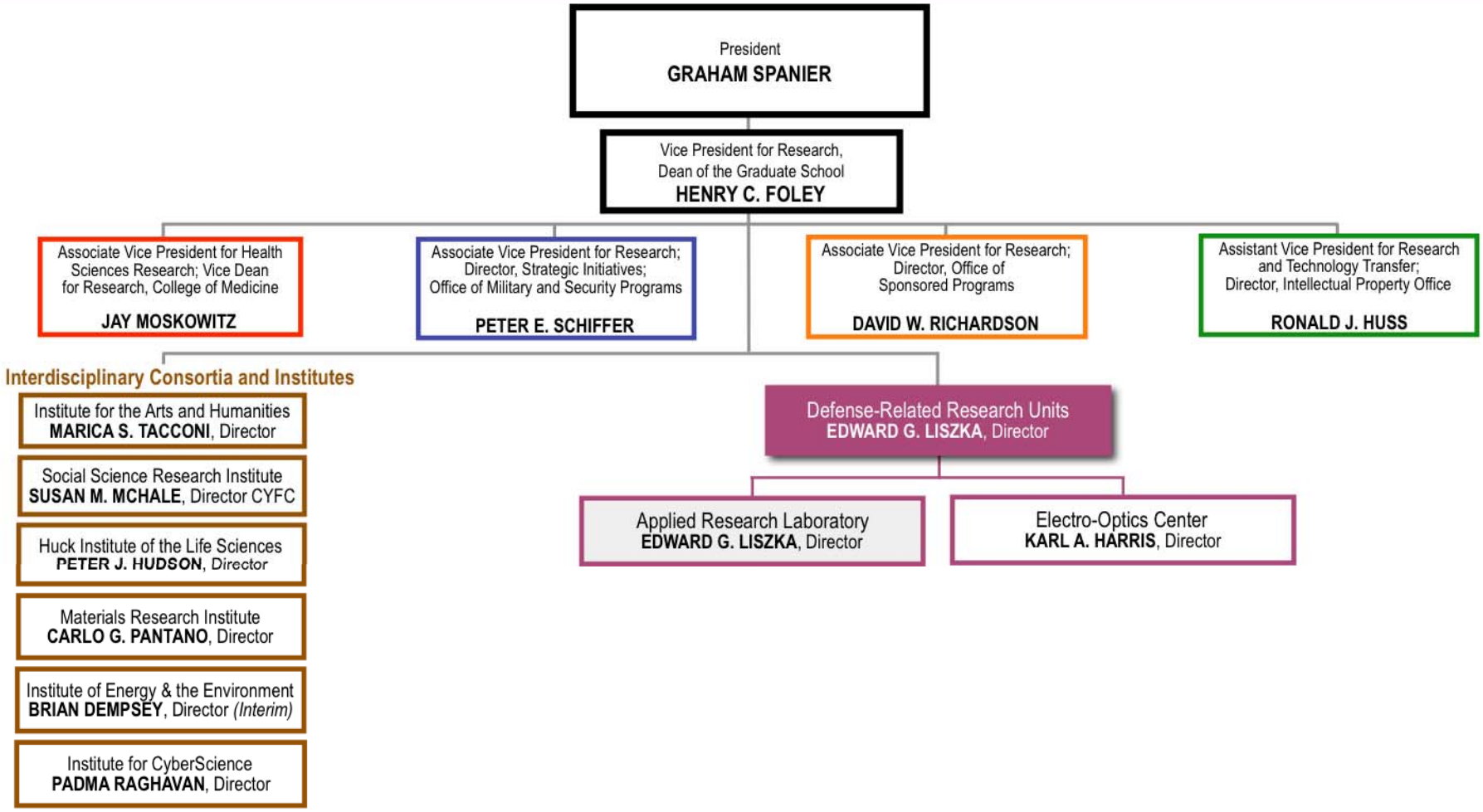
As a DoD designated University-Affiliated Research Center (UARC) ARL Penn State…

- **"…maintains a special long-term strategic relationship with Navy and DoD."**
- We have the freedom to partner with multiple organizations in responding to BAA's or other government calls.
- We can act as a trusted agent of the government.

ARL also maintains special relationships with the Intelligence Community

- ARL maintains 12,000 square feet of SCIF space.
- Classified computing networks
- Classified phone networks

How ARL Fits into the University?



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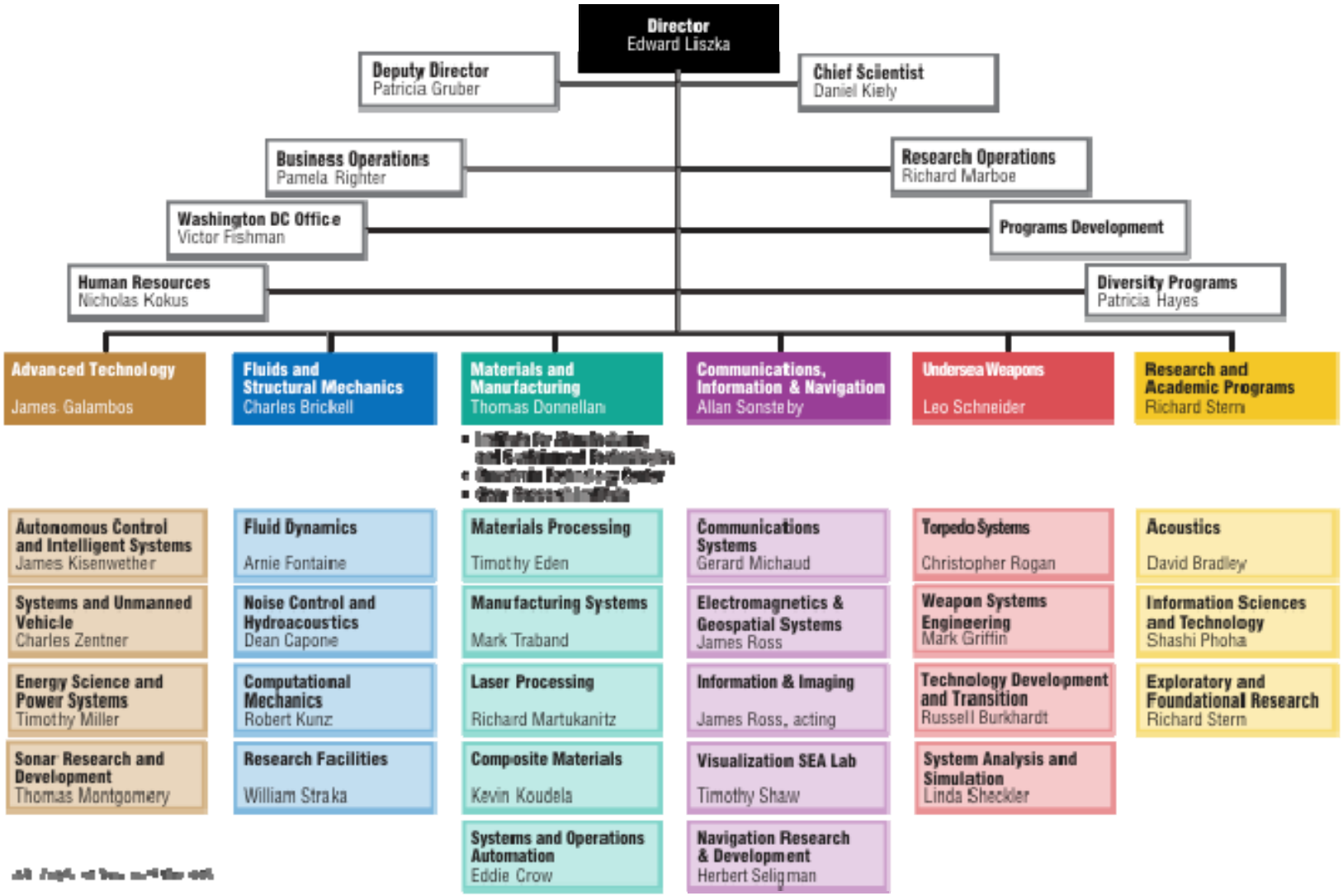
How is ARL Organized?



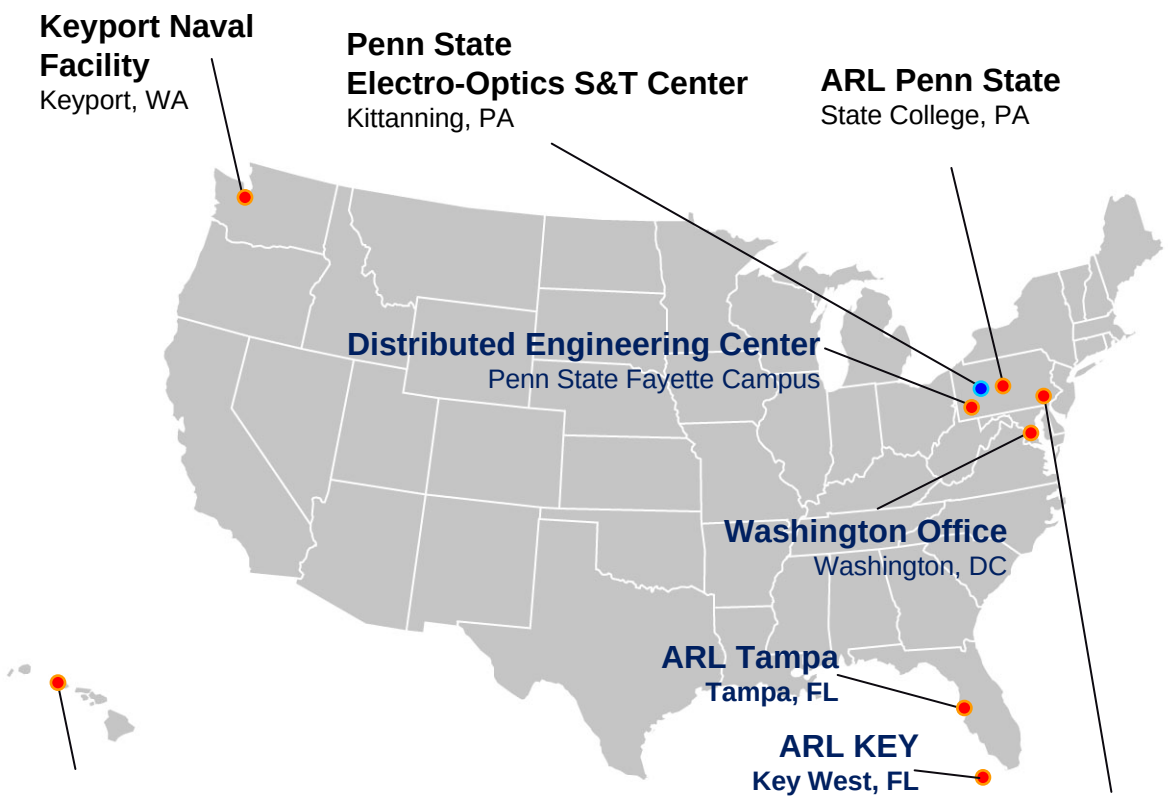
Applied Research Laboratory Locations and Offsite Activities


APPLIED RESEARCH LABORATORY BUILDING


APPLIED SCIENCE BUILDING


GARFIELD THOMAS WATER TUNNEL


NAVIGATION RESEARCH & DEVELOPMENT CENTER




ARL-3 WEST, SCIENCE PARK ROAD


ARL CATO PARK

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VISUALIZATION SEA LAB

Visualization Programs and Our Unique Relationship with Law Enforcement

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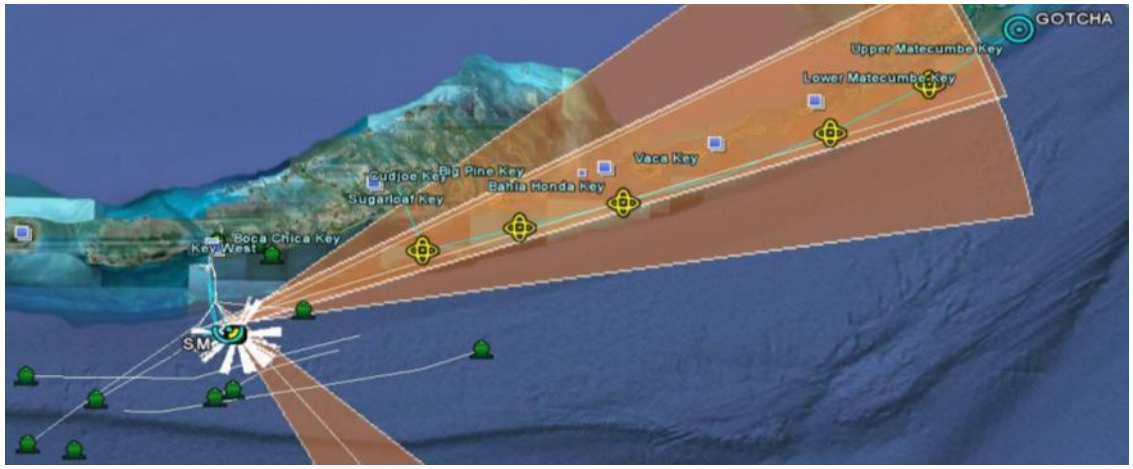
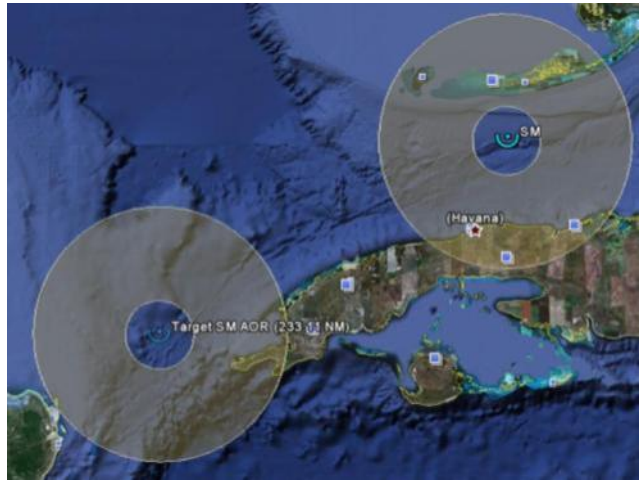
Tactics and Planning (TAP) Table

Small group collaboration tool
- Multi-touch/gesture activated surface
- Geospatial visualization/data correlation
- Real-time distributed collaboration



Real-time correlated data feeds for situational awareness
- Force laydown and status
- Target tracks and Intel
- Weather
- Logistics



Command and Control (C2)
- Intuitive user interface to task sensor platform to fill collection gap

Providing intelligence, operations, and support personnel a means to collaboratively interact with an integrated Common Operational Picture (COP)

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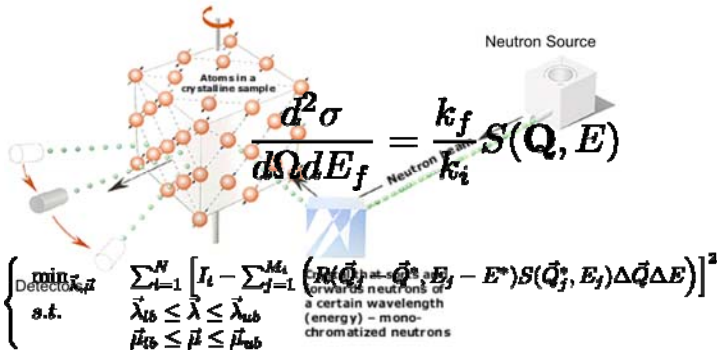
INFORMATION AND IMAGING

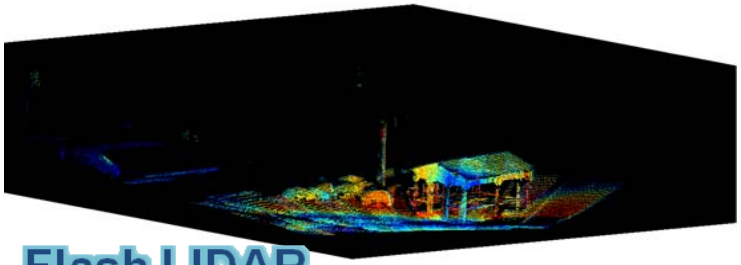
Information and Imaging Division: An *ARL* Basic Research Division

Information and Imaging Division

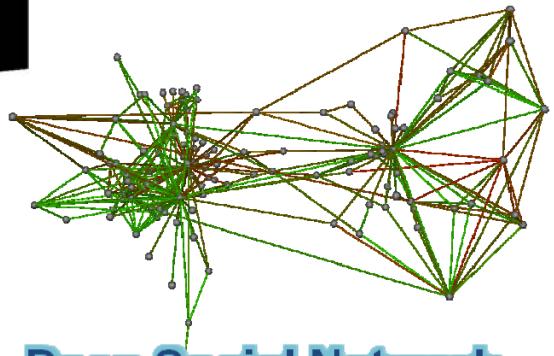
- Algorithms for understanding systems from kinematics, text, images, video and audio (*modeling*)
- Algorithms for predicting systems from kinematics, text, images, video and audio (*prediction*)
- Algorithms for controlling systems with kinematics, text, images, video and audio (*control*)



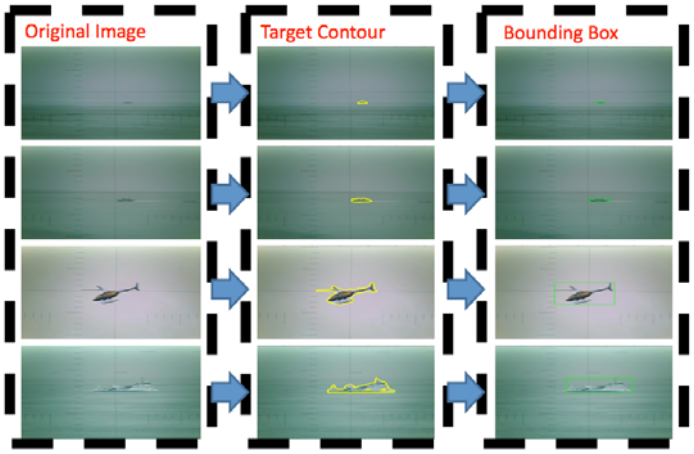
Large Scale Statistics for Neutron Science



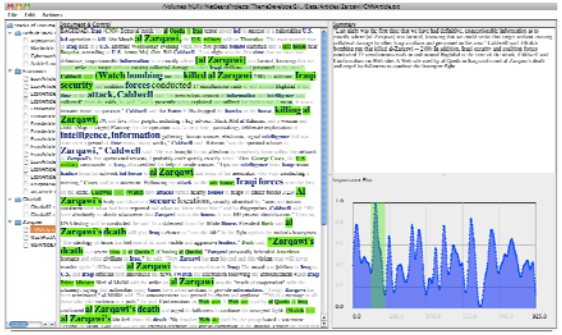
Flash LIDAR



Deep Social Network Analysis



Periscope Image Analysis



Automated Text Analysis

SAMPLE PROJECTS

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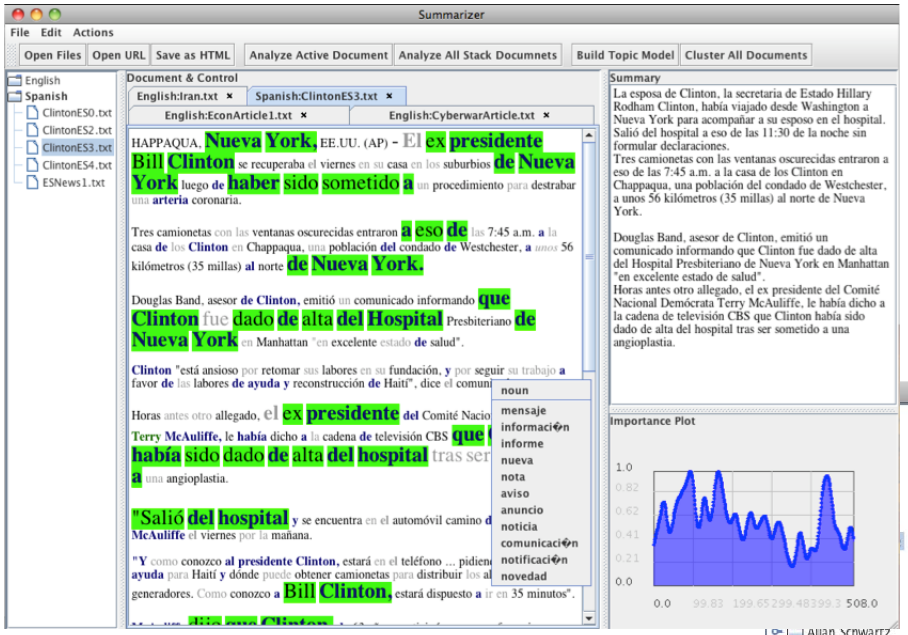
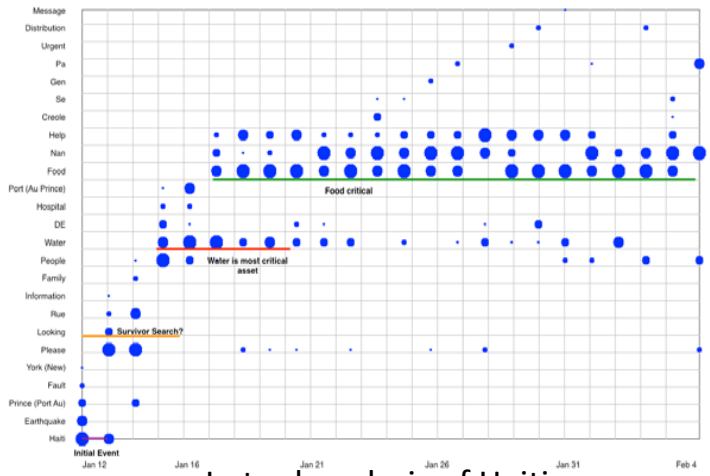
INFORMATION PROGRAMS

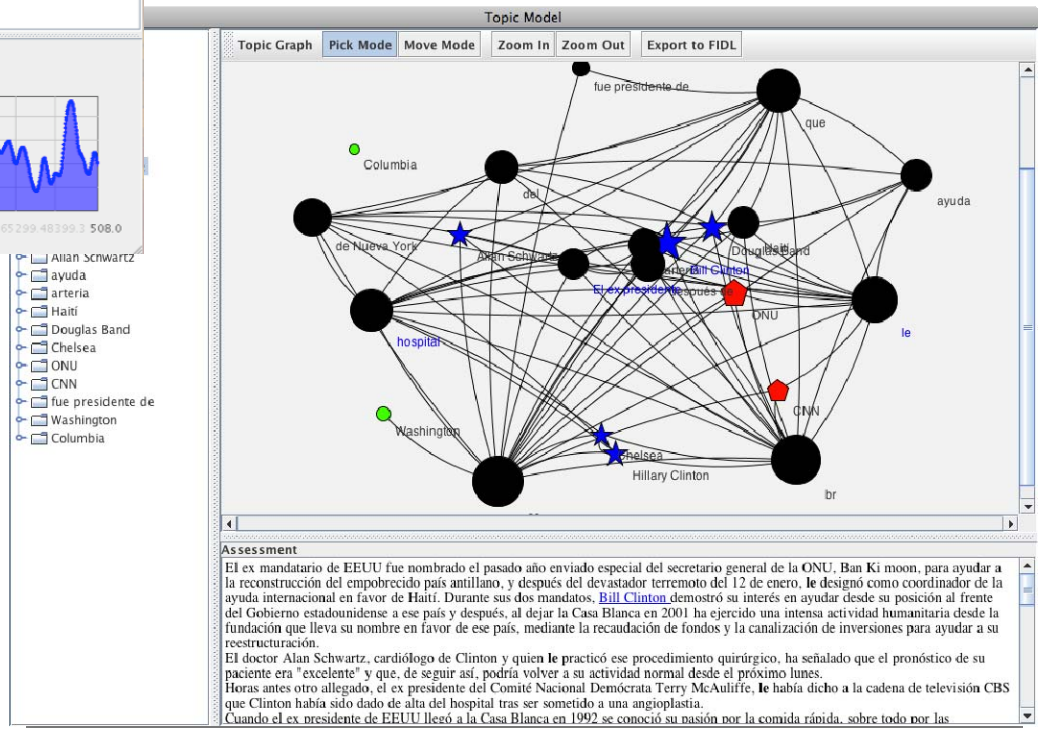
ARL Theme Developer



- POS/Synonyms etc.
- Negation detection
- Key meme detection and highlighting
- Auto-summarization
- Multi-lingual support

- Multi-document summarization
- External data source hyper-linking
- Topical projection into a graph
- Information spectrogram
- Topical extraction
- Automated document clustering



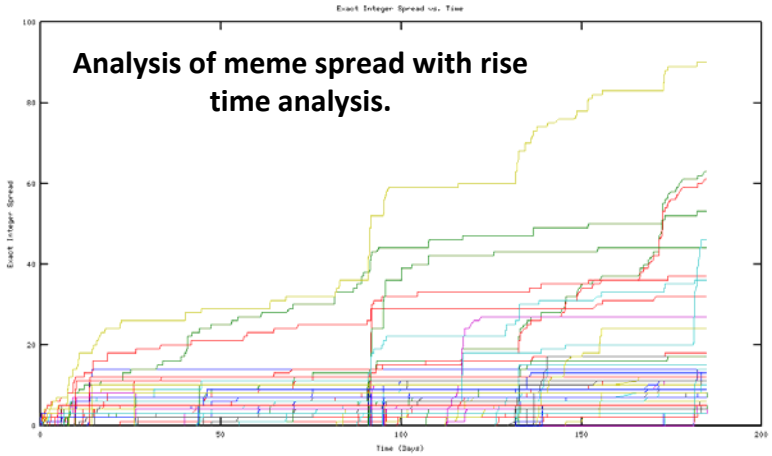


In tool analysis of Haiti Earthquake Data

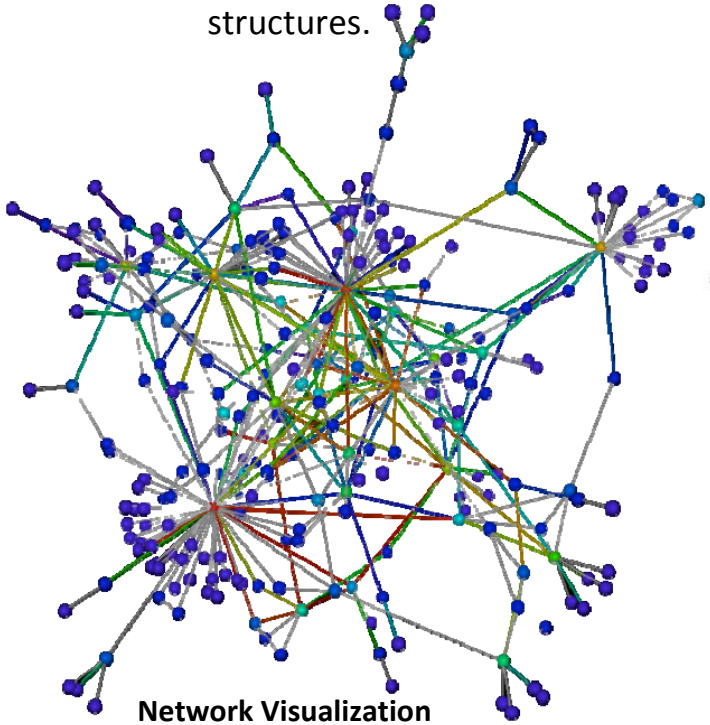
Deep Social Network Analysis

Deep Social Network Analysis

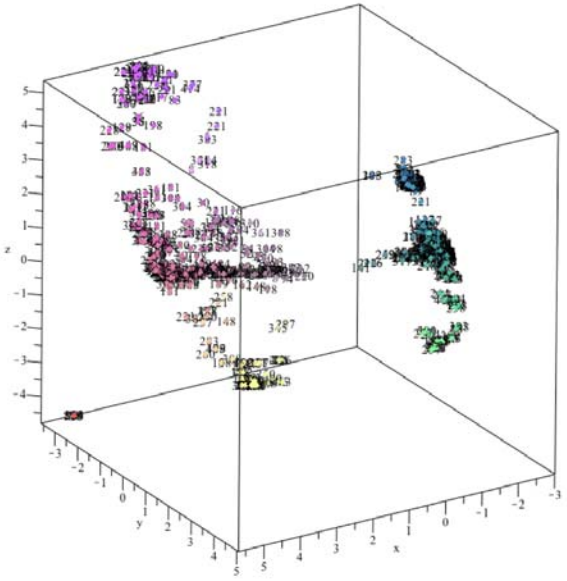
- Apply automated text mining techniques on the message internals
- Mathematical characterization of some social science theories as they apply to group interactions
- To achieve a scientifically grounded approach to using message internals to ***augment*** the analysis of social network structures.



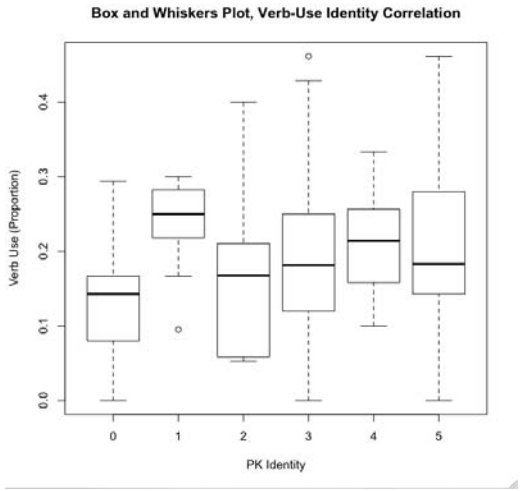
Analysis of meme spread with rise time analysis.



Network Visualization



Non-linear Message Clustering



Identify comparison through linguistic indicators (including sentiment analysis).

What's Next: High Performance Text Extraction and Analysis

- Next Steps
  - *Increase computational power to process more messages faster.*
  - Enhance model fidelity and incorporate human psychological factors more deeply into our mathematical models.
  - Take advantage of the power hybrid models can offer on high performance computing infrastructures.
- Our work in high performance data analysis for neutron scattering experiments (with Oak Ridge National Lab) has enabled us to become familiar with issues in HPC. Porting our text analysis systems to HPC hardware is now a priority:
  - Sponsor is providing a small cluster computing system (~1.25 TFLOPS)
  - ARL is building a cloud computing infrastructure to explore computation in this medium.

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Cyber Security Graduate Students

- ARL began a program of supporting graduate students to do novel work in the area of cyber-security.
- Currently three students are being funded.
- Work is broad ranging including computer science, mathematics and psychology.
  - Chosen to have a long-range impact on DOD cyber-security policy
  - Interesting and academically challenging problems were especially important in the selection process.

- Kurt Braddock (Dr. Horgan, Psychology): Typology of cyber-actors. Using modern criminological methods, Kurt is attempting to profile the behavior of cyber-criminals, terrorist and vigilantes to determine effective deterrence policy.
- Dan Keating (Dr. Liu, CSE): Insider threat in the cloud. Dan is using the current cloud computing infrastructure available within Dr. Liu's LION Lab to study the impact of insider threat in cloud computing applications.
- Jacob Turner (Dr. Morton, Math): Holographic Algorithms to investigate Shor's Algorithm. Using work by Valiant, Turner is investigating whether Shor's algorithm can be simulated in polynomial time on a classical computer.

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IMAGING PROGRAMS

3D Flash LIDAR Imaging and Object Detection

- We are working with Flash LIDAR systems to develop real-time point cloud images of operating areas of interest.
- Unlike scanning LIDAR, a complete 3D image is returned in one shot. Color and dimensional information can be extracted.
- Change-point detection can be used for detecting objects of interest within the camera's field of view.

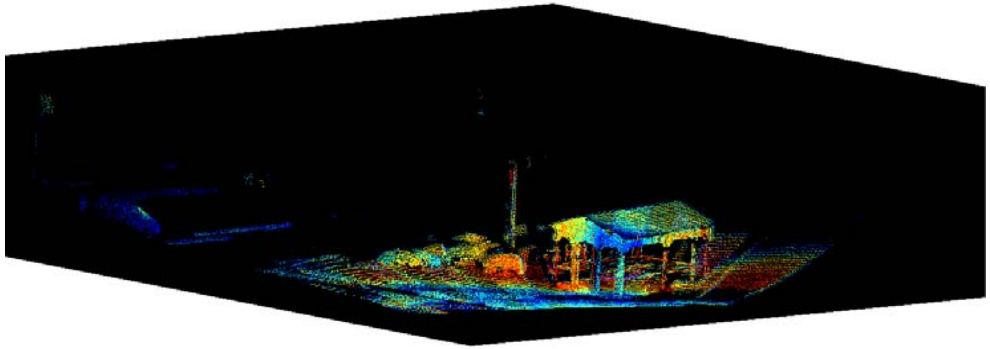
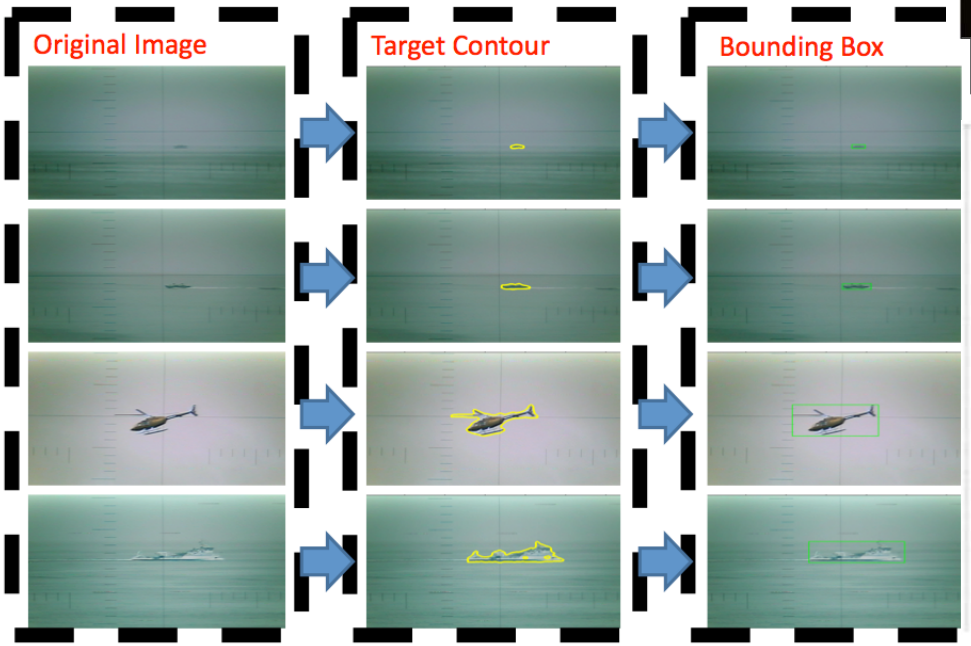
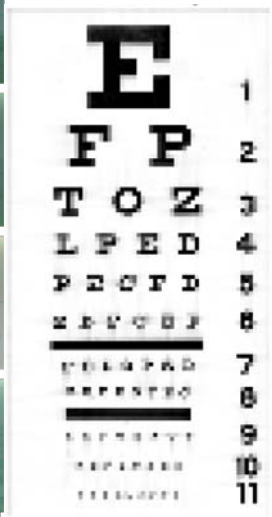


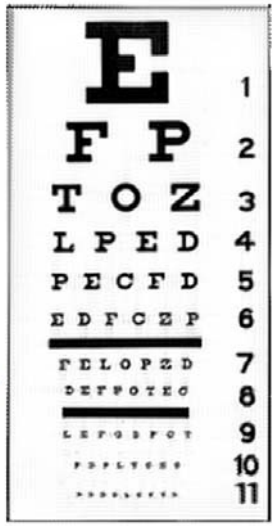
Image Segmentation and High Dynamic Range Super Resolution

- Our group has expertise in image segmentation methods.
- As a UARC we have worked on periscope programs to provide automated object detection and contouring.
- Our surveillance-specific HDR techniques allow images taken with varying exposure to be combined in such a way that the resulting image has an extremely high degree of detail, regardless of overexposed and underexposed regions in the image.
- We've developed novel super-resolution techniques useful for reading vehicle markings or identifying human targets.





Novel Super Resolution techniques take low resolution video data and create high resolution images useful for reading vehicle markings or Identifying human targets by appearance.

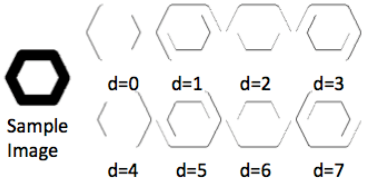


Map Text Extraction and Recognition

- **Our group developed an automated map text extraction systems:**
- Developed new line representation system using directional morphological operations that operate as directional edge detectors
- Lines with arbitrary curvature & orientation extracted correctly even when intersecting and passing through characters
- Developed custom character recognition engine and system to deal with rotated and skewed text.

Directions *d*

Neighborhoods of the directional operations for *d=0*



Sample image & its corresponding directional edges

Non-directional Operators (4 & 8 neighbors) neighborhoods (a),(b))

$D_{n4}f = f \cup (\cup_{d=0,2,4,6} f[d])$ $\quad D_{n8}f = f \cup (\cup_{d=0}^{7} f[d])$

$E_{n4}f = f \cap (\cap_{d=0,2,4,6} f[d])$ $\quad E_{n8}f = f \cap (\cap_{d=0}^{7} f[d])$

Fan Directional Operators (neighborhood (c))

$D_{>d}f = f \cup (\cup_{i=d+3}^{d+5} f[i])$ $\quad E_{>d}f = f \cap (\cup_{i=d-1}^{d+1} f[i])$

Single Directional Operators (neighborhood (d))

$D_{=d}f = f \cup f[d+4]$ $\quad E_{=d}f = f \cap f[d]$

Directional Operators orthogonal to d (neighborhoods (e),(f))

$D_{=*d}f = D_{=d-2}f \cup D_{=d+2}f$

$D_{>*d}f = D_{>d-2}f \cup D_{>d+2}f$

$E_{=*d}f = E_{=d-2}f \cap E_{=d+2}f$

$E_{>*d}f = E_{>d-2}f \cap E_{>d+2}f$

Macro Operators

$Open\ f = D(Ef)$

$Close\ f = E(Df)$

$End_d f = f \cap \overline{E_{>d}f}$

Masked Operations

$D_{;g}f = g \cap Df$

$E_{;g}f = E(f \cup g)$

$Open_{;g}f = D_{;g}(Ef)$

$Close_{;g}f = E(D_{;g}f)$

$D_{;*}f = f \cap Df$

Iterative Application

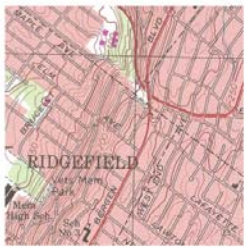
$D^2 f = D(Df)$

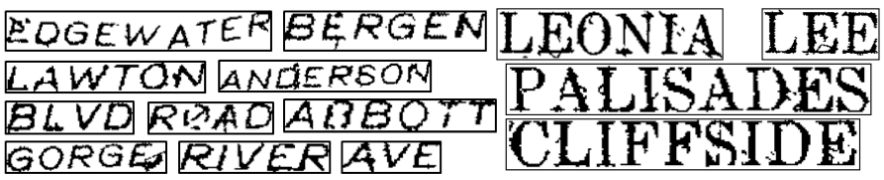
$E^3 f = E(E(Ef))$

$Open^m_{>*d;g}f = D^m_{>*d;g}E^m_{>*d}f$

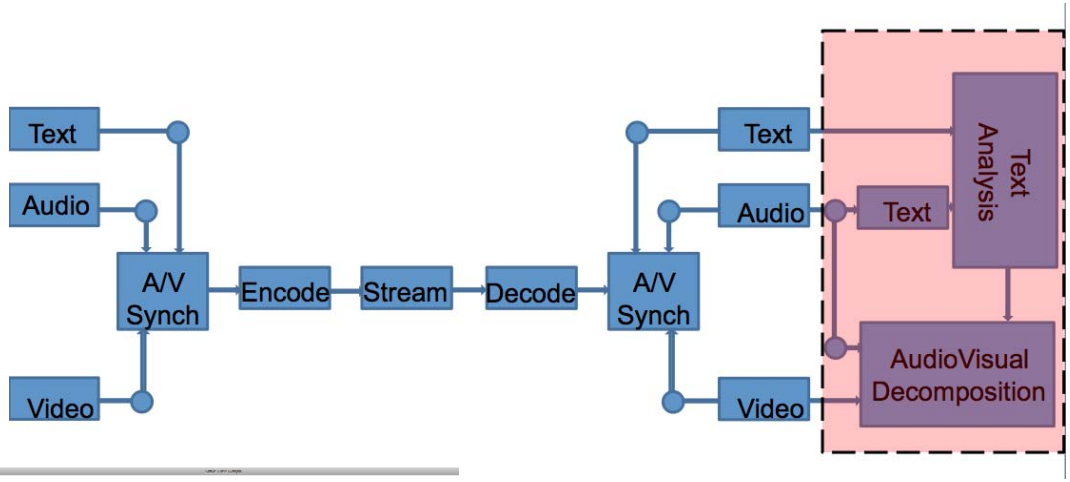
$Close^m_{>*d;g}f = E^m_{>*d}D^m_{>*d;g}f$

Set of basic Multi Angled Parallelism operators

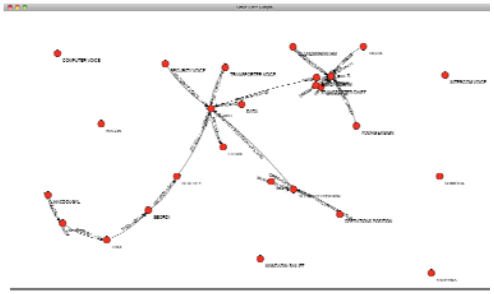




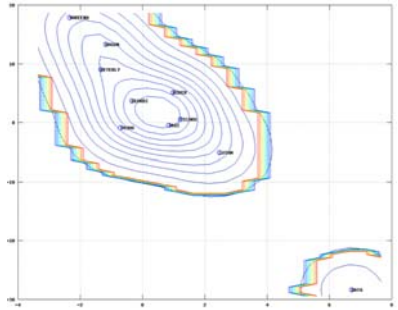
What's Next: Combined Audio / Video / Text Analysis



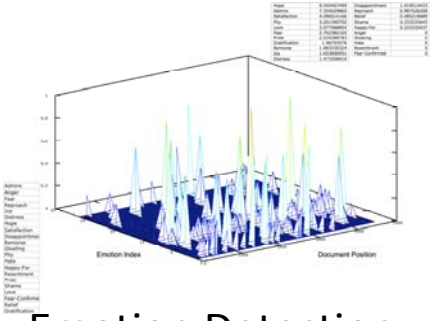
- We're now beginning to work on programs that involve the fusion of text, video and audio analysis.
- The goal of this program is to show that each analytic process can cross-inform the other, helping to reduce error and noise.
- We envision a product that extracts audio from movie files and transforms it to text. This text can then be analyzed.
- Information from the text analysis informs an image recognition problem and identifies key parts of the video.
- Information from image recognition can then back inform text analysis and help reduce audio to text translation.



Hierarchy / Role Detection



Actor Speech Analysis



Emotion Detection

Image / Text Cross Correlation

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Conclusions

- ***ARL Penn State has a 65-year proud legacy of delivering advanced technology and R&D products to the national defense***
- ***The UARC designation captures our trusted agent status and the strategic relationship that exists between Penn State and the DoD***
- ***Our "track record" is based upon a first principles "systems engineering" research approach***
- ***ARL fulfills a key role in developing a cadre of engineers and scientists needed for the future defense and IC workforce***
- ***We are working on programs that are critical to current forces and their future capabilities***