Big Data R&D Initiative

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Image Credit: Exploratorium
The Landscape: Smart Sensing, Reasoning and Decision

Environment Sensing

Percepts (sensors) → Agent (Reasoning) → Actions (controllers) → Pervasive

Emergency Response

Situation Awareness: Humans as sensors feed multimodal data streams

Computing

People-Centric Sensing

Social

Smart Health Care

Informatics

Personal Sensing

Public Sensing

Social Sensing

Evaluate

Sense

Intervene

Identify

Assess

Credit: Photo by US Geological Survey

Source: Sajal Das, Keith Marzullo
Paradigm Shift: from Hypothesis-driven to Data-driven Discovery

• Data-driven discovery is revolutionizing scientific exploration and engineering innovations

• Automatic extraction of new knowledge about the physical, biological and cyber world continues to accelerate

• Multi-cores, concurrent and parallel algorithms, virtualization and advanced server architectures will enable data mining and machine learning, and discovery and visualization of Big Data
Examples of Research Challenges

• More data is being collected than we can store
  • Analyze the data as it becomes available
  • Decide what to archive and what to discard
• Many data sets are too large to download
  • Analyze the data wherever it resides
• Many data sets are too poorly organized to be usable
  • Better organize and retrieve data
• Many data sets are heterogeneous in type, structure, semantics, organization, granularity, accessibility …
  • Integrate and customize access to federate data
• Utility of data limited by our ability to interpret and use it
  • Extract and visualize actionable knowledge
  • Evaluate results
• Large and linked datasets may be exploited to identify individuals
  • Design management and analysis with built-in privacy preserving characteristics
Administration’s Big Data Research and Development Initiative

- Big Data Senior Steering Group – chartered in spring 2011 under the Networking and Information Technology R&D (NITRD) Program
  - Members from NIH, NSF, DARPA, DOD OSD, DHS, DOE-Science, HHS, NARA, NASA, NIST, NOAA, NSA, and USGS
  - Co-chaired by NIH and NSF

Image Credit: Fuqing Zhang and Yonghui Weng, Pennsylvania State University; Frank Marks, NOAA; Gregory P. Johnson, Romy Schneider, John Cazes, Karl Schulz, Bill Barth, The University of Texas at Austin
NSF Strategy to Address Big Data

Foundational research to develop new techniques and technologies to derive knowledge from data

New cyberinfrastructure to manage, curate, and serve data to research communities

New approaches for education and workforce development

New types of inter-disciplinary collaborations, grand challenges, and competitions

Policy
A Complex Policy Setting

• Researchers want data.
• Public policy requires access to data.
• Public policy also requires protection of privacy and intellectual property and other sensitive information.
• Much more to be done: Policy on data management and data access
Foundational research to advance the core techniques and technologies for managing, analyzing, visualizing, and extracting useful information from large, diverse, distributed and heterogeneous data sets.

Image Credit: Jurgen Schulze, Calit2, UC-San Diego

Cross-Directorate Program: NSF Wide
Multi-agency Commitment: NSF and NIH
**BIG DATA Research Thrusts**

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<tr>
<th><strong>Collection, Storage, and Management of “Big Data”</strong></th>
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<tr>
<td>• Data representation, storage, and retrieval</td>
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<td>• New parallel data architectures, including clouds</td>
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<td>• Data management policies, including privacy and access</td>
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<td>• Communication and storage devices with extreme capacities</td>
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<td>• Sustainable economic models for access and preservation</td>
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<th><strong>Data Analytics</strong></th>
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<td>• Computational, mathematical, statistical, and algorithmic techniques for modeling high dimensional data</td>
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<td>• Learning, inference, prediction, and knowledge discovery for large volumes of dynamic data sets</td>
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<td>• Data mining to enable automated hypothesis generation, event correlation, and anomaly detection</td>
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<td>• Information infusion of multiple data sources</td>
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<th><strong>Research in Data Sharing and Collaboration</strong></th>
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<td>• Tools for distant data sharing, real time visualization, and software reuse of complex data sets</td>
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<tr>
<td>• Cross disciplinary model, information and knowledge sharing</td>
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<td>• Remote operation and real time access to distant data sources and instruments</td>
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Credit: Fermilab Photo
Big Data to Address National Priorities

Health & Wellbeing

Environment & Sustainability

Emergency Response & Disaster Resiliency

Manufacturing, Robotics, & Smart Systems

Secure Cyberspace

Transportation & Energy

Education and Workforce Development
The ability to acquire, aggregate and mine clinical, scientific, behavioral data will create an unprecedented amount of high quality data from individuals and population

Enabling evidence-based medicine, early diagnoses, personalized assessments and care
Era of “Big Data” in Healthcare

• Large volumes of data currently collected
  EHRs and PHRs
    Multi-scale and multi-source
  During hospitalizations
    For safety and diagnosis
  On an out-patient basis
    Typically event monitors
  Via ubiquitous mobile sensors
    Behavior, physiology, environment
  As part of clinical studies
    To evaluate safety and efficacy
  From growing body of scientific knowledge
    In biomedical research literature

• Gigabits/patient/day
  High sampling rates
  Multiple signals

• Accumulating data is getting easier, but using data is hard
New interdisciplinary program that aims to support fundamental scientific advances and technologies to protect cyber-systems from malicious behavior, while preserving privacy and promoting usability.
Cyberlearning: Transforming Education

*Integrate technology with knowledge about how people learn*

### Goals:

- Understand how people learn in technology rich environments
- Design and study ways in which innovative technologies and tools can promote learning and support assessment
- Prototype new technologies and integrate them into learning environments
Big Opportunities for the Future

- Our investments in research and education have returned exceptional dividends to our nation.

- Scientific discovery and technological innovation are at the core of our response to national and societal challenges – from environment, energy, transportation, sustainability and healthcare, to cyber security and national defense.

- Many of tomorrow’s breakthroughs will occur at the intersections of diverse disciplines.
Thanks!

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