Education & Training Program Presenters

Ivo D. Dinov
Assoc. Director
MIDAS
Ed & Training

Erin Shellman
Research Scientist
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Patrick Harrington
Co-Founder
Chief Data Scientist
CompGenome.com

Nandit Soparkar
CEO, Ubiquiti

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MIDAS Data Science Education & Training:

Challenges & Opportunities

Ivo D. Dinov

Associate Professor, School of Nursing

Associate Education Director, Michigan Institute for Data Science (MIDAS)

University of Michigan
http://MIDAS.umich.edu/education

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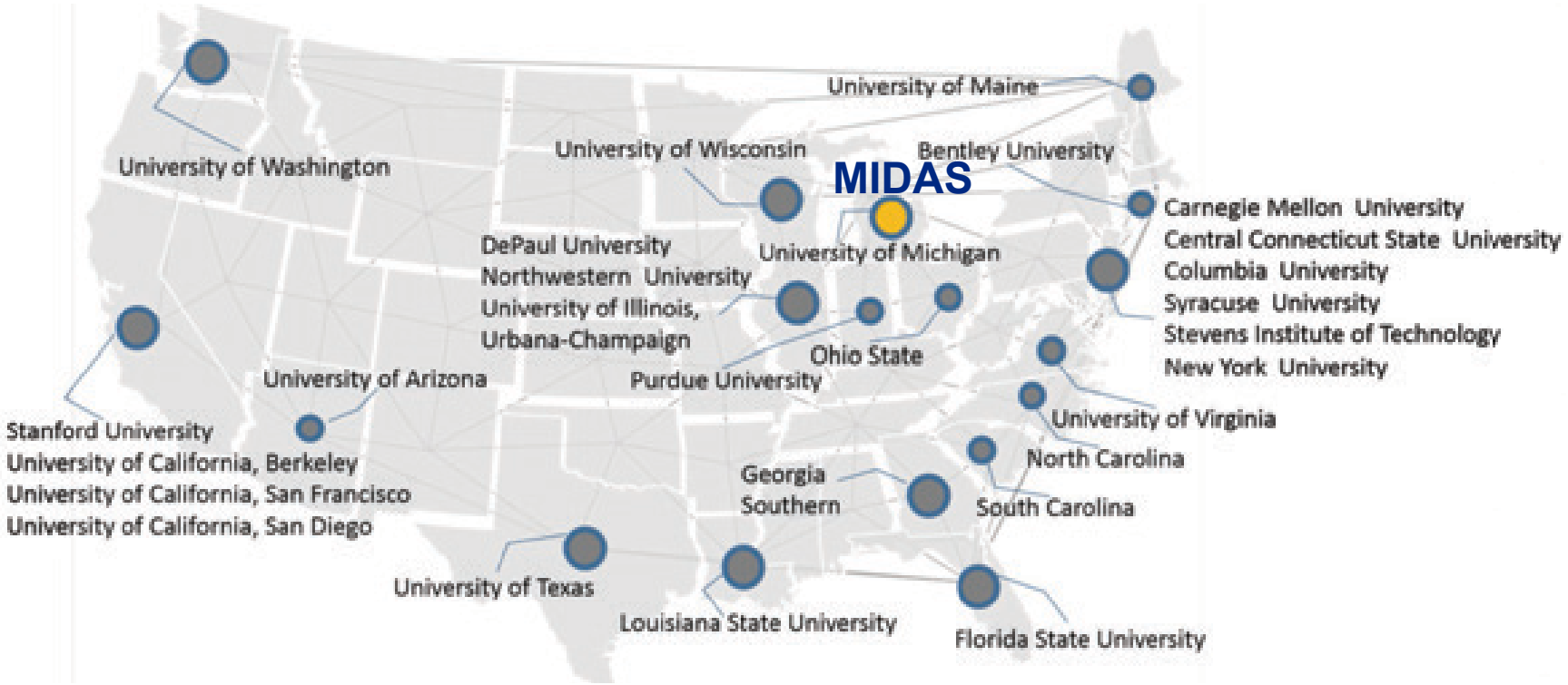
National Big Data Science Curricula Constellation



Recently established Data Science institutes and curricular programs

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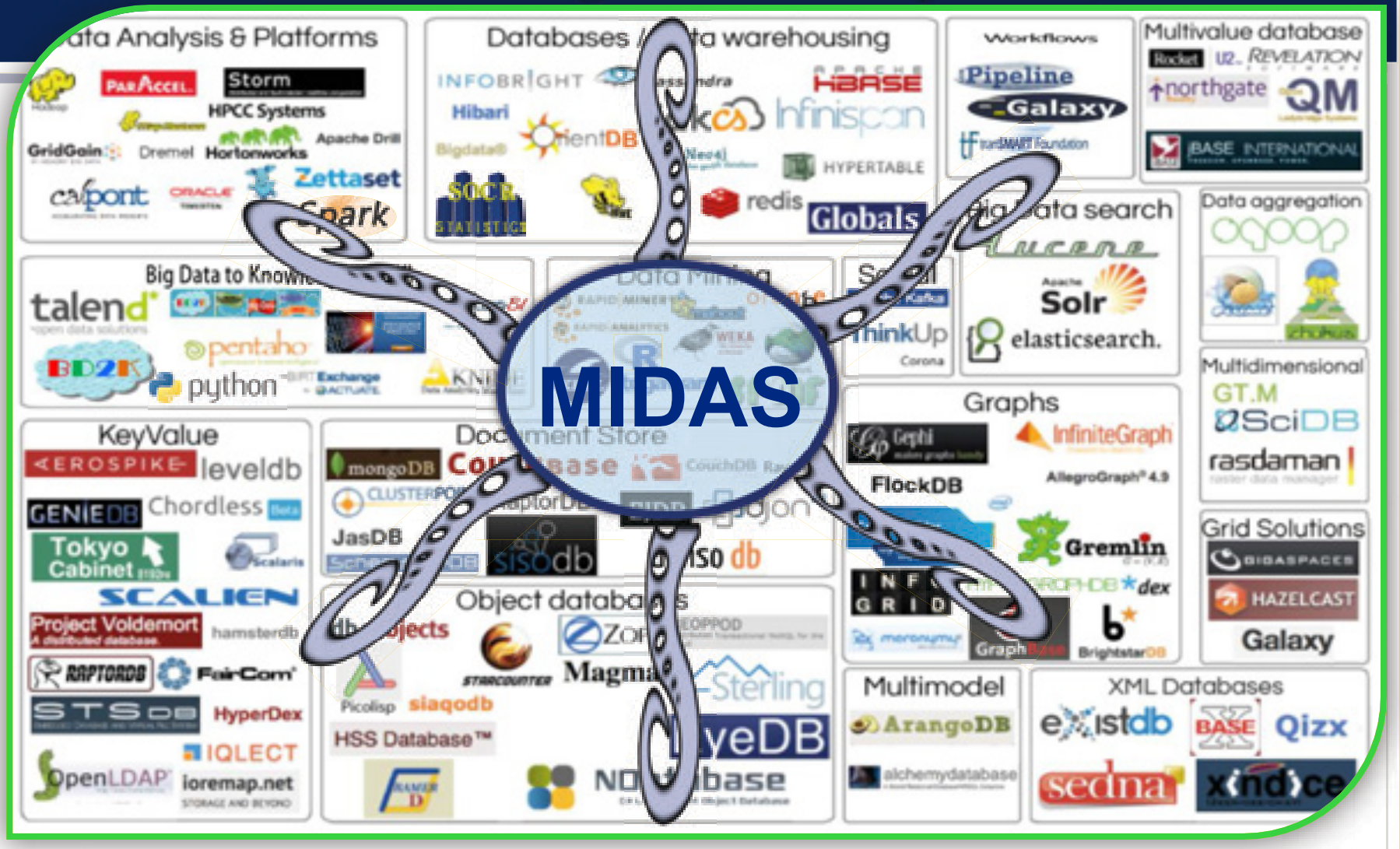
MIDAS Big Data Ecosystem



http://socr.umich.edu/docs/BD2K/BigDataResourceome.html

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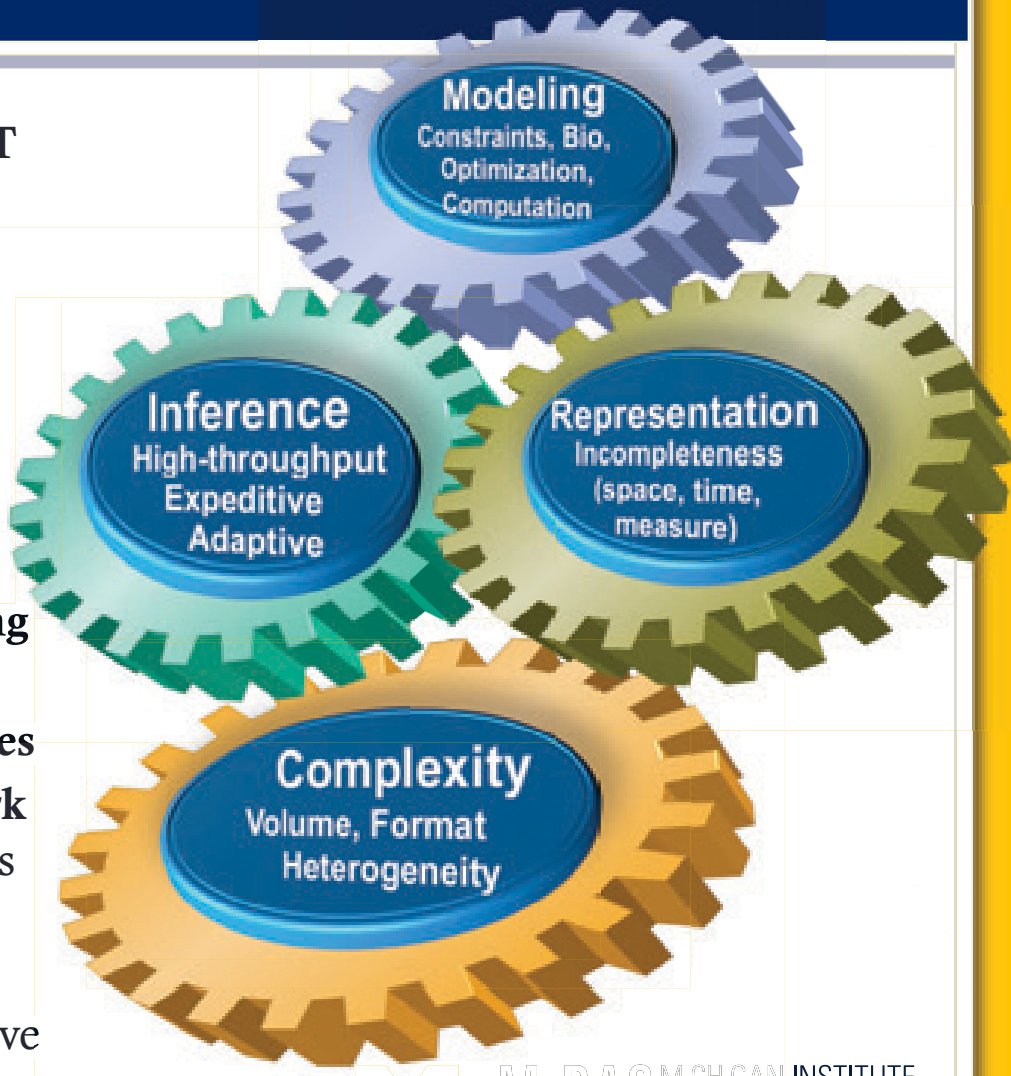
MIDAS Focus on Developing Big Data Skills

- **Listening**: streams, analyzing sentiment, intent and trends;
- **Looking**: searching, indexing and memory management of heterogeneous datasets; Raw, derived or indexed data as well as meta-data;
- **Programming**: Handling Map-Reduce/HDFS, No-SQL DB, protocol provenance, algorithm development/optimization, pipeline workflows;
- **Inferring**: Principles of data analyses, Bayesian modeling, inference, uncertainty and quantification of likelihoods; Reasoning & logic; Analytics: Regression, feature selection, dimensionality reduction, temporal patterns, validation; Actionable Knowledge
- **Machine Learning**: Classification, clustering, mining, information extraction, knowledge retrieval, decision making;
- **Predicting**: Forecasting, neural models, deep learning, and research topics;
- **Summarizing**: Presentation of data, processing protocol, analytics provenance, visualization, synthesis

Specific Data Science Training Challenges

- Technological advances and **students' IT skills far outpace educators' technological expertise** and the current rate of IT adoption in college curricula
- **Lack of** open learning resources and interactive interoperable platforms
- **Difficulty sharing** data, tools, materials & activities across different disciplines
- Limited technology-enhanced **continuing instructor education opportunities**
- Discipline-specific **knowledge boundaries**
- **Skills for communication and teamwork** involving cooperation in dynamic groups of dispersed researchers
- **Ability to aggregate & harmonize data** (e.g., fusion of qualitative and quantitative elements).

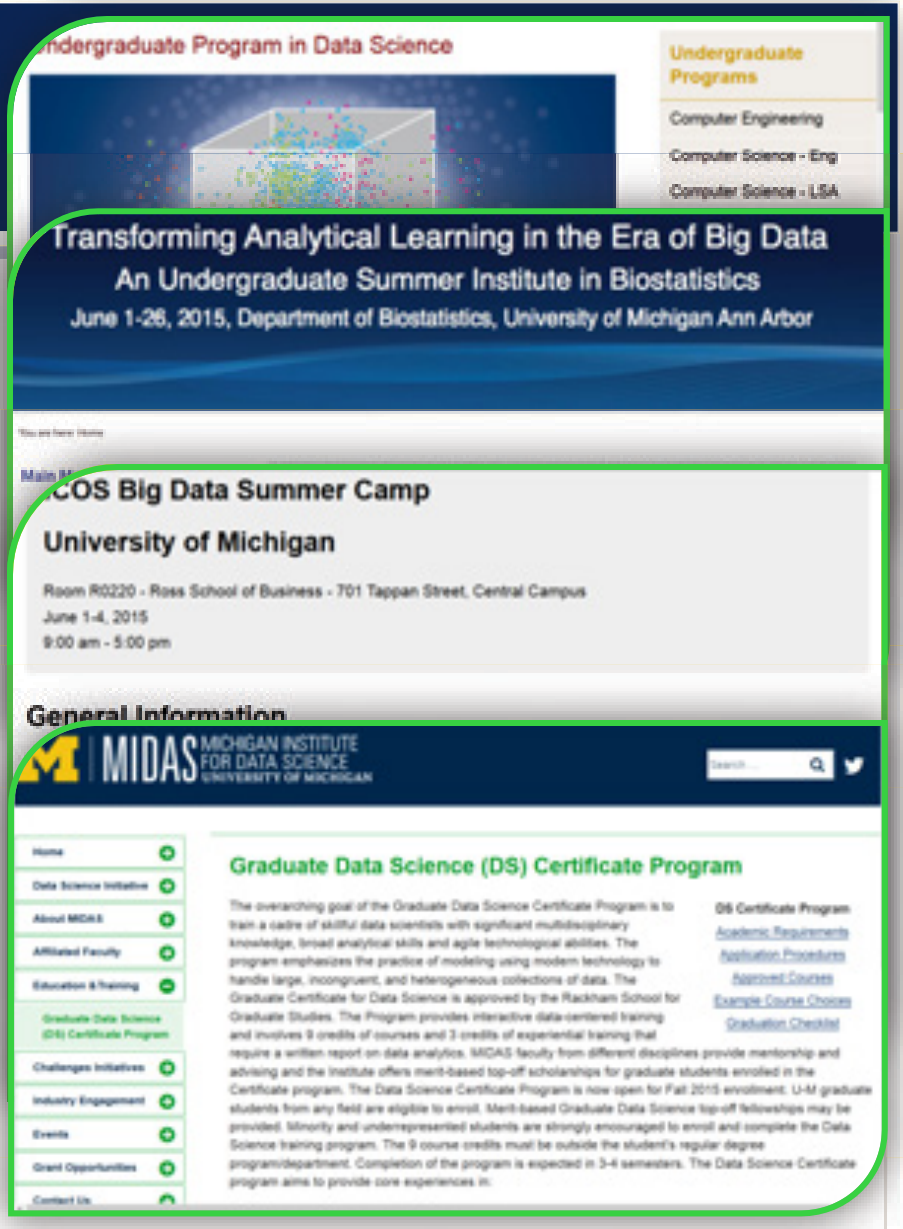


Core MIDAS Education Components

- **Drivers**: Motivations, datasets (6D of Big Data), challenges, applications
- **Methods**: foundational and trans-disciplinary scientific techniques
- **Tools**: web-services, software, code, platforms
- **Analytics**: practice of data interrogation

Existent Data Science Education & Training

- Undergraduate DS Degree Program
  - Stats + Engineering
  - Started Fall 2015
  - www.eecs.umich.edu/eecs/undergraduate/data-science
- DS Summer Institute (Public Health)
  - 20+ faculty, 40+ trainees
  - Full support/in residence (1 month)
  - BigDataSummerInst.sph.umich.edu
- Big Data Summer Bootcamp
  - 5 years running, Business-Engineering
  - Practice of Econ-Bio-Social Analytics
  - ibug-um15.github.io/2015-summer-camp
- Graduate DS Certificate Program
  - Transdisciplinary (SM,SPH,LS&A,SN,CoE,SI)
  - 12 cr, Modeling+Technology +Practice
  - http://MIDAS.umich.edu/certificate



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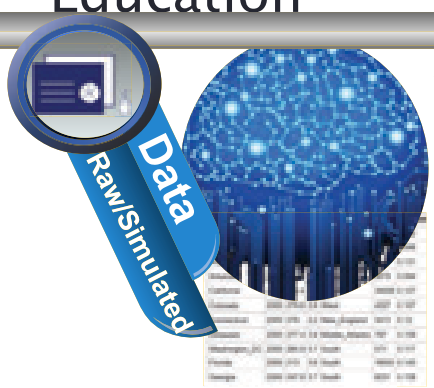
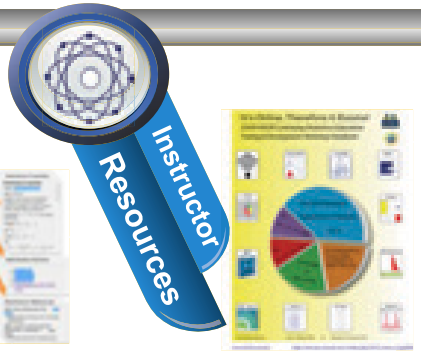
MIDAS Education & Training (Going Forward)

- Graduate Data Science Certificate Program
  - Enrollment of 100 (UMich) students
- Develop the Online Graduate Data Science Certificate Curriculum
- Develop a 5-yr dual undergrad-grad MS Program in Data Science
- DS Summer Institute (Public Health)
- Big Data Summer Bootcamp
- MIDAS Seminar Series (academia, industry, government, partners)
  - Web-streamed and archived for broader impact
- National Events
  - BD2K, Midwest Big-Data-Hub, Math, Stats, Computer Vision, Machine Learning, Informatics, …
- Funding: NIH, NSF, Foundation: Research & Traineeship Applications

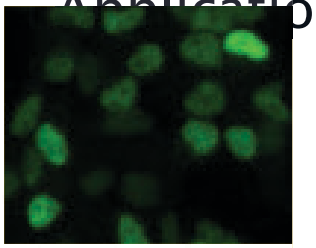
Michigan Difference in Data Science Education & Training

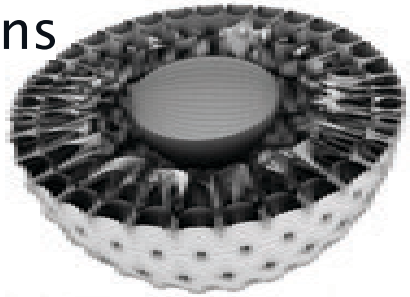
- Public–Private–Partnership (PPP) Model
- Integration of Research + Practice + Education

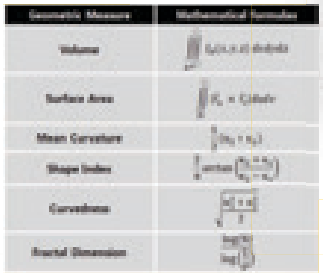




- Problems + Modeling + Technology + Applications







AtheyLab

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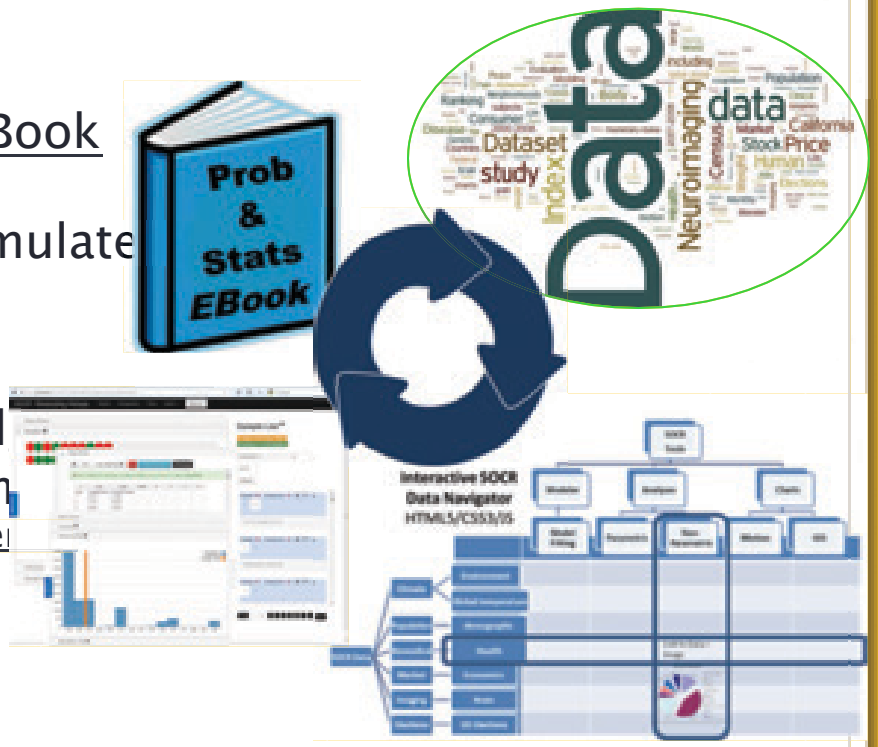
Statistics Online Computational Resource (SOCR) Integration of Education, Research & Practice

- Probability and Statistics EBook
  - Motivation, Methods, Techniques, Practice
  - wiki.socr.umich.edu/index.php/EBook
- Data sets
  - 100's of Research, Observed & Simulate
  - wiki.socr.umich.edu/index.php/SOCR_Data
- Hands-on Activities (Team-focused
  - Modeling, Inference, Concept Dem
  - wiki.socr.umich.edu/index.php/SOCR_EduMate
- Applets and Webapps
  - Over 500 Web tools
  - Distributed services based on Java, HTML5/JavaScript



Features: Free, Cloud-service, no-barrier access, LGPL/CC-BY

Ref: Dinov *et al.*, TS (2013), DOI: 10.1111/test.12012

SOCR has over 9.6M users worldwide since 2002

www.SOCR.umich.edu

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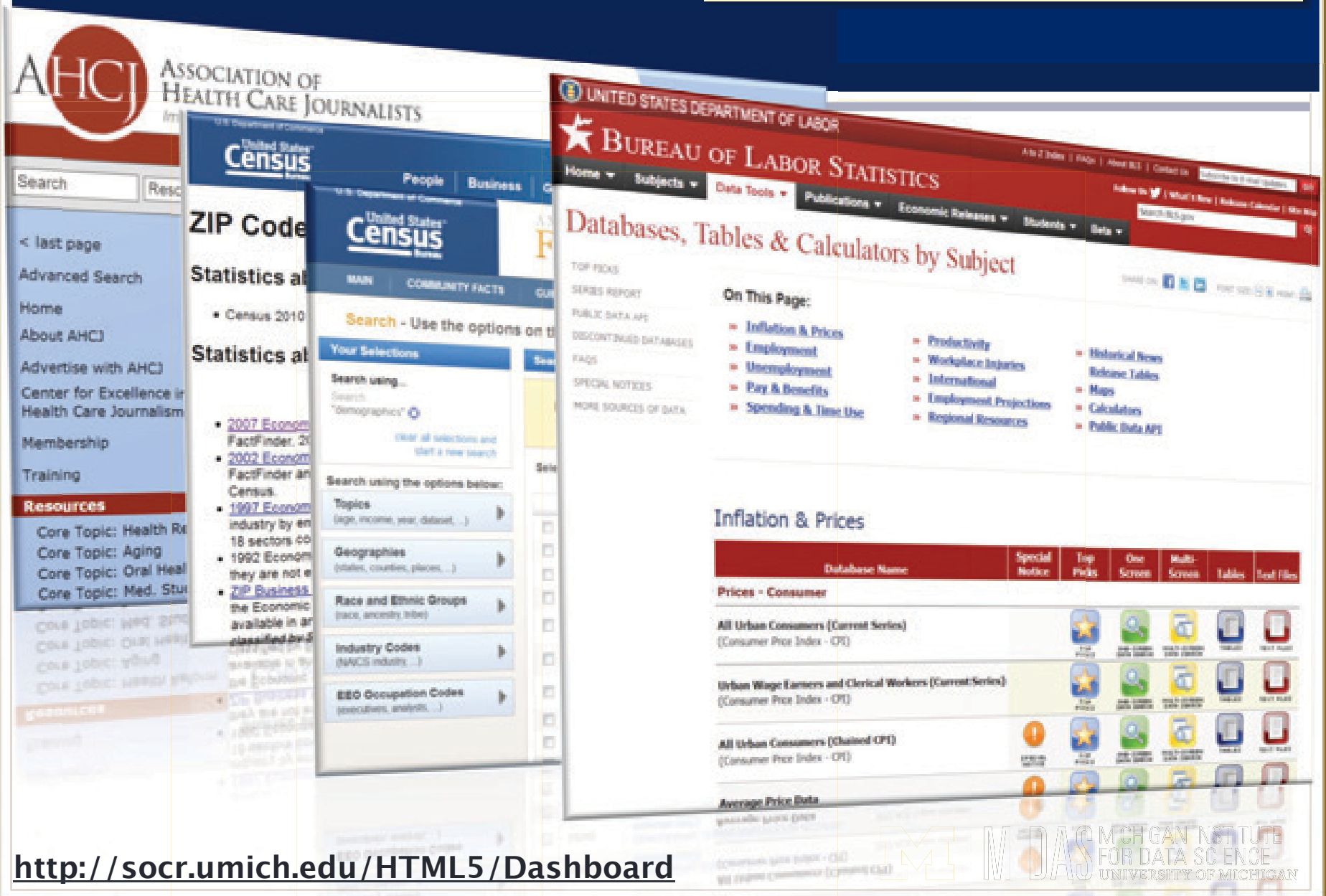
MIDAS-SOCR Dashboard: Big Data Fusion Example



http://socr.umich.edu/HTML5/Dashboard

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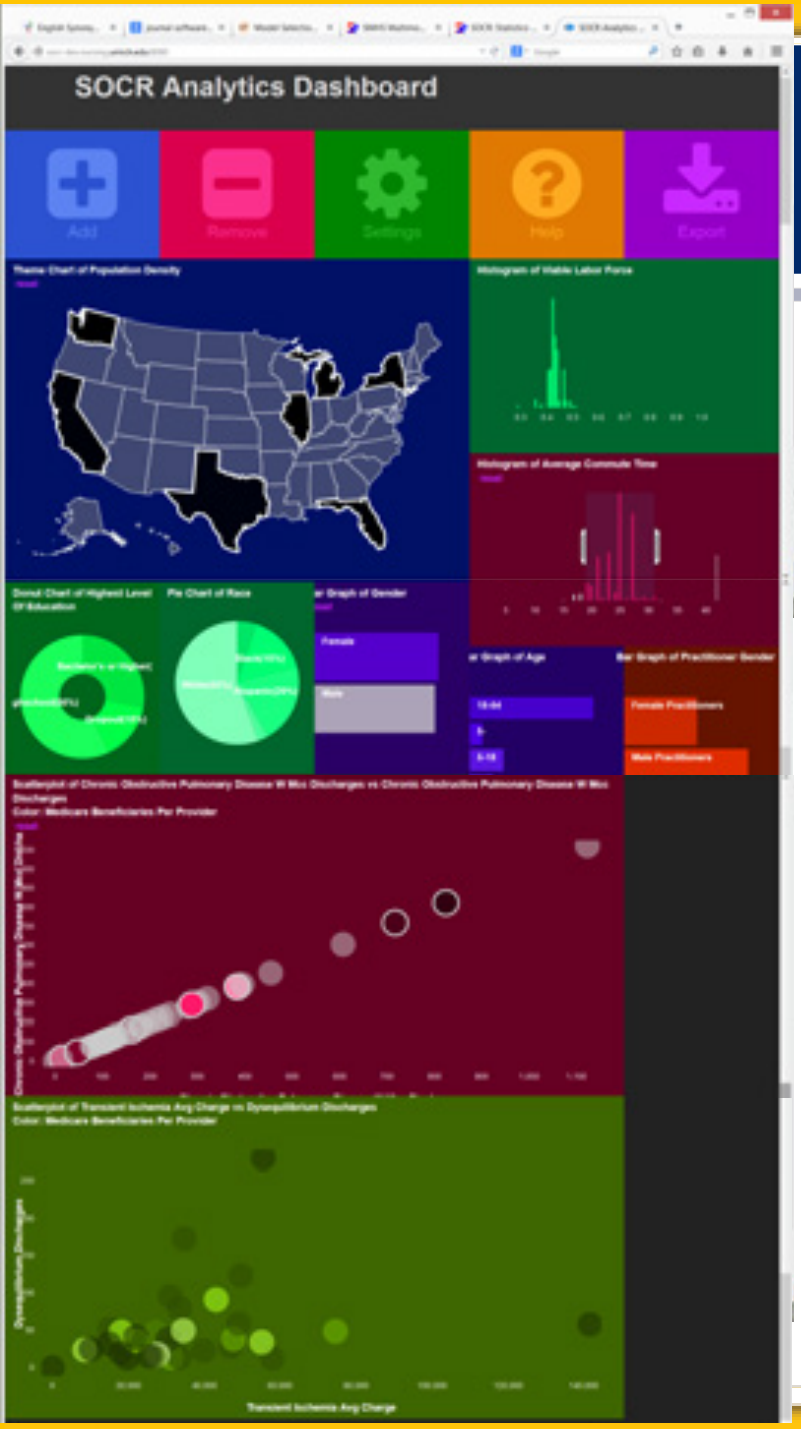

Big Data Analytics

http://socr.umich.edu/HTML5/Dashboar

- Web-service combining and integrating multi-source socioeconomic and medical datasets
- Big data analytic processing
- Interface for exploratory navigation, manipulation and visualization
- Adding/removing of visual queries and interactive exploration of multivariate associations
- Powerful HTML5 technology enabling mobile on-demand computing

Husain, et al., 2015, J Big Data

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MIDAS Online Data Science Education Program (DSEP)

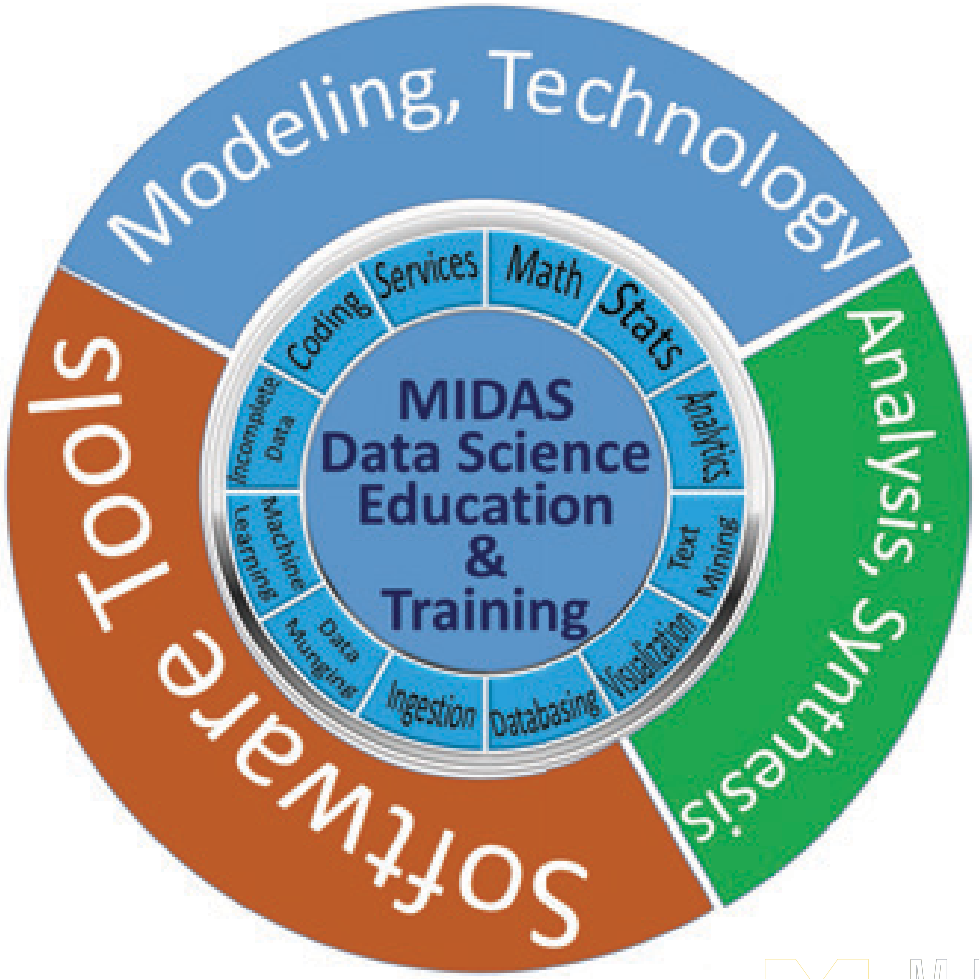
MIDAS plans to:

- Develop new hands-on **MOOC DS courses** (data, learning modules, services, code snippets, applications/partners) …
- Deploy MIDAS **Training as a Service (TaaS)** MOOC platform
- Compile **Datasets** (research-derived, observational, simulated) – identify, aggregate, manage, navigate, and service exemplary Big Data sets
- **Faculty/Mentors**–instructors, collaborators, partners, students and staff to develop a core DS course-series (4 courses)
- Instructional resources and complete end-to-end **learning modules**
- **Track and Validate the DSEP Program** – annual reports (MIDAS ETC), review of evaluations, sustainability (financial, resources, space), impact

How to Engage & Partner in MIDAS Education?

Partners

- Open-Source Community
- Academia
- Trainees
- Industry
- Non-profit
- Government
- Philanthropy
- Community Orgs



Activities

Drivers
- Challenges
- Datasets
- Applications

Methods

Technologies

Tools / Services

Training Opps
- Mentorship
- DS Projects
- Internships

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MIDAS Education & Training Team

MIDAS Education & Training Committee

Ivo Dinov, Margaret Hedstrom, Honglak Lee, Sebastian Zöllner, Richard Gonzalez, Kerby Shedden

Other Contributing MIDAS Faculty

Engineering

- Alfred Hero: Electrical Engineering and Computer Science; Biomedical Engineering, Stats
- H. V. Jagadish: Electrical Engineering and Computer Science
- Mike Cafarella: Computer Science and Engineering
- Karthik Duraisamy: Atmospheric, Oceanic, and Space Sciences
- Judy Jin: Industrial & Operations Engineering
- Dragomir Radev: School of Information; Computer Science and Engineering; Linguistics

Information & Health Sciences

- Brian Athey: Computational Medicine and Bioinformatics, Medicine
- Carl Lagoze: School of Information
- Qiaozhu Mei: School of Information
- Jeremy Taylor, Biostatistics, Public Health

Basic Sciences

- Vijay Nair: Statistics & Engineering
- George Alter: Institute for Social Research, History
- Christopher Miller: Physics & Astronomy
- August Evrard: Physics & Astronomy
- Anna Gilbert: Mathematics, Engineering
- Stephen Smith: Ecology and Evolutionary Biology
- Ambuj Tewari: Statistics; Computer Science and Engineering

Contact

http://MIDAS.umich.edu

midas-contact@umich.edu

Dinov@umich.edu

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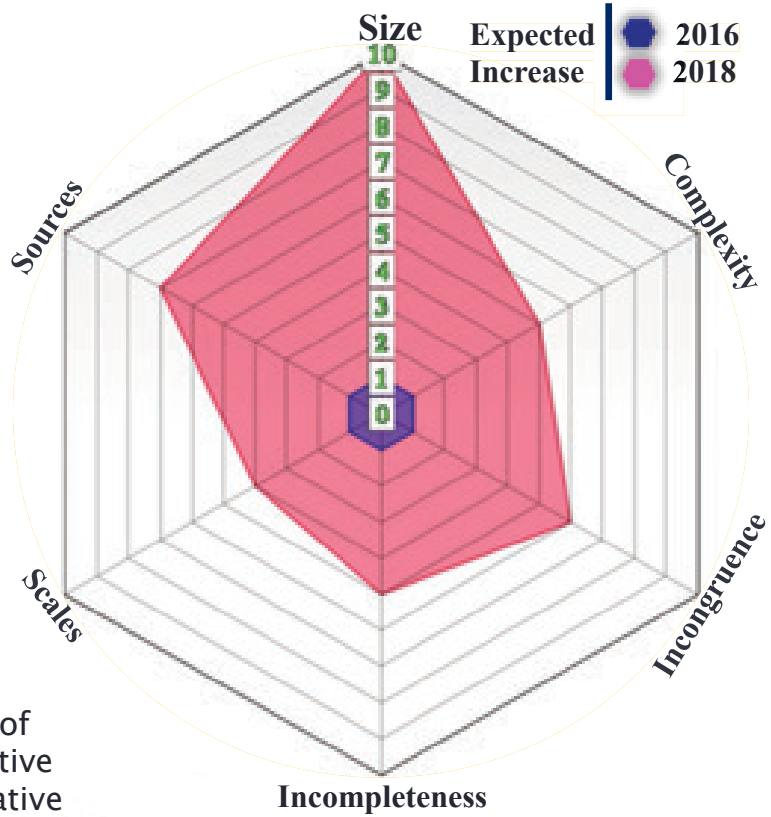
Big Data Science

From a descriptive to a constructive definition of Big Data

- **IBM's 4V's – volume, variety, velocity** (speed) **and veracity** (reliability)
- **MIDAS Big Data Characterization** – identifies gaps, challenges & needs



Mixture of quantitative & qualitative estimates

Dinov, et al. (2014)

Example: analyzing observational data of 1,000's Parkinson's disease patients based on 10,000's signature biomarkers derived from multi-source imaging, genetics, clinical, physiologic, phenomics and demographic data elements.

Software developments, student training, service platforms and methodological advances associated with the Big Data Discovery Science all present existing opportunities for learners, educators, researchers, practitioners and policy makers

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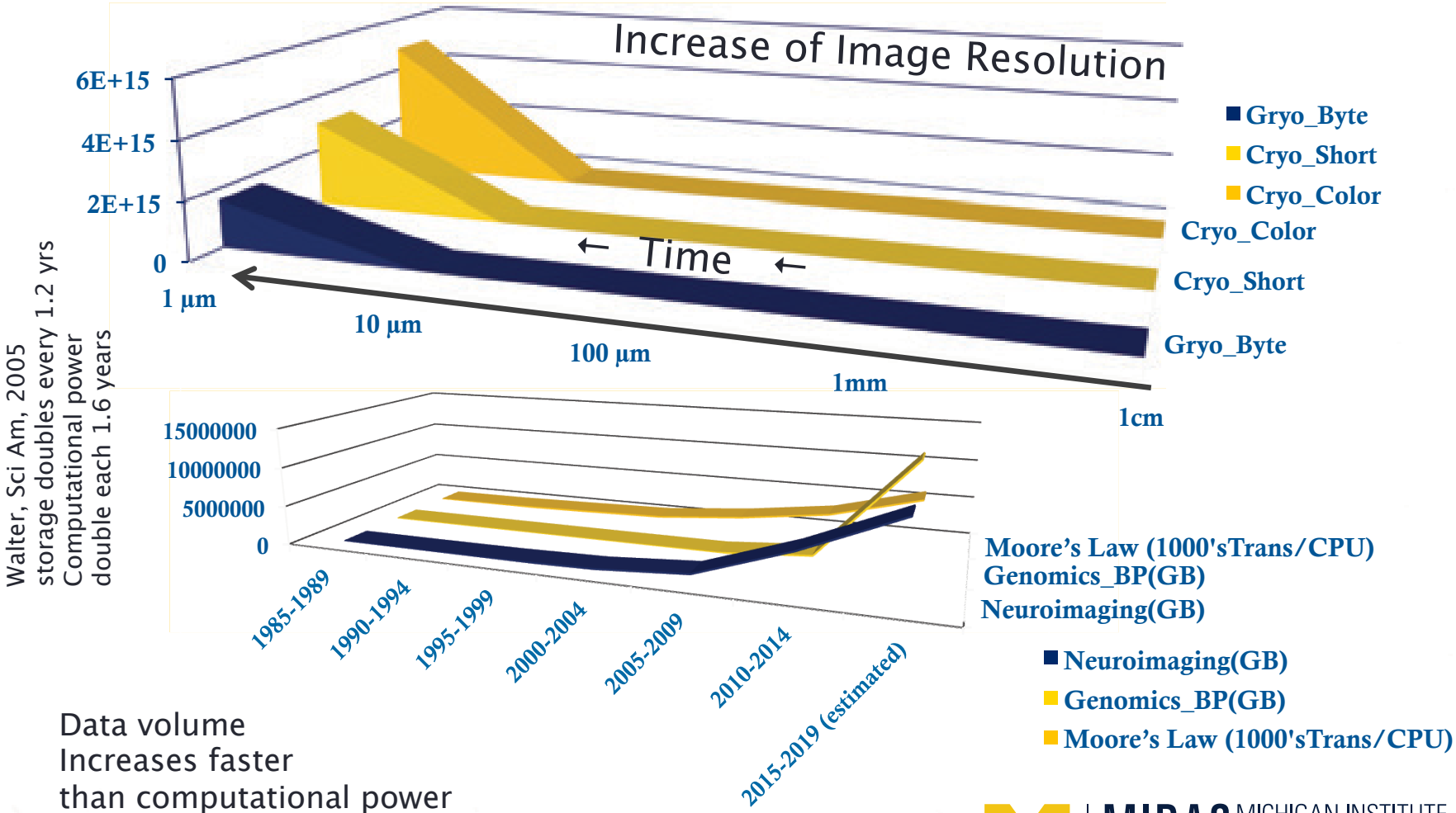
Kryder's law: Exponential Growth of Data



Data volume
Increases faster
than computational power

Dinov, et al., 2014

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Data Science Training Program: Core Curriculum

Themes	Training	Examples
Data Scrubbing	Big Data Management	Big Data technology, Searching, indexing, memory management, Information extraction, feature selection, Supervised and unsupervised-learning, stream mining
	Big Data Representation	Matrix Representation of Sets, Minhashing, Jaccard Similarity, Distance Measures, Euclidean Distances, Jaccard Distance, Cosine Distance, Edit Distance, Hamming Distance, Networks, Graph similarity, Sets as Strings, Prefix Indexing, Data Streams and Processing, Representative Samples, Bloom Filter, Flajolet-Martin Algorithm, TF/IDF, MoM, MLE, Alon-Matias-Szegedy Algorithm for Second Moments, Datar-Gionis-Indyk-Motwani Algorithm (DGIM)
Data Mining	Mining Social-Network Graphs	Bio-Social Network Graphs, Root-Mean-Square Error, UV-Decomposition, The NetFlix Challenge, Tweeter Challenge, Distances and Clustering of Social-Network Graphs, Network Cluster Betweenness, Complete Bipartite Subgraphs, Graph Partition, Matrices and Graphs, Eigen-values/ vectors of the Laplacian Matrix, Graph Neighborhood Properties, Diameter of a Graph, Transitive Closure and Reachability, Crowdsourcing Algorithms
	Modeling	Statistical Modeling, Machine Learning, Computational Modeling, Feature Extraction, Power Laws, Map-Reduce/Hadoop
	Link Analysis	PageRank, Spider Traps, Taxation and loops in Big Data traversal, Random Walks
Data Inference	Clustering	Curse of Dimensionality, Classification and Regression Trees/Random Forests, Hierarchical Clustering, K-means Algorithms, Bradley, Fayyad, and Reina (BFR) Algorithm, CURE Algorithm, Clusters in the GRGPF Algorithm
	Classification	Random Forest, SVM, Neural Networks, Latent Class Models, Finite Mixture Models
	Dimensionality Reduction	Eigenvalues and Eigenvectors, Principal-Component Analysis, Singular-Value Decomposition, Wrapper-Based vs Filter-Based Feature Selection, Independent Components Analysis, Multidimensional Scaling, CUR Decomposition

Big Data	Information	Knowledge	Action
Raw Observations	Processed Data	Maps, Models	Actionable Decisions
Data Aggregation	Data Fusion	Causal Inference	Treatment Regimens
Data Scrubbing	Summary Stats	Networks, Analytics	Forecasts, Predictions
Semantic-Mapping	Derived Biomarkers	Linkages, Associations	Healthcare Outcomes

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