Technology for X-Informatics
Kmeans and MapReduce Parallelism

June 19 2013

Geoffrey Fox

gcf@indiana.edu

http://www.infomall.org/

Associate Dean for Research, School of Informatics and Computing

Indiana University Bloomington

2013

Big Data Ecosystem in One Sentence

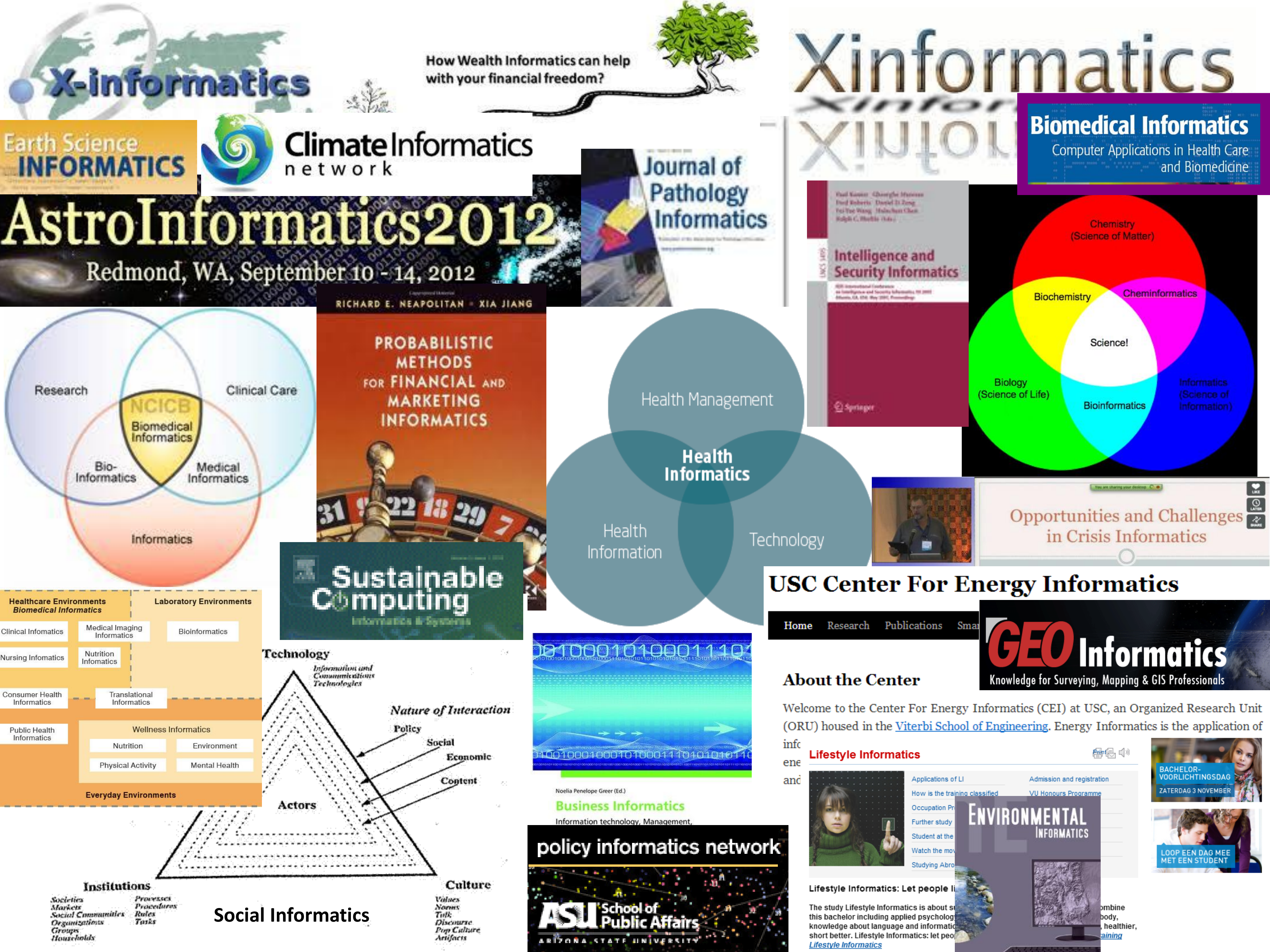
Use Clouds running Data Analytics Collaboratively processing Big Data to solve problems in X-Informatics (or e-X)

X = Astronomy, Biology, Biomedicine, Business, Chemistry, Climate, Crisis, Earth Science, Energy, Environment, Finance, Health, Intelligence, Lifestyle, Marketing, Medicine, Pathology, Policy, Radar, Security, Sensor, Social, Sustainability, Wealth and Wellness with more fields (physics) defined implicitly

Spans Industry and Science (research)

Education: Data Science see recent New York Times articles

http://datascience101.wordpress.com/2013/04/13/new-york-times-data-science-articles/



X-informatics

How Wealth Informatics can help with your financial freedom?

Xinformatics

Earth Science INFORMATICS

Climate Informatics network

Biomedical Informatics
Computer Applications in Health Care and Biomedicine

AstroInformatics2012
Redmond, WA, September 10 - 14, 2012

Journal of Pathology Informatics

Intelligence and Security Informatics

Springer

RICHARD E. NEAPOLITAN • XIA JIANG

PROBABILISTIC METHODS FOR FINANCIAL AND MARKETING INFORMATICS

Opportunities and Challenges in Crisis Informatics

Sustainable Computing
Informatics & Systems

Social Informatics

Noelia Penelope Greer (Ed.)

Business Informatics

Information technology, Management,

policy informatics network

ASU School of Public Affairs
ARIZONA STATE UNIVERSITY

USC Center For Energy Informatics

Home Research Publications Smar

About the Center

Welcome to the Center For Energy Informatics (CEI) at USC, an Organized Research Unit (ORU) housed in the Viterbi School of Engineering. Energy Informatics is the application of info
ene
and

GEO Informatics
Knowledge for Surveying, Mapping & GIS Professionals

Lifestyle Informatics

Applications of LI
How is the training classified
Occupation Pr
Further study
Student at the
Watch the mov
Studying Abro

Admission and registration
VU Honours Programme

Lifestyle Informatics: Let people li

The study Lifestyle Informatics is about su ombine this bachelor including applied psycholog body, knowledge about language and informatic , healthier, short better. Lifestyle Informatics: let peo aining
Lifestyle Informatics

ENVIRONMENTAL INFORMATICS

BACHELOR-VOORLICHTINGSDAG
ZATERDAG 3 NOVEMBER

LOOP EEN DAG MEE MET EEN STUDENT

MapReduce Kmeans in Python

Slightly Changed Sequential version

- We change to allow MapReduce implementation
- Overall iteration over starting positions
  - Initialize Centroids
  - Iterate until converged
    - Call **map** to find association and do first step in find centroids as sum over point vectors and distortion
    - **Reduce** step: Divide summed centers by points in center to get centroid
      - Do other book keeping
      - Delete zero size clusters
    - Check convergence
- Return best solution based on Quality criterion

Parallel MapReduce Version

```
Iseven = np.empty([tot], dtype=bool)
for i in arange(tot):
        Iseven[i] = (i%2 == 0);
obs1 = compress(Iseven, obs, 0)
obs2 = compress(logical_not(Iseven), obs, 0)

avg_dist = []
diff = thresh+1.
while diff > thresh:
        #
        if Parallelism == 1:
                code_book, NumPointsinClusters, distortsum, distortmax, NumPoints  = Kmeans_map(obs, code_book)
        if Parallelism == 2:
                # Can be Parallel Map Operations
                code_book1, NumPointsinClusters1, distortsum1, distortmax1, NumPoints1  = Kmeans_map(obs1, code_book)
                code_book2, NumPointsinClusters2, distortsum2, distortmax2, NumPoints2  = Kmeans_map(obs2, code_book)
                #
                #       Following are 4 Reduction Operations
                #       Note maps include local reductions
                code_book = np.add( code_book1, code_book2)
                NumPointsinClusters = np.add( NumPointsinClusters1, NumPointsinClusters2)
                distortsum = distortsum1 + distortsum2
                distortmax = np.maximum(distortmax1, distortmax2)
                NumPoints = NumPoints1 +  NumPoints2
        #
        code_book = compress(np.greater(NumPointsinClusters, 0), code_book, 0)
        #       remove code_books that didn't have any members
        #
        j = 0
        nc = code_book.shape[0]
        for i in arange(nc):
                if NumPointsinClusters[i] > 0:
                        code_book[j,:] = code_book[j,:] / NumPointsinClusters[i]
                        j = j + 1
```

Map

Reduce

Map for Kmeans

```
def Kmeans_map(obs, code_book):
        No = obs.shape[0]
        nc = code_book.shape[0]
        # nc is current number of clusters (may decrease if zero clusters last iteration)
        #
        #compute membership and distances between obs and code_book
        obs_code, distort = vq(obs, code_book)
        distortsum = np.sum(distort)
        distortmax = np.amax(distort)
        #
        # vq returns an indexing array obs_code mapping rows of obs (the points) to code_book (the centroids)
        # distort is an array of length No that has difference between observation and chosen centroid
        # vq stands for vector quantization and is provided in SciPy
        #
        VectorDimension = obs.shape[1]
        NewCode_Book = np.zeros([nc, VectorDimension])
        NumPointsinClusters = np.zeros([nc])
        for i in arange(nc):
                #               Loop over clusters labelled with i
                cell_members = compress(equal(obs_code, i), obs, 0)
                NumPointsinClusters[i] = cell_members.shape[0]
                #               Extract Points in this Cluster; extract points whose quantization label is i
                #
                NewCode_Book[i] = np.sum(cell_members, 0)
                #               Calculate centroid of i'th cluster
        return NewCode_Book, NumPointsinClusters, distortsum, distortmax, No
```

- This routine takes Points in obs and Centroids in code_book and associates each point with nearest centroid
- It calculates Non normalized centroids (sum over vectors in cluster), Number of points in each cluster and convergence measures (mean and max of distance between points and centers)

Comments!

- Extension to P-way parallelism simple
  - Divide data into P parts
  - Run P separate maps with each having all centers
  - Sum (or max) P versions of center sums, Point sums, convergence criterion in Reduce
- Maps can run in parallel
- Reduce would run in a single process except for large levels of parallelism
- Sequential code uses mean directly not sums
- Parallel code does center sums and
- Divides by total number of points in Reduce