eHumanities –
From big data and digital technologies to new and/or enhanced methods in humanities and social sciences

ICT-Workshop „eHUMANITIES“
Aachen, Germany, April 9th, 2014

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Outline

I. Introduction
   - Definitions
   - The Waves: Examples

II. Some more regional stuff
   - Research Structures in Germany
   - Funding by the BMBF...
   - ... and Funding by the EC

III. Connections to Big Data
   - Big Data
   - Distributed Systems
   - Artificial Intelligence

IV. Future Developments
   - More Examples
   - From Big Data...
   - ... to Cyber Physical Systems, the Internet of Things and Industry 4.0
At the beginning was the 'e'
eHumanities – Sorry?

Origin: eScience

eScience derives from the natural sciences and refers to a globally connected form of scientific working using distributed IT-resources, knowledge, tools and manpower. [Aschenbrenner et.al. 2007]

[i: hjumænətiz]

Enhanced Humanities or 'Digital Humanities' is a interdisciplinary research area that combines Humanities, Social and Cultural Sciences with Computer Sciences. [Rehbein, Univ. Passau, web]

Disciplinary Background

Humanities deals with human behavior, human nature, social and political values and covers various disciplines like linguistics, history, religious and ethics studies.

Digital humanities enrich these subjects by special ways of thinking, approaches and methods of computer sciences computational linguistics or computational philology. [http://humanitiesforums.org]

The BMBF defines eHumanities as the sum of all approaches, that are able to
- facilitate or to improve the scientific work in the humanities
- by developing, integrating and using innovative information technologies.
What’s the world interested in…?
Ask Google

Google Trends: Understanding interests

A search-term is analyzed relative to the total search-volume across various regions of the world, and in various languages.

http://www.google.de/trends/explore

eHumanities compared along nations: not enough data
A look ahead

About the potential of Big Data in social science

NSF 2011-2016 Strategic Plan

“The revolution in information and communications technologies is another major factor influencing the conduct of 21st century research. New cyber tools for collecting, analyzing, communicating, and storing information are transforming the conduct of research and learning. One aspect of the information technology revolution is the “data deluge,” shorthand for the emergence of massive amounts of data and the changing capacity of scientists and engineers to maintain and analyze it.”

The new availability of data, presents a huge potential for researchers in social science

Peter Doorn, director at Data Archiving and Network Services

“In social science research, there is a great tradition of survey methodology with people doing interviews about all kinds of ideas people may have. However, a new approach is to do things like a sentiment analysis on Twitter posts, for example. This is a totally new way of getting knowledge about what is going on in society.”
The appearance of the new-model DH around 2004-2008 wasn’t a paradigm shift [...] in which competing models within a discipline lead to a new dominant view. It was more like a “fork” of humanities computing [...] that established a new ‘branch’” [Jones 2014]

Originally called (with slight variations)
- digital humanities
- computing in the humanities
- humanities computing
- ...

“The DH [...] concerned with the intersection of computing and the disciplines of humanities. [...] It involves investigation, analysis, synthesis and presentation of information in electronic form. It studies
- how these media affect the disciplines in which they are used,
- and what these disciplines have to contribute to our knowledge of computing.”
## Waves of Digital Humanities / eHumanities

### The first wave: 1990s and early 2000s

- **Early eHumanities** focused on:
  - **digitalization & digitability** mainly of existing (non digital) content
  - large-scale digitization projects
  - technological infrastructure

### The generative second wave: eHumanities “2.0” (?)!!)

- **Frist steps towards analysis, ...**:
  - ordinary text analysis
  - within established disciplines

- **creating** the environments and tools for producing, curating, and interacting with **knowledge that is ‘born digital’**

- **Focus on analysis:**
  - Intelligent, partly autonomous, autonomous - influence form **“big data”** scene
  - Over different disciplines
Virtual research infrastructure facilitates connected research

An example from text-based humanities, TextGrid, since 2006 – first generation (focus on Literary science, history, and linguistics, „digital ecosystem, digital tools for philological editing and collaborative research“):

eInfrastructure including long term perspectives: sources have to be archived WITH their application software

“TextGrid”  
www.textgrid.de  
Coordinator: University of Göttingen  
10 project partners  
DARIAH & CLARIN (EU with BMBF)
When stones speak
Between the Waves: MayaArch3D

Make archaeological data available to a wide community of researchers, cultural heritage managers and the general public

Filling the gap: 3D technologies are used for access and visibility studies, statics, performance studies, phenomenological studies, aesthetics, astronomical alignments

Features:
- Reality based 3D models
- Geometries linked to attributes
- Query functionalities
- Data retrieval from external DB

Core of the QueryArch3D: GIS data from/to PostgreSQ and PHP as a scripting language
Applying Big Data for reading:
computational analysis of books, finding out whether there is a ‘signal’, specific word or phrase that reveals information about their genre

Based on theoretical work in rhetoric (Kaufer & Butler 1996) and their applied work in representational theories of language

One Possible Example:
Take “David Copperfield”, feed books into a computer program, unsupervised without any other human input – and the program figures out whether it’s a gothic novel or a ‘Bildungsroman’.

“DocuScope is a text analysis environment with a suite of interactive visualization tools for corpus-based rhetorical analysis. David Kaufer created what we call the generic (default) dictionary, consisting of over 40 million linguistic patterns of English classified into over 100 categories of rhetorical effects. Suguru Ishizaki designed and implemented the analysis and visualization software, which can annotate a corpus of text against any dictionary of regular strings that are classified into a hierarchy of rhetorical effects. ...”
A bit of a jump into the deep end
Wave 2 incl. Social Media: Predicting human behavior

Transparent consumers:
How Target figured out a teen girl was pregnant before her father did...

Unique Target Id
Each interaction with retailer is assigned to that id

Group of pregnant customers

Customer profiles
Clustering customers into groups, for example to identify disruptions in life (e.g. weddings, job changes and pregnancy)

Andrew Pole
Statistician working for Target

Pole identified about 25 products that allowed him to assign each customer a “pregnancy prediction” score and the estimated due date

Coupon campaign

Influence of social media 2011!:
Facebook were a country it would be the world’s 3rd largest and twice the size of the U.S. population.” [Qualman 2011]

By 2014 - more “like India”
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Digital Humanities and eHumanities 2.0
Chairs and Centers in Germany – more on the newcomers side

Univ. Basel (Full)
Professorship Digital Humanities (2014)

Univ. Bern (Full)
Professorship Digital Humanities (2012)

Cologne Center for eHumanities
(Univ. of Cologne (+Bonn))
Univ. of Cologne (W1)
Jun.-Prof. (2013)

Univ. Trier (W2)
Professorship Digital Humanities (2011)

Sabine Bartsch, visiting professorship, Univ. Saarland, (in 2012)

Center für digitale Systeme
(part of CEDIS, FU Berlin)

DHd: „Aktuell werden in Deutschland sowie weltweit zahlreiche Digital Humanities-Studiengänge eingerichtet. …“
[www.ifdhberlin.de]

Gregory Crane, Pioneer of DH, Humboldt appointment, Univ. of Leipzig (2012)

Univ. Leipzig: (Full) Professorship Digital Humanities (2012)
Digital Humanities and eHumanities 2.0

Related Academic Studies in Germany - DHd

DHd: „Digital Humanities im deutschsprachigen Raum“

Executive chairman:
Prof. Jan Christoph Meister
University Hamburg

[www.dig-hum.de]
BMBF programs to promote research and development projects

<table>
<thead>
<tr>
<th>Year</th>
<th>Program Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Funding of innovative research infrastructure as TextGrid – Virtual Research Environments for Humanities</td>
</tr>
<tr>
<td>2011</td>
<td>Funding of innovative research projects in the humanities and social sciences with equal acceptance of computer sciences</td>
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</tbody>
</table>

21.01.2013 - 31.05.2014: Promotion of research and development in the area of eHumanities

- „projects, in which humanities and social sciences together with fields close to computer sciences develop new research approaches for their fields“
- „... projects should not primarily address singular field-specific research questions but should contribute significantly to the future development of the field of eHumanities“

Funding line 1: junior research groups
- young researchers funding to address new research questions

Funding line 2: Centers
- building infrastructural centers for IT-based research in humanities

See additional material in the folder on your table
I: E-Infrastructures

**Topic:** e-Infrastructures for virtual research environments (VRE)

**Challenge:** potential and room for development in the use of virtual research environments.

**Objective:** empower researchers through service-driven digital research environments, services and tools tailored

**Deadline:**
2015-01-14 17:00:00 (Brussels local time)

**www:**

...build on requirements from real use cases, e.g. for integration of heterogeneous data from multiple sources and value-added services for modelling, simulation, data exploration, mining, visualization

VREs may target any area of science and technology, especially interdisciplinary ones, including ICT, mathematics, web science and social sciences and humanities
European Union and the ‘e’

The Funding Structures in the European Union (2)

II: FET Open

**Topic:** Coordination and Support Activities
- FET Observatory
- FET Communication
- FET Exchange

**Challenge/ Objective:** to make Europe the best place in the world for collaborative research on future and emerging technologies

**Deadlines:**
30.9.2014, two more deadlines in 2015

**www:**

“FET Open supports early-stage joint science and technology research around new ideas for radically new future technologies. It will build up a diverse portfolio of targeted projects to explore a wide range of new technological possibilities, inspired by cutting-edge science, unconventional collaborations or new research and innovation practices. Early detection of promising new areas, developments and trends, along with attracting new bold-visioned and high-potential research and innovation players will be key. **FET-Open represents 40% of the overall FET budget in Horizon 2020.**”
European Union and the ‘e’
Projects Funded by the European Union

Academic Careers Understood through Measurements and Norms, http://research-acumen.eu/


RECommendations for Open Access to Research Data in Europe, http://recodeproject.eu/

On citation stress and pub pressure
by BARRI DE RUCKE 20 MAR 2014
Our article on citation stress and publ in biomedical went online this week – with colleagues from the Free University Medical Centre Utrecht: Tjijl Rijcke, C.M. Volbers, V.M. Smulders. Read the full article —

How does science go won by BARRI DE RUCKE 13 FEB 2014
We are happy to announce that our article accepted for the 2014 Conference of Concave for Political Research (E3G) be held in Glasgow from 3-6 September. Our paper is included in a paper on 'The role of ideas'. Read the full article —

The Effect Of Internet On Human St by BARRI DE RUCKE 20 MAR 2014

Home
The Policy RECommendations for Open Access to Research Data in Europe (RECODE) project will leverage existing networks, communities and projects to address challenges within the open access data dissemination and preservation sector and produce policy recommendations for open access to research data based on existing good practice.

The open access to research data sector includes several different networks, initiatives, projects and communities that are fragmented by discipline, geography, stakeholder categories (publishers, academics, repositories, etc.) as well as other barriers. Many of these organizations are already addressing key barriers to open access to research data, such as standardization, fragmentation, technical and institutional issues, ethical and legal issues, and state and institutional policy fragmentation. However, these organizations are often working in isolation or with limited contact with one another. RECODE will provide a space for European stakeholders interested in open access to research data to work together to provide common solutions for these issues. It will promote ever-evolving recommendations for a policy framework to support open access to European research data.

The RECODE partners will identify relevant stakeholders, build upon and strengthen existing stakeholder engagement mechanisms. It will conduct studies of good practice and exchange good practice with relevant stakeholders and institutions during networking activities. The RECODE project will culminate in a series of policy recommendations for open access to research data targeted at different stakeholders and policy-makers.
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In search of a definition
Let’s ask Google

“**Big data** is the term for a collection of **data sets so large and complex** that it becomes difficult to process using on-hand database management tools or traditional data processing applications. The challenges include **capture, curation, storage, search, sharing, transfer, analysis and visualization**.”

“**Big Data** refers to technologies and initiatives that involve data that is **too diverse, fast-changing or massive** for conventional technologies, skills and infrastructure to address efficiently. Said differently, the volume, velocity or variety of data is too great. But today, **new technologies make it possible to realize value** from Big Data.”

“Every day, we create 2.5 quintillion bytes of data - so much that 90% of the data in the world today has been created in the last two years alone. **This data comes from everywhere**: sensors used to gather climate information, posts to **social media** sites, digital **pictures** and **videos**, purchase transaction records, and **cell phone GPS signals** to name a few. This data is **big data**.”
Evolution of the term ‘Big Data’
Is there a definitive date?

In parallel: The term ‘software’ was established in 1958 in the article “The American Mathematical Monthly”, written by John Tukey.

What is about the term ‘Big Data’? Is there such a definitive date?

“We call this the problem of big data.”
Term first mentioned in a research article 1997

[Gregory Piatetsky-Shapiro, Editor at KDnuggets]

“Google Trends for Big Data shows an explosive growth in popularity of this term, starting around 2011”

[Google Search Trends ‘Big Data’]
Evolution of ‘Big Data’ as a research topic

Taking a look at the published papers

‘Big Data’ in research emerged around 2008 [Halevi and Moed 2012]

1. First appearance of the term in 1970 in an article on atmospheric and oceanic soundings
2. Until 2000 led by computer engineering but also in areas such as building materials, electric and telecommunication
3. Since 2000 the field is led by computer science followed by engineering and mathematics

Number of ‘Big Data’ papers per year

- 0
- 20
- 40
- 60
- 80
- 100
- 120

1970s 1980s 1990s 2000s 2010s
Evolution of ‘Big Data’ as a research topic
... and the related disciplines

‘Big Data’ research is addressed by multiple disciplines [Halevi and Moed 2012]

1. Top subject area in Big Data research is computer science

2. Other disciplines investigate the topic (like engineering, mathematics, ...)

3. Some areas expected to be evident show no significant growth (like chemistry, energy and humanities)

In fact, there is a growing interest in the development of infrastructure for e-science for humanities

- Computer Science: 171 papers
- Engineering: 75
- Mathematics: 33
- Business, Management and Accounting: 26
- Physics and Astronomy: 23
- Biochemistry, Genetics and Molecular Biology: 19
- Social Science: 18
- Materials Science: 15
- Medicine: 14
- Decision Sciences: 13
- Multidisciplinary: 13
- Arts and Humanities: 11
What are the main characteristics of data in ‘Big Data’?

<table>
<thead>
<tr>
<th>Volume</th>
<th>Velocity</th>
<th>Variety</th>
<th>Veracity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data at rest</td>
<td>Data in motion</td>
<td>Data in many forms</td>
<td>Data in doubt</td>
</tr>
<tr>
<td>Terabytes to exabytes of existing data to process</td>
<td>Streaming data, milliseconds to seconds to respond</td>
<td>Structured, unstructured, text, multimedia</td>
<td>Uncertainty due to data inconsistency, incompleteness, ambiguities, latency, deception, approximations</td>
</tr>
</tbody>
</table>

**The 3Vs of Big Data** [Gardner 2001]
The crux of the matter

**Big Data induce “Intelligence”: From Big Data to Smart Data...**

→ **The Big Data analysis pipeline...**

- ... transfers big data (many...) into smart data (meaningful data)
- ... accumulates intelligence from information fragments
- ... is a pipeline of aggregating (artificial) intelligence.

Acquisition/Recording ➔ Extraction/Cleaning/Annotation ➔ Integration/Aggregation/Representation ➔ Analysis/Modeling ➔ Interpretation

**BIG DATA** + **SMART DATA** ➔ **INTELLIGENCE/DECISION/INSTRUCTION**
Further characteristics

Big Data is distributed

<table>
<thead>
<tr>
<th>Generated by a distributed world</th>
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<tbody>
<tr>
<td>In multiple domains, applications and users generate data that is (partially) Big Data. Hence, Big Data is generated by a distributed world.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stored in distributed file systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Data is structured and unstructured (variability) and its size is enormous (volume). Distributed file systems are required to reliably scale to petabytes of data and thousands of machines.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analyzed by distributed computing</th>
</tr>
</thead>
<tbody>
<tr>
<td>The requirements of Big Data analytics regarding volume and velocity can only be satisfied, by distributed computing solutions.</td>
</tr>
</tbody>
</table>
The way so far and beyond

Two Worlds coming together

Distributed Systems
- Big data - Volume
- Distributed sources
- Distributed computing
- Distributed storage
- Velocity

Distributed Artificial Intelligence

DISTRIBUTED

DS →

Artificial Intelligence

SMART
- Autonomy
- Real-time capability
- Variety
- Veracity
- Social media data

Natural language analysis
- Prediction
- Smart data

Big data - Volume
- Distributed sources
- Distributed computing
- Distributed storage

Velocity

Distributed Systems

AI
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A look ahead

Google Flu: Predicting Future (Predicting the spread of diseases)

It all started with the flu ... [Google Correlate 2011]

Explore flu trends around the world

We’ve found that certain search terms are good indicators of flu activity. Google Flu Trends uses aggregated Google search data to estimate flu activity. Learn more.

actual flu trend can be identified 7-10 days earlier by ‘Google Flu Trends’ than by official data of the Center for Disease Control (CDC) [Helft 2008]
A look ahead

Pandemics: Exploring New Patterns of Complex Scenarios

A circle-model to foresee and to analyze pandemics [Brockmann and Helbing 2013]

“Computational work conducted at Northwestern University has led to a new mathematical theory for understanding the global spread of epidemics.” [ScienceDaily 2013]

The spreading takes place on the worldwide air transportation network of more than 4000 airports and 25000 direct links. [Brockmann/Helbing 2013]

“Is the spread of infectious diseases ... complex, or does it look just complex?” [Erickson 2013]

Using data of flights, trains, etc. the cities are rearranged. Result is simple: a circular wave that produces a stone in the water. Here: distances of places and countries adjusted depending on the flight connections
A look ahead
Predicting human behavior: Election forecast

“How Nate Silver won the election with Data Science” [Smith 2012]

Many data sources
Using the past
Consistent models
Understanding limitations

The man behind the forecast
Nate Silver (born January 13, 1978)
2008 Presidential Election
(49 out of 50 states correct)
2013 Academy Awards
(3 of 4 winners correct)
2012 Presidential Election
(50 out of 50 states correct)

90.9% Chance of Winning
9.1%
A look ahead
"Roboter Recruiting": Don't call us, we'll call you

"... in more and more companies, computer algorithms are part of the employment of new workers..." [Handelsblatt 03/2014]

CV data are combined with “success data” of the particular company or field
- Germany: about 40%
- USA: > 90%

"Great developers are everywhere, and Gild can prove it.” on www.gild.com

Fairness? – different mental models between human and computer
- software based selection is incapable of analyzing “true motivation”, extraordinary engagement etc.
- Talents might be overlooked / lost

But:
- Selection shows a higher degree of equal opportunities regarding gender, age, culture, etc.
- Selection shows a higher degree of tolerance in respect of disruptions in the CV
- ...
A look ahead
IBM’s Watson in Action

Challenge: Building a computer system that could compete at the human champion level in real time in the American TV quiz show, Jeopardy [Ferrucci et al. 2010]

Watson is an artificial intelligence capable of answering questions in natural language

What is Watson?

Represented by the IBM’s Smarter Planet logo, Watson is ten racks of ten Power 750 servers. Watson’s life began five years before the show as a “Grand Challenge” for IBM (like Deep Blue and Blue Gene before).

“I, for one, welcome our new computer overlords”

Ken Jennings' response to losing to an exhibition Jeopardy match to Watson
“Grandparent” used to be “a synonymous with a spring of knowledge... called upon to pass down treasures of information to new generations” [Emling 2013]

Grandparents knowledge:
- informal knowledge
- everyday life experience
- incl. “common sense”

The survey of 1,500 grandparents found that children are increasingly using the internet to answer simple questions. [Telegraph 2013]

Google Trends [Biermann 2013]

Trending How To...
2013, United States
1. How to Tie a Tie
2. How to File
3. How to Get a Passport
4. How to Blog
5. How to Knit
6. How to Kiss
7. How to Flirt
8. How to Whistle
9. How to Unjailbreak
10. How to Vader

Towards the next steps in artificial intelligence:

Google – from an “expert system” to a machine with “common sense”?
### Facts about the digital universe

#### Some Facts on Data in the digital universe

| Fact 1 | From **2005 to 2020**, the digital universe will **grow by a factor of 300**, ...(more than 5,200 gigabytes for every man, woman, and child). **From now until 2020**, the digital universe will about double every two years. |
| Fact 2 | **The investment** in spending on IT considered the "infrastructure" of the digital universe **will grow by 40%** between **2012** and **2020**. As a result, the investment per GB will drop from $2.00 to $0.20. |
| Fact 3 | A **majority of the information** in the digital universe, 68% in 2012, is **created by consumers** [...]. Yet **enterprises** have **liability or responsibility for nearly 80%** ...They deal with issues of copyright, privacy, and compliance ... |
| Fact 4 | Only a **tiny fraction** of the digital universe has been explored **for analytic value**. By **2020**, as much as **33%** of the digital universe will **contain information** that might be **valuable if analyzed**. |

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[IDC 2012]
The fourth industrial (r)evolution

Big Data meets Industry 4.0 - Everybody & everything is networked

“The first three industrial revolutions came about as a result of mechanisation, electricity and IT. The introduction of the Internet of Things is ushering in a fourth industrial revolution. ... Industry 4.0 will address and solve some of the challenges facing the world today such as resource and energy efficiency, urban production and demographic change.”

Henning Kagermann et.al., acatech, 2013

Vision of Wireless Next Generation System (WiNGS) Lab at the University of Texas at San Antonio, Dr. Kelley

Weidmüller, Vision 2020 - Industrial Revolution 4.0
Intelligently networked, self-controlling manufacturing systems

Vision of Things

„local“ to „global“

around 1750

1st industrial revolution
Mechanical production systematically using the power of water and steam

around 1900

Power revolution
Centralized electric power infrastructure; mass production by division of labor

around 1970

Digital revolution
Digital computing and communication technology, enhancing systems’ intelligence

today

Information revolution
Everybody and everything is networked – networked information as a “huge brain”
... let’s have a look

[CAR2CAR, 2011] and [ConnectSafe, 2011]
The fourth industrial (r)evolution

Not Restricted to Industry: CPS / Internet of Things in All Areas

Back to: The earth converted into a huge “brain”… Tesla 1926

Integrating complex information from multiple heterogeneous sources opens multiple possibilities of optimization: e.g. energy consumption, security services, rescue services as well as increasing the quality of life

- Building automation
- Smart grid
- Room automation
- Smart metering
- "hospitality 4.0"
- "house 4.0"
- "room 4.0"
- "power grid 4.0"
- "smart environment"
- "mobility 4.0"
- "health 4.0"

... and more
Thank you!

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1997 – 2000  Research Fellow, TU Berlin, Institute for Mathematics
2000 – 2001  Lecturer, Georgia Institute of Technology, GA/USA
2001 – 2004  Project leadership, TU Berlin, Institute for Mathematics
04/2004  Ph.D. (Dr. rer. nat.), TU Berlin, in the field of Computer Sciences
from 2004  Set-up and leadership of the Multimedia-Center at the TU Berlin
2005 – 2007  Juniorprofessor „New Media in Mathematics & Sciences“ &
              Director of the Media-center MuLF, TU Berlin
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              Center (RUS), Department of Electrical Engineering, University of Stuttgart
since 06/2009  Univ.-Professor, Institute for Information Management in Mechanical Engineering (IMA)
              & Center for Learning and Knowledge Management (ZLW)
              & Institute for Management Cybernetics (IfU), RWTH Aachen University
since 10/2011  Vice dean of the department of Mechanical Engineering, RWTH Aachen University
since 03/2012  Chairwoman VDI Aachen