On the Future of Informatics Departments:

Informatics Research & Education

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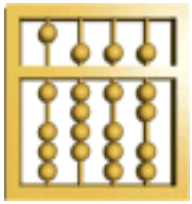

The scientific mission ...

- Information is a scientific phenomenon as fundamental as
  - energy (physics)
  - material (chemistry)
  - ...
- Informatics aims at understanding and utilizing the role of information
  - in natural sciences (physics, chemistry, ...)
  - in life sciences (biology, medicine, ...)
  - in human behaviour (psychology)
  - in society (economy)
  - in reasoning (logics)
  - in computations (computer science)
  - in economy ("Wirtschaftsinformatik")
  - in engineering (building software intensive systems)

  in theory, methodology, and application

Information ... and its many facets ...

- Static: Data Models
  - Representing data
  - Related by functions and relations
  - Specified by laws and rules
- Dynamic: Computation & interactive system behaviour
  - Algorithms, functions and procedures
  - Processes, interaction and reaction, control
  - Real time
  - Behaviour
- Information is the result of interpretation and abstraction

Informatics is an enabler ...

- High performance computing:
  - calculation
  - simulation
  - deduction
- Data storing systems
  - storing mass data
  - data mining
  - information systems
- Graphics, animation, visualisation
  - Image processing
- Communication
  - Transmission
  - Local and global networks for speech and data processing

... that has changed the world

- Advanced tools and assistance
  - mobile multi-functional devices
  - virtual reality
  - social networks
- Global networks: the web and internet
  - pervasive ubiquitous information
- Cyber physical systems
  - embedded systems
  - pervasive ubiquitous computing
- Advanced domain theories and modelling
  - knowledge engineering
- Global knowledge engineering

Informatics as academic discipline

Three in one ...

- fundamental science of information and computing
  - theory: syntactic expressiveness, computability, complexity
  - algorithmics, data structures, logics of programming
  - digital systems and their models
- science of engineering software & information systems
  - information engineering
  - software technology
  - software evolution
  - software project organisation and management
- informatics in application domain engineering
  - domain theories
  - domain modelling
  - the science of the virtual

Is informatics actually a scientific discipline?

Yes!

- Information is a fundamental phenomenon in many scientific disciplines (physics, chemistry, biology, psychology, economy, technology), such as
  - energy in physics
  - material in chemistry
  - life in biology
- informatics addresses
  - the fundamental theory of information,
  - its representation and processing
- information is fundamental in human thinking and behaviour
  - perception
  - reasoning & reflection
  - reaction
  - language
  - knowledge representation

Example: Information and humans' intellect

- Historical
  - spoken languages
  - written languages
  - representing information and calculating (numbers, ...)
  - formalizing reasoning (logics)
- Understanding human information processing
  - brain structures and processes
  - ways humans think (rationally) - languages and logics
  - ways humans communicate
- Man machine issues
  - man machine interaction
  - advanced assistance systems
  - context aware adaptive user interfaces
  - workflow

What the example shows

- Close interaction between
  - foundational research in informatics
  - domain theories
  - applications
- Highly interdisciplinary
  - informatics
  - linguistics
  - medicine
  - psychology
  - history
  - mathematics
  - engineering
  - ...

The challenge: understanding information

- What is the nature of information?
- How to represent it?
- What is the role of information?
  - in physics
  - in biology
  - in chemistry
  - in human life
  - in reasoning
  - in human thinking
  - in computing
  - in technical systems
- Informatics opens the door into new ways of
  - capturing
  - analysing
  - operationalizing

  knowledge in various application domains

Is informatics an engineering discipline?

Yes!

- The engineering of software intensive systems is one of the grand challenges of today
  - engineering hybrid systems: integrating mechanics, digital hardware, software
  - information systems
  - advanced assistance systems
  - usable, reliable, safe, secure, affordable, ...
- Software intensive system evolution
  - shows all the characteristics of engineering disciplines
  - has become a major field of engineering
  - shows tight interactions and relationships with other engineering discipline
  - society depends critically on software
- But essentially different to classical engineering

Example: advanced avionics

Fly by wire

- Engineering fly by wire systems
  - domain engineering
  - functional safety
- From reality to the virtual
  - requirements capture
  - from the abstract to the concrete
- From the virtual to reality
  - reliable and safe implementation and operation
  - augmented reality
  - advanced mission assistance - automation
  - context awareness and adaptation
  - system quality engineering

The example avionics: conclusion

- Capturing the real world
  - ◇ how to grasp the real world by sensors, actuators, internal representations (data and functions)
- Man machine issues
  - ◇ man machine interaction under stress
- Augmented reality, context awareness, adaptivity
  - ◇ information and reaction at the right time in the right situation
- New patterns of perception
  - ◇ virtual reality

The growing role of informatics ...

- In a very short time, informatics
  - has become a key discipline both
  - in scientific research as well
  - as a substantial social, technical and economical factor.
- ... has changed the world by its cyber-physical systems comprising
  - embedded systems,
  - domain specific software applications and
  - global networks

and its interdisciplinary role ...

- The future of informatics departments and informatics research will be determined to a large extend by the question
  - how these quite different dimensions of informatics can be covered and integrated
  - education and research is organised along these lines
  - the interaction with key partner disciplines is organized
- A critical topic both for teaching and research is
  - the synergy between theory and engineering
  - the organisation and structuring of topics and themes in the cooperation with partner disciplines
  - the importance of informatics in education (in school, high school, academic education)
  - the moderation of a social consensus about the use of information in the age of cyber-physical systems

Informatics: the historical roots ...

- Before computers
  - numbers, hieroglyphs, scripture
  - algorithms, arithmetic, calculators, nickelodeons, punch cards
  - the formalisation of mathematics, logics, λ-calculus
- When computers have been invented, more than seventy years ago,
  - computer programming was considered a minor issue
  - compared to all the difficulties to construct computing devices.
- Only over the years it has become more and more apparent that
  - software: the programming of computers is a major challenge.
- Step by step it became visible that
  - the challenge is not only to master the pure coding but
  - to gain a deep understanding of computing and information
  - as a major concept and of
  - its impact and its application in all kinds of domains.

Informatics: the rapid development

- From lab computing to desk tops, lap tops and hand helds
- From sequential algorithms and batch processing to distributed interactive concurrent computing
- From file processing to data bases and to the world wide web
- From punch cards to multi-modal user interfaces
  - ◇ from plotters to high resolution animation
- From stand alone computers to global computer networks
  - ◇ wireless
  - ◇ pervasive & ubiquitous
- From isolated computations to service oriented architectures
- From single purpose devices to multi-functional systems

Blinded by the light ... informatics today

- The enormous growth of informatics as a technical and economical factor
  - danger of covering some of the more scientific and fundamental aspects
- Today, informatics has grown into a major scientific discipline which comprises
  - the basic science of information and computing on its own
  - the scientific of engineering software and information
  - a rich number of fields of application with their specific domain theories, techniques and methods
- Today informatics as a scientific discipline shows
  - a number of different facets including
  - fundamentals of information,
  - communication and computing,
  - the engineering of information processing systems and
  - the domain specific application of Informatics in various fields

Informatics changes our abilities and possibilities

- Higher order of automation
  - Connecting quite different events
- New forms of communication
  - Communication networks
  - Virtual social communities
- Informatics changes our capabilities
  - higher level of transparency
  - data mining and advanced search
  - the end of privacy and anonymity?
  - new monopoles of information
  - digital divide

Informatics tomorrow

Informatics

- for the mass: for every one, always and everywhere
  - ◇ what does that mean for schools and education
- critical infrastructures
  - ◇ long term software evolution
- tight synergy between the virtual and reality
- enhanced domain engineering
  - ◇ new forms of understanding
- new possibilities need new rules
  - ◇ the compliance rules of the age of advanced information processing

Informatics know how needed on all levels ...

- The intellectual ranges of informatics competencies
  - Core informatics know
  - Informatics and its specific application domains
  - Ethics and limits of informatics systems
- Informatics competencies - from using to understanding to evaluating information processing systems
  - Using informatics systems
  - Developing informatics systems
  - Understanding informatics systems
- Informatics governance
  - Deciding about informatics systems

The two big areas of engineering ...

- Digital systems and computation:
  - Theories of computing and interaction
  - Software and system models
  - Operating systems, middleware, protocols,
  - Programming and programming languages, compilation and interpretation
- Applications: domain engineering
  - Taxonomies and ontologies
  - Advanced data models
  - Descriptive models
  - Operational and computational models: control & simulation

Research hot spots in the core ...

- Man Machine Interaction - MMI
  - adapted user interfaces
- Programming languages and concepts
  - Abstraction
  - Interaction, concurrency, distribution, real time
  - programming methodology
- Software & systems evolution
  - advanced software & system modelling
  - seamless engineering
  - tool support
- Software safety, security, reliability
  - high quality software
- Advanced forms of computing

Interplay theory and practice

- In some field practice much stronger than academic research
  - hot spots (example data mining and search engines)
- In other field some practice far behind theory
  - software engineering
- Lack of empirical facts and data
  - What do we know about the rules of software and systems evolution
- Interaction academic research / industry
  - a lot of "business as usual" in funding programmes
  - strategic partnerships rare

Domain modelling

- Software cannot be better than the domain know how on which it is based
- Software requires a deep understanding of domain knowledge
- Domain knowledge has to be captured in software specific forms that it can be directly integrated into software
  - This requires targeted modelling techniques
  - Domain modelling may contribute to the know how in the application domain

Informatics in academia ...

- ... its academic stature
  - is it a science (faculty, department) on its own!
- ... its related disciplines
  - Electrical engineering
  - Mathematics
  - Economics
- ... its role in universities
  - who should host the chairs for specific areas of application?
  - does every university need an informatics department?
  - is informatics to be integrated into many other curricula?

Teaching informatics

- Teaching foundations and theory
  - Information and their representation
  - Computation
  - Logics
- The methodological kernel
  - Programming
  - Systems modelling
- Engineering informatics systems
  - Software evolution
- Key application areas
  - ...

Teaching informatics ...

- Teaching core informatics students
  - ◇ science and research
  - ◇ professionals
    - leadership and information governance
  - ◇ high school teachers
- Teaching students from application fields and disciplines
  - ◇ applying informatics tools
  - ◇ using informatics modelling techniques
  - ◇ working in teams with informatics professionals

Teaching informatics: spaghetti a la Bologna

- Bachelor: the basics
  - Theory
  - Programming methodology
  - Programming languages, compilers
  - Information systems
- Master: Specialized curricula
  - Interdisciplinary
  - Focused
    - science of information
    - engineering
    - specific areas of application
  - Joint programmes between different disciplines

Do we teach the right topics ...

- Theory for theory's sake
  - which theory for which purpose
- Too specialized short term topics
  - better solid topics than
  - newest hypes
- No appropriate scientific foundation
  - ad hoc methods do not help on the long term
- Enabling our students
  - to understand the foundations
  - to do engineering
  - to work interdisciplinary
  - for leadership

The challenge in curricula: attracting more students

- Why more students in informatics?
  - Badly needed in practice!
  - Badly needed in research!
  - Badly needed in education!
  - Best professional perspectives!
- Why so difficult to attract students?
  - Image
  - Leadership
- Why so difficult to attract high potentials?
  - We have to show the intellectual challenges
  - We have to show clear images of careers “Berufsbilder”

Further education needs ...

There is not enough understanding ...

- with people using information systems
  - privacy
  - capabilities
- with people taking part in software development projects
- in management
  - software project governance
  - corporate knowledge and information systems engineering
- in politics

Conclusion

- Informatics is much more than
  - producing software by writing programs
  - theory
- Software contains domain knowledge often implicitly
  - software engineering enforces the understanding of application domains
- Software validation & verification requires to make domain knowledge explicit
- The future of informatics departments lies
  - in the interaction between application domains and models of informatics
  - the seamless engineering of software intensive systems
  - the understanding and exploitation of the role of information
- Making one out of the three
  - theory and basics
  - engineering software and information systems
  - domain specific informatics