Rethinking software engineering research and education in the light of digital humanism

Carlo Ghezzi

DEIB—Politecnico di Milano
Title: Building dependable situation-aware software: how to self-adapt to environment changes

Speaker:
Prof Carlo Ghezzi
Department of Electronics and Information
Politecnico di Milano

Date/Time:
14 November 2014, Friday, 01:00 PM to 02:30 PM
This talk
This talk

• Not technical
This talk

• Not technical

• Reflection on the effects of digital technology on humans and society
This talk

• Not *technical*

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• Not technical

• Reflection on the effects of digital technology on humans and society

• How these reflections lead to re-thinking the way we do software research and education
Setting the stage: a brief historical perspective
Historia vero testis temporum, lux veritatis, vita memoriae, magistra vitae, nuntia vetustatis

History, the witness of time, the light of truth, the life of memory, the directress of life, the herald of antiquity

Cicero, De Oratore, II, 9, 36
Progress of science and technology

Thomas Kuhn

1962
Progress of science and technology

- Science and technology undergo periodic revolutions (paradigm shifts) followed by normal science, when scientists attempt to enlarge the central paradigm.

Thomas Kuhn

1962

The Structure of Scientific Revolutions

A brilliant original analysis of the nature, causes, and consequences of revolutions in basic scientific conceptions.
Progress of science and technology

- Science and technology undergo periodic revolutions (paradigm shifts) followed by normal science, when scientists attempt to enlarge the central paradigm.

- It has been shown that revolutionary changes in science/technology also lead to revolutionary changes in society and human life.
Back to the 17th century
Back to the 17th century

- Invention of the scientific method—the mother of paradigm shifts
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• Invention of the scientific method—the mother of paradigm shifts

• Explosion of modern science: physics, mechanics, thermodynamics … chemistry, electricity, …)
Industrial revolution (1700 – 1900) ignited by the invention of machines
Disruptive changes in society and human life
Disruptive changes in society and human life

Agriculture
farming
craftsmanship&commerce

Factories,
machines,
… finance
Disruptive changes in society and human life

Agriculture
farming
craftsmanship&commerce

Factories,
machines,
… finance

Countryside

City
Disruptive changes in society and human life

Agriculture
- farming
- craftsmanship & commerce

Factories, machines, … finance

Countryside

City

Feudalism

Capitalism
Yuval Noah Harari

Sapiens

A Brief History of Humankind

‘I would recommend Sapiens to anyone who’s interested in the history and future of our species’

BILL GATES
Understanding the digital revolution

• More disruptive than industrial revolution

• Three main dimensions
  • breadth
  • depth
  • speed
Understanding the digital revolution

• More disruptive than industrial revolution

• Three main dimensions
  • breadth: All aspects of society are affected
  • depth
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  - breadth: All aspects of society are affected
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Understanding the digital revolution

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- Three main dimensions
  - breadth: All aspects of society are affected
  - depth: Changes are radical
  - speed: Unprecedented change rate, *decades vs centuries*
Understanding the digital revolution

• More disruptive than industrial revolution

• Three main dimensions

  • breadth  All aspects of society are affected

  • depth  Changes are radical

  • speed  Unprecedented change rate

  decades vs centuries

• A cyber-physical world where humans interact with the physical world and artificial autonomous entities in new space and time dimension
Digital technologies: what makes them special?
Digital technologies: what makes them special?

- Physical machines—*hardware*
Digital technologies: what makes them special?

- Physical machines—*hardware*
- Interaction/cooperation among machines—*networking*
Digital technologies: what makes them special?

• Physical machines—*hardware*

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• Interaction with humans and physical world—*sensors, actuators, HCI*
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• Software —> *universal machines*
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• Software —> *universal machines*
Evolution: disappearing boundary, invisible technology
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Evolution: disappearing boundary, invisible technology

designing technology ←→ designing society
←→ designing the world
Digital technologies give us unprecedented opportunities
Digital technologies generate unprecedented threats
Digital technologies generate unprecedented threats
Digital technologies generate unprecedented threats
Digital technologies generate unprecedented threats

Privacy violations
Biased decisions
Echo chambers
Digital technologies generate unprecedented threats

Privacy violations

Biased decisions

Echo chambers

People surveillance
Digital technologies generate unprecedented threats

- Privacy violations
- Biased decisions
- Platforms and sovereignty
- Echo chambers
- People surveillance
Digital technologies generate unprecedented threats

Privacy violations
Biased decisions
Platforms and sovereignty
Echo chambers
Generative AI: autonomy
People surveillance
Outline
Outline

- WHY SHOULD WE CARE?
Outline

• WHY SHOULD WE CARE?
  • Software technology creates the new world
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  • Are technological skills enough to make decisions on what technology does?
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• WHAT CAN WE DO?
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• WHAT CAN WE DO?
  • How can technological developments be aligned with human and societal values and goals?
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• WHAT CAN WE DO?
  • How can technological developments be aligned with human and societal values and goals?
  • How does this affect research and education?
Why should we care?
A software-defined world

• The world exists through software

• Software defines new entities, new actions, new behaviors, … the rules of behavior

• Design responsibilities (and skills required) transcend pure technology
Code is law

- Code as regulator of the cyberspace
Code is law

• Code as regulator of the cyberspace
Code is law

- Code as regulator of the cyberspace

This code, or architecture, sets the terms on which life in cyberspace is experienced. It determines how easy it is to protect privacy, or how easy it is to censor speech. It determines whether access to information is general or whether information is zoned. It affects who sees what, or what is monitored. In a host of ways that one cannot begin to see unless one begins to understand the nature of this code, the code of cyberspace regulates.

Prof. L. Lessig (2000), Constitutionalist, Harvard Law School,
Who is responsible? Who is accountable?

- Traditionally, societies are regulated through well-defined human processes and deliberations.
- In democratic societies, decision processes involve citizen participation.
- Responsibilities are clearly defined.
- All this is blurred, **opaque** in the digital world.
Epistemic opacity of the software-defined world

- Opacity of responsibilities
  - No explicit assumption of responsibilities
- Opacity of software-defined rules and behaviors
  - Complexity, leading to brittleness
Complexity

• Hard to understand and describe

• Hard to provide assurances

• Current shift from automation to autonomy due to AI makes all even more critical, scaling up opacity

• AI software, learned components

“Essential complexity”
“there is no single development, in either technology or management technique, which by itself promises even one order of magnitude [tenfold] improvement within a decade in productivity, in reliability, in simplicity."
Basic questions
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• Who is directing our future?
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• We? Market? Governments? Technologists? None of them, ... all of them? ...
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• Can we direct our future?
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• Can we direct our future?

• Shall we direct our future?
Basic questions

• Who is directing our future?
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• Can *we* direct our future?

• Shall *we* direct our future?

• Which *founding principles*?
Basic questions

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• Which founding principles?
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Digital humanism

Humans at the center

Technology for humans not

humans for technology
How does digital humanism relate to/affect software engineering?
Which systems?

- Most systems developed by software engineering are *socio-technical* in nature
  - interaction between people and technology in workplaces and in private life
  - They also interact with and may affect the physical world
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Humans at the center
Sustainable
Digital Humanism
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Back to the basics
Back to the basics

• Michael Jackson and Pamela Zave (1990s)
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  - The WORLD and the MACHINE
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  • We need to understand the specific domain/environment, its properties, and make assumptions
Back to the basics

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  - The WORLD and the MACHINE
    - We build (abstract) machines to achieve certain real-world goals, satisfy certain requirements
    - We need to understand the specific domain/environment, its properties, and make assumptions
    - Software engineer’s responsibility: $M, E \models R$
The current practice
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- Goals/requirements should express human/societal concerns and values
- Context/environment should refer to human and social properties/assumptions
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- Implementation owned by software engineers
As a result

• We deliver systems where seemingly “technical” decisions have “non-technical” unacceptable effects on people, society, environment

• **Ex-post** patches to mitigate
  
  • privacy violations

  • unfair operations/racist decisions/gender issues (e.g., due to bias induced by ML learned components)

  • ...

• This is bad, due to quick transfer of technology to real world

  • **Towards "ex ante" approaches?**
Can we build better systems?
Can we build better systems?

Better systems for a better world
Can we build better systems?

Better systems for a better world

Can we build systems that comply with the principles of digital humanism?
What does “better” mean? —right and wrong, good and bad—

• Are questions about what is right/good and what is wrong/bad part of SE practice?

• Are questions about what is right/good and what is wrong/bad part of SE education?

• When we identify goals and set requirements?

• When we implement and assess alternative solutions?

• When we validate/verify?
Computational Thinking

It represents a universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use.
2020: Ethical thinking
2020: Ethical thinking
2020: Ethical thinking
Ethics and ethical deliberations as necessary pillars of SE EDUCATION and PRACTICE
Three dimensions

- The human dimension
  - preserve and enhance **human values**

- The societal dimension
  - preserve and enhance **societal values**

- The natural world dimension
  - preserve and enhance **environmental values** to establish a sustainable relation with the planet
Objective: anticipate consequences/uses

• What can/should/must the future system do?

• What can be the broader effects/consequences?

• Is it good/bad? Is it right/wrong?

• Make explicit choices, take responsibility
Towards "ethical software engineering"?
Code of ethics: is that all we need?

ACM Code of Ethics and Professional Conduct

Affirming our obligation to use our skills to benefit society

- General Ethical Principles
- Professional Responsibilities
- Professional Leadership Principles
- Compliance with the Code
- Case Studies
- Using the Code

IEEE Code of Ethics

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members, and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

Overview - Version II

The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems
Code of ethics: is that all we need?

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1. To uphold the highest integrity, responsible ethical conduct in all our work and dealings.
2. To be informed about and to incorporate into our professional work the ethical and professional implications of our technologies and their applications.
3. To adopt and use, where appropriate, principles of human rights and of fair, just, and equal treatment of all.
4. To avoid unfair or self-serving use of information, and to report improper use.
5. To seek, accept, and share of technical work, to correct errors, to be open to new ideas and other contributions of others.
6. To maintain and improve our competence and to teach others, for others only or experience, or for the advancement of the art, science, or profession.

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The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems
Goals

• Make ethics actionable in the conception and construction of socio-technical systems
  • Ethical deliberations as first-class elements of the process

• Difficulties
  • Who should be involved?
  • Good/bad, right/wrong sometimes setting the border is not obvious, most decisions are not binary
  • How are these specified? How are they validated?
Who decides? Who contributes?

- How can human/social/environmental concerns be addressed?
- Can they be left in the hands of software engineers?
- Additional knowledge/contributions needed, e.g. from humanities, social/political sciences, law, …
- Collective process leading to responsible design
Existing efforts


• Working on an approach supporting ethical deliberation in Agile processes

• Lero, Ireland, "Responsible Software Engineering" (B. Nuseibeh)
Revisiting research goals
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• Enrich the technical perspective with other perspectives that are context-relevant (ethical, social, legal, political, economical)
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  • Requirements: how can ethics and stakeholder values be addressed
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  • Requirements: how can ethics and stakeholder values be addressed

  • Software processes: which processes better support ethical deliberations?
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    - From agile to new forms of participatory design
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  - Verification and validation: throughout the lifecycle, including run-time
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  • Software processes: which processes better support ethical deliberations?

    • From agile to new forms of participatory design

  • Verification and validation: throughout the lifecycle, including run-time

  • Supporting continuous evolution, including self-*
Towards transparent software systems
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• Transparency needed for responsible use and trust at all levels (users, designers, policy makers, regulators, …)
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• Friendly, adaptive transparency
Education

• How to educate professionals for the new world created by technology?

• Software engineers should be able to co-design systems and speak a common language with other experts

• Challenge for education

  • We need to find ways to break disciplinary silos without compromising technical depth
Make existing CS curricula DigHum-aware

- Bottom line: ethics in education
  - from code of ethics for students to ethics in the profession to general ethical thinking
- Encourage taking courses from humanities and social sciences
- Introduce cross-discipline lab activities, mixing students/mentors with different backgrounds
Can humans drive the process to ensure that is for their good?
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**Digital Humanism**

ensuring that technology development remains centered on human interests

a growing debate by a growing and diverse community
The Vienna DigHum initiative
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- Roadmap for Digital Humanism
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Back to history: The Vienna Circle (1930’s)

Moritz Schlick, Otto Neurath, Hans Hahn

Some other initiatives

https://pci2023.wpengine.com/

Co-funded by Mei Lin Fung and Vint Cerf

https://www.humanetech.com/

Together we can align technology with humanity’s best interests.
Conclusions: the need for engagement

• Software technology affects all

• Software technologists need to engage with others

• While they design technology

• The need to engage with the public sphere (decision makers, regulators, politicians, layers, …, people)