Steering Technological Change?

Why Technology Involves more than Technology

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Bejing, November 10th, 2018

Some questions

- ‘steering’ alludes to the cybernetical paradigm
  - what are the handles and what the instruments?
  - what, if we have no parallel worlds at our disposal, where we could observe how things would have evolved if no action or an alternative action would have been taken?
- is there currently ‘rapid technological change’?
  - no fundamental breakthroughs since decades
  - many promising and necessary concepts abandoned (e. g. secure, reliable systems and networks are still a desideratum)
  - what is happening is scaling up along lines laid-out in mid 20^{th} century (e.g. Moore’s law)
  - and broad diffusion based on economies of scale

Steering technological change may result

- sometimes in tremendous success
  - the mechanical clock as a public institution supported by urban citizenships
  - digital computing, networking and GPS as created by the US DoD, DoE and Telco regulation (AT&T Bell Labs)
  - civil nuclear energy as created by the DoE and Westinghouse
- sometimes in deferred success
  - the Jacquard loom pushed by Napoleon Bonaparte
- and sometimes in outstanding failure
  - nuclear energy as sponsored by the German government (the energy suppliers stayed with the proven technology)
  - likewise semiconductors (there is no point in emulation only)

Technological change

- displays phases in time
  - inception, not necessarily by a single author and in one place
  - early adoptions and ripening with high cost and suffering
  - broad diffusion (in the successful cases)
- results from the confluence of various currents
  - diversity of scientific knowledge —new or only rediscovered
  - craftmanship and broad technological experience
  - supporting social forces, needs and interests
  - conducive structures, institutions, industries
  - social practices of adoption and usage
  - infrastructural, legal and institutional adaption
- involves more than only technology

Steering technological change requires

- a broad and solid base of expertise
- a grasp of technological potentials
- the awareness of a good associated with it
- supporting and adaptive social forces
- a conducive, communicative environment
- the investment of time, labour and money
- patience and a preparedness to take risks
- the awareness of path dependencies
  - it is difficult to replace a proven, established technology
  - neglect of emerging technologies and respective application areas may result in gaps filled by others and hard to reverse

20th century roots of digital electronic IT

- mathematics, linguistics and computer science
  - metamathematics: logic, proof theory, computability
  - syntax theory and programming languages
  - logic, algebra, category theory and computational semantics
  - functional analysis and numerical methods
  - descrete structures and algorithms (graphs, trees, queues)
- physics
  - quantum mechanics and atomic physics
  - applied to solid state physics → semiconductors
  - optics and electrodynamics → laser, high frequency radio
- a broad technological base
  - tradition of building cybernetic devices (clock, Jacquard loom)
  - precision optics, chemical processing for high purity materials
  - efficient manufacturing of discrete units with high variance

Agency and social forces in IT

- state
  - military: cybernetics, numerical computing, numerical control, network computing and scientific communication (ARPANet)
  - administrative: statistics, meteorological, geological survey
- corporate
  - financial: accounting, payment, inventory (ERP)
  - product development: design, calculation (CAD, FEM, PLM)
  - manufacturing: numerical control, robotics
  - office: text processing, spreadsheet, presentation
- private — enabled by and enabling further price falls
  - office and educational
  - entertainment and shopping
  - communication

Current trends in IT

- hardware and network
  - progressive miniaturization of devices
  - availability of large storage and massive parallel computers
  - pervasiveness of networked processors, sensors and actors
- software
  - collection and handling of massive amounts of data
  - advanced pattern recognition (ANN, machine learning)
  - increased reliance on non-explicit specifications
- system level
  - proliferation of embedded systems (CPS, IoT)
  - expansion of automatic system functions
  - increased dependency on networked resources
  - absence of transparent specifications (machine learning)
  - growing complexity and vulnerability

Fields deserving of particular attention

- dependency vs. resilience of socio-technical systems
- technology and infrastructure: who has control?
- internetworking platforms: who defines the standards?
- natural resources: energy, rare minerals, waste
- not all applications are useful, responsible and efficient
- many organizations/enterprises lack the expertise
- information monopolies are inevitable, but dangerous
- scaling up near-distance activities and relations
  - spatial polarization: social imbalance, RE-bubbles, traffic jam
  - increased energy consumption, waste and pollution
  - avoidance of labour regulations, deflationary tendencies and slowing productivity growth