Innovation, productivity, AI, robots and employment: an impossible deal

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Introduction

Will robotisation and automation drastically affect the structure of our society, resulting in a significant increase of unemployment? Are the Neo-Luddites right?

In this presentation I want to put the sometimes alarming trends in a proper context.

Indeed, besides potential dangers and negative effects, there is an enormous potential for robots and other forms of automation:

• to make our society more inclusive, and
• to create a new industrial fabric to support innovation
• to eventually create a new society, not exclusively based on GDP
A few concepts

**The Industrial Revolutions**

- **FiIR**: mechanisation
- **SIR**: electrification en automation of production processes
- **TIR**: informatisation of the industrial environment and society
- **FoIR**: digital networks of ‘things’ (IoT, Industrie 4.0, CPS (Cyber Physical Systems))

Robots are programmable machines that interact with their environment (objects or people)

Mechatronics is the integrated design paradigm in which the mechanical, control and informatics components of a (complex) system are simultaneously optimised (simultaneous engineering, systems engineering)
A few concepts

**Innovation**

- **Schumpeter**: innovation is ‘creative destruction’
- It is the **combination** of existing ideas and concepts in original products and services that appeal to the market
- **IBM**: “The Enterprise of the Future aims beyond articulated needs and wants, creating first-of-a-kind products, services and experiences that were never asked for, but are precisely what customers desire.”
- **Incremental** (automotive industry) versus **radical/disruptive innovation** (Internet, 3D-printing)
- **Open** versus **closed innovation**
- **Crowd sourcing**: ‘the crowd as wisdom’
Natural versus artificial intelligence

• Techno-utopist Ray Kurzweil: ‘the Singularity is near (2045)’, the time instant when the computer becomes more intelligent than the human

• The information processing triangle

Doing the right thing at the right moment, taking into account the context (technical, economical, moral,…
Natural versus artificial intelligence

- Is AlphaGo intelligent? No!
- When would a robot/machine have ‘general intelligence’? When it:
  - is self-conscious and can reflect about itself;
  - knows its place in the world (the grounding problem);
  - can generalise (can solve new problems based on a limited set of examples).
- Solving the grounding problem requires an answer to following fundamental questions:
  - How does the robot structure the information it acquires through its sensors?
  - How does the robot connects this structure to the world in which it acts (meaning)?
  - How does it create meaningful communication?
  - Why does the robot do something rather than nothing? What makes it move? (intrinsic motivation)
- Is general intelligence possible without body? (the ‘embodiment’ problem)
Natural versus artificial intelligence

• Moravec’s Paradox
  • “What is trivial for people is difficult for robots and vice versa”.
    • A child is able to knot its shoelaces
    • The amazing flexibility of plumbers and cabinet makers
    • Folding clothes
• Impressive progress through data analytics and deep learning, e.g. in medical diagnosis.
• But general intelligence is still far away!
• No robot/computer has passed the Turing test successfully so far
Man-machine/robot communication

• Before: robots and humans operated in separated worlds (fences)
• Now: robots invade people’s daily lives (lawn mowers, companion robots, ..)
  • Communication should be ‘natural’ to facilitate acceptance
    • Voice control
    • Gesture control
    • Human demonstration
    • Brain control interface (BCI)
  • Robots should be intrinsically safe
Manipulation tasks (MT) versus information processing tasks (IPT)

- MTs are much more difficult than pure IPTs
  - Threading a needle, sewing
  - The ‘Piano-movers’-problem
  - ‘Bin picking’
- Will 35% of the plumbers have lost their job by 2050? Certainly not!
Innovation, productivity and employment

• Innovation stimulate employment by:
  • Productivity growth
  • Introduction of new products
  • New business models

• Innovation through productivity growth
  • Existing studies show: productivity growth \(\xrightarrow{+} \) employment
  • The effect: innovation \(\xrightarrow{?} \) productivity growth/employment
    • seldom investigated (innovation is difficult to quantify)
  • Studies in the European manufacturing industry show:
    • Product innovation \(\xrightarrow{++} \) total productivity
    • Process innovation \(\xrightarrow{+?} \) total productivity
Innovation, productivity and employment

• Two visions
  • Vision 1: innovation is growth
  • Vision 2: innovation is shrinkage

**Vision 1 mostly wins**

Vision 1: **Innovation is growth**

- **Product innovation** creates new markets, by incremental innovation (automotive industry) or disruptive innovation (Smartphone, iTunes)

- **Process innovation** is a powerful engine for productivity growth in the service sector (ICT) and in the manufacturing industry (3D printing)

- **Businessmodel innovation** creates disruptions in taxi (Uber)- and hotel sectors (AirBnB); also in traditional industries (Design Build Finance Maintain (DBFM))

Vision 2: **Innovation is shrinkage** (Neo-Luddites)

- After robots have taken over our jobs there are no new jobs available
- Even if there come new jobs, the rate at which existing jobs disappear will always be larger
- And what will remain when robots become more intelligent than humans?

‘Absurd’ say Vision 1 adherents:

• There is **no limit to human consumption drift**
• **Money will be replaced by time**, leading to part-time working habits
Innovation, productivity and employment

- **The Total factor productivity (TFP)** is better to measure productivity
  - **US**: 4% productivity growth is needed to safeguard employment
    - In reality: between 0 and 1.5%
  - **Flanders**:
    - **Growth intensity of employment, GDP and productivity**

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<tbody>
<tr>
<td>GDP</td>
<td>3,4</td>
<td>2,0</td>
<td>2,2</td>
<td>1,6</td>
<td>1,5</td>
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<td>Employment</td>
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<td>0,2</td>
<td>0,6</td>
<td>0,9</td>
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<td>Arbeidsintensiteit van de groei</td>
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<td>0,1</td>
<td>0,3</td>
<td>0,6</td>
<td>0,6</td>
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<td>Arbeidsvolume</td>
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<td>-0,1</td>
<td>0,2</td>
<td>0,5</td>
<td>1,1</td>
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<tr>
<td>Productiviteit per uur</td>
<td>4,2</td>
<td>2,1</td>
<td>2,0</td>
<td>1,1</td>
<td>0,4</td>
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<tr>
<td><strong>Productivity per person</strong></td>
<td><strong>3,2</strong></td>
<td><strong>1,8</strong></td>
<td><strong>1,6</strong></td>
<td><strong>0,7</strong></td>
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Innovation, productivity and employment

• **Productivity growth is misunderstood** (Brynjolfsson)
  • Reaping the benefits of new technologies requires complementary inventions and investments
    • Ex: replacement of steam engine by one big electric motor did not increase productivity. Decentralised drive systems are needed (**mechatronics approach**)

• **Productivity growth vs competitive advantage**
  • **Dream** (unions): productivity growth **leads to** higher salaries
  • **Reality**: high productivity is **needed to justify** the high salary costs.
  • **Result**: **self-referential system** that kills the potential of productivity growth for increasing the competitive position of a company
Innovation, productivity and employment

• Innovation through innovative products and new business models
  • New technologies normally need less workforce
    • Hardware manufacturing requires more workforce than software production

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<th></th>
<th>Workforce</th>
<th>Yearly Revenue (billion $)</th>
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<tr>
<td>Apple</td>
<td>90 000</td>
<td>260</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>640 000</td>
<td>235</td>
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• The manufacturing industry remains important to maintain/increase employment
Shifts in employment: job polarisation

• Five types of tasks:
  • (i) **manual routine tasks** (e.g. assembly line),
  • (ii) **manual complex tasks** (e.g. plumbing),
  • (iii) **cognitive routine tasks** (e.g. travel agencies, administration)
  • (iv) **processing of new information** (e.g. trouble shooting),
  • (v) **solving unstructured problems** (e.g. product design).

*The number of middle paying jobs decreases while the amount of low paying and high paying jobs increases*

- **Moravec’s paradox**: ‘Manual (i) and cognitive routine tasks (iii) are easy to automate while tasks requiring manipulative skills (ii) are much more difficult to automate.

- Tasks requiring **general intelligence** (iv) and (v) are still impossible to automate
Shifts in employment: job polarisation

• Employment shifts in US

<table>
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<th>Year</th>
<th>Low skills</th>
<th>Middle skills</th>
<th>High skills</th>
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<tr>
<td>1979</td>
<td>13,7</td>
<td>61,1</td>
<td>25,2</td>
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<tr>
<td>2016</td>
<td>18,2</td>
<td>43,2</td>
<td>38,6</td>
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• Employment in agriculture (US)
  • 1900: 40%       2019: <2%
  • Production higher, living standard higher
  • Leaves room for invention, innovation, job and wealth creation
Shifts in employment: job polarisation

• Employment shifts *between activity sectors*

![Employment shifts 2008 – 2011 chart]

- Industry
- Finances, insurances
- Agriculture, Forestry, Mining
- Real estate
- Electricity, gas, steam
- Water, sewage, recycling
- Construction
- Administration
- Science and technology
- Transportation, storage
- Other services
- Hotel and catering
- ICT
- Wholesale, retail, repair
- Public sector

Health, defence, public administration, education
Shifts in employment: job polarisation

• The manufacturing industry
  • Employment in Flandes’ manufacturing industry decreases (still 14% of the total employment, 20% in Europe), but:
  • A strong manufacturing industry remains important:
    • Because of the multiplier effect of the sector
    • To maintain and develop a high-tech industrial fabric as a cornerstone of innovation
    • ‘To innovate you should make’
    • Examples:
      • the demise of the Belgian machine tool industry
      • Brainport around Eindhoven, the Netherlands

• Over-education
  • The ‘1000€ - generation’ in Italy
  • Too many highly educated graduates are employed in routine jobs (only 10% of the working people are doing creative jobs, much less than in other high-tech regions in Europe (Oxford, Stockholm)
  • ‘Employing more creative minds in our companies may result in 18000 additional jobs’ (Prof. Sleuwaegen, KU Leuven)
Are the robots coming?

• **What are they capable of?**
  • Accurately position and move objects
  • Accuracy
  • Tireless
  • Slower than humans
  • Human/robot communication difficult

• **Robot population**
  • Globally: 69 robots/10000 employees
  • Korea: 531
  • Largest growth market: China
  • Japan: decreasing trend
  • 2015: 253748 robots installed
  • Growth rate of 15% per year

• **Market of service robots** is (still) much smaller
  • 2015: 41060 professional service robots installed
  • What? Half were AGV’s, military and intervention robots (demining), milking robots, fruit picking robots, medical robots, …
Are the robots coming?

- Unemployment levels versus number of installed robots

- Robots are no threat (yet) for employment
- Watchfulness is advised: ‘Design for the unexpected’
Robots create new opportunities

- Introducing robots also creates jobs (several hundred thousands)
  - Where precision and consistancy requirements cannot be achieved without robots
  - Where work environments are harsh and unhealthy
  - To prevent outsourcing for cost reasons

- Robots offer opportunities to support society, e.g. in health care, surgery, rehabilitation, services, production
  - Intervention robot
  - Demining
  - Museum guides
  - Robot butlers
  - Fruitpicking robots
  - 3D-printing robots
  - etc
Robots create new opportunities
Education and innovation

• Innovation requires **creativity and** multi- and **transdisciplinary thinking**

• Both should be trained at all levels of the education system, starting from kindergarten
  • Silicon Valley and Montessory

• Creativity is congenital but can (and should) be trained

• Transdisciplinary thinking should be trained and sharpened by teaching courses such as **STEM**, system theory, mechatronics, CPS (cyber-physical systems), conceptual engineering design
The future of jobs

• There will never be enough jobs for a fully employed society

• **Which new jobs in 2050?**
  • Impossible to tell (and more or less useless to try to predict)
    • Would you have been able to predict in 1970 the jobs that emerge now after 50 years, such as:
      • 3D-printing technologist,
      • Industrie 4.0 technologist
      • cyber security engineer,
      • solar and wind energy technologist,
      • block chain developer,
      • virtual reality game designer,
      • website developer, app developer

• We even don’t know which technologies will be emerging within 50 years
  • The jobs that are necessary at that time will be created.
  • Will that be enough? No!
The future of jobs

• **Past scenarios**
  • The jobs that were lost in agriculture through automation (from 50 to 3%) have been absorbed, often after turbulent transients, by manufacturing and the jobs lost in manufacturing (from 30% to 14% now, to ?%) are being and will be absorbed by opportunities offered by the emergence of new technologies and products

• **What happened during these transitions?**
  • New technologies and innovations emerged, creating new employment
  • Global employment has remained more or less constant
  • Living standards have dramatically increased, but not for everyone
The future of jobs

• A few questions
  • Will there be enough jobs? No! Never!
  • What about job polarisation? LS? MS? HS?
    • Are the predictions realistic? No!
      • Example: plumbers: 35% chance of computerisation (2013: Frey and Osborne) !?
  • Has time not come to redefine the notions of progress, work and standards of living, not uniquely based on exponential growth and GDP?
    • How did people’s spiritual health and happiness evolve, along with more ‘wealth’?
    • What if the standards of living of the developing countries start matching those of the already developed countries?
    • What if Earth Overshoot Day (*) is coming closer and closer to Jan 1st? In 2019: July 29th
  • Wouldn’t a new paradigm for the concept and remuneration of work become necessary?
  • Could it be that the future of work is ultimately the end of human work?
  • In the meantime:
    • Overcome the transient periods by innovation and creating as many jobs as possible like it always has been

(*) the day that human demand for ecological resources and services has surpassed what the earth can regenerate in a year
Take-away messages

• The Singularity point is still far away, if it ever comes

• Many jobs will still be reserved for humans
  • Manipulative jobs
  • Jobs requiring general intelligence

• Innovation is the key source of employment

• Robots are no threat (yet) for employment

• Robots create unique opportunities towards a more inclusive society

• The manufacturing industry remains of paramount importance
  • For its multiplier effect
  • To (re)create a high-tech industrial fabric as the base of innovation

• Education, at all levels, should be based on training creativity and interdisciplinarity

• Thinking and action about the future of work becomes urgent
Thank you!