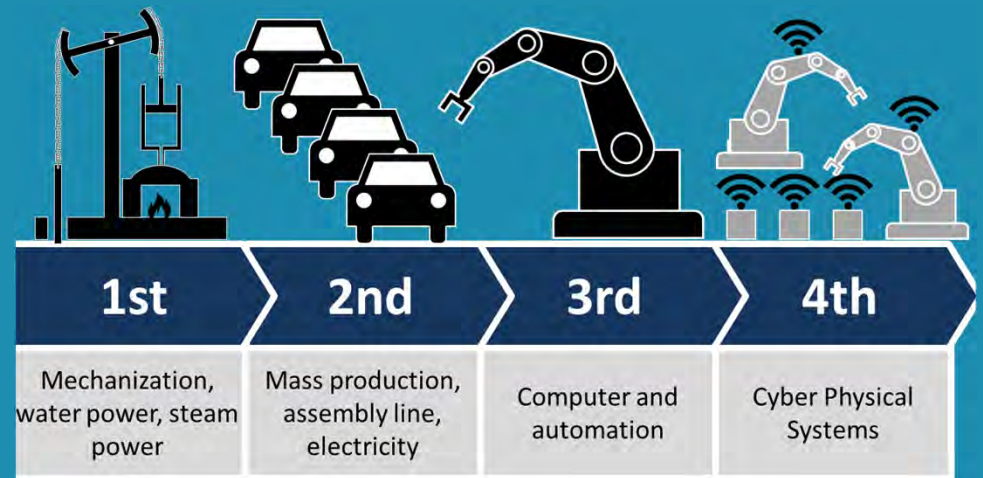


# Innovation, productivity, AI, robots and employment: an impossible deal

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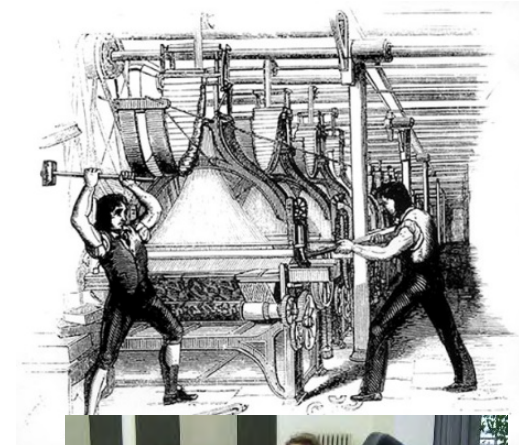
# Introduction

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*

- **FilR**: 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

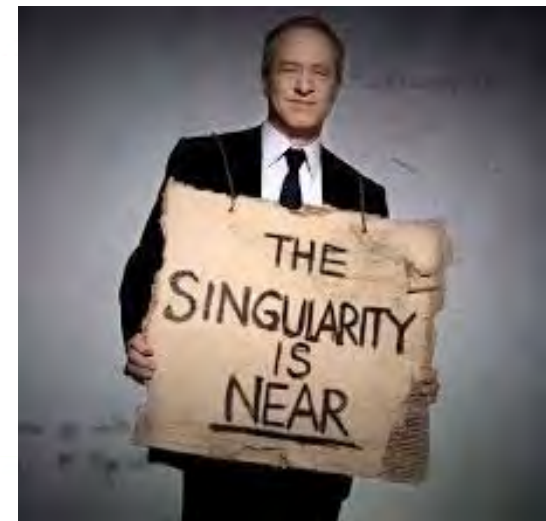
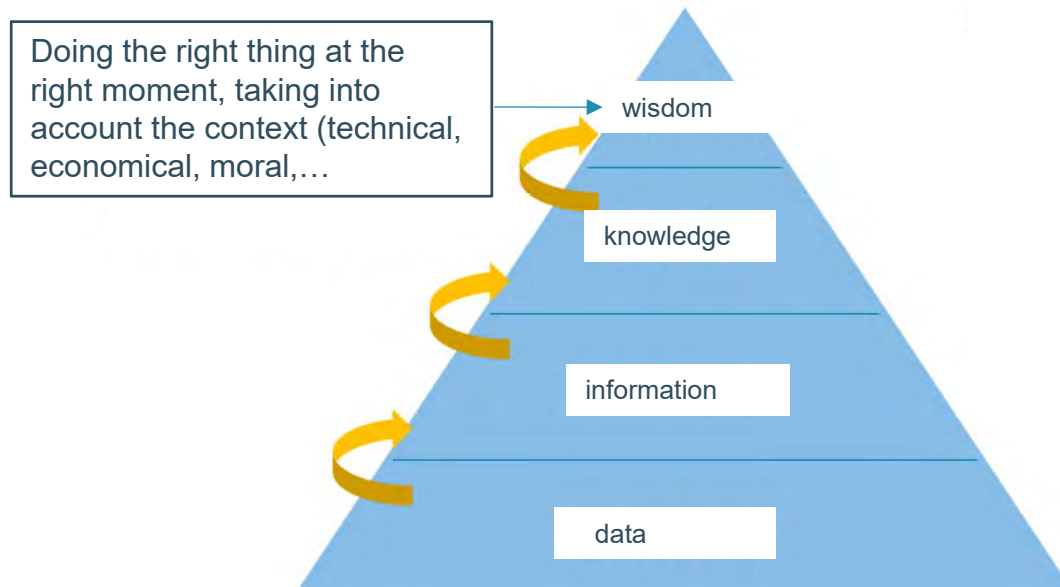
## *Innovation*



- **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**



# 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

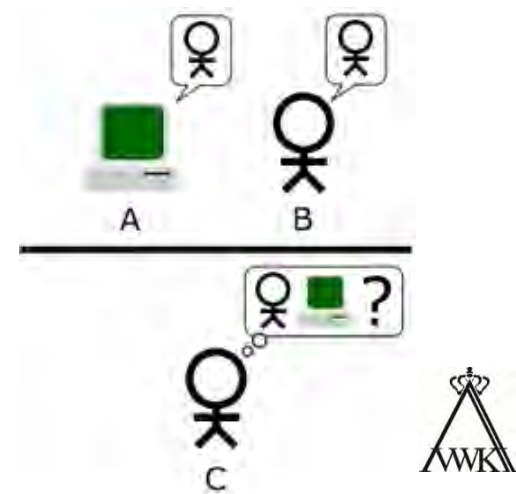
- **Moravec's Paradox**

- *“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

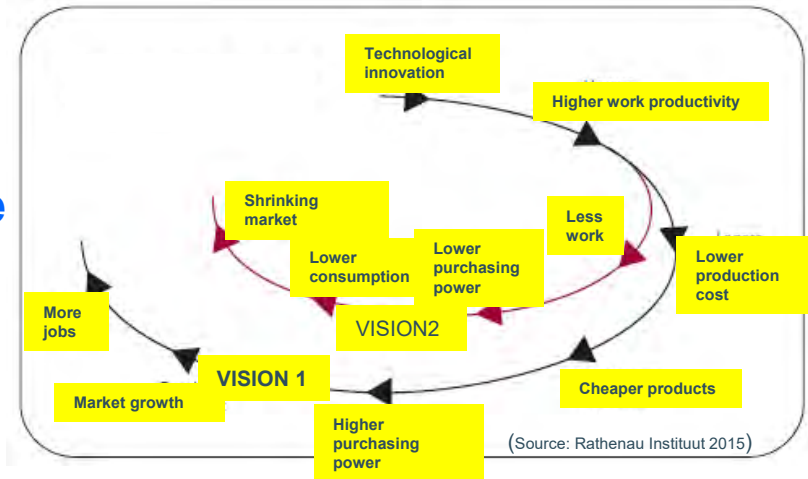
- Existing studies show: productivity growth  $\xrightarrow{+}$  employment
- The effect: innovation  $\xrightarrow{?}$  productivity growth/employment
  - seldom investigated (innovation is difficult to quantify)
- Studies in the European manufacturing industry show:
  - Product innovation  $\xrightarrow{++}$  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**

	1971-1980	1981-1990	1991-2000	2001-2010	2011-2015
<b>GDP</b>	3,4	2,0	2,2	1,6	1,5
<b>Employment</b>	0,2	0,2	0,6	0,9	0,9
Arbeidsintensiteit van de groei	0,1	0,1	0,3	0,6	0,6
Arbeidsvolume	-0,8	-0,1	0,2	0,5	1,1
Productiviteit per uur	4,2	2,1	2,0	1,1	0,4
<b>Productivity per person</b>	3,2	1,8	1,6	0,7	0,7



# Innovation, productivity and employment

- **Productivity growth is misunderstood** (Brynjolffson)
  - **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

	Workforce	Yearly Revenue (billion \$)
Apple	90 000	260
Volkswagen	640000	235

- The manufacturing industry remains important to maintain/increase employment

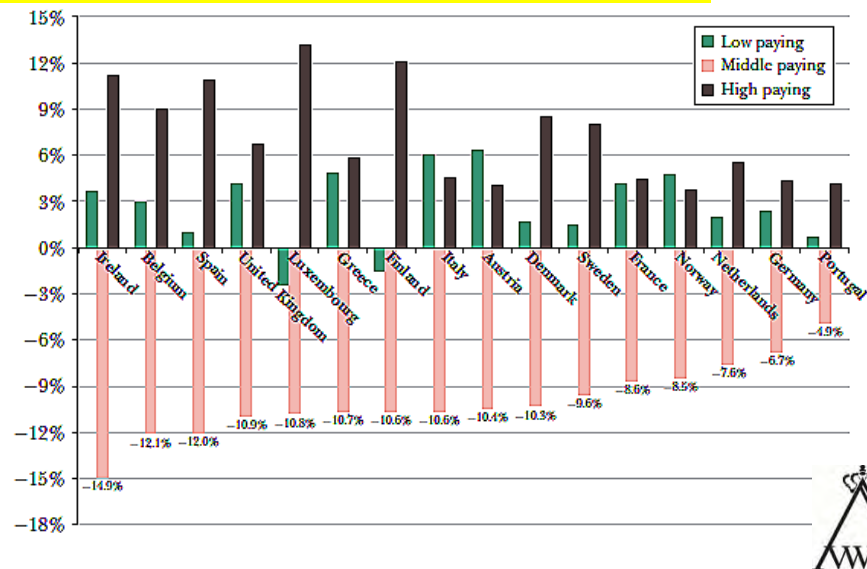


# Shifts in employment: job polarisation

- 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

	Low skills	Middle skills	High skills
1979	13,7	61,1	25,2
2016	18,2	43,2	38,6

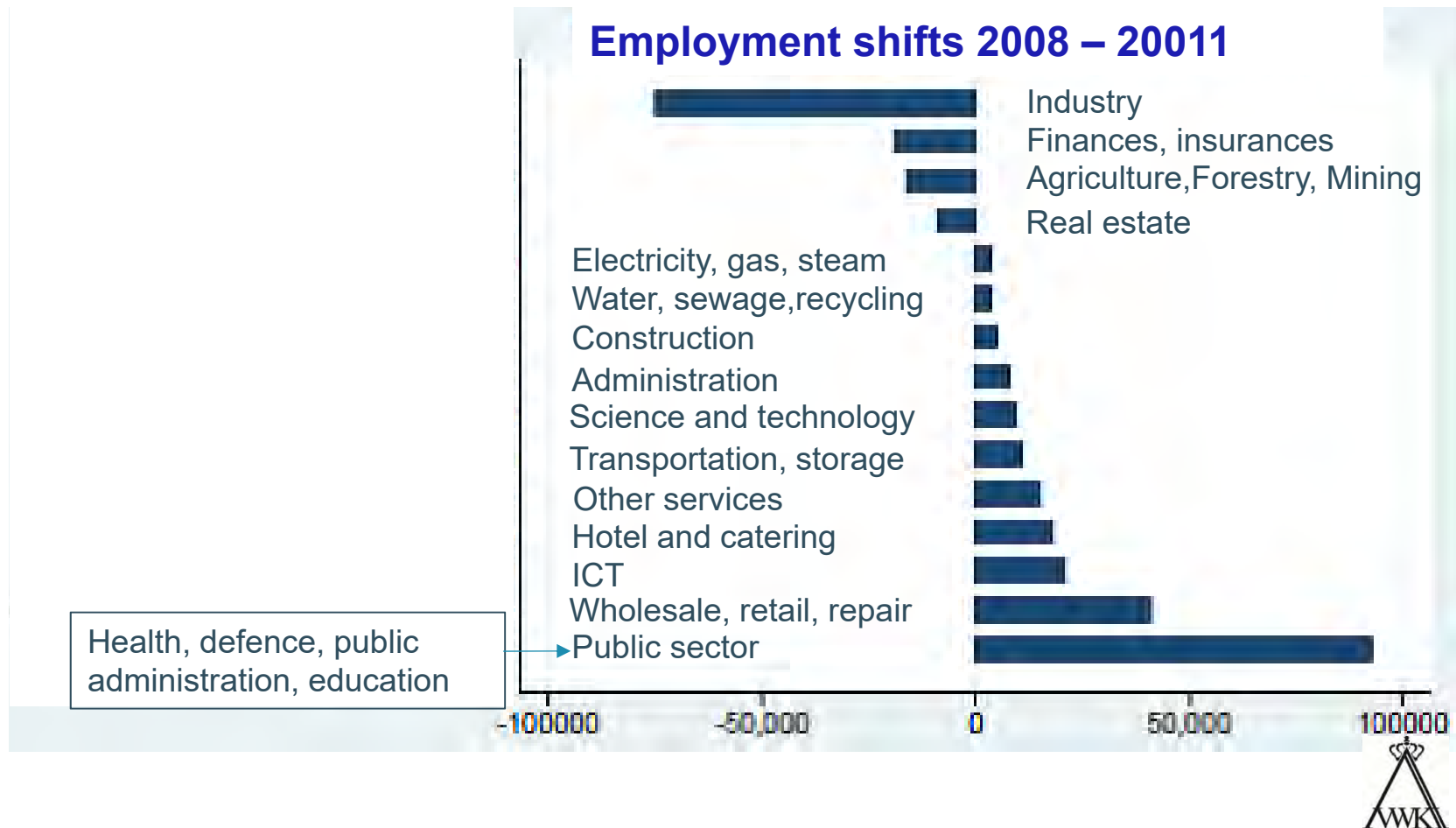
- Employment in agriculture (US)
  - 1900: 40%      2019: <2%
  - Production higher, living standard higher
  - Leaves room for invention, innovation, job and wealth creation





# Shifts in employment: job polarisation

- Employment shifts **between activity sectors**



# Shifts in employment: job polarisation

- **The manufacturing industry**

- Employment in Flanders' 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?**

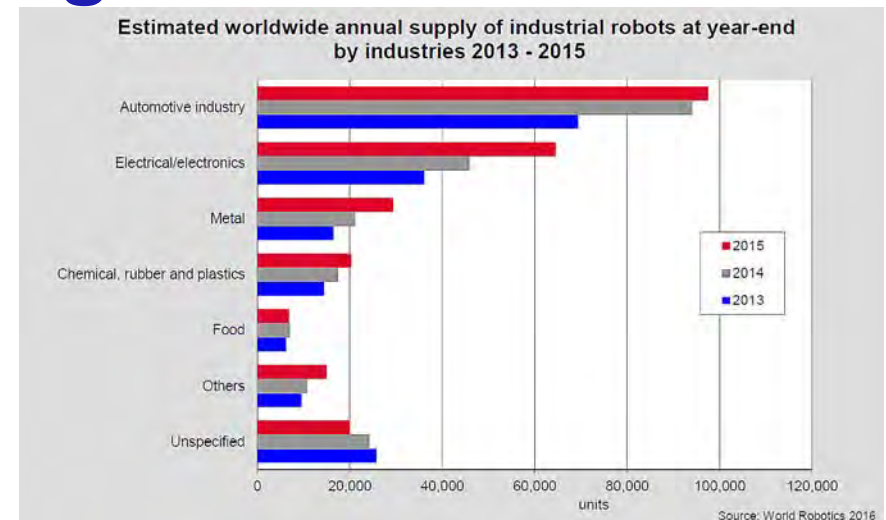
- Accurately position and move objects
- Accuracy
- Tireless
- Slower than humans
- Human/robot communication difficult

- **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

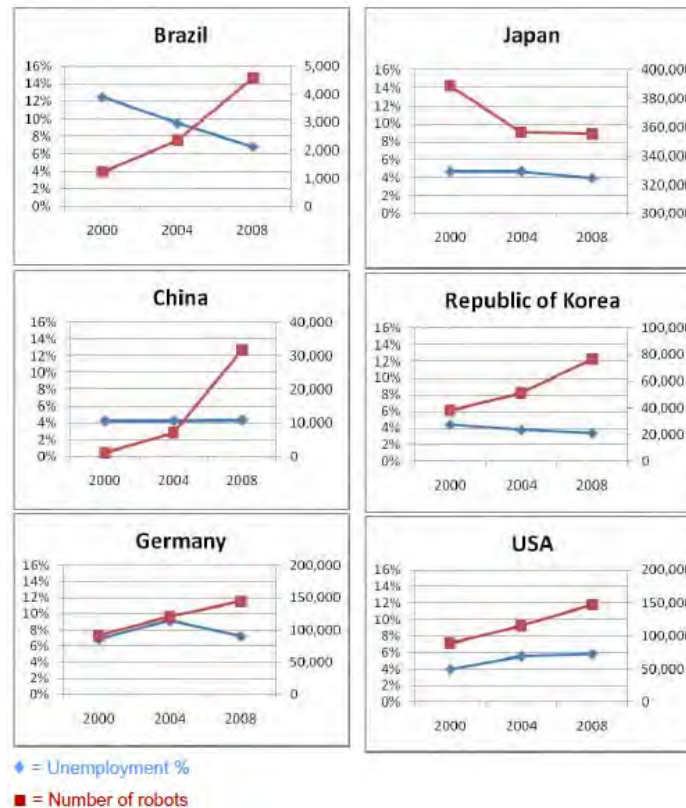
- **Market of service robots** is (still) much smaller

- 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

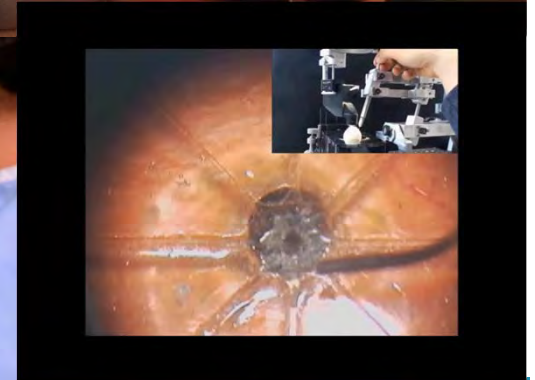


- Robots are **no threat (yet)** for employment
- Watchfulness is advised: 'Design for the unexpected'

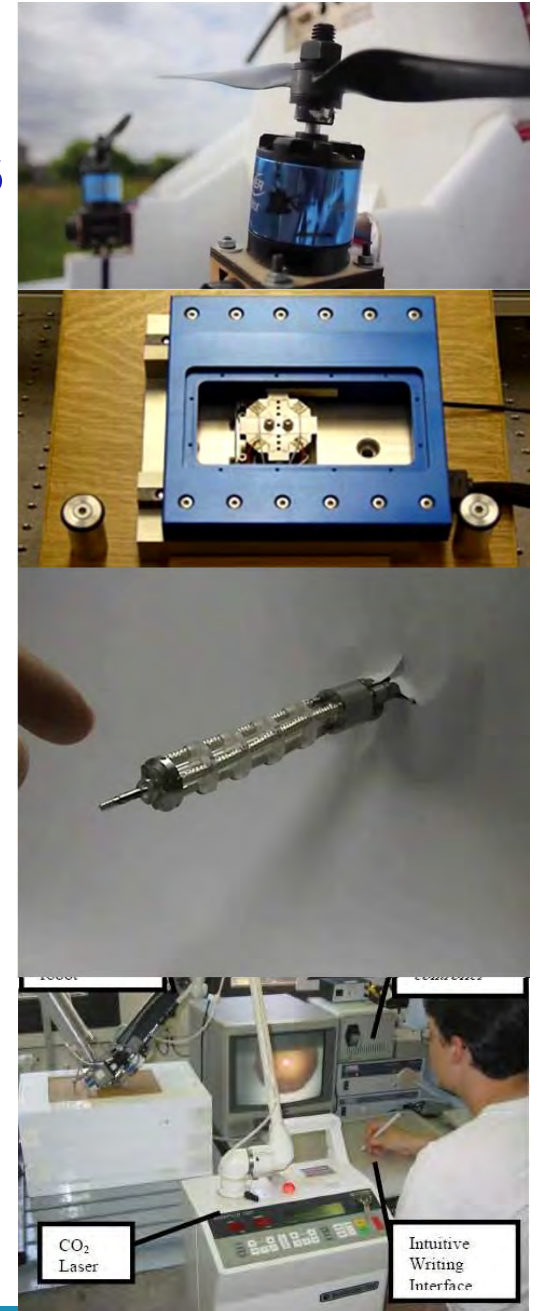


# Robots create new opportunities

- Introducing robots also creates jobs (several hundred thousands)
  - Where precision and consistency 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 Montessori
- 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 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!*