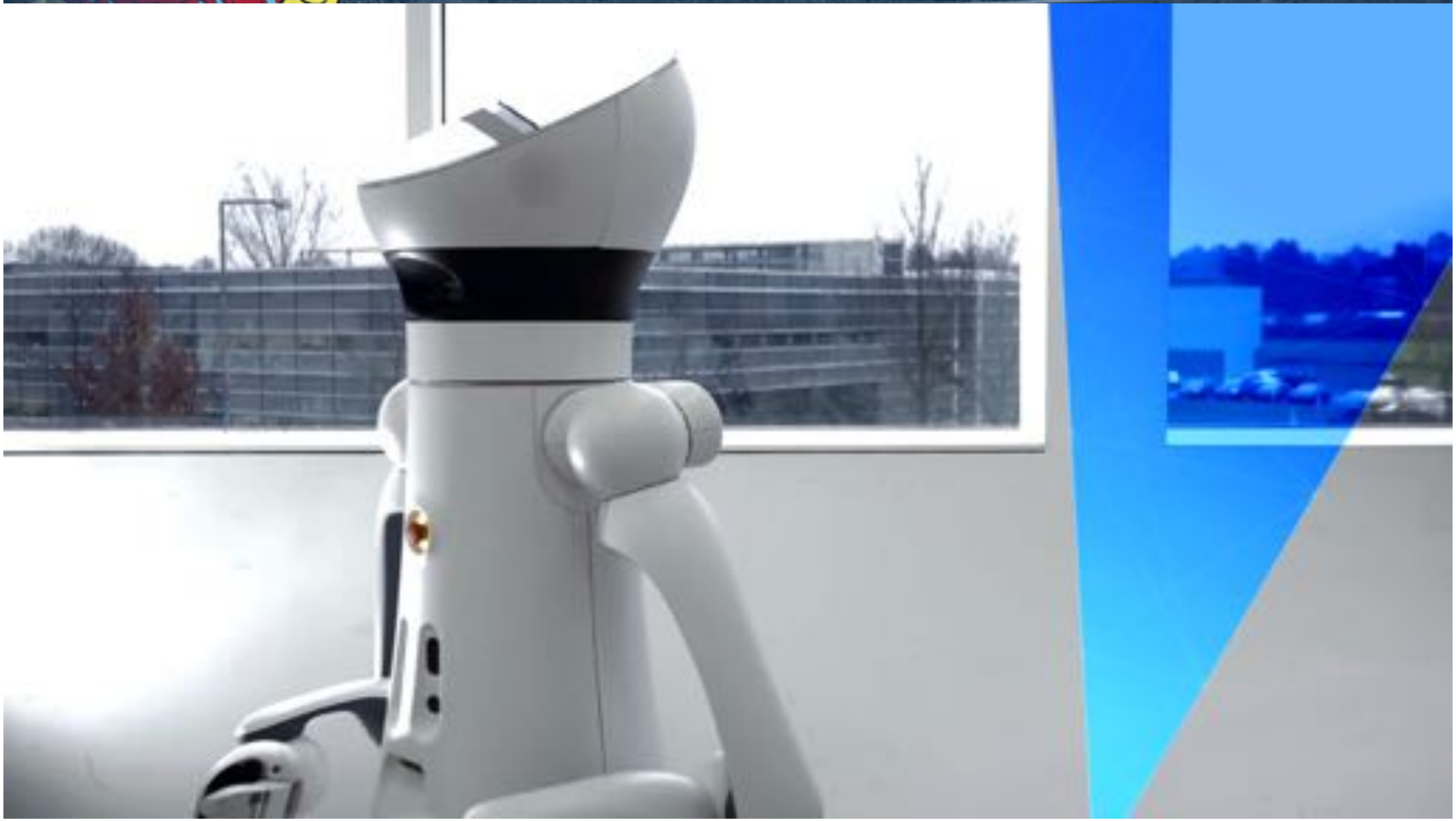
Robotics: the new industrial and social revolution

Paolo Fiorini
Altair Robotics Laboratory
Department of Computer Science
University of Verona, Italy

The Robotics Revolution



- In the next 5 to 10 years, we will face a new generation of Cognitive Robots, capable of acting based on autonomous reasoning. This will bring a number of changes that we need to be prepared to manage
- A new technology is **trusted** if
  - it brings benefits,
  - it is safe,
  - It is well-regulated and,
  - It is subject to robust investigation, when accidents happen.
- Commercial aircraft are so safe because of **good design**, well **trained pilots**, tough **safety certification** processes and, robust processes of air **accident investigation.**
- How can we create the same strong process, also for autonomous robots?

Ethical Path to Autonomy

The trust in a new technology is based on the connection between **ethics, standards** and **regulation**.

- **Ethics** addresses the balance between benefits and risks of a technology
- **Standards** formalize ethical principles into a structure to evaluate the system or to provide guidelines to identify and mitigate ethical risks
- **Regulation** mandates that systems are compliant with standards.

Public Attitude Towards Robotics and AI

- There are public fears around robotics and artificial intelligence over how the technology might impact jobs or privacy.
- According to the Eurobarometer Survey (2014), there is a decrease of respondents showing a positive attidude towards robotics (fomr 70% to 64%), and 89% believe that autonomous systems require careful management.
- **Ethics** are the foundation of trust in technology, and underpin good practice.
- Principles of good practice can be found in **Responsible Research and Innovation** (RRI) of the Rome Declaration whose pillars are: Engagement, Gender equality, Education, Ethics, Open Access, and Governance.

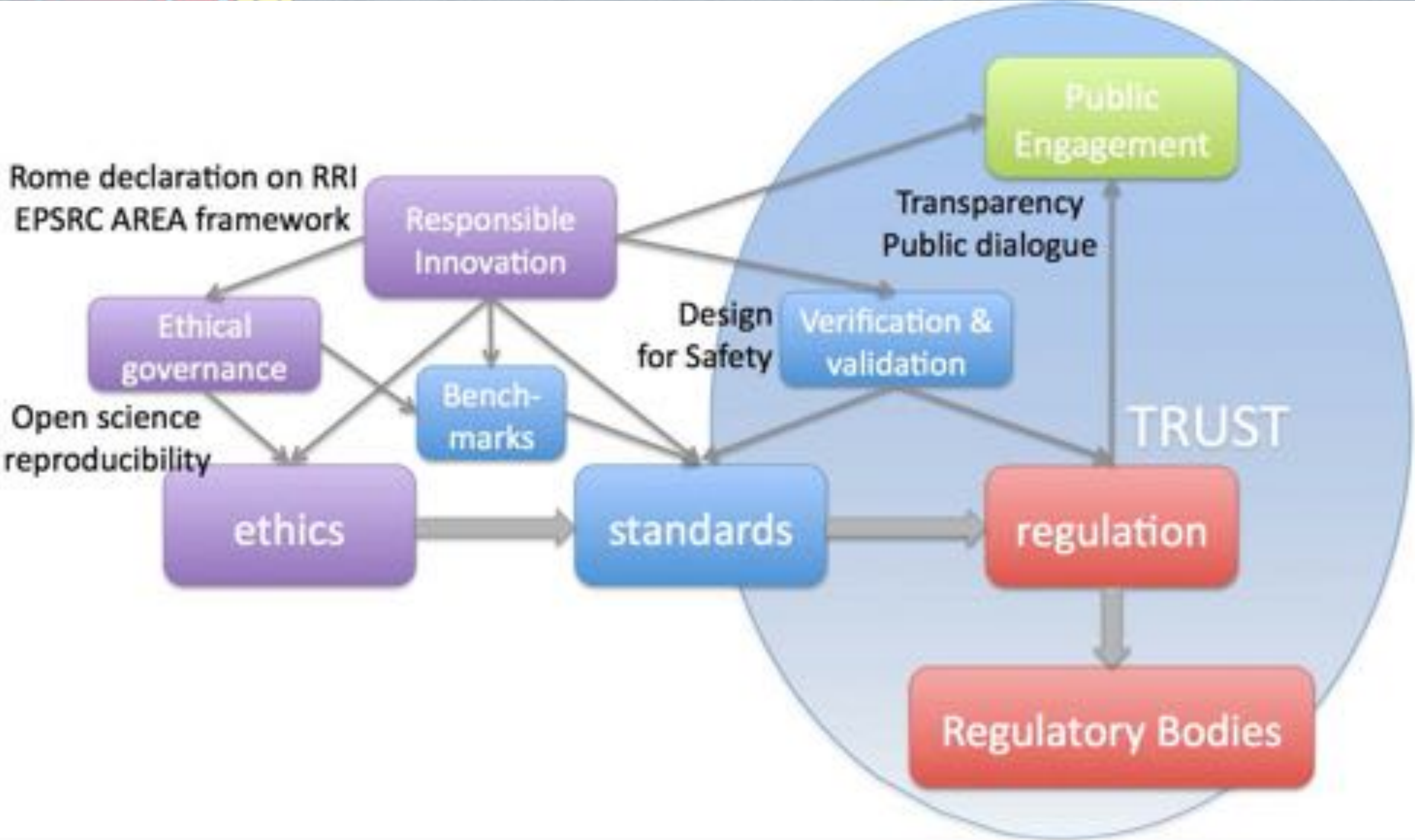
Responsible Research and Innovation

- Ethics and Standards both fit within the framework of **Responsible Research and Innovation** (RRI).
- Responsible Innovation typically requires that research is conducted ethically: **ethical governance**
- Another key principle of RRI is the ability to measure system capabilities: **benchmarks**.
- Other elements of RRI, are **verification and validation**, to provide assurance of safety and fitness for purpose.
- **Verification** => a system satisfies specifications
- **Validation** => a system is fit for a task
- **Verification and validation** are done according to standards, which are the requirement for certification.
- **Verification and validation** links to both standards and regulation.


Rome declaration on RRI
EPSRC AREA framework
Responsible Innovation
Ethical governance
Open science reproducibility
Bench-marks
Design for Safety
Verification & validation
ethics
standards
regulation

- In general technology is **trusted** if it brings benefits while also being safe, well-regulated and, when accidents happen, subject to robust investigation. One of the reasons we trust airliners is that we know they are part of a highly regulated industry with an excellent safety record. The reason commercial aircraft are so safe is not just good design, it is also the tough **safety certification** processes and, when things do go wrong, robust processes of air **accident investigation**. Should driverless cars, for instance, be regulated through a body similar to the Civil Aviation Authority (CAA), with a driverless car equivalent of the Air Accident Investigation Branch?

Building Public Trust



Ethical Principles of Robotics

- Robots are multi-use tools. Robots should not be designed solely or primarily to harm humans, except in the interests of national security.

1. Humans, not robots, are responsible agents.
    1. Robots should be designed according to standards, and
    2. Operated to comply with existing laws & fundamental rights
2. Robots are products. They should be designed using processes which assure their safety and security.
3. Robots are manufactured artefacts. They should not be designed in a deceptive way to exploit vulnerable users; instead their machine nature should be transparent.
4. The person with legal responsibility for a robot should be identified.

Talk Outline

- We should examine how these principles are being applied to three important examples:
- Industrial manufacturing
- Health care
- Military

- Source: https://eu-robotics.net/eurobotics/about/projects/2013-2016-rockeu.html

- Emergence of new technologies (biotechnologies, nanotechnologies, nuclear power, etc.) usually cause a vast amount of discussion among the public and amongst the decision makers about the consequences of the usage and the appearance of these technologies. Robotics does not escape these interrogations and the fears people may have towards it. What can we expect from these machines capable of understanding, acting, learning and adapting their behaviour?
- What can we expect from these machines capable of understanding, acting, learning and adapting their behaviour? What are the consequences of introducing autonomous machines into our society?
- Providing answers to these questions and thereby addressing Ethical, Legal and Societal (ELS) issues is thus crucial to make the further spread of robotics in our society possible. Hostilities or doubts can have disastrous consequences on the development of this technology.
- The report reviews the existing literature on the employment effects of technological change to derive policy implications and to identify open research questions. This part draws comparisons with past technological innovations.
- recent studies conducted on regulations in military robotics and highlight the opportunity it represents for civil robotics
- who identifies a set of investigations about ethics and robotics.

- https://eu-robotics.net/eurobotics/about/projects/2013-2016-rockeu.html

Robotics and Employment

- Recent advances in the field of digitization and robotics, such as largely autonomous smart factories, service robots or 3D printing, give rise to public fears that technology may substitute for labor on a grand scale.
- Existing literature on the employment effects of technological changes **show that they affected the structure of employment**, but had only little or even positive effects on the level of employment
- The main challenge for the future of work lies in coping with **rising inequality**, as technological change creates both winners and losers.
- Let's first address the "fairness" of technology and the building of trust

Effects of New Technologies

- Technological advances in the 19th and 20th century typically created more jobs than they displaced in the first place.
- A “Second Machine Age”, can be represented by the driverless car, the largely autonomous smart factory, service robots or 3D printing.
- These technologies are driven by advances in computing power, robotics and artificial intelligence and ultimately redefine what type of human capabilities machines are able to do.
- Fears on a “jobless future” have recently been fueled by recent studies predicting that 47 % of US jobs are at risk of becoming automated
- However, the potential of new technologies to complement human labor, and economic processes, often is not discussed
- Workers typically adjust to changing capital endowments of firms by changing workplace tasks or by upgrading their skills
- Firms increase their productivity and to offer a larger variety of products at lower prices. As a result, demand, production and ultimately employment may rise.

Employment Theories

- A first theory argues that new technologies complement highly qualified workers. **Skill-Biased Technological Change (SBTC)** hypothesizes that technological change is biased towards specific skills or qualifications. The model predicts an increasing college wage premium, higher wage inequality as well as increasing wages and productivity for both skill groups.
- But it is not able to explain several empirical observations:
  - The decline in relative wages for low-skilled workers is observed only in Anglo-Saxony countries but less in Continental European countries (10 year lag)
  - The application of robots led to an increase in labor demand for high-skilled relative to low-skilled workers, while there is no clear effect on the medium-skilled workers

Employment Theories

- A second theory is **Routine-Reducing Technological Change (**RRTC) that distinguishes between three main sets of tasks: manual, routine and abstract tasks. The RRTC hypothesis then argues that computerization replaces routine labor input
- **Routine tasks** are tasks which follow a well-defined protocol, such that they can be codified and executed automatically based on algorithms using modern ICT. These tasks can be manual-routine or **cognitive-routine.**
- **Manual non-routine tasks** are tasks that require situational adaptability, visual and language recognition as well as in-person interactions. Such tasks are widespread in many low-paid service occupations including food preparation and serving jobs, cleaning and janitorial work as well as heath care and security services and can only hardly be replaced by computers.
- **Abstract (or cognitive non-routine) tasks** involve problem-solving capabilities, intuition, creativity and persuasion that cannot be performed by computers yet and often are complementary to computers.

Employment Theories

- The predictions of the RRTC theory are:
    1. The declining costs for computers should be associated with a shift of workers' tasks away from routine to manual or cognitive tasks.
    2. A decline in the share of routine, middle-paid occupations and thus a polarization of employment, where the middle of the wage distribution is shrinking while the poles (high and low wage occupations) grow
    3. Explains wage polarization, i.e. faster wage growth at the poles of the wage distribution compared to the middle of the wage distribution
- RRTC hypothesis relies on a narrower definition of technological change by explicitly focusing on the computerization through which machines become increasingly able to perform routine tasks.

Labor Adjustments to Technology

- Product and Process innovations are stimulated by new technologies
- **Product innovations** are more related to new products, whereas **process innovations** refer to new ways of producing a certain product.
- **Product innovations** are more likely to be associated with positive employment effects than process innovations, as the former potentially generate new demand and could thus lead to rising production and employment.
- **Process innovations**, on the other hand, can lead to declining employment as they often reduce the required labor inputs per unit of output.
- However, there are several adjustments that counteract these simple assumptions:

- **Mechanism 1 – Direct labor-creating effect:**
  - Technological change can raise employment in the firms that develop or produce new technologies.
  - Firms typically use these new technologies as process innovations, aiming at raising the efficiency of production. The rising efficiency due to these process innovations can reduce labor input per unit of output, which would lead to a labor-saving effect.

Labor Adjustments to Technology

- **Mechanism 2 - Direct labor-saving effect:**
  - Technological change initially reduces employment in firms that introduce new technologies to reduce their production costs.
  - Process innovations raise productivity and competitiveness, which generates new demand and thus can raise production and employment
- **Mechanism 3 – Productivity-induced labor-enhancing effect:**
  - Labor-saving technologies can reduce costs and prices, inducing higher demand, output and employment.
- **Mechanism 4 – Income-induced labor-enhancing effect:**
  - Technological change can generate new income that induces higher demand, production and employment, also in sectors that are not directly affected by the new technologies.
- **Mechanism 5 – Wage-induced labor-enhancing effect:**
  - In a competitive labor market, wage adjustments partially counteract employment effects of technological change.

Firms Adjustments to Technology

- At the **firm level**, empirical studies often find positive correlations not only between product innovations and employment, but also between process innovations and employment (mech 1, 3): the use of robots raised both productivity and value added at the sectoral level and had neutral effects on total hours worked,
- These studies also take into account adjustment processes between sectors, within regions. By viewing regions as small economies, the effects can be interpreted as macroeconomic effects

    1. Computerization has first led to a substitution of labor by capital in the tradable sector (mostly production), thus reducing labor demand (Mech 2).
    2. Then routine-intensive regions became more productive and competitive as a result of lower production costs, which led to lower goods prices and higher product demand (Mechanism 3) that more than compensated the former effect.
    3. Computerization raised income which was partially spent on local non-tradable goods (mostly services), inducing positive local spillover effects on employment in the non-tradable sector (Mechanism 4).

Combined Effects of Adjustments

- Labor demand increased by 11.6 million jobs due to computerization between 1999 and 2010 in the EU 27, thus suggesting that the job-creating effect of RRTC overcompensated the job-destructing effect
- The income effect of technological change (Mechanism 4)seems to be relevant in all countries.
- For the period 1985 to 2009 innovations and technological progress did not have long-term effects on unemployment, so that the job-creating effect seems to be strong enough to compensate the labor-saving effect of technological change.

Firms Adjustments to Technology

- However, they raise unemployment in the medium run. A potential reason for the medium-run effect on **unemployment could be due to slow adjustments of workers to changing labor market requirements**. This depends crucially on the type of technological progress. In fact if new technologies are implemented in new jobs whereas the old jobs are destroyed. If, instead, the new technologies are introduced by updating the existing jobs' equipment so that the workers have the chance to adjust their skills to the new requirements within their jobs, the effect is actually reversed and new technologies lead to lower unemployment

- In summary, the evidence seems to be in favor of a positive or neutral net employment effect of new technologies, although the evidence is not fully conclusive. Labor-creating effects often seem to outweigh the initially labor-saving impact of technological advances, but the impact seems to depend on the market environment, the institutional setting as well as the **ability of workers to adjust their skill sets to the changing demands** that are related to the introduction of new technologies.

Impact of AI and Machine Learning

- Recent advances in artificial intelligence and machine learning are often perceived as a potentially **more disruptive** dimension of technological change as these technologies allow for automating tasks that until recently seemed to be fully limited to the human domain (such as driving a car).
- The domain that continues to be limited to humans appears to shrink sizably as machines are increasingly able to perform cognitive tasks such as learning.
- Innovation speed could exceed the capabilities of many workers to adjust to this change, putting their jobs at risk
- However, of all tasks performed both across as well as within occupations, only 9 % of US workers and only 12 % of German workers have a relatively strong focus on tasks that could be automated.

Considerations on Job Losses

- "jobs at risk" should still not be equated with actual or expected employment losses from technological advances for three reasons,

  1. **The technological capabilities are based on subjective assessments of technology experts,**

  2. Eeven if technologies enter the economy, **they often change jobs rather than replacing them**

  3. Even if new technologies initially lead to declining employment in some segments of the labor market, **they also create new jobs**.

- It is particularly low-skilled and low-paid workers who face the largest automation potentials. This implies that these workers might face a high pressure to adjust to technological change, as they might have to upgrade their skills through training, undergo occupational retraining to switch to growing occupations or as their remuneration and employment stability might worsen

How to Enforce Job Fairness

- Mechanisms that **counteract labor-saving effects of new technologies should be in force**. However, the upcoming technological advances might be more disruptive than past technological change if the **speed of technological innovations and its diffusion increase,** although legal and ethical hurdles will slow down this process to a certain extent.

- Digitization and robotic technologies will likely affect the structure of employment towards jobs and occupations where worker hold a comparative advantage over machines.

- One important means of achieving the necessary adjustments in terms of skills and qualifications is an **educational and further training system** that concentrates on skills and competencies that remain difficult for machines to acquire

- Compared to skilled and high-skilled workers, low-skilled workers will probably face even higher adjustment needs since they tend to perform a higher share of tasks that are at risk

How to Enforce Job Fairness

- Hence, policies could focus on raising the **participation rates of low-skilled workers in training measures** that improve their chances to retain their job and employability
- Public training programs could complement private efforts to create incentives to participate in training.
- Occupational re-training may be necessary for workers in shrinking occupations or for those unemployed and lacking the skills that are needed on the labor market.
- Moreover, today there is almost **no evidence on which skills will be required in the future**.

Robotics and Regulations

- **Regulations are consequences** of this deployment of robotics in our life in order to ensure safety of people at work or to guarantee one's privacy.
- **Robots in the Industry**, that has been quite broaden since the interconnections of systems and sensors beyond human perception;
- **Urban Robotics and Self-Driving Cars**, which questions the existing regulation currently and in the coming years;
- **Robots in the Healthcare**, which is an emerging topic
- **Drones and military robots**, which stressed the importance of a balanced regulation.
- There are a set of **cross cutting issues** like security/ hacking, safety, data protection and liability

Legal Background

- Need to specify precisely what "autonomous systems" are in order to be more general and less specific to robotics
- There are many kinds of artificial, decision-capable agents operating without the direction of a human being. Examples include physical robots and drones as well as purely digital software agents.
- Need to distinguish between automation and autonomy: a set of automatic sliding doors may fit within certain people's views of an autonomous system:
  - One man's 'robot' may be another man's simple machine and therefore, when we begin to discuss **giving robots legal personhood**, **we do need to be precise** and give some thought to what we are actually talking about.

Past Work on Laws for Robotics

- 2010-2012 *"Suggestion for a green paper on legal issues in robotics"*
- RoboLaw: Legal and ethical implications of emerging robotic technologies.
- Legal questions:
  - *What are the legal obstacles to put advanced robotics on the market?*
  - *Are those obstacles due to national or European regulations?*
  - *What are the international legal difficulties?*
  - *Do legal obstacles contribute to increased social and cultural prejudices against machines?*
  - *What specific changes are needed in regulation at national and European level?*

Cross Cutting Legal Issues

- This new technology will cut across all aspects of life and so all existing laws and regulations may need to adapt or change to take this into account.
  - Security / hacking
  - Security and safety (how the concept of safety changes: for industry and in general)
  - Innovation / market /regulations / public funding of research
  - Data Protection
  - Liability
- **Intellectual property**, who should be the owner of the intellectual property generated by an intelligent agent? Should it be the software programmer who wrote the algorithm that enabled the autonomous systems to communicate or learn? Or must it be another individual or corporation that sits somewhere in the chain?

Cross Cutting Legal Issues

- **Product liability** e.g. robotic surgeons performing operations autonomously, without any human intervention
- As to **negligence**, in common law jurisdictions one has the concept of one party owing a duty of care to another and this duty of care changes when the risk increases of harm being caused by one party to the other.
- There is an inherent flexibility in common law countries that will allow judges and lawyers to look at analogous events from the past and draw new conclusions based upon new facts.
- This flexibility mais not in civil code countries where law is subject to strictly codified practice – and so the code must change.

Cross Cutting Legal Issues

- One issue is to determine if robots can have "Personhood".
  - legal attribute or civil status: such as a last and a first name, an identification number, an address and an owner
  - a capital depending on the risks
  - an insurance
- robot's autonomy increases, the issue of **civil liability** will rise
- French civil code for instance, two kinds of liability may apply to machines:
  - liability for damage caused by a manufacturing defect, that is a lack of safety of a product
  - liability for damage caused by an interaction of the machine with its environment

Cross Cutting Legal Issues

- Both kinds of liability do not suit the specific case of autonomous machines.
- A principle of cascading liability applied to robots which identifies:
  1. the designer of the platform of artificial intelligence
  2. the user
  3. the owner
  4. the seller
  5. the manufacturer
- The allocation of a capital to the robot should be proportional to the risks potentially created by the robot
- Protecting the privacy of an individual means protecting the memory of the robot. Robots will become "intimate hubs" of the life of their user. The EU General Data Protection Regulation should therefore be fortified.

Robot in the Industry

- **Internet of Things** describes a world where just about anything can communicate and becomes one big information system.
- "**Cloud Robotics**” suggests a new paradigm where they exchange data and perform computation via networks.
- The cloud may prove to be a **disruptive innovation**, “as was the emergence of cheap electricity on demand a century or so ago” Us
- Cloud robotics does, however, provide a different degree of functionality that may be harnessed by corporations and/or individuals.
- Are users of such autonomous systems liable for the solutions/answers that such systems produce or do the corporations selling these new cloud robotics solutions. No liability is assumed by the corporation for the solution/answer provided.

- **Big data**: This huge potential lies in the expected predictive capacity that they can offer if analysed in a certain domain.

- Big data combined with **learning machines** can create a self-enhancing development. Learning machines are indeed particularly promising as a tool to improve the capacity of the technology by a self-development of new skills, grounded on previous experience.

Regulatory Aspects

- **Safety regulations**
  - ***Directive on Machinery 2006/42/EC**20*, mandatory for all those products covered by European Directives and for the EU market. The CE mark is a certificate of compliance with the strict European standards on safety
  - All autonomous agents have to obtain this CE marking in order to ensure safety of persons, like workers or consumers but also domestic animals and goods.
  - Technical Committee ISO/TC 199, *Safety of machinery* in order to see what specifically should be regulated for robots.
- ***Privacy and surveillance***
  - electronic correspondence, i.e. Human Dignity, the Right to Privacy, the protection of personal data and the relevance of the aims pursued by the collection of data.
  - Part II deals specifically with the case of email correspondence,
  - European Court of Human Rights has held that monitoring an employee's private chat history, while at work, was not a breach of his Article 8 right to respect for private and family life.

Robotics and Discrimination

- ***Robots and discrimination law***

- Employers must not engage in discrimination in respect of job applicants or their staff, and in some situations are liable for the discriminatory acts of their employees.

- In a scenario of large-scale redundancies resulting from humans being replaced by robots **employers cannot discriminate on the grounds of age.**
- Assu**ming that younger employees will be more tech-savvy and acting on that basis in any context is likely to result in claims for discrimination.**
- Similarly, a **re-training bursary** or grant to be awarded on redundancy would have to be administered carefully to avoid claims of discrimination

- Perhaps a more obvious interface between robotics and discrimination law arises in relation to **disability discrimination.**
- The use of robotic technology to provide auxiliary aids is a fascinating area of development. It is entirely possible that in time **these sorts of technologies could become reasonable adjustments for employers** to make for disabled staff.
- Reasonable adjustments are about removing a disadvantage to a disabled person. Is there anything that would require **employers to 'enable' employees who do not have a disability,** but who would nevertheless like to benefit from an exoskeleton that enhanced their natural abilities?

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	Monitoring of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Regulation of Car Autonomoy

- 1968: Vienna convention on Road Traffic (for European countries). Article 8: **"every moving vehicle or combination of vehicles shall have a driver; every driver shall at all times be able to control his vehicle or to guide his animal.**"
- "The State of California, which presently does not prohibit or specifically regulate the operation of autonomous vehicles, desires to encourage the current and future development, testing and operation of autonomous vehicles on the public roads of the state. The state seeks to avoid interrupting these activities while at the same time creating appropriate rules intended to ensure that the testing and operation of autonomous vehicles in the state are conducted in a safe manner"
- Interesting definitions:
- "Autonomous vehicles means technology that has the capability to drive a vehicle **without the active physical control or monitoring by a human operator**"
- "Autonomous vehicle means any vehicle equipped with autonomous technology that has been integrated into that vehicle"
- "An "operator" of an autonomous vehicle is the person who is seated in the driver's seat, or if there is no person in the driver's seat causes the autonomous technology to engage"

Regulation of Car Autonomoy

- Obligations provided by the International conventions aimed to foster road safety partly by ensuring that **vehicles could be *controlled*.** *Control* is thus the key concept

- The purposes of *control* can be defined as
  1. ensuring compliance with the road traffic code,
  2. ensuring reasonableness in situations not regulated by the codes / in case of fallacies of the vehicle / in case of unlawful conduct or mistakes by other drivers.
- Situations not regulated by the codes and fallacies of the technical system can occur. Then the real-time human intervention is the only possibility to solve the problem.
- According to the present regulations, currently there are no problems with partial automation vehicles or driver assistance systems: the control is still possible and the vehicle operates within the monitoring activities of the human driver.

- In high automation and full automation systems, however, there is no control by the human driver, but he/she could be able to intervene in case of necessity.
  - Is an average human driver capable of supervising an autonomous vehicle?
  - Is a plane's auto pilot a useful analogy for such systems? (possible differences: an autonomous vehicles driver is expected to immediately react to quick events, while for a pilot events are not so quick; a pilot is extensively trained, while a human driver is not)

Liability of Autonomous Cars

- **Liability**
- Autonomous vehicles will eventually become safer than human driven cars. However, malfunctioning due to for example a production defect,

- The individual regimes of the 28 Member States show a wide variation in rules for determining liability for damage in situations where motor vehicles are used.

- **Product Liability Directive**
- The PLD addresses liability for damage caused by defective, unsafe products.
- As long as consumers can prove the defect, the damage and the causal relationship between those two criteria,56 compensation can be sought not only from the actual producer, but also from among others the importer, the manufacturer of raw material and components and the end-supplier of the defective product.
- However, proving that there was a defect in the software requires a deep technological understanding of the functioning and the malfunctioning of (parts of) autonomous vehicles.
- Victims have to prove the causal relationship between defect and damage, which may also be observed to form a heavy burden for claimants.

- Furthermore, the PLD states that a producer cannot be held liable when “the state of scientific and technical knowledge at the time when he put the product into circulation was not such as to enable the existence of the defect to be discovered
- UK Department for Transport (DfT) said: "for cars with high automation, we consider that the situation [regarding strict liability for product defects] would not be significantly different to the current situation with technologies such as ABS [anti-lock braking] and ACC [adaptive cruise control], where malfunctioning can cause collisions and injuries. It is anticipated that the regime of strict manufacturer liability would continue to apply.”

Ethics of Autonomus Cars

- ***Ethical Issues***
- Much of the discussion around the ethics of driverless cars concerns the inherent absence of a human making moral decisions in extreme situations. Many argue that an autonomous car, pre-programmed to behave in a certain way in a given situation, should not be allowed to itself make these ethical choices and that a human driver should always be present to take over the vehicle in extreme situations.
- In the interim between now and full adoption, perhaps the greatest challenge to regulators is to look forward to full autonomy while partially-autonomous test vehicles are being trialled.

Robotics in Health Care

- Key product/market combinations and from which six representative areas can be regarded ripe for further investigation and roadmapping:
  - Smart medical capsules (for endoscopy, biopsy and targeted drug delivery)
  - Intelligent prosthetics
  - Robotised patient monitoring systems
  - Robotised surgery (a combination of the areas related to the facilitation of the surgeon in the operating room)
  - Robotised motor coordination analysis and therapy
  - Robot assisted mental, cognitive and social therapy
- In these cases, it is particularly interesting to use the expression “autonomous agents” because the technological innovations concern also apps, learning and autonomous devices for telemedicine and further technologies which interact with “physical” robots.

Regulations of Medical Robots

- ***Council Directive 93/42/EEC of 14 June 1993 concerning Medical Devices94***
- Telemedicine and Robots (autonomous systems):
  - Hypothesis 1 - Devices programmed to check the patient's conditions and indicate the dosage of medicines or, more in general, what behaviour to get.
  - Hypothesis 2 - InTouchHealth and IRobot are creating a robot designed to provide remotely located physicians (e.g. family doctors, specialists, etc.) with insight into how their patients are recovering when treated at area hospitals.
- Questions:
  - Who is responsible if the patient does not follow the path?
  - Who is responsible if the patient follows the path but he does not improve his conditions or he has a deterioration of his conditions?
  - Responsibility of the doctor who chose the type of device for the specific patient?
- For adaptive devices: Increased level of responsibility for the patient according to the length of time that has passed since he started using the device.

Military Robotics: Drones

- Drones can be used for hobbies, precision agriculture, environment monitoring, transportation, surveillance, inspection, protection and law enforcement. Even if the military sector isn’t a priority for these companies, it remains nevertheless a *financial opportunity*.
- However, even though this kind of modularity and multi-function capability is a guarantee of profits, it also represents a high risk of proliferation and unintended utilization. The use of the drone by *Islamic state group* to attack some friendly infrastructures has proven it.

Regulations of Drones

- In line with the definition provided by the International Civil Aviation Organization (ICAO) in its "Circular 328/ AN/190 on Unmanned Aircraft Systems", the term drone104 refers to an uninhabited platform (called UAV, Unmanned Aerial Vehicles) and can be remotely piloted by a human (called RPAS, Remotely Piloted Aircraft Systems) or be autonomous, (« an unmanned aircraft that does not allow pilot intervention in the management of the flight »).
- The drones above 150KG fall under European Aviation Safety Agency (AESA) Regulation (216/2008/EC) and those under 150KG fall under Member's State Regulations.
- France has recently adopted a new legislation about the use of drones on 17th of December 2015.

Regulations of Drones

- 1. With the development of drones, the aeromodelling has deeply changed. It used to be reserved to some experts who knew the regulation. The arrival of low-cost drones has attracted many gamers and racers, new technology fans, often ignorant of laws.
- 2. Apart from people not being aware of laws, terrorists, criminals, insurgents and activist groups can use drones for their activities108.
- Alternative supply sources have multiplied thanks to the worldwide spreading of this kind of technology and its easy commercial availability.
- Apart from the misuse of the platform; a drone's system could be hacked.
- The Parliament has called on the European Commission to table legislation ensuring the safe use of drones113. So, the executive has charged its aviation safety agency (AESA) to develop common rules for operating drones in Europe.
- The Federal Aviation Administration (FAA) is the agency for drone’s regulation.
- FAA bans civil drones with many exemptions and limits recreational uses

Regulations of Drones

- Work by the British Standards Institute technical subcommittee on Robots and Robotic Devices led to publication – in April 2016 – of BS 8611: Guide to the ethical design and application of robots and robotic systems [4]. BS8611 is not a code of practice; instead it gives "guidance on the identification of potential ethical harm and provides guidelines on safe design, protective measures and information for the design and application of robots". BS8611 articulates a broad range of ethical hazards and their mitigation, including societal, application, commercial/financial and environment risks, and provides designers with guidance on how to assess and then reduce the risks associated with these ethical hazards. The societal hazards include, for example, loss of trust, deception, privacy & confidentiality, addiction and employment.
- Significant recent work towards **regulation** was undertaken by the EU project RoboLaw. The primary output of that project is a comprehensive report entitled *Guidelines on Regulating Robotics* [9]. That report reviews both ethical and legal aspects; the legal analysis covers rights, liability & insurance, privacy and legal capacity.

Software Robots

- The primary focus so far has been on robotics and autonomous systems, and not **software artificial intelligence**. This reflects the fact that most work toward ethics and regulation has focused on robotics. Because robots are physical artefacts (which embody AI) they are undoubtedly more readily defined and hence regulated than distributed or cloud-based AIs.
- This and the already pervasive applications of AI (in search engines, machine translation systems or intelligent personal assistant AIs, for example) strongly suggest that greater urgency needs to be directed toward considering the societal and ethical impact of AI, including the **governance and regulation of AI**.

Ethics of AI

- How can we trust the decisions made by AI systems, and – more generally – how can the public have confidence in the use of AI systems in decision making?

- If an AI system makes a decision that turns out to be disastrously wrong, **how do we investigate the logic by which the decision was made**?
- Medical diagnosis AIs or driverless car autopilots. Systems that make such decisions are ***critical* systems**.
- Existing critical software systems are not AI systems, nor do they incorporate AI systems**. The reason is that AI systems (and more generally machine learning systems) are generally regarded as impossible to verify for safety critical applications.**

Verification of AI

- First is the problem of verification of systems that learn. Current verification approaches typically assume that the system being verified will never change its behaviour, but **a system that learns does – by definition – change its behaviour**
- Second is the black box problem. Modern AI systems, and especially the ones receiving the greatest attention, so called Deep Learning systems, are based on Artificial Neural Networks (ANNs). A characteristic of ANNs is that after the ANN has been trained with data sets (which may be very large, so called "big data" sets – which itself poses another problem for verification), any attempt to examine the internal structure of the ANN in order to understand why and how the ANN makes a particular decision is impossible
- The problem of **verification and validation** of systems that learn may not be intractable, but is the subject of current research
- The black box problem may be intractable for ANNs, but could be avoided by using algorithmic approaches to AI

Conclusions

- It is vital that we address public fears around robotics and artificial intelligence, through **renewed public engagement and consultation.**
- **Training and life long learning** should be strengthened to reduce the risk of unemployment
- Work is required to first identify and then **develop new standards** for intelligent autonomous robots, together with the **benchmark tests** and **verification & validation processes** that would assure compliance against those standards.
- Research should be pushed towards **certification methods** of intelligent systems.