Chapter 10
Trends in Teaching Artificial Intelligence for Industry 5.0

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Abstract As Industry 5.0 is about refining the collaborative interactions between humans and machines and so taking a step further, the efficiency and productivity of machines, processes, and systems together with humans, the Artificial Intelligence (AI) paradigm teaching at the university level for engineering has globally changed in last years, with local and regional exceptions, from a wide range of background of principles, tools, algorithms in the field of pattern recognition, clustering, intelligent decision-making education to a narrow band of AI basic principles and very specific, restricted useful tools/information such as: Machine Learning, especially Deep Leering, Convolutional Neural Networks, and Brain Computer Interface (BCI).

Keywords Artificial intelligence (AI) · Industry 5.0 · Skills · Competencies · Training · Courses · University curricula

1 Introduction—Public Policies and Leading Organizations Recommendations on AI Tuition for the Industry 5.0 Approach

According to Ref. [1], Industry 5.0 approach contributes to three of the European Union Commission's priorities, and the first element pertinent to Industry 5.0 is already part of its major policy initiatives as adopting a human-centric approach for digital technologies including artificial intelligence. The second one about up-skilling and re-skilling European workers, particularly digital skills, are not so open about specifically going as far as AI teaching (at least as basics) since no mention about Artificial Intelligence or Robotics could be found in none of Skills Agenda or Digital Education Action plan.

A priority of the European Commission on AI in context of Industry 5.0 is shown in the statements published in Ref. [2]. However, as produced by a policymaker legal body, the main part of this document is somehow centered on safety problems related to the use of such systems, and the main concern is that "changing functionality of

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AI systems," "can give rise to new risks that were not present when the system was placed on the market." Is nothing wrong on considering all aspects of the risk, but it seems that core issues were omitted by ignoring the huge effort of industrial companies, research units, together with universities to design, implement, continuously improve, produce, and deliver impressive high precision AI-based robots, autonomous systems, and other Internet of Things-AI-based tools.

All these, besides the high financial investment, rely on know-how, knowledge on AI theory and applications that is currently developing and spread to people mostly by teaching or by self-learning. As the fastest way to learn on specific technical issues such as robotics, AI implementations and maintenance are to subscribe and follow a course on the subject, it comes clear that education and all levels of organized tuition are great part of future Industry 5.0 approaches.

At the current stage, steps have been made toward covering all required knowledge for the educational purpose of all actors involved in appropriate building the collaborative interactions between humans and machines. Four main categories of actors in need for AI and its industrial applications tuition each at the appropriate level can be identified in decreasing order of required specific education level/amount:

- Engineers, researchers, developers, advanced users, and maintenance teams members of practical implementations such as robotics operating in Industry 5.0 framework.
- Decision-makers either coming from the State policy Regulatory bodies either from the top management/stake holders of industrial companies to provide realistic laws/recommendations/industrial business decisions about the future of Industry 5.0.
- Human Workers together with AI learning machines, processes, and systems increase the productivity and quality up to the Industry 5.0 level.
- General Public/Consumers requires personalized products or somehow benefits from the newly efficient production ways, resulting from Industry 5.0 level manufacturing.

In Ref. [3], the things are going furthermore on safety precautions, but in the same way of not considering the help of the information provided as training, practical skills, and work experience of users with such AI, IOT and robotic systems and mainly suggesting just the need of "Explicit obligations for producers could be considered also in respect of mental safety risks of users when appropriate (ex. collaboration with humanoid robots)."

The [4] document is the one that raises the problems of the Skills, up-skilling, and re-skilling in the context of evolution of technologies especially digital skills and artificial intelligence knowledge and understanding. It is perfectly true that some digital skills may not have been on the curriculum at the time workers concluded their education and training, but the idea that the educational and training institutions are unable to respond to skills shortage is far from being true. There is a gap in training workers at the re-conversion level, in the field of digital skills at the higher education level (e.g., universities), including lifelong learning courses there is an advanced training even for AI techniques that were not yet put into practice for industry use.

The recommendation for basic understanding of how AI works and to know the potential benefits and limitations of this technology in Ref. [4] fits only for the fourth category of actors identified before: General Public/Consumers.

As shown in recent document [5] on Industry 5.0, the AI role, perception, and its main suite of core technologies are somehow minimized by the statement that AI "often still referring to advanced correlation analysis technologies," which is not entirely true as a lot of existing techniques include causality based. All 10 recommendations of further AI development were already scientifically discovered and reported and can be again implemented to any appropriate specific industrial field if the problem requires so, although there are very well and reliable pure correlation or other statistical based technologies that fit much better for a specific problem than deterministic-based AI, as the focus is to do the job properly and increase efficiency.

The true expectations from the Industry 5.0 regarding **increasing collaboration and interconnectedness between human workers and AI-based machines such as robots** were clearly defined by a second type of identified actor (the decision-making) in the person of Founder and CTO of Universal Robots in Ref. [6].

According to Ref. [7], Industry 5.0 applications in the medical field that relies on artificial intelligence is the combination of big data, artificial intelligence-specialized software (including machine learning), and the Internet resulting in collaborative robots to efficient perform precise and complicated surgery and increasing accuracy of detecting diseases, so better treating patients. A specific hint is on future development of sensors with artificial intelligence that analyses the data quickly.

Based on the keyword analyses and the systematic literature review in Industry 4.0 made in [8] the only term related to Artificial Intelligence in their search that is Machine Learning was placed on the 17th position, however, with a simple search now on Industry 5.0; there are few references that can miss the (key) word artificial intelligence or AI.

As discussed in Ref. [9], it is expected that Industry 5.0 will create a new manufacturing role: Chief Robotics Officer (CRO)—an individual with expertise in understanding robots and their interactions with Humans, adding or removing them from the factory as needed. Such person needs to be trained in robotics, artificial intelligence, human factors modeling, and human–machine interaction.

Based on this new role of CRO and on great industrial experience in 2017, North America's expectations, as described in Ref. [10], were great as *realizing that education must occur to build the bridge from Industry 4.0 to 5.0 and hoping that* North America is uniquely positioned to lead the next, through industry 5.0. A study on future global competitiveness, by Deloitte Global and the U.S. Council on Competitiveness, predicted that the USA will dislodge China as the most competitive manufacturing nation in the world in 2020. This fact not just that did not happen but one of world's leaders USA president Joe Biden stated recently that a long-term strategy competition with China must be prepared together with Europe and others, so also the industry competitiveness is forced to do steps forward.

Meanwhile, Japan has defined Industry 5.0 as "Society 5.0" a "human touch" revolution: "a human-centered society that balances economic advancement with

the resolution of social problems by a system that highly integrates cyberspace and physical space."

The debate on the research problem presented in this chapter started with the analysis of specific courses covered by AI curriculum offered as part of BSc or MSc by top universities around the world. This inventory is presented in Appendix and grouped three categories:

A. Specific AI courses and programs from top universities in the USA—**Looking at first five Best Online Artificial Intelligence Degrees for 2021** at top 10 universities in the USA from Ref. [11] and joining the course titles from their AI curriculum; it shows that there is a shift from AI to ML as term usage in the last decade. Here, it is stated an equivalence ("Artificial Intelligence, also known as Machine Learning") but realistic, it remains an inclusion that Machine Learning is included in Artificial Intelligence wider range of topics. Technologies behind AI include **machine learning, deep learning, neural networks, and algorithms. Thus, five universities were included in the analysis.**
B. Specific AI courses from European universities (as filtered from word ranking)—examples from top first five universities in the university ranking.
C. Examples of AI courses and programs from two top Asian universities.

The selection of the universities was piloted by the Academic Ranking of world universities—Shanghai Ranking's Global Ranking of Academic Subjects 2020—Computer Science & Engineering as from Ref. [12]. Table 1 includes the top 25 universities, considering that AI is included in Computer Science and does not have a separate ranking itself in this classification.

The word cloud be generated with the selected specific courses covered by AI curriculum offered as part of BSc or MSc by top universities around the world. Figure 1 shows the most often domains or topics presence in the curricula. The actual "obsession" of teaching staff is very well expressed by a metaphor "Learning—Vison—Computer" or may be better considered as Computer Learning Vision, but in the actual vision together with "Robotics—Deep—Data" and accompanying by "Data," "Theory," and "Human." These key words discovered by the basic semantic analysis summarize the key topics and approaches that have been introduced into the academic curricula in the last years to better align the training programs to the Industry 5.0 new context and requirements (also known as the twenty-first century skills).

2 Hi-Tech Job Requirements for the Industrial Areas that Are Meeting Conditions to Become 5.0 Ready

As the current worldwide job offers and application announcements are mainly from large companies that exhibit often transnational even transcontinental borders, the requirements concerning the knowledge acquired by the candidates during their degree tuition do not seem to include visible geographical or cultural differences.

Table 1 Computer science and engineering University ranking from Ref. [12]

1	Massachusetts institute of technology (MIT)
2	Stanford University
3	University of California, Berkeley
4	Carnegie Mellon University
5	ETH Zurich
6	Harvard University
7	Tsinghua University
8	Nanyang Technological University
9	University of Toronto
10	University of Oxford
11	University of California, Los Angeles
12	Princeton University
13	University of Technology Sydney
14	Cornell University
15	University of Southern California
16	The University of Texas at Austin
17	University of North Carolina at Chapel Hill
18	National University of Singapore
19	Shanghai Jiao Tong University
20	Zhejiang University
21	Harbin Institute of Technology
22	The Chinese University of Hong Kong
23	University College London
24	Peking University
25	University of Science and Technology of China

This does not apply to work experience requirements, which is considered second after degree or specific courses or knowledge specified as compulsory, or as a plus.

To analyze the matching between the real job needs as to be realistic into the position of transitioning to the Industry 5.0 era for those who are pioneering and then for all those who will be tracked by the competition to evolve, according to this study, were identified four large types of mentioning the degree/specific courses/knowledge in the job posts/announcement having no visible hierarchy or index as a matter of better or faster recruitment. The search was done to focus on how well the initial undergraduate or postgraduate degree earned by candidates from the universities is fulfilling the needs described by the recruitment. To describe the four main types, letters will be used to reveal that no style proved yet to rank over another.

A type *of mentioning the job required general degree and some of AI-studied subjects as knowledge.*

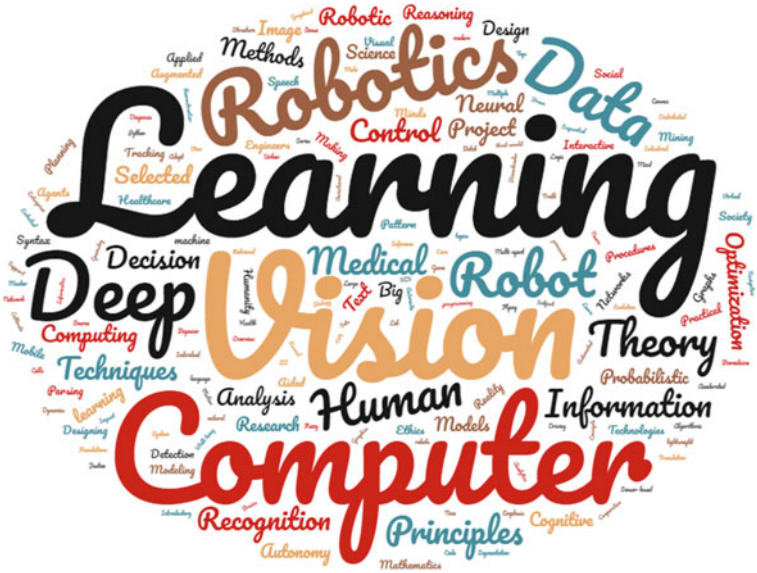

Fig. 1 Word cloud be generated with the selected courses related to AI field

Surprisingly, some top companies that might be the core of Industry 5.0 transitioning as the first in Robotics (Universal Robots) are providing just the degree with poor detailing or none about the specific subjects or knowledge required from the field of AI, but about fundamentals as mathematics, physics, and programming. By example in Refs. [13, 14],respectively, one can find.

"A degree in a technical major such as computer science, robotics," "disciplines required to create user-facing software for a collaborative robot."

"**Can prove your talent during your studies.**"

- Expert in microcontroller programming.
- Writing high-quality, efficient, clean, maintainable code.
- Fluent in written and spoken English.

And "**It is a plus if you have knowledge and experience with any of following**":

- Robot engineering
- Motor control
- Mathematics and physics
- Python
- C++
- Functional safety/safety-related software
- Analog and digital electronics
- RTOS/real-time systems
- FPGA, VHDL
- Continuous integration and revision control systems (GIT).

B type *of mentioning the AI job required related degree and none of AI studied subjects as knowledge but just as work experience*

For this, we are taking the automotive industry as example from Ref. [15].

"B.S. or higher in Computer Science or Engineering"

On an example, healthcare job announcement [16] requiring to "Be an ML/AI thought leader" as qualifications it is only specified.

"Master's degree in a Science, Engineering, Mathematics, Statistics, Data Science, Analytics, Computer Science, Health Science or related fields; Ph.D. preferred."

"University degree in computer science, automation, electronics and telecommunications, informatics, mathematics or comparable" is mentioned in example from Ref. [17] also.

C type *of not mentioning the job required university degree but some of AI studied subjects as knowledge and others as work experience*

As in example from Ref. [18], only the following AI domain applies:

"Publications or experience in machine learning, AI, computer vision, optimization, computer science, statistics, applied mathematics, or data science."

In the Lockheed Martin example from Ref. [19], there are only possibly studied subject as:

"Familiarity with AI/ML domain programming languages (e.g. Python, C++, Java, GO, MatLab)."

"Familiarity integrating and deploying AI/ML models, with a knowledge of machine learning frameworks and deep learning toolsets."

D type *of not mentioning the job required university degree but some of AI subjects only as work experience.*

In job announcements as in Ref. [20], only work experience is mentioned as: "You have a good understanding of stats and ML. You have solid knowledge of text classification (spaCy, Huggingface, Scikit-Learn). You have some experience with conversational AI (familiarity with at least a open-source chatbot framework, e.g. RASA, Snaps, DeepPavlov), You have knowledge of exploratory data analysis (e.g. clustering, visualizations), Hands-on experience with deep learning libraries like PyTorch, Tensorflow or equivalent., Hands-on experience implementing production-grade NLP architectures."

At work courses/tuition/learning by experience

In general, the "at work courses" or practical experience is very good but that does not exceed the few days limit or the practical information delivered does not lead to innovative conduct as the one required by the Industry 5.0 behavior in fulfilling its specifications as collaborative between human and robots. This could be only achieved by a very strong initial study performance during the degree expected to be hold by the employer at academic level completed by innovative ideas in most cases. By example in Ref. [21], the outcome result of the training at work is summarized as follows:

"After attending this 2-day factory-authorized course, you will have the hands-on experience with a UR robot that you need in order to feel comfortable with key aspects of operating one."

AI jobs and tuition matching comments as prospective evolution of the domain

According to [22], many of the company states, in the job description, that they want somebody with AI or ML knowledge and the know-how to apply AI and ML to solve current problems, but once one gets hired, it is a completely different reality as in the following:

- Do just data analysis in excel or R or Python because no AI/ML currently exists.
- Data are sparse and that the company does not have the right features to do what it wants.
- Real-world problems show a high degree of non-linearity and the AI/ML solutions that you learned in university studies do not really apply.

By example: A typical real-world scenario is, you run a AI model and the model comes back with a 45% accuracy, which is not much better than a 50% random guess.

3 Conclusions on AI-Related Studied as Universities Offer and Real-World Needs for the Transition to 5.0 in Industry

It has become clear that AI domains are wide, and its applications field gets wider everyday. Also, the AI as science, including Machine Learning and Deep learning, also Robotics as science were positively interfering in a lot of manufacturing devices, leading to any new level of work optimization due collaborative human to robot stage. All main advances as theory and practice were launched by academic level of universities, colleges, research institutions, either of them belonging to a top national or worldwide education system or coming as a part of research team of a company. From this large and interesting offer of study offered as bachelor (undergraduate) or master level (graduate) or even PhD/Post Doc research studies by the universities around the world, only a targeted part is specifically required at now stage by the must of job announcements in the field. It is obviously that there remains not specified a lot of subjects' knowledge that are probably assumed to be known for each candidate that claims to have studied advanced level of it.

However, the worry specified in [4] by EU regarding a possible gap between the tuition and employers' expectations from the employees in the AI for main Industry 5.0 achievements does not exist as general rule in that sense. At contrary, there are many AI job applicants willing and up to being enthusiastic to use a lot of theirs learned knowledge in those new Machine Learning algorithms for the new job. For each of such new job advertised as the ones like [20], until the deadline of application closure there are tens or hundreds of people to submit request, also proofing there is a huge human resources potential for the work on transition to Industry 5.0.

Possible evolutions on the field of AI study integration for the benefit of Industry 5.0 concepts as part of every company's strategy to move forward according to its

own resources, strategy planning and also competition, which is determinant factor as always are summarized in the next issues:

– The troubleshooting/non-optimistic way that things might move around.

One of the greatest mistakes any low experienced computer programmer can do is to release first instance produced code at the level that in works, this level including inside a lot of unexpected bugs and poor overall quality as regard to the produced software and its re-usability. Similarly, any good intention that was not punished yet as the one to build AI implementations for the human to robot collaboration as by the book can have all good intentions but starving by quality coding of software implementation if the AI designer is not as talented for programming. This really applies when at the firm/company level the high-tech personnel are not well integrated to the software development team.

Another possible, not wanted outcome from all these AI tuition and jobs is that for the now stage of transitional impact of novel implementations in collaborative work we expect that the usage of let's say recurrent neural networks or convolutional architectures are going to be useful for a long time, but in fact, the field will have moved away from that onto something else. That else without university-level tuition, we do not yet understand. One can say that this is a proof that changings in AI field take it closer to engineering and far from math's but remember that it is basic principles were not changed and those initials considered big at the time delivered useful software as regard of available memory and computational capabilities and data amount to process for that time. As in many other fields, there is no obvious path for modeling the needed AI for the collaborative human to robots as there is none from perceiving the task and to building a complex/effective model of the world of 5.0 ready.

There is a high risk that at this stage, even with all the good intentions and wiling of the world, the costs of personalized items produced by the newly concept of implementing strategies defined in Industry 5.0 by means of a lot of AI and robotics will increase as much so, as well as the self-driving cars could be too expensive for worldwide use soon.

Following any of these possible not wanted paths, it is possible that investors who can make more money shortly will pass the now discussed focusing idea of more use of AI knowledge for advance towards 5.0.

An optimistic way: The invention of a super-intelligent system as from Ref. [23]: "It has tremendous potential to benefit the world and its peoples, with immense value in growing a smart economy, enhancing global sustainability and national securities and opening new frontiers in science, technology, education, medicine, communication and deep space exploration."

This could be the positive and optimistic way of advances for the Industry 5.0 strategy, also leaving to the near future as expected by 2025 the benefits that we can only imagine now. Of course that the step by step way of building the AI tools required to perform optimal and safe the collaborative interaction between humans and machines (intelligent robots in our case) seem the most realistic but we have to take into account that the solution is obviously not unique and one can find better such

a system configuration than the others and so a newly super-intelligence delivering technique could benefit to the unification of scientific discoveries efforts toward the same goal.

According to the Ref. [23], "the man-AI symbiosis is any type of a close and long-term social-cybernetic interaction between two different species, where each termed a symbiont. There are five main **symbiotic relationships**: mutualism, commensalism, predation, parasitism, and competition."

As a final conclusive remark is that at his present stage, there is no gap in Artificial Intelligence areas tuition (especially machine learning) and the most required and challenging jobs offer in the field of further manufacturing process automation in the sense of the Industry 5.0 applications. There are many situations when advanced AI knowledge from enthusiastic machine learning experts or scientists is stopped of putting into practice their ideas, proposals, and knowledge by management or bureaucratic or even lack of IT support and enough open minded to accept major changes due to such intelligent applications. This does not apply always for the work experience way of gathering new knowledge as in this study only qualifications were considered. However, as changes and progress is very high in this area, a most benefit way of update remains to take a course/tutorial that is offered at required standard manly by the universities and very often online due to the recent pandemic conditions.

Annex 1

A. **Specific AI courses and programs from top universities in the USA Specific AI courses and programs from top universities in the USA**

1. Carnegie Mellon University as from http://coursecatalog.web.cmu.edu/schools-colleges/schoolofcomputerscience/artificialintelligence/#curriculumtextcontainer

   - Concepts in Artificial Intelligence
   - Artificial Intelligence: Representation and Problem Solving
   - Introduction to Machine Learning (SCS Majors)
   - Computer Vision
   - Natural Language Processing
   - Neural Computation
   - Autonomous Agents
   - Truth, Justice, and Algorithms
   - Cognitive Robotics: The Future of Robot Toys
   - Planning Techniques for Robotics
   - Mobile Robot Algorithms Laboratory
   - Robot Kinematics and Dynamics
   - Deep Reinforcement Learning & Control
   - Intermediate Deep Learning

- Machine Learning for Structured Data
- Machine Learning for Text Mining
- Introduction to Deep Learning
- Advanced Methods for Data Analysis
- Speech Processing
- Computational Perception
- Computational Photography
- Vision Sensors
- Design of Artificial Intelligence Products
- Designing Human Centered Software
- Human Robot Interaction
- Artificial Intelligence and Humanity
- AI, Society, and Humanity
- Human Information Processing and Artificial Intelligence
- Perception
- Human Memory
- Visual Cognition
- Language and Thought

2. Stanford University as from https://ai.stanford.edu/courses/

- Applied Machine Learning
- Computational Logic
- Continuous Mathematical Methods with an Emphasis on Machine Learning
- Artificial Intelligence: Principles and Techniques
- Introduction to Robotics
- Natural Language Processing with Deep Learning
- Natural Language Understanding
- Machine Learning with Graphs
- Social and Information Network Analysis
- Experimental Robotics
- Machine Learning
- Machine Learning Theory
- Deep Learning
- Computer Vision: From 3D Reconstruction to Recognition
- Convolutional Neural Networks for Visual Recognition
- Reinforcement Learning
- Principles of Robotic Autonomy
- Principles of Robot Autonomy II
- Decision Making Under Uncertainty
- The Human Genome Source Code
- Computational Biology: Structure and Organization of Biomolecules and Cells
- Topics in Advanced Robotic Manipulation
- Advanced Robotic Manipulation

- Machine Learning Systems Design
- Deep Multi-Task and Meta Learning
- Representation Learning in Computer Vision
- Machine Learning Methods for Neural Data Analysis
- Artificial Intelligence for Disease Diagnosis and Information Recommendations
- Designing AI to Cultivate Human Well-being
- Interactive and Embodied Learning
- Seminar in Artificial Intelligence in Healthcare

3. Massachusetts Institute of Technology as from https://ocw.mit.edu/courses/find-bytopic/#cat=engineering&subcat=computerscience&spec=artificialintelligence

- Identification, Estimation, and Learning
- Artificial Intelligence
- Introduction to Machine Learning
- Mobile Autonomous Systems Laboratory
- Autonomous Robot Design Competition
- Robocraft Programming Competition
- The Battlecode Programming Competition
- Machine Vision
- The Human Intelligence Enterprise
- Techniques in Artificial Intelligence
- Under actuated Robotics
- Natural Language and the Computer Representation of Knowledge
- Advanced Natural Language Processing
- Machine Learning
- The Society of Mind
- Knowledge-Based Applications Systems
- Computational Models of Discourse
- Adventures in Advanced Symbolic Programming
- Introduction to Deep Learning
- Machine Learning for Healthcare
- Statistical Learning Theory and Applications
- Pattern Recognition for Machine Vision
- Ethics for Engineers: Artificial Intelligence
- Prediction: Machine Learning and Statistics
- Principles of Autonomy and Decision Making
- Cognitive Robotics
- Statistical Learning Theory
- Mathematics of Machine Learning
- Minds and Machines
- Medical Artificial Intelligence
- Medical Decision
- Medical Decision Support

- Affective Computing
- Ambient Intelligence
- A Course on Computer Systems That Adapt To, and Learn From, Context
- Common Sense Reasoning for Interactive Applications
- Relational Machines
- Special Topics in Media Technology: Cooperative Brave New Planet
- Brains, Minds and Machines
- Exploring Fairness in Machine Learning for International Development

4. University of California, Berkeley as from http://ai.berkeley.edu/more_courses_berkeley.html

   - Introduction to Artificial Intelligence
   - Machine Learning
   - Intro to Data Science
   - Probability
   - Optimization
   - Cognitive Modeling
   - Machine Learning Theory
   - Vision
   - Robotics
   - Natural Language Processing

5. Harvard University as from https://www.seas.harvard.edu/computer-science/courses

   - Artificial Intelligence
   - Advanced Topics in Programming Languages
   - Decision Theory
   - Machine Learning
   - Introduction to Computational Linguistics and Natural-language Processing
   - Advanced Topics in the Theory of Machine Learning
   - Tiny Machine Learning
   - Research Topics in Human-Computer Interaction
   - Topics in Machine Learning: Interpretability and Explainability
   - Multi-Robot Systems: Control, Communication, and Security
   - AI for Social Impact
   - Advanced Machine Learning
   - Topics in Machine Learning: Batch Reinforcement Learning
   - Computer Vision
   - Optimization Algorithms for Robotics
   - Multi-Agent Systems
   - Machine Learning for Natural Language
   - Advanced Topics in Computer Vision
   - Biologically-inspired Multi-agent Systems

B. **Specific AI courses from European universities (as filtered from word ranking)**

1. University of Oxford as from https://www.ox.ac.uk/admissions/graduate/courses

   - Artificial Intelligence
   - Machine Learning
   - Advanced Topics in Machine Learning
   - Advanced Machine Learning

2. University of Cambridge as from https://www.cl.cam.ac.uk/teaching/1819/

   - Machine learning for programming
   - Further Human–Computer Interaction
   - Interaction with machine learning
   - Introduction to Natural Language Syntax and Parsing
   - Machine Learning for Language Processing
   - Advanced topics in machine learning and natural language processing
   - Introduction to Natural Language Syntax and Parsing
   - Natural Language Processing
   - Overview of Natural Language Processing
   - Machine Learning and Real-world Data
   - Formal Models of Language
   - Further Human–Computer Interaction
   - Computer Vision
   - Artificial Intelligence
   - Machine Learning and Bayesian Inference
   - Machine Learning
   - Probabilistic Machine Learning

3. ETH Zuric has from http://www.vvz.ethz.ch/Vorlesungsverzeichnis/sucheDozierendePre.view?lang=en

   - Probabilistic Artificial Intelligence
   - Introduction to Machine Learning
   - Machine Learning for Health Care
   - Information Retrieval
   - Big Data
   - Deep Learning
   - Computational Intelligence Lab
   - Machine Perception
   - Data Mining: Learning from Large Data Sets Information
   - Computational Biomedicine
   - Information Theory
   - Natural Language Processing
   - Big Data for Engineers

4. University of Edinburgh as from https://course.inf.ed.ac.uk/previous_session_index.shtml

   - Accelerated Natural Language Processing
   - Algorithmic Game Theory and its Applications
   - Automated Reasoning
   - Automatic Speech Recognition
   - Bioinformatics 1
   - Doing Research in Natural Language Processing
   - Human–Computer Interaction
   - Image and Vision Computing
   - Individual Project in Advanced Natural Language Processing
   - Informatics 2D—Reasoning and Agents
   - Introduction to Vision and Robotics
   - Introductory Applied Machine Learning
   - Machine Learning Practical
   - Machine Learning and Pattern Recognition
   - Natural Computing
   - Natural Language Understanding, Generation, and Machine Translation
   - Reinforcement Learning
   - Robotics: Science and Systems
   - Text Technologies for Data Science

5. Technical University of Munich as from https://www.in.tum.de/en/current-students/modules-and-courses/module-catalog/

   - Image Understanding II: Robot Vision
   - Augmented Reality
   - Computer Aided Medical Procedures
   - Computer Aided Medical Procedures II
   - Image Understanding I: Machine Vision Algorithms
   - Virtual Machines
   - Techniques in Artificial Intelligence
   - Machine Learning
   - Robotics
   - Sensor-based Robotic Manipulation and Locomotion
   - Knowledge-based Systems for Industrial Applications
   - Principles of Computer Vision
   - Robot Motion Planning
   - Tracking and Detection in Computer Vision
   - Computer Vision II: Multiple View Geometry
   - Combinatorial Optimization in Computer Vision
   - Computer Vision I: Variational Methods
   - Introduction to Surgical Robotics
   - Medical Augmented Reality

- Practical Research Project in Bioinformatics
- Advanced Deep Learning for Physics
- Robot Programming and Control for Human Interaction
- Autonomous Navigation for Flying Robots
- Machine Learning for Graphs and Sequential Data
- Probabilistic Graphical Models in Computer Vision
- Convex Optimization for Computer Vision
- Statistical Modeling and Machine Learning
- Interdisciplinary Project in an Application Subject
- Introduction to Deep Learning
- Advanced Deep Learning for Robotics
- Autonomous Driving
- Machine Learning for Computer Vision
- Natural Language Processing
- Advanced Deep Learning for Computer Vision
- Fundamentals of Human-Centered Robotics
- Control of modern lightweight robots
- Computer Vision III: Detection, Segmentation, and Tracking
- Advanced Robot Control and Learning
- Statistical Foundations of Learning
- Selected Topics in Artificial Intelligence and Robotics
- Selected Topics in Computer Graphics and Vision
- Selected Topics in Machine Learning and Analytics
- Selected Topics in Robotics

C. **Examples of AI courses and programs from two top Asian universities**

1. Tsinghua University as from https://ac.cs.tsinghua.edu.cn/curriculum.html

   - Machine Learning
   - Distributed Systems
   - Human Computer Interaction Technologies
   - Introduction to Big Data Systems
   - Natural Language Processing
   - Deep Learning

2. Nanyang Technological University as from http://scse.ntu.edu.sg/Programmes/ProspectiveStudents/Graduate/msc-AI/Pages/CourseContent.aspx

   - Introduction to AI and AI Ethics
   - Machine Learning: Methodologies and Applications
   - Deep Learning and Applications
   - Mathematics for AI
   - Python Programming
   - Computer Vision
   - Text Data Management and Processing

- Time Series Analysis
- Neuro Evolution and Fuzzy Intelligence
- Multi-Agent System
- Advanced Computer Vision
- Deep Neural Networks for Natural Language Processing
- Urban Computing
- AI Master Project

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