LINZ INSTITUTE
OF TECHNOLOGY

Artificial Intelligence

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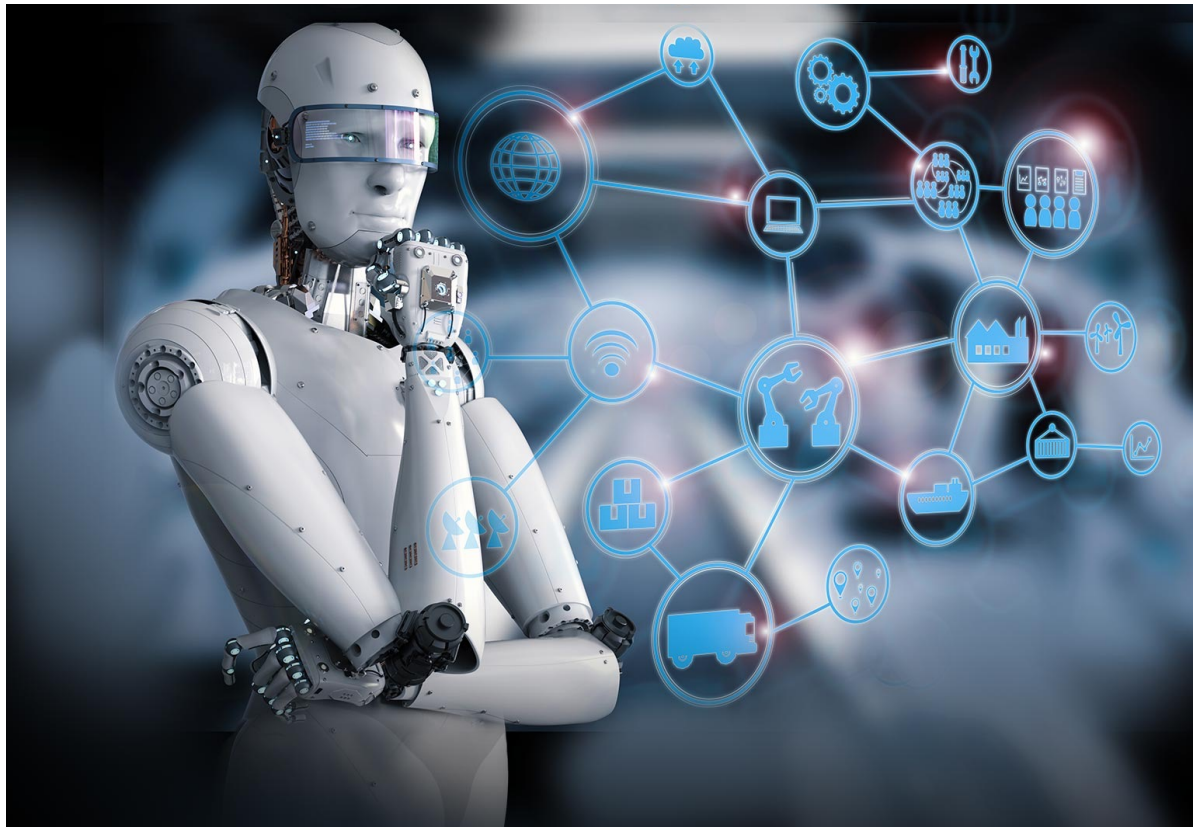
Outline

- What is Artificial Intelligence (AI)?
  - Definition
  - Interdisciplinarity
  - Impact on society & economy
  - Modern applications
- Study Program
  - General information
  - Distance learning
  - Study plan
  - Qualification profile and admission criteria



Artificial Intelligence (AI)

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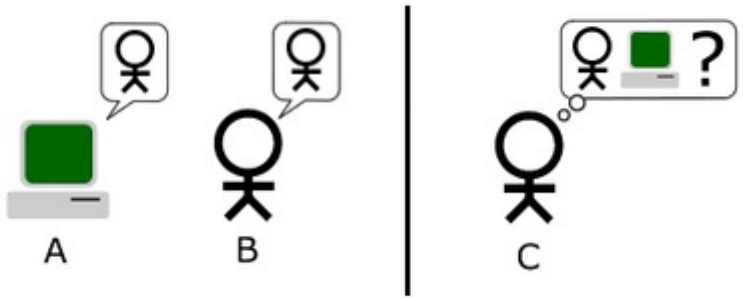
- Artificial Intelligence refers to the ability of machines to perform cognitive tasks commonly associated with human intelligence including perception, learning, reasoning, planning, speech and language, and taking actions

- Turing Test (1950)



Interdisciplinarity

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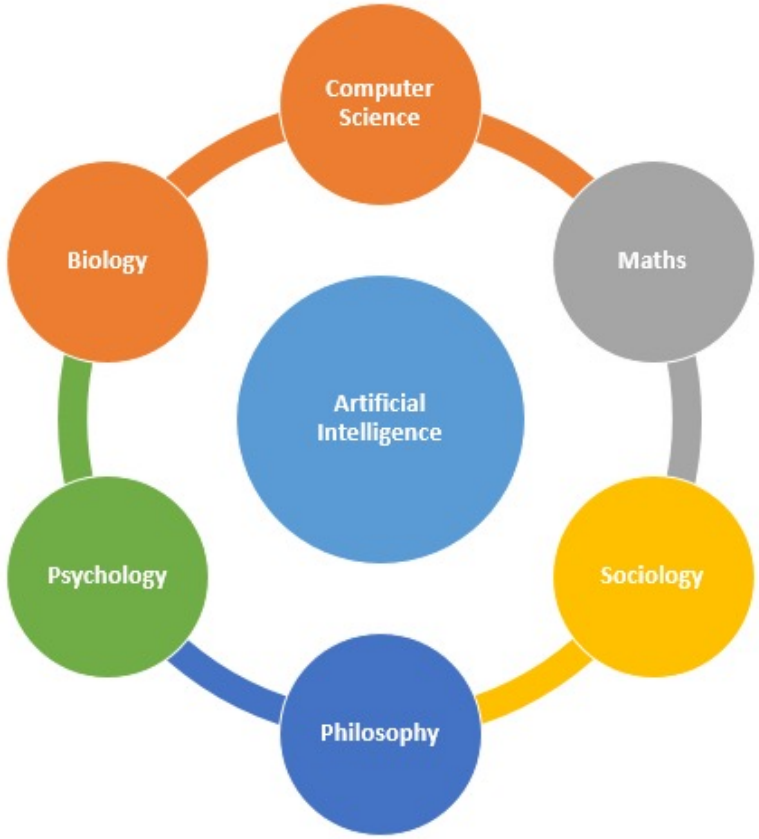
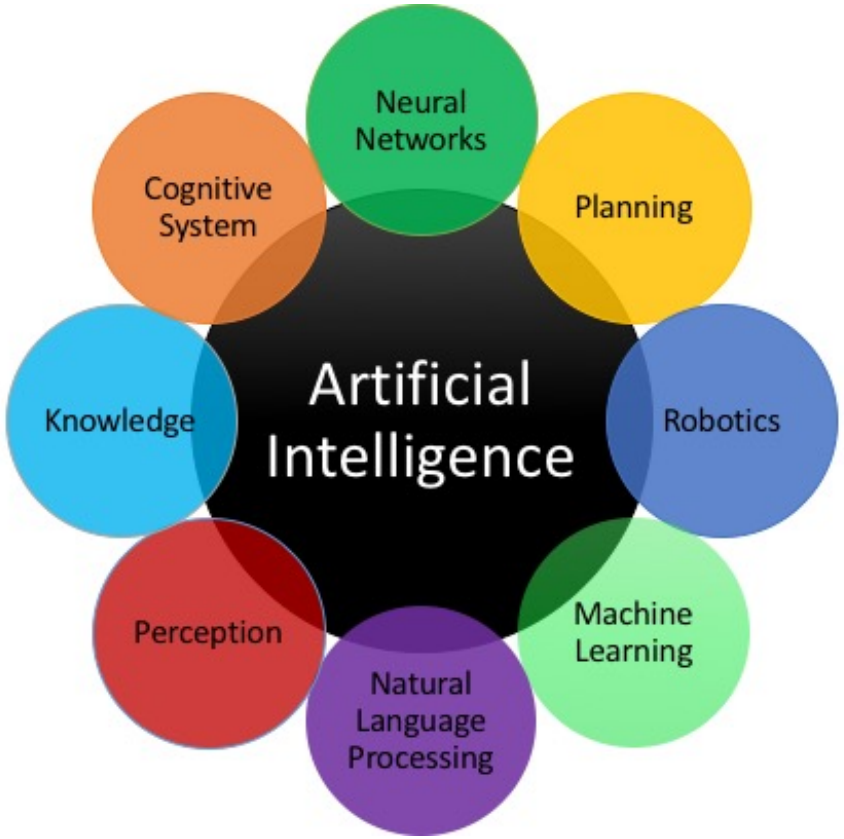
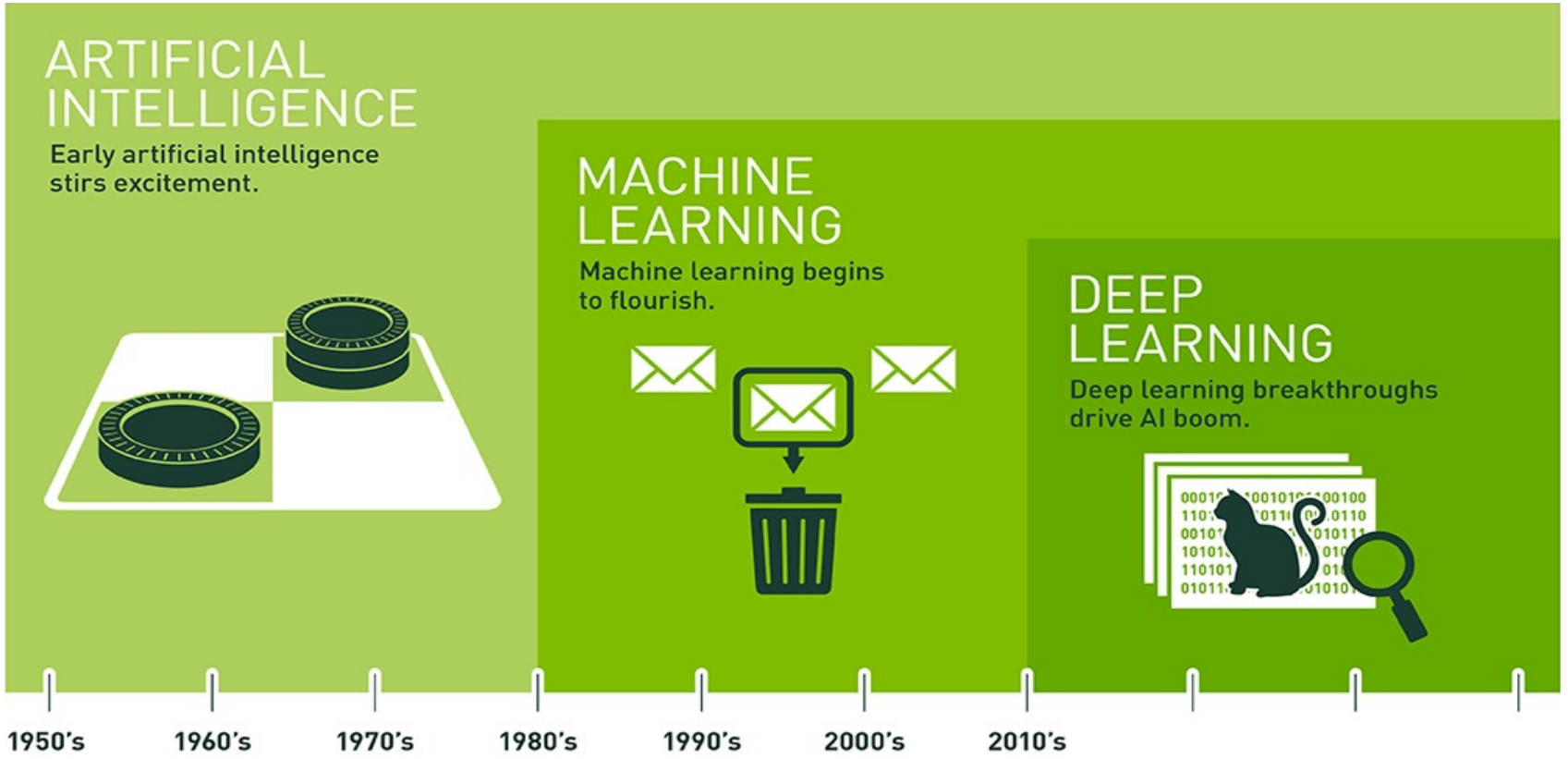
AI relates to many other fields of science



AI is composed of many sub-disciplines



Relationship: Artificial Intelligence – Machine Learning – Deep Learning



Arthur Samuel's checkers, Perceptron, Joseph Weizenbaum's Eliza, …

Optical Character Recognition, Spam Filters, Genomics, Google Search, …

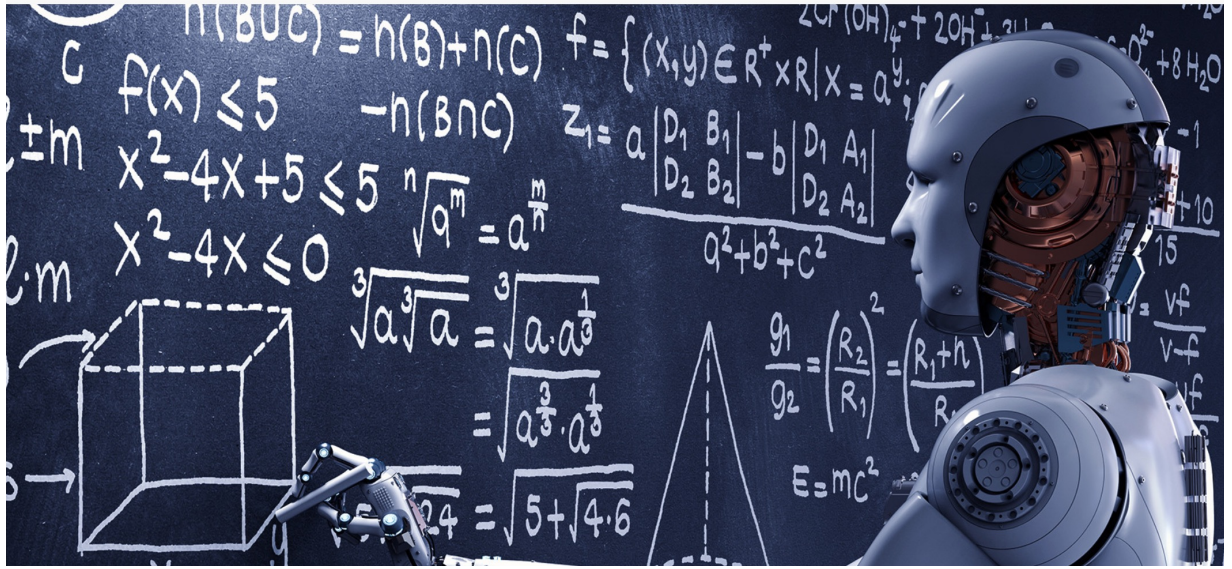
Image-, Text-, Voice-, Music-, Video Recognition/Processing, Autonomous Driving, AlphaGo, …

Fast computers & large data sets → Deep Learning Revolution

Oil and Electricity

Data and AI

Data is Today's Oil,
Artificial Intelligence is
the New Electricity



AI will be omnipresent

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- AI pervades commercial applications in an unprecedented manner
- AI is fundamentally changing how businesses operate across virtually all sectors

– Information technology
  speech and image recognition, translation

– Manufacturing and supply chains
  optimize production and delivery processes

– Medicine and healthcare
  diagnoses & evaluations, drug design

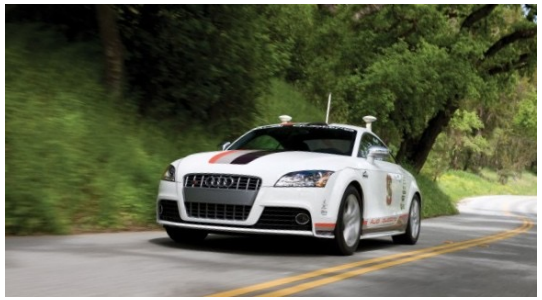
– Education, news / publishing / marketing, financial / legal / tax services
  recommender systems

– Transportation
  self-driving cars and trucks

Hey Siri

Google Translate

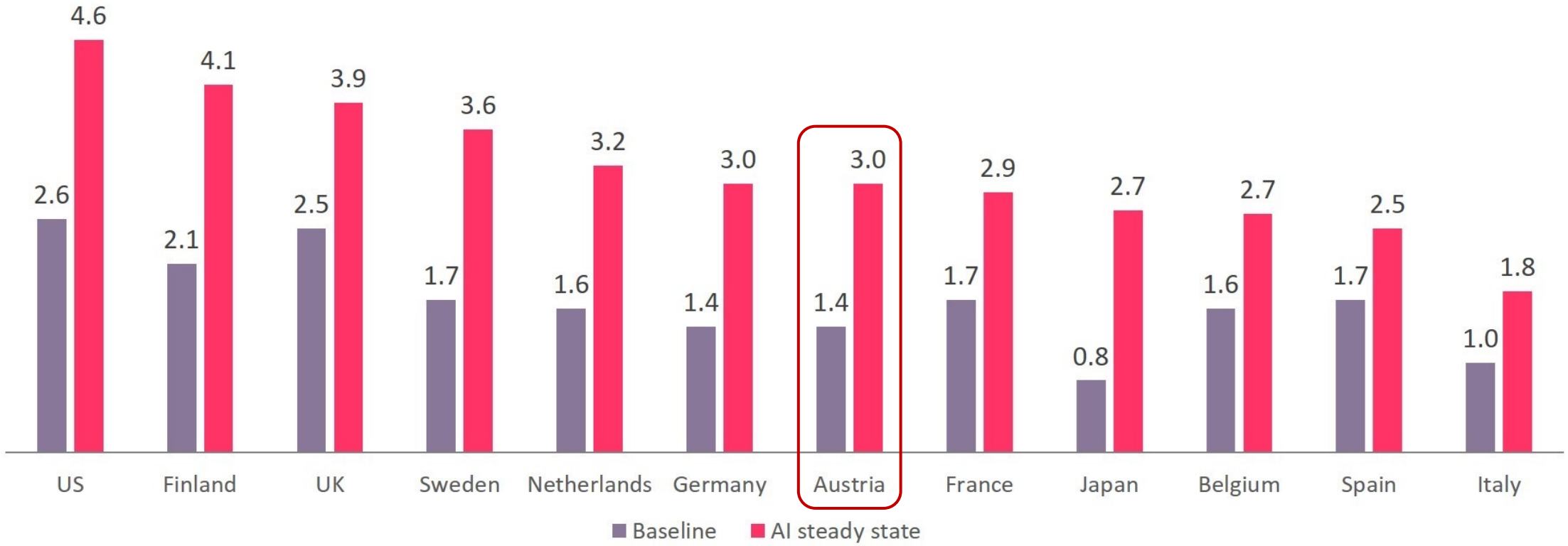
amazon alexa



Impact on the Economy

- Accenture (2016): AI doubles annual GDP growth rate until 2035 (similar studies: McKinsey, PwC ,…)

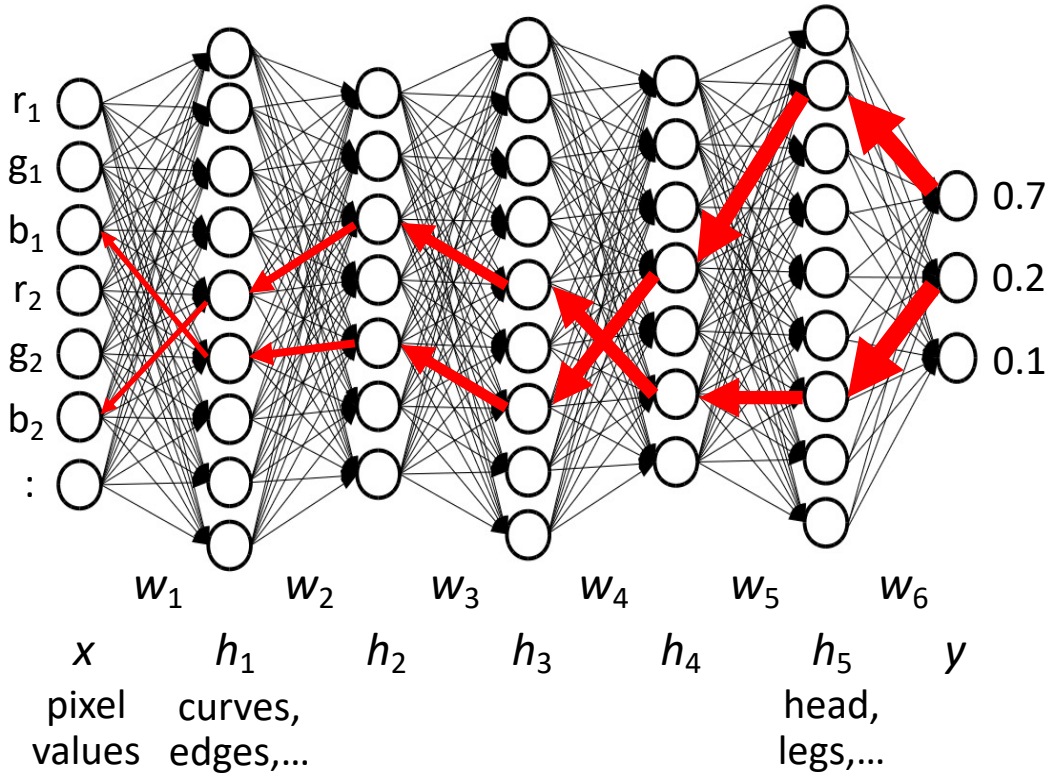
  Austria: without AI adoption: 1.4% growth rate
  with AI adoption: 3.0% growth rate



Source: Accenture and Frontier Economics

Deep Learning – Deep Neural Networks

- Multiple (hidden) layers in artificial neural network

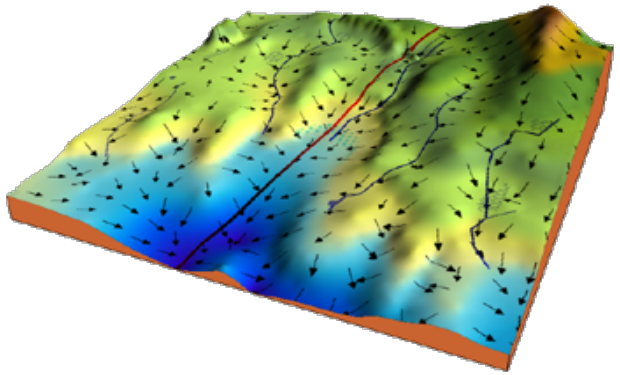


Horse

Dog

Cat

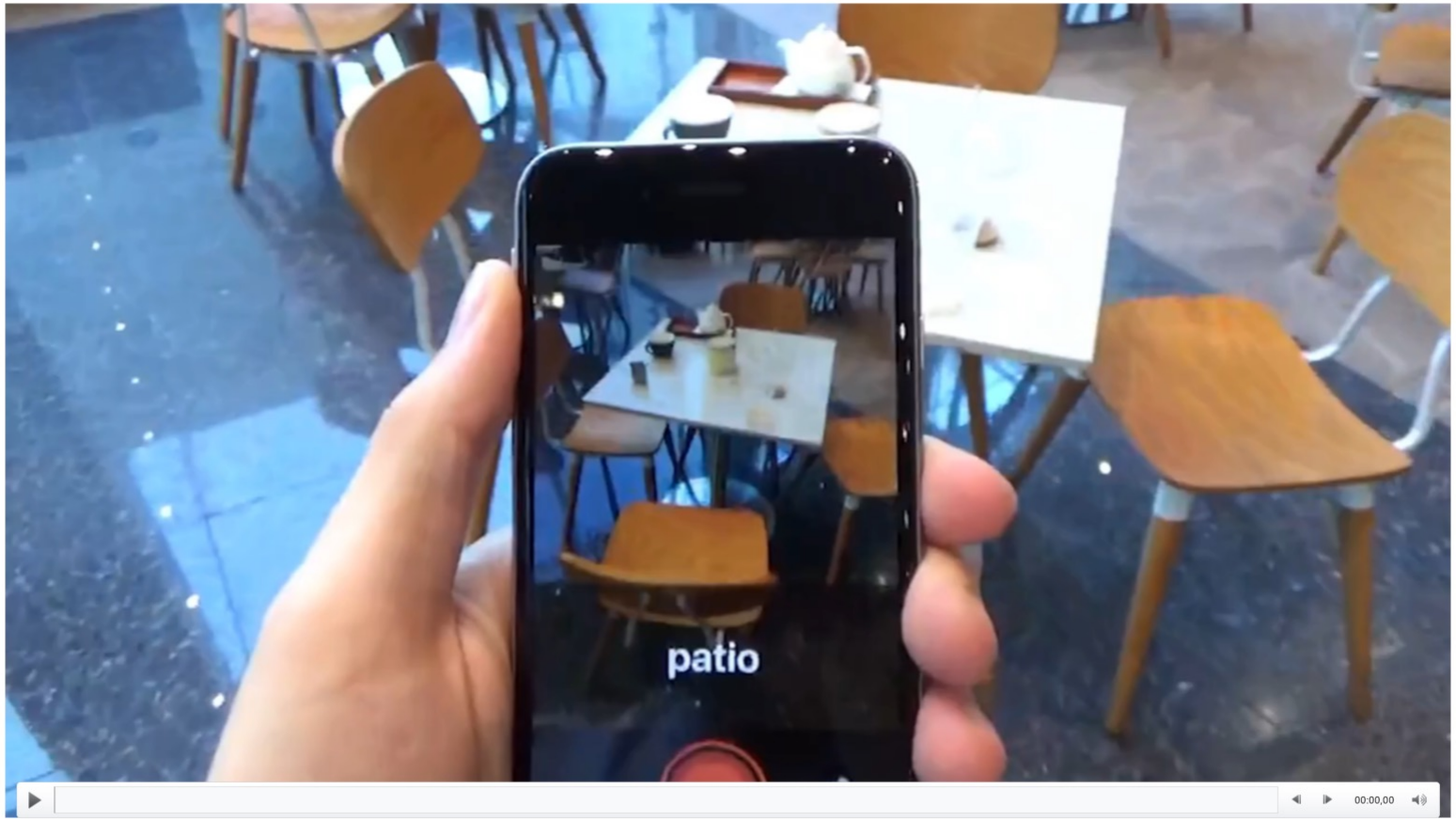
- Gradient descent minimizes error



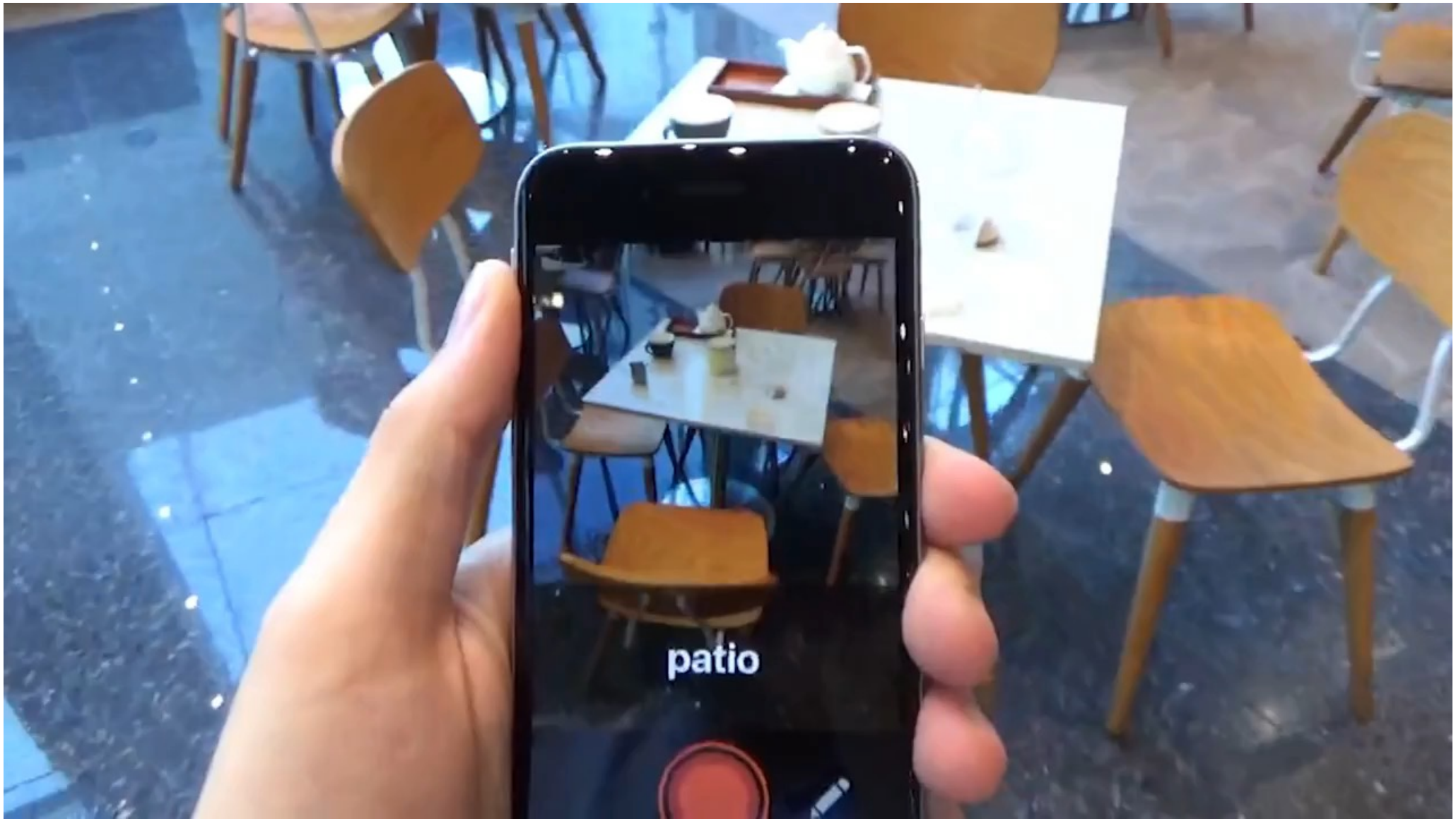
– Feedback = total gradient of error

Aipoly Vision: Sight for Blind & Visually Impaired

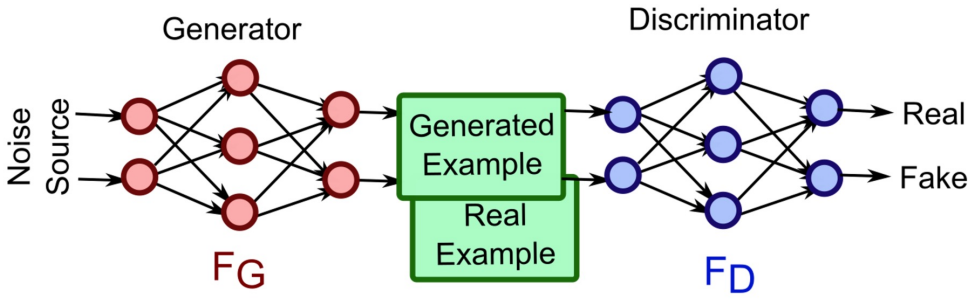
- 2 billion processed images
- 5000 recognizable objects
- 26 supported languages



Video – Aipoly Vision



Generative Adversarial Networks (GANs)

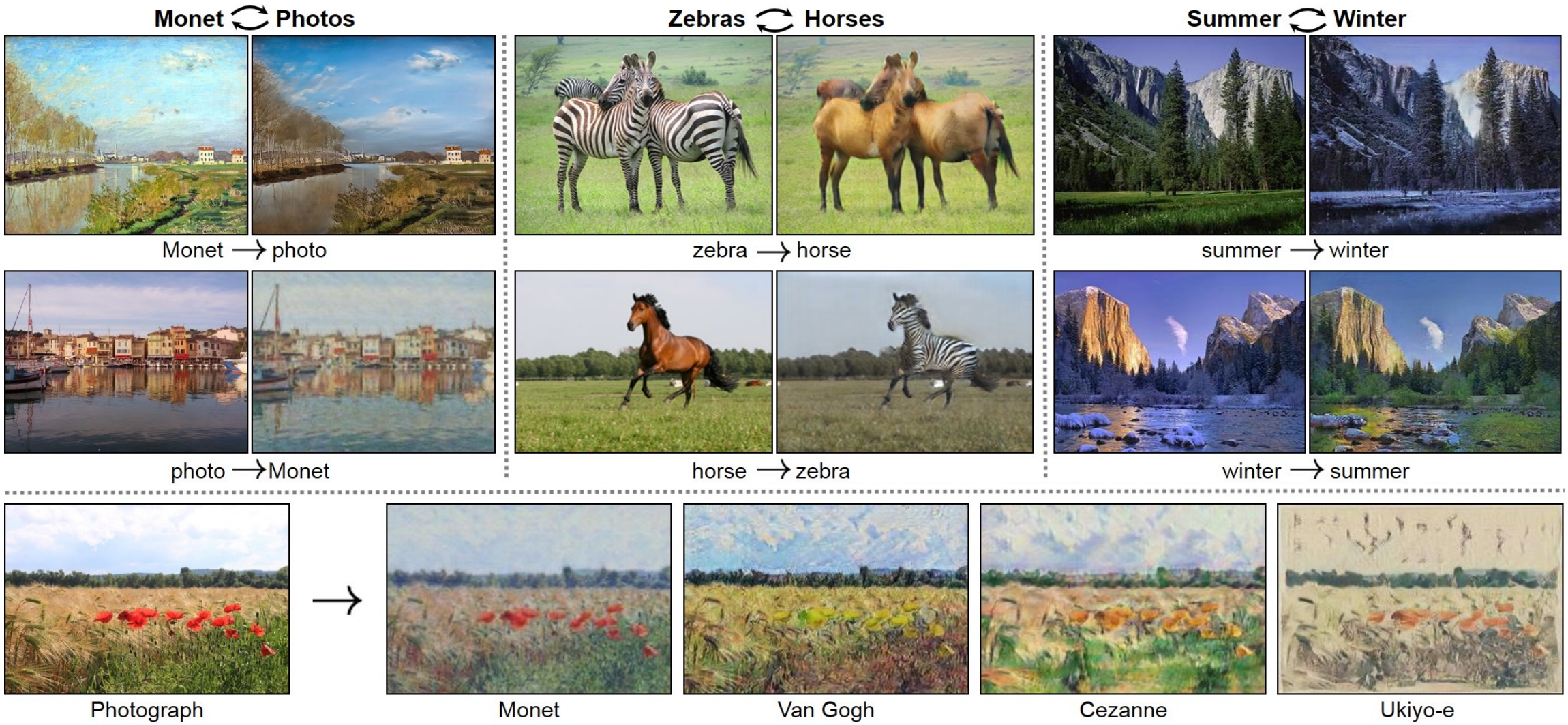


- Generator network tries to fake images
- Discriminator network tries to distinguish between real and fake
- Both networks get better and better while training against each other

NVIDIA (2018)

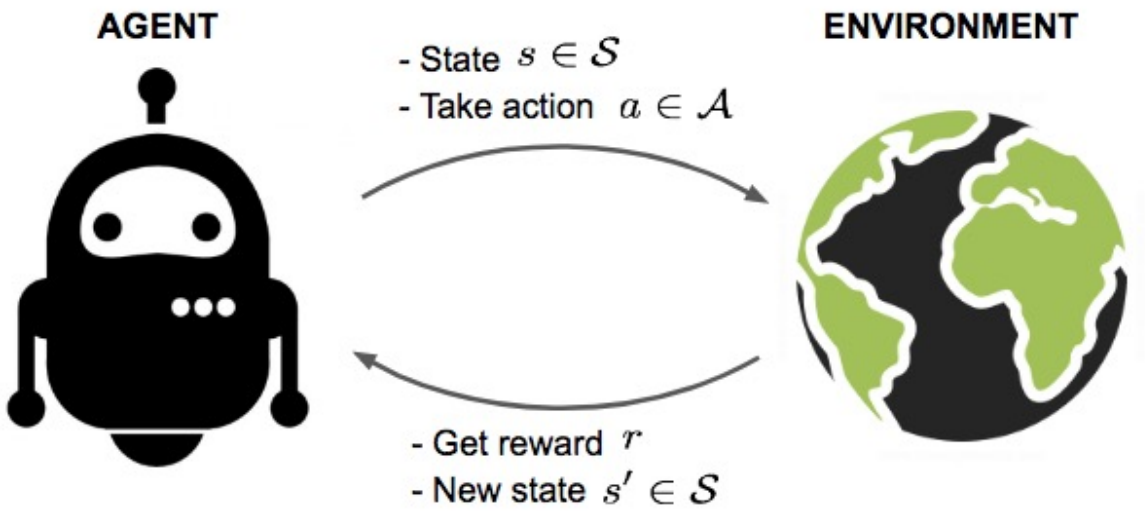
Arthur Samuel (1956)

Generative Adversarial Networks (GANs)



UC Berkeley, arxiv 1703.10593

Reinforcement Learning



ETH Zürich (2017)

- Agents take actions in an environment to maximize reward (optimal control theory), e.g.

  for drone: not crashing

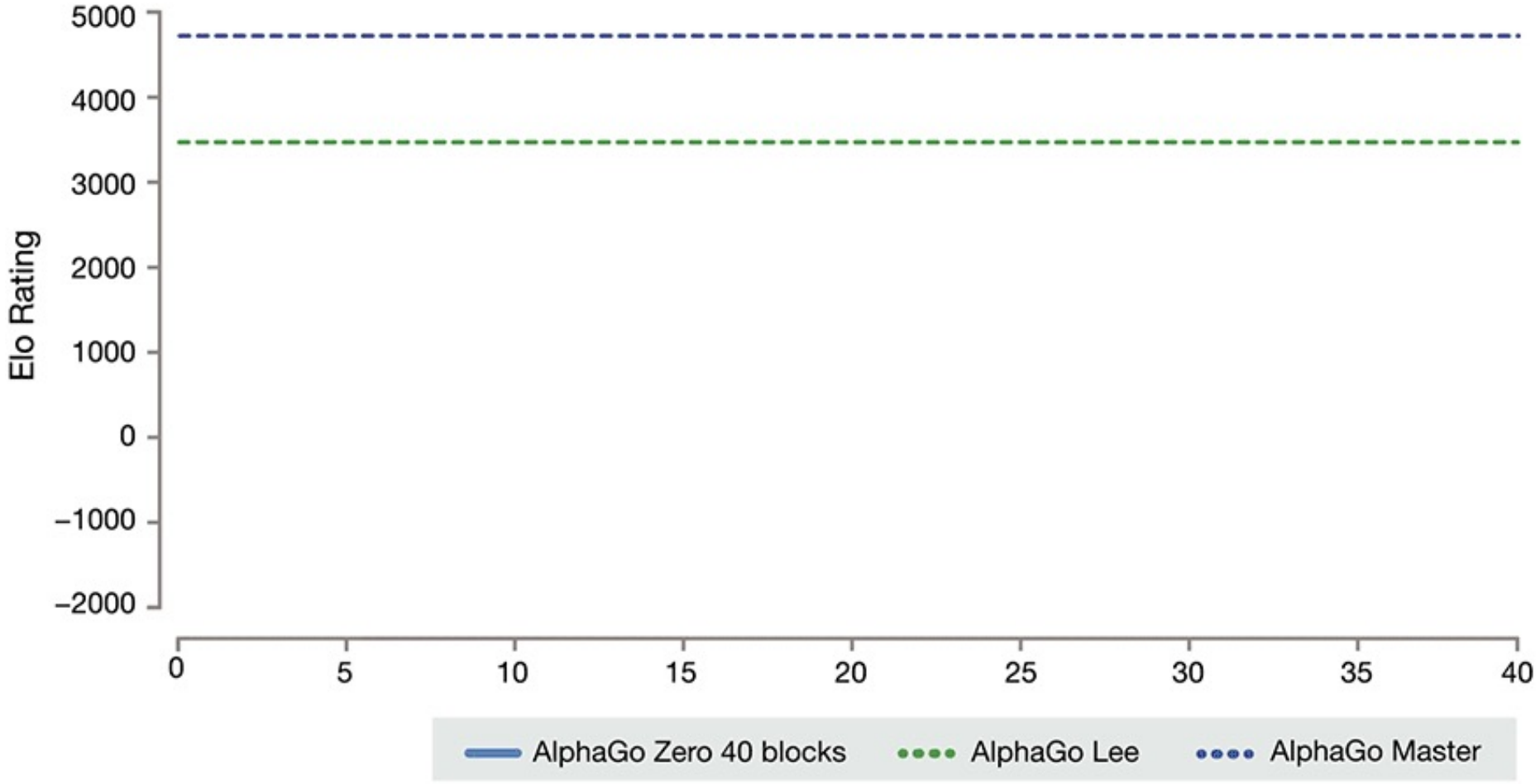
  in Go: winning the game

Deep Blue – AlphaGo

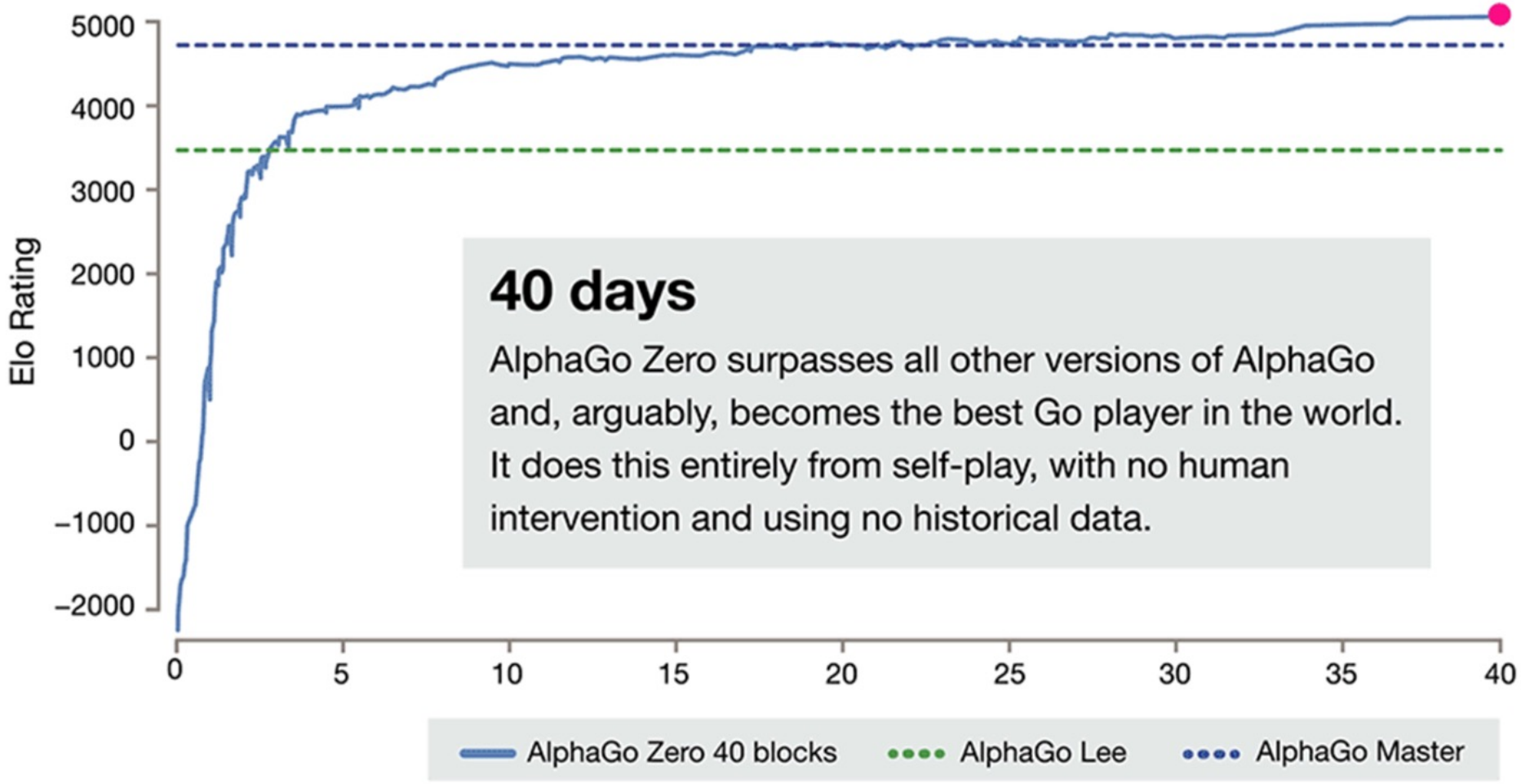
- Chess: India/Persia/China (≈ 2000 years old)
- Simple rules
- Game tree complexity: 10^{123}
- Deep Blue: brute force program, position value hard coded
- 1997: Deep Blue beats Garri Kasparow 3.5:2.5

- Go: China: (≈ 2500 year old)
- Very simple rules
- Game tree complexity : 10^{360}
- Today‘s „normal“ programs reach medium strength (Dan 5)
- Alpha Go: position valued by deep neural net
- 2017: AlphaGo beats Ke Jie (Dan 9) 3:0

AlphaGo Zero

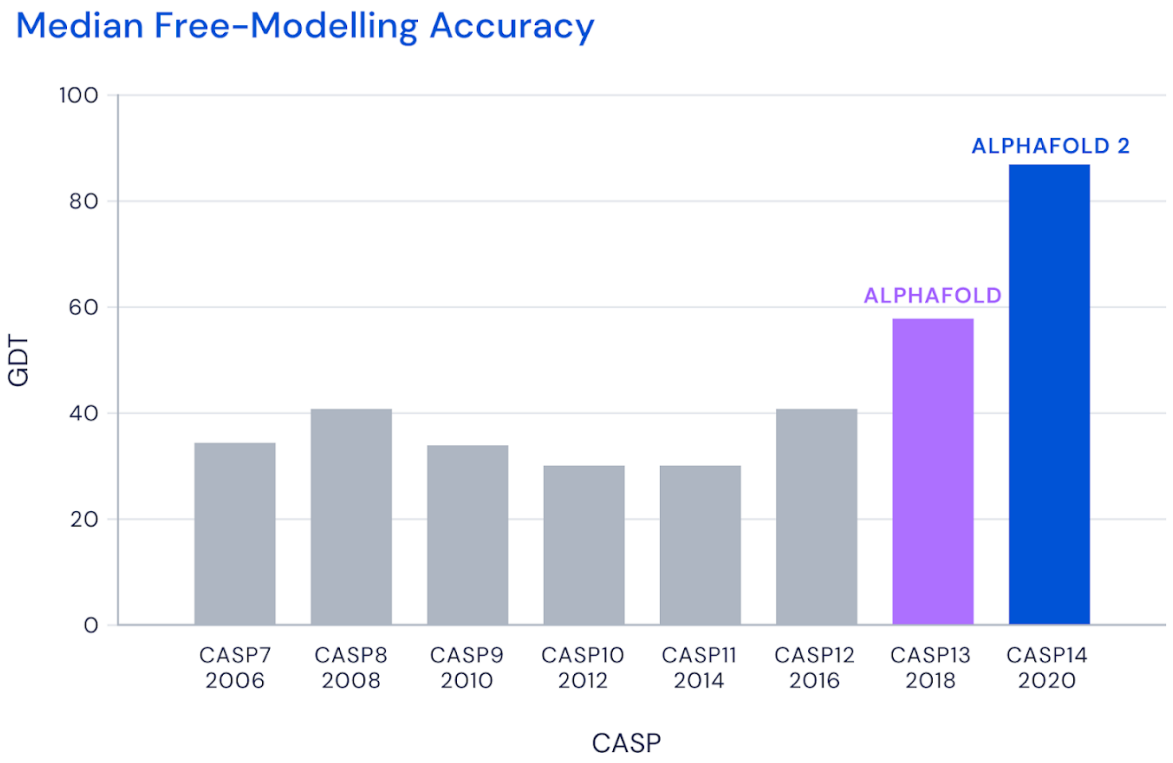


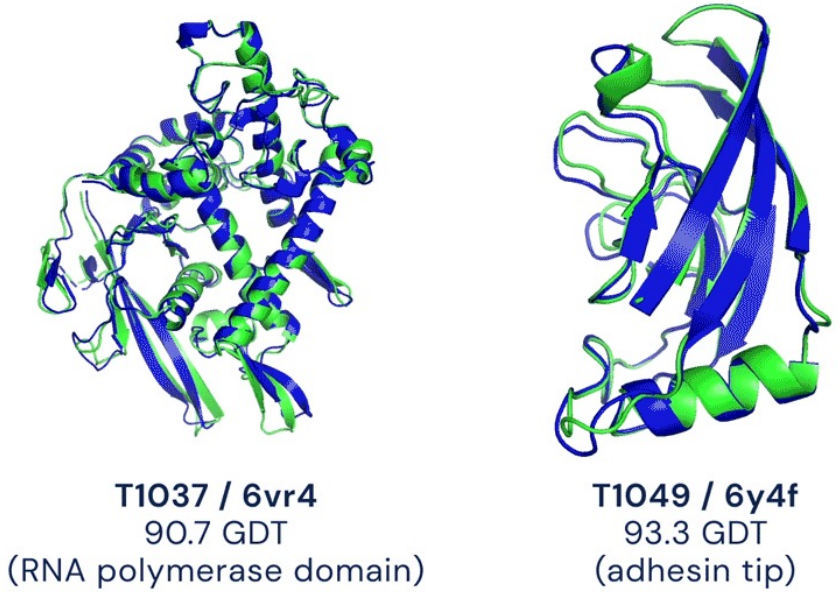
AlphaGo Zero



AlphaFold

- Understanding protein structures has been a grand challenge in biology for decades
- AlphaFold uses Deep Learning to generate accurate 3D models of proteins from their genetic sequence





“Real” AI Still Science Fiction

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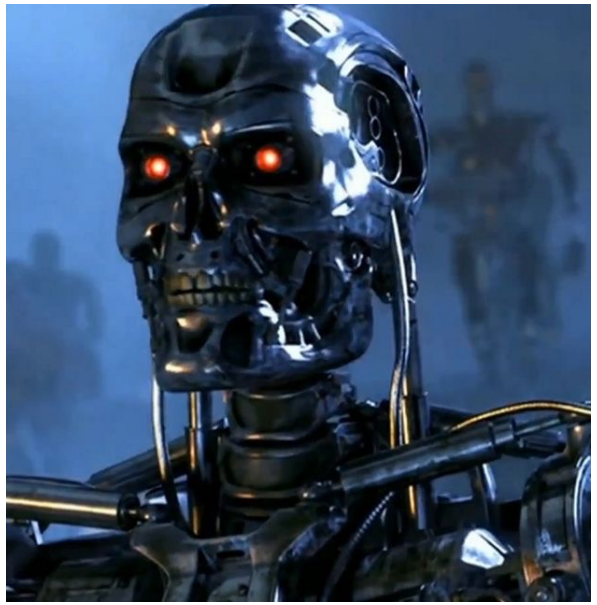

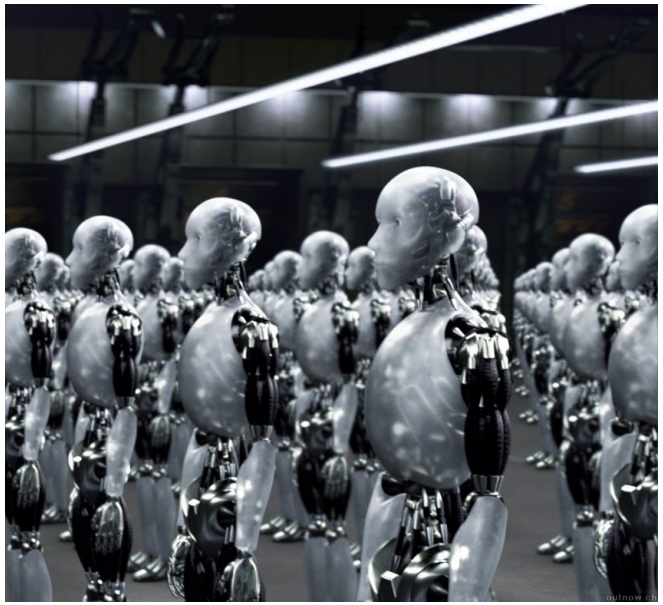

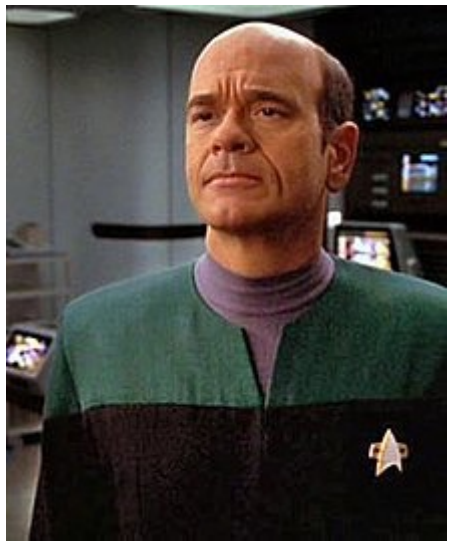

Artificial General Intelligence (AGI) = Strong AI

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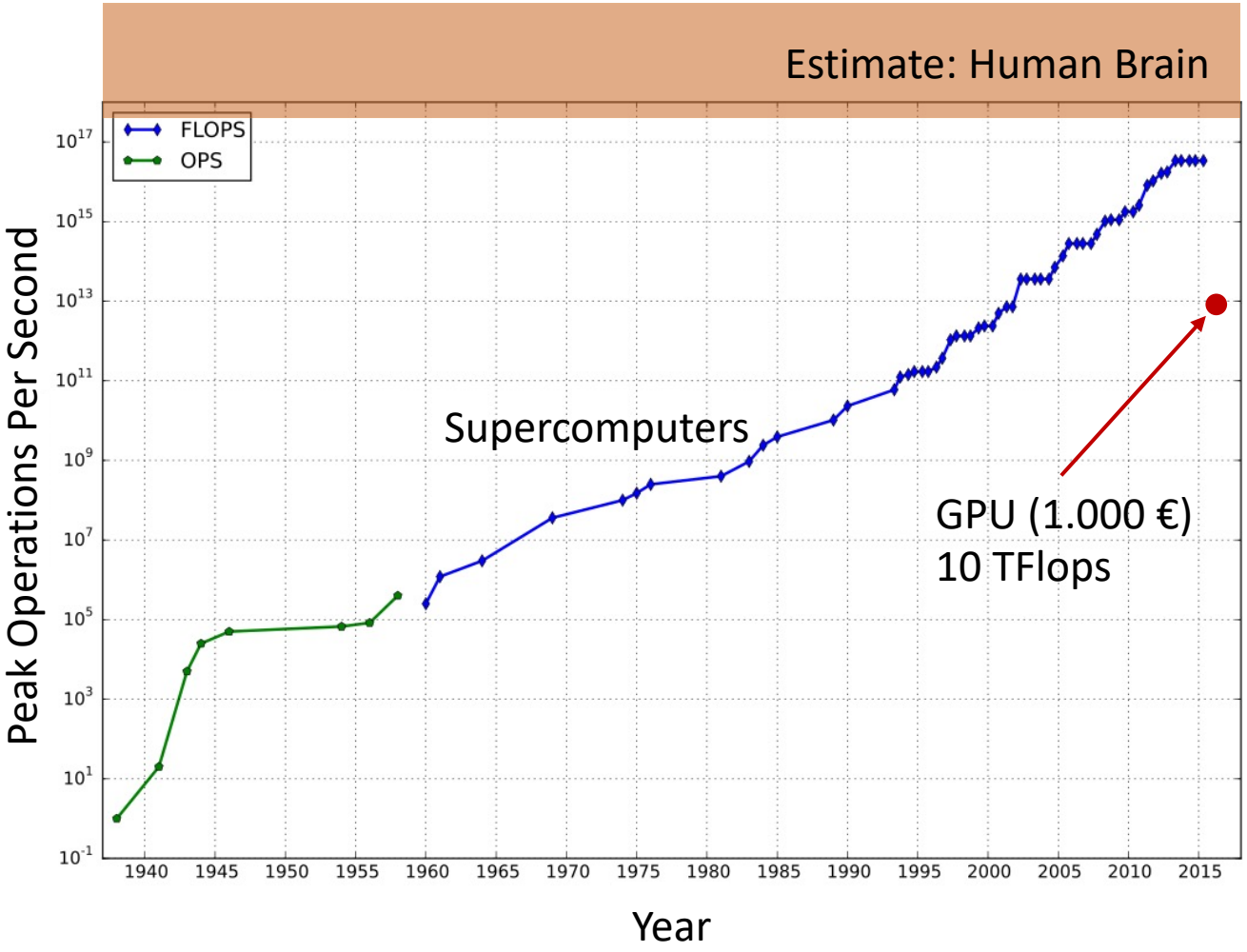
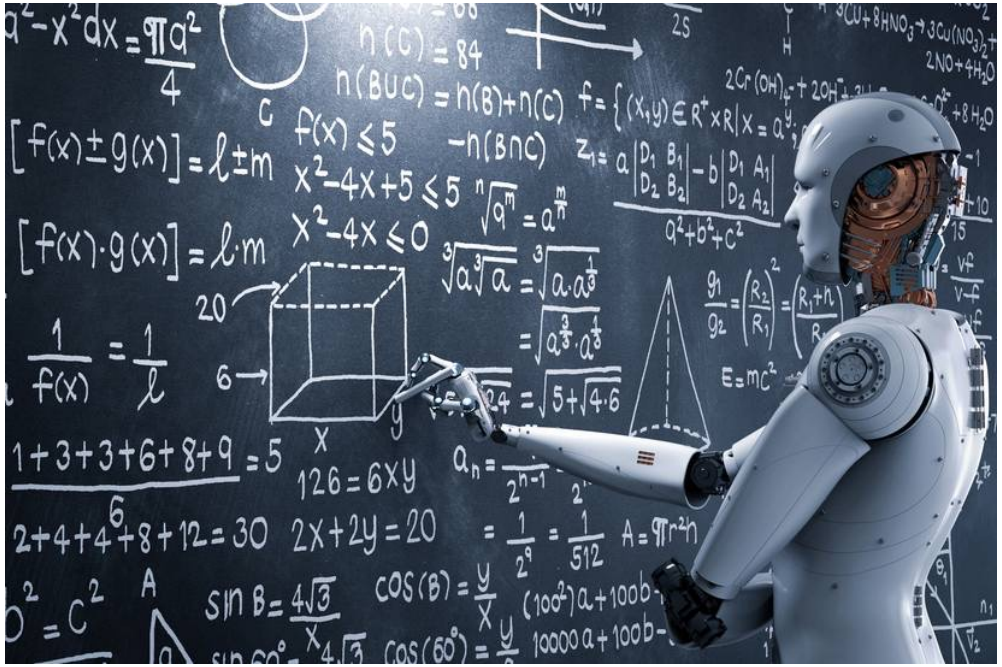
- Hypothetical machine with behavior at least as skillful and flexible as human





Study Program “Artificial Intelligence” at JKU

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Bachelor's and Master's Program "Artificial Intelligence"

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- Both programs:
  - Started October 2019
  - No access restriction
  - Among the first AI programs in Europe
  - First AI program in Austria
  - Fully taught in English
  - Largely available via distance learning (see next slide)
  - Technical program, but also wider scope: "AI and Society" (e.g. sociological and legal questions)
- Bachelor's program:
  - 6 semesters
  - Fundamentally interdisciplinary (education in computer science, mathematics, and core AI subjects)
- Master's program:
  - 4 semesters
  - Focus on Deep Learning
  - Four elective tracks (two in Mechatronics, one in Maths, one in Life Sciences)

Distance Learning and Enrolment

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- Physical presence at JKU is of course possible for all courses (after the Corona pandemic)
- The AI curriculum is largely available via Distance Learning
  - Course contents are available online (lecture notes or slides)
  - Most courses are live streamed and/or can be streamed for at least two weeks afterwards
  - Exercises allow online participation
  - Exams are either online or on site (three options: JKU, Vienna, Bregenz)
  - Number of required days of physical presence at JKU (except exams): only about 1 per semester
  - More information from perspective of a Vienna-based Master Student: right after this talk
- Enrollment for next Winter Term: probably online; if not: probably doable without coming to JKU
  - Web: https://www.jku.at/en/degree-programs/prospective-students/register-to-enroll/
  - Email: admission@jku.at

Bachelor's Program "Artificial Intelligence"

JOHANNES KEPLER UNIVERSITÄT LINZ

KEY FACTS

DEGREE
Bachelor of Science (BSc)

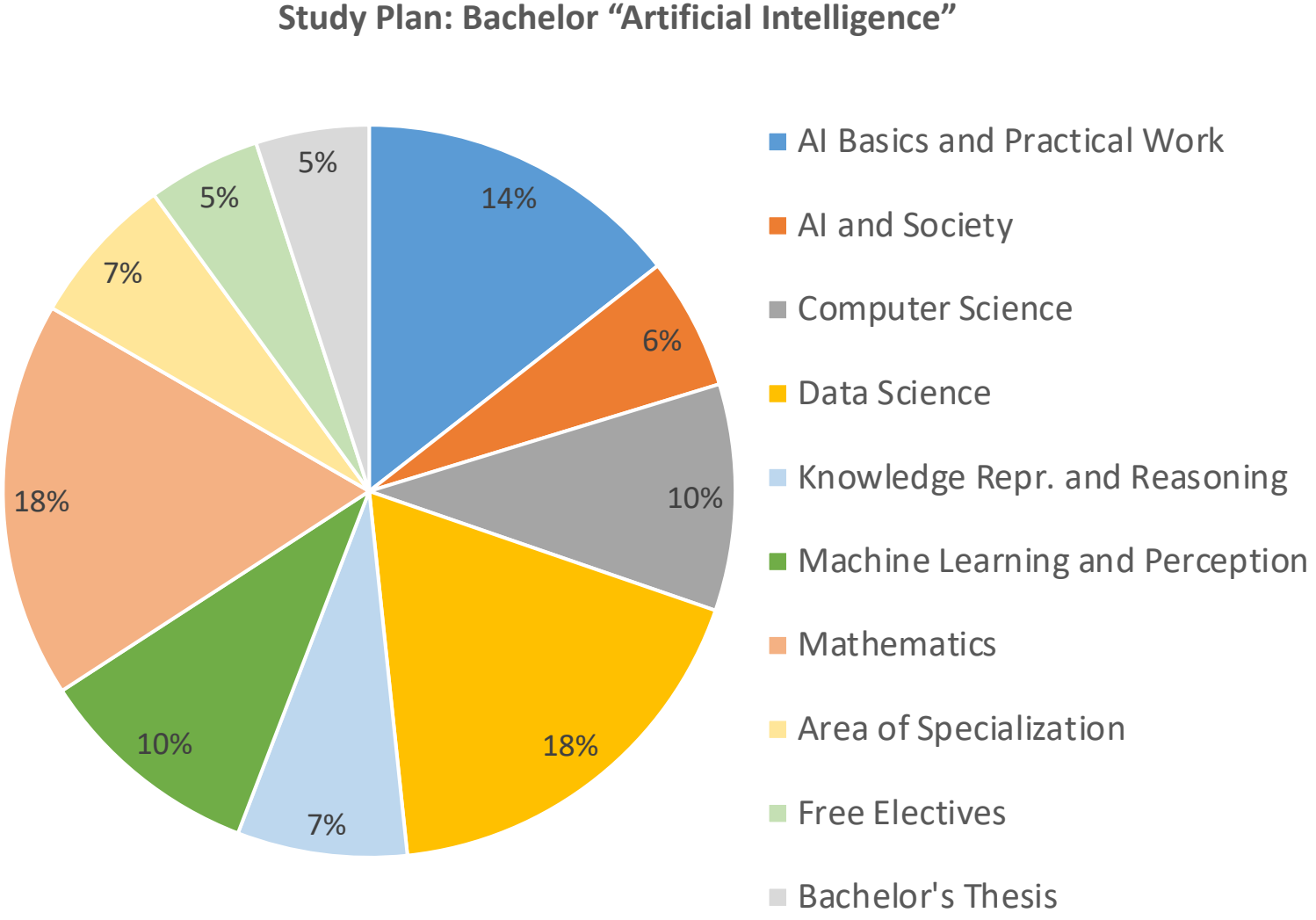
DURATION
6 Semesters

ECTS
180 Credits

LANGUAGE
English

LOCATION
Linz, optional with Distance Learning

PROGRAM
Full-time



Bachelor's Program "Artificial Intelligence"

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1st Semester (WS)		2nd Semester (SS)		3rd Semester (WS)		4th Semester (SS)		5th Semester (WS)		6th Semester (SS)		
Subject/Course	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	
AI Basics and Practical Work Hands-on AI I (1.5 VL) Hands-on AI I (1.5 UE) Introduction to AI (3 VL)	6.0	**AI Basics and Practical Work** Hands-on AI II (1.5 VL) Hands-on AI II (3 UE)	4.5	**AI Basics and Practical Work** Artificial Intelligence (3 VO) Artificial Intelligence (1.5 UE)	4.5	**AI Basics and Practical Work** Seminar in AI (3 SE)	3.0	**AI Basics and Practical Work** Practical Work in AI (7.5 PR)	7.5			25.5
AI and Society Lecture Series Artificial Intelligence (1.5 KV) Responsible AI (3 KV)	4.5	**AI and Society** Technology and Society (3 KV)	3.0							**AI and Society** Gender Studies	3.0	10.5
Computer Science Programming in Python I (3 VL) Programming in Python I (3 UE)	6.0	**Computer Science** Algorithms and Data Structures 1 (3 VL) Algorithms and Data Structures 1 (1.5 UE) Programming in Python II (1.5 VL) Programming in Python II (1.5 UE)	7.5	**Computer Science** Algorithms and Data Structures 2 (3 VL) Algorithms and Data Structures 2 (1.5 UE)	4.5							18.0
		Data Science Statistics for AI (3 VL) Statistics for AI (3 UE)	6.0	**Data Science** Basic Methods of Data Analysis (3 KV) Visual Analytics (3 VL) Visual Analytics (1.5 UE)	7.5	**Data Science** Computational Data Analytics (3 KV) Learning from User-generated Data (3 VL) Learning from User-generated Data (1.5 UE)	7.5	**Data Science** Introduction to Computational Statistics (3 VL) Introduction to Computational Statistics (1.5 UE) Natural Language Processing (1.5 VL) Natural Language Processing (1.5 UE)	7.5	**Data Science** Digital Signal Processing (3 VL) Digital Signal Processing (1.5 UE)	4.5	33.0
Knowledge Representation and Reasoning Logic (3 VL) Logic (1.5 UE)	4.5					**Knowledge Representation and Reasoning** Formal Models (3 VL) Formal Models (1.5 UE)	4.5	**Knowledge Representation and Reasoning** Computational Logics for AI (3 VL) Computational Logics for AI (1.5 UE)	4.5			13.5
				Machine Learning and Perception Machine Learning: Supervised Techniques (3 VL) Machine Learning: Supervised Techniques (1.5 UE)	4.5	**Machine Learning and Perception** Machine Learning: Unsupervised Techniques (3 VL) Machine Learning: Unsupervised Techniques (1.5 UE) Machine Learning and Pattern Classification (3 VL) Machine Learning and Pattern Classification (1.5 UE)	9.0	**Machine Learning and Perception** Reinforcement Learning (3 VL) Reinforcement Learning (1.5 UE)	4.5			18.0
Mathematics Mathematics for AI I (6 VL) Mathematics for AI I (3 UE)	9.0	**Mathematics** Mathematics for AI II (6 VL) Mathematics for AI II (3 UE)	9.0	**Mathematics** Mathematics for AI III (6 VL) Mathematics for AI III (3 UE)	9.0	**Mathematics** Numerical Optimization (3 VL) Numerical Optimization (1.5 UE)	4.5					31.5
						Area of Specialization	1.5	**Area of Specialization**	3.0	**Area of Specialization**	7.5	12.0
								Free Electives	3.0	**Free Electives**	6.0	9.0
										Bachelor's Thesis Bachelor's Thesis Seminar in AI (9 SE)	9.0	9.0
	30.0		30.0		30.0		30.0		30.0		30.0	

Total ECTS: 180.0

Qualification Profile Bachelor's Program

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- Admission criterion: "Matura" (or equivalent)
- Broad and balanced foundational education in mathematics and computer science
- Specialized training in core AI subjects such as machine learning, data science, knowledge representation and reasoning, and natural language processing
- Students will learn about broader ethical implications of AI for society
- Focus primarily on systematic problem solving; promotes social competences in team work; practical training allows the students to acquire skills relevant for their later careers
- Program prepares graduates for subsequent Master studies and for immediate entry into job market, where they will be able to develop AI solutions in many different sectors of industry and economy

Master's Program "Artificial Intelligence"

JOHANNES KEPLER UNIVERSITÄT LINZ

KEY FACTS

DEGREE
Master of Science (MSc)

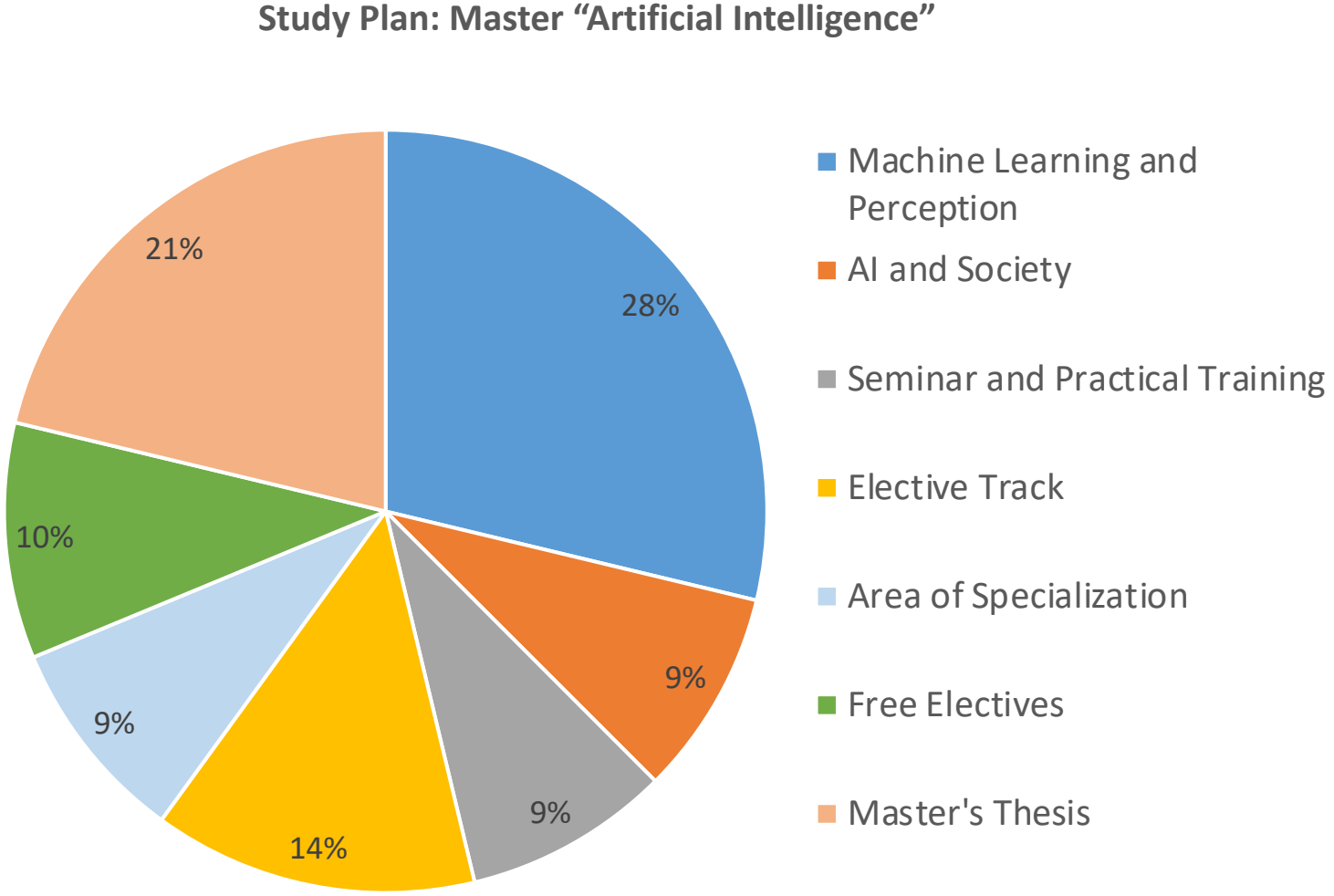
DURATION
4 Semesters

ECTS
120 Credits

LANGUAGE
English

LOCATION
Linz, optional with Distance Learning

PROGRAM
Full-time



Master's Program "Artificial Intelligence"

Elective Track: AI and Mechatronics – Robotics and Autonomous Systems

1st Semester (WS)		2nd Semester (SS)		3rd Semester (WS)		4th Semester (SS)		
Subject/Course	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	
Machine Learning and Perception Computer Vision (3 VL) Computer Vision (1.5 UE) Deep Learning and Neural Nets I (3 VL) Deep Learning and Neural Nets I (1.5 UE) LSTM and Recurrent Neural Nets (3 VL) LSTM and Recurrent Neural Nets (1.5 UE)	13.5	**Machine Learning and Perception** Deep Learning and Neural Nets II (3 VL) Deep Learning and Neural Nets II (1.5 UE) Deep Reinforcement Learning (3 VL) Deep Reinforcement Learning (1.5 UE) Theoretical Concepts of Machine Learning (3 VL) Theoretical Concepts of Machine Learning (1.5 UE)	13.5	**Machine Learning and Perception** Explainable AI (1.5 VL) Explainable AI (1.5 UE) Probabilistic Models (3 VL) Probabilistic Models (1.5 UE)	7.5			**34.5**
AI and Society AI and Law I (3 VL) Artificial Intelligence in Society (1.5 KV)	4.5	**AI and Society** AI and Law II (1.5 VL) Robopsychology (3 KV)	4.5	**AI and Society** Communicating AI (1.5 KV)	1.5			**10.5**
				Seminar and Practical Training Seminar in AI (Master) (3 SE) Practical Work in AI (Master) (7.5 PR)	10.5			**10.5**
Elective Track: AI and Mechatronics – Robotics and Autonomous Systems Control Systems (3 VL) Control Systems (1.5 UE) Production Automation Systems (3 VL)	7.5	**Elective Track: AI and Mechatronics – Robotics and Autonomous Systems** Introduction to Autonomous Systems (3 VL) Introduction to Autonomous Systems (1.5 UE) Introduction to Robotic Systems (3 VL) Introduction to Robotic Systems (1.5 UE)	9.0					**16.5**
Area of Specialization	1.5	**Area of Specialization**	1.5	**Area of Specialization**	7.5			**10.5**
Free Electives	3.0	**Free Electives**	1.5	**Free Electives**	3.0	**Free Electives**	4.5	**12.0**
						Master's Thesis Seminar	3.0	**3.0**
						Master's Examination	1.5	**1.5**
						Master's Thesis	21.0	**21.0**
	30.0		**30.0**		**30.0**		**30.0**	

Total ECTS: 120.0

Master's Program "Artificial Intelligence"

Elective Track: AI and Mechatronics – Embedded Intelligence and Signal Processing

1st Semester (WS)		2nd Semester (SS)		3rd Semester (WS)		4th Semester (SS)		
Subject/Course	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	
Machine Learning and Perception Computer Vision (3 VL) Computer Vision (1.5 UE) Deep Learning and Neural Nets I (3 VL) Deep Learning and Neural Nets I (1.5 UE) LSTM and Recurrent Neural Nets (3 VL) LSTM and Recurrent Neural Nets (1.5 UE)	13.5	**Machine Learning and Perception** Deep Learning and Neural Nets II (3 VL) Deep Learning and Neural Nets II (1.5 UE) Deep Reinforcement Learning (3 VL) Deep Reinforcement Learning (1.5 UE) Theoretical Concepts of Machine Learning (3 VL) Theoretical Concepts of Machine Learning (1.5 UE)	13.5	**Machine Learning and Perception** Explainable AI (1.5 VL) Explainable AI (1.5 UE) Probabilistic Models (3 VL) Probabilistic Models (1.5 UE)	7.5			**34.5**
AI and Society AI and Law I (3 VL) Artificial Intelligence in Society (1.5 KV)	4.5	**AI and Society** AI and Law II (1.5 VL) Robopsychology (3 KV)	4.5	**AI and Society** Communicating AI (1.5 KV)	1.5			**10.5**
				Seminar and Practical Training Seminar in AI (Master) (3 SE) Practical Work in AI (Master) (7.5 PR)	10.5			**10.5**
Elective Track: AI and Mechatronics – Embedded Intelligence and Signal Processing Optimale und Adaptive Signalverarbeitungssysteme (3 VL) Optimale und Adaptive Signalverarbeitungssysteme (1.5 UE) Radarsignalverarbeitung (3 VL) Radarsignalverarbeitung (1.25 UE)	8.75			**Elective Track: AI and Mechatronics – Embedded Intelligence and Signal Processing** Pervasive Computing: Design and Development (3 VL) Pervasive Computing: Design and Development (1.5 UE) Pervasive Computing: Systems and Environments (3 VL) Pervasive Computing: Systems and Environments (1.5 UE)	9.0			**17.75**
Area of Specialization	1.75	**Area of Specialization**	7.5					**9.25**
Free Electives	1.5	**Free Electives**	4.5	**Free Electives**	1.5	**Free Electives**	4.5	**12.0**
						Master's Thesis Seminar	3.0	**3.0**
						Master's Examination	1.5	**1.5**
						Master's Thesis	21.0	**21.0**
	30.0		**30.0**		**30.0**		**30.0**	

Total ECTS: 120.0

Master's Program "Artificial Intelligence"

Elective Track: Reasoning and Knowledge Representation

1st Semester (WS)		2nd Semester (SS)		3rd Semester (WS)		4th Semester (SS)		
Subject/Course	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	
Machine Learning and Perception Computer Vision (3 VL) Computer Vision (1.5 UE) Deep Learning and Neural Nets I (3 VL) Deep Learning and Neural Nets I (1.5 UE) LSTM and Recurrent Neural Nets (3 VL) LSTM and Recurrent Neural Nets (1.5 UE)	13.5	**Machine Learning and Perception** Deep Learning and Neural Nets II (3 VL) Deep Learning and Neural Nets II (1.5 UE) Deep Reinforcement Learning (3 VL) Deep Reinforcement Learning (1.5 UE) Theoretical Concepts of Machine Learning (3 VL) Theoretical Concepts of Machine Learning (1.5 UE)	13.5	**Machine Learning and Perception** Explainable AI (1.5 VL) Explainable AI (1.5 UE) Probabilistic Models (3 VL) Probabilistic Models (1.5 UE)	7.5			**34.5**
AI and Society AI and Law I (3 VL) Artificial Intelligence in Society (1.5 KV)	4.5	**AI and Society** AI and Law II (1.5 VL) Robopsychology (3 KV)	4.5	**AI and Society** Communicating AI (1.5 KV)	1.5			**10.5**
				Seminar and Practical Training Seminar in AI (Master) (3 SE) Practical Work in AI (Master) (7.5 PR)	10.5			**10.5**
Elective Track: Reasoning and Knowledge Representation Model Checking (3 VL) Model Checking (1.5 UE) Planning and Reasoning in Artificial Intelligence (3 VL) Planning and Reasoning in Artificial Intelligence (1.5 UE)	9.0	**Elective Track: Reasoning and Knowledge Representation** Knowledge Representation and Learning (3 VL) Knowledge Representation and Learning (1.5 UE)	4.5	**Elective Track: Reasoning and Knowledge Representation** Automated Reasoning (3 VL) Automated Reasoning (1.5 UE)	4.5			**18.0**
Area of Specialization	1.5	**Area of Specialization**	4.5	**Area of Specialization**	3.0			**9.0**
Free Electives	1.5	**Free Electives**	3.0	**Free Electives**	3.0	**Free Electives**	4.5	**12.0**
						Master's Thesis Seminar	3.0	**3.0**
						Master's Examination	1.5	**1.5**
						Master's Thesis	21.0	**21.0**
	30.0		**30.0**		**30.0**		**30.0**	

Total ECTS: 120.0

Master's Program "Artificial Intelligence"

JOHANNES KEPLER UNIVERSITÄT LINZ

Elective Track: AI and Life Sciences

1st Semester (WS)		2nd Semester (SS)		3rd Semester (WS)		4th Semester (SS)		
Subject/Course	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	**Subject/Course**	**ECTS**	
Machine Learning and Perception Computer Vision (3 VL) Computer Vision (1.5 UE) Deep Learning and Neural Nets I (3 VL) Deep Learning and Neural Nets I (1.5 UE) LSTM and Recurrent Neural Nets (3 VL) LSTM and Recurrent Neural Nets (1.5 UE)	13.5	**Machine Learning and Perception** Deep Learning and Neural Nets II (3 VL) Deep Learning and Neural Nets II (1.5 UE) Deep Reinforcement Learning (3 VL) Deep Reinforcement Learning (1.5 UE) Theoretical Concepts of Machine Learning (3 VL) Theoretical Concepts of Machine Learning (1.5 UE)	13.5	**Machine Learning and Perception** Explainable AI (1.5 VL) Explainable AI (1.5 UE) Probabilistic Models (3 VL) Probabilistic Models (1.5 UE)	7.5			**34.5**
AI and Society AI and Law I (3 VL) Artificial Intelligence in Society (1.5 KV)	4.5	**AI and Society** AI and Law II (1.5 VL) Robopsychology (3 KV)	4.5	**AI and Society** Communicating AI (1.5 KV)	1.5			**10.5**
				Seminar and Practical Training Seminar in AI (Master) (3 SE) Practical Work in AI (Master) (7.5 PR)	10.5			**10.5**
		Elective Track: AI and Life Sciences Artificial Intelligence in Life Sciences (1.5 VL) Artificial Intelligence in Life Sciences (1.5 UE) Genome Analysis & Transcriptomics (3 KV) Structural Bioinformatics (3 KV)	9.0					**9.0**
Area of Specialization	9.0	**Area of Specialization**	1.5	**Area of Specialization**	7.5			**18.0**
Free Electives	3.0	**Free Electives**	1.5	**Free Electives**	3.0	**Free Electives**	4.5	**12.0**
						Master's Thesis Seminar	3.0	**3.0**
						Master's Examination	1.5	**1.5**
						Master's Thesis	21.0	**21.0**
	30.0		**30.0**		**30.0**		**30.0**	

Total ECTS: 120.0

Qualification Profile Master's Program

JOHANNES KEPLER UNIVERSITÄT LINZ

- Thorough education in modern developments in the field of AI, in particular in deep learning
- Students will acquire practical training, learn about connections of AI to the legal system as well as its sociological implications, and acquire in-depth knowledge in a chosen elective track
- Four elective tracks: AI and Mechatronics – Robotics and Autonomous Systems
  AI and Mechatronics – Embedded Intelligence and Signal Processing
  Reasoning and Knowledge Representation
  AI and Life Sciences
- Tracks make use of existing academic excellence and infrastructure at JKU; mechatronics tracks tailored to the strong local industrial environment in manufacturing systems engineering, plant construction, and general engineering
- Preparation for subsequent PhD studies and for immediate entry into job market

Admission Criteria for Master' Program in AI

JOHANNES KEPLER UNIVERSITÄT LINZ

- With Bachelor's degree in Artificial Intelligence at JKU or equivalent program:

  → no admission conditions

- With Bachelor's degree in related „technical" discipline (JKU: "Informatik", "Technische Mathematik", "Technische Physik", "Mechatronik", "Elektronik und Informationstechnik", "NaWi-Tec", "Statistik", "Wirtschaftsinformatik", "Bioinformatics", *or equivalent*):

  → 9 ECTS points required (can be completed within "Area of Specialiazation" or "Free Electives" within the 120 ECTS of the Master's program itself)

  - "Machine Learning: Supervised Techniques" (VL, 3 ECTS)
  - "Machine Learning: Unsupervised Techniques" (VL, 3 ECTS)
  - either "Statistics for AI" (VL, 3 ECTS) or "Statistik" (VO, 3 ECTS) or "Basic Methods of Data Analysis" (KV, 3 ECTS)

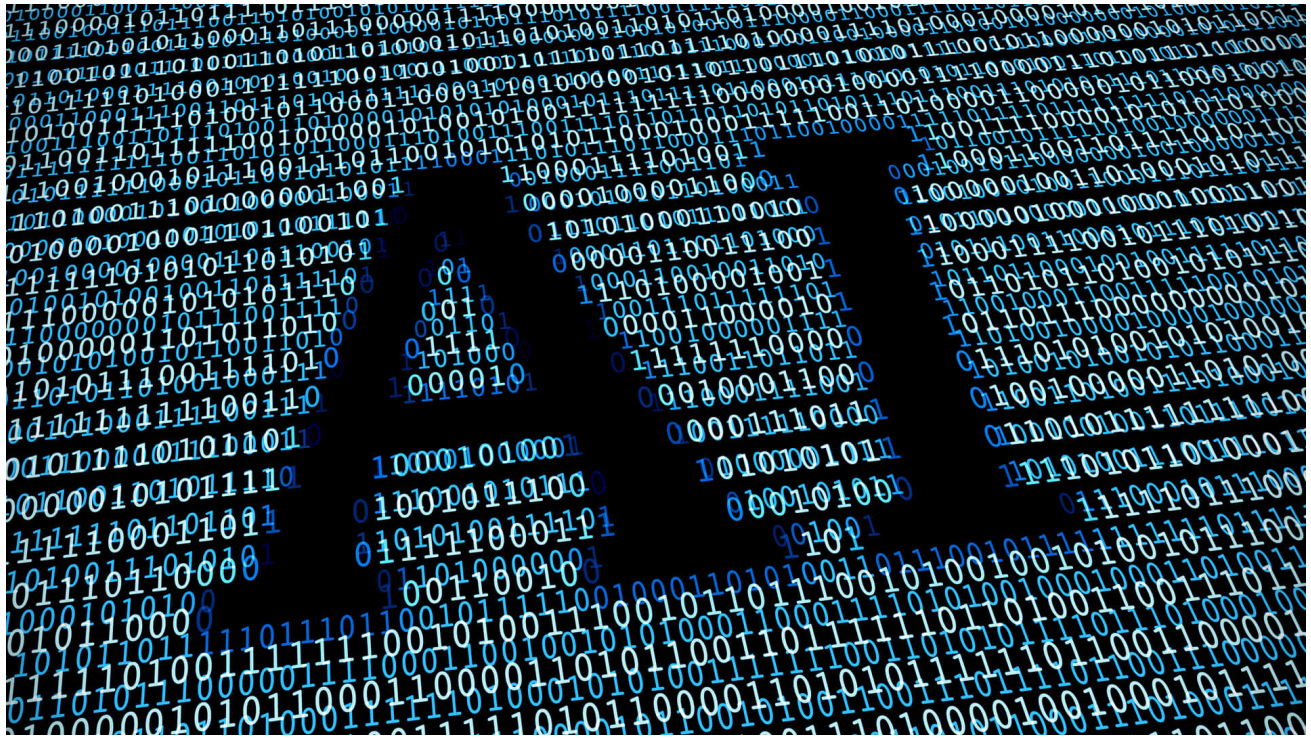
- With any other Bachelor's degree

  → admission can be granted under condition of up to 40 additional ECTS points

Further Information

JOHANNES KEPLER
UNIVERSITÄT LINZ

- Bachelor AI: https://www.jku.at/studium/studienarten/bachelordiplom/ba-artificial-intelligence/
- Master AI: https://www.jku.at/studium/studienarten/master/ma-artificial-intelligence/
- Easier to just Google „AI JKU“ ☺



LINZ INSTITUTE
OF TECHNOLOGY

Thank you for your attention!

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