WASP AI4X

Collecting Ideas and Identifying Challenges for Future AI Research in Sweden

Wallenberg Artificial Intelligence, Autonomous Systems and Software Program – WASP

WASP | WALLENBERG AI, AUTONOMOUS SYSTEMS AND SOFTWARE PROGRAM

WHAT IS AI?

According to one of the founders of AI, John McCarthy, Artificial intelligence is the science and engineering of intelligent machines, especially intelligent computer programs.

This captures the essence of AI, which is to endow computers with cognitive functionalities. Two central cognitive functionalities are /learning/, to automatically construct models, facts, and knowledge that accurately captures some aspect of a real or virtual phenomena from observations, assumptions, prior knowledge, and interactions with the environment, and /reasoning/, to draw valid conclusions from models, facts, observations, assumptions, and knowledge.

It is important to make a distinction between intelligent agents and AI-enabled systems. An intelligent agent should be autonomous, pro-active, and goal directed. It should interact with the world around it, be it digital or analog, both to sense it and to influence it. The agent should be able to both quickly react to events and to achieve long-term goals through deliberation and pro-active behavior. Very few existing systems can be said to be intelligent agents in this sense. Instead, there are many AI-enabled systems that include one or more components which uses AI-techniques, such as a recommendation component, a planning/scheduling component, or a learned classifier.

AI is a broad research area, which includes many sub-disciplines. While machine learning and knowledge representation and reasoning are two of the main ones, the area also includes multi-agent systems, robotics, game theory, and natural language processing. Building on recent developments and successful applications, machine learning is currently generating the most interest and value, but all areas are useful and necessary to build truly intelligent systems.

WASP AI4X was a series of one-day conferences, during Spring 2018, on Artificial Intelligence in Sweden. WASP, funded by the Knut and Alice Wallenberg Foundation, organised the conferences. The aim was to collect ideas and identify challenges for future AI research in Sweden.

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Text: Danica Kragic Jensfelt, KTH Royal Institute Of Technology, Daniel Gillblad, RISE, Fredrik Heintz, Linköping University, Mikael Hansson, Umeå University (partly page 12-27).
Production and layout: Mikael Hansson, Umeå University.
Photos: dragonstock/stock.adobe.com , ktsdesign/stock.adobe.com, elnur/stock.adobe.com, damiengeso/stock.adobe.com, ipopba/stock.adobe.com, flashmovie/stock.adobe.com, gonin/stock.adobe.com, metamorworks/stock.adobe.com.

FOREWORD

Wallenberg Artificial Intelligence, Autonomous Systems and Software Program – WASP

With developments in Artificial Intelligence predicted to have a major impact on research activities and society at large, the Knut and Alice Wallenberg Foundation decided to award grants amounting to SEK 1.15 billion over the coming decade for research into AI research as an extension of the WASP program.

The Wallenberg Artificial Intelligence, Autonomous Systems and Software Program – WASP, is known as Sweden's single largest research initiative. The aim is to put Sweden at the international forefront in this field. The Foundation's financial commitment totals SEK 2.625 billion in the period to 2026, of which SEK 1.15 billion is earmarked for AI. Together with co-funding from the universities involved and Swedish industrial groups, the entire initiative is worth SEK 3.815 billion.

A key element of the program is the establishment of a platform for academic research and education that can interact with Swedish industry. This is founded on a clear knowledge building process aimed at future challenges facing industry. One example is the graduate school, which is run in collaboration between the WASP universities and Swedish companies. Infrastructure such as demonstration platforms and national demonstration arenas are other features of the joint program.

The aim of the entire WASP program is to recruit up to 60 new research teams, and over 300 PhD students, of whom at least 75 should be sponsored by industry. The ambition is to establish an internationally leading environment in the field of autonomous systems, software and AI.

The research initiative within AI have two main themes. The first is machine and deep learning, and next generation AI. The second is about fundamental mathematical principles underlying AI. However, the robotics and visual recognition areas will also be covered by the initiative. The industrial collaboration aspect of the initiative is important, but the focal point is basic research. The program includes Chalmers University of Technology, KTH Royal Institute of Technology, Linköping, Lund and Umeå universities, as well as research teams at other institutions of higher education.

The initiative also includes an international recruitment program, and establishment of demonstrator arenas where research and private enterprise can meet in specific projects. The aim is to build up a solid knowledge platform that will enable Swedish industry to remain competitive and be right at the cutting edge.

The ambition is to establish an internationally leading environment in the field of autonomous systems, software and Artificial Intelligence.

INTRODUCTION

WASP AI4X was a series of one-day conferences, during Spring 2018, on the theme of Artificial Intelligence (AI), its development and application in different sectors in Sweden. WASP, funded by the Knut and Alice Wallenberg Foundation, organised the conferences.

The aim was to collect ideas and identifying challenges for future AI research in Sweden and also lay the ground for building a network of researchers, companies, representatives of public and private sectors and end users, interested in developing and applying AI.

AI is expected to have a profound impact on our society, both short- and long-term. It has made important progress during the last decades and there is now an accelerating transfer of research result into commercial applications. At the same time, there are huge needs for more competence in the area and for further research and development. Many of the ideas and solutions have historically been generated in academia and made it to commercial applications through successful collaboration between academia and industry.

Sweden is a technologically advanced country with a high level of digital maturity. However, there are other countries that seem to take a bigger and faster advantage of applying AI in various sectors. It is therefore essential that we as a country take advantage of the opportunities provided by AI too - not tomorrow, today. To do this we need to seriously strengthen the competence, research and development of AI in Sweden. These type of conferences are a first step towards this.

The purpose of the first round of WASP AI4X conferences was to bring together people from companies, academia, and the public sector and end users to present and discuss the current and planned use of AI. The goal was to get a better understanding of the status of AI in Sweden, its challenges and opportunities.

Based on the work presented at the conferences, this report summarises what companies, researchers and organizations are using AI for today, what they expect to use AI for in the near future, what AI techniques and technologies they are using, what applications they are using these for and the challenges and needs they see for the future.

Beforehand WASP invited organisations in different sectors to give short pitches of the application and development of AI in their organisation. The sectors was expected to be interpreted broadly and inclusively. Presentations were awaited from participants who either develop, apply or plan to apply AI in their organisation. These presentations and talks were presented to all participants followed by a poster session with more in-depth discussions. At the poster session there was also made room for researchers presenting their expertise in the area to provide a basis for potential future collaborations.

From the conferences, it is clear that Swedish companies, from small startups to large industries, see AI technologies as a key component in their products and services for the future. While the maturity level varies widely from already existing strategic agendas and use of AI technologies today to open questions around what AI could mean for the company, there is a strong sense of urgency. Likewise, the interest from academia is strong, where also researchers and groups that have perhaps earlier not worked directly with AI are willing to contribute.

AI expertise is critical for the competitiveness of Sweden, and WASP will ensure that we build excellent basic research and educate PhD students that can help develop the next generation of AI applications. However, it is critical that we build a strong AI ecosystem in Sweden where this expertise can be utilised fully. And for that, we need national investments that are long term of benefit to industry, public sector and society at large. Here, efforts from government and industry are needed to not only strengthen research but also to make sure these technologies are applied on a broad scale in practice. Preferably, such efforts should be coordinated and complementary - we should primarily be competing with large investments in other countries than against ourselves.

Applying AI in practice often requires both AI expertise and strong domain knowledge. It is therefore essential to both have a critical mass of AI experts with deep technical knowledge and a broader group who understand the basics of AI technology while being experts in their own area, and that there is a free flow of ideas and knowledge between them. Building such a strong AI ecosystem will take time, commitment and continued investment from all actors to build. To make a difference, we have to think nationally and long term.

Danica Kragic Jensfelt,
KTH Royal Institute Of Technology

Daniel Gillblad,
RISE

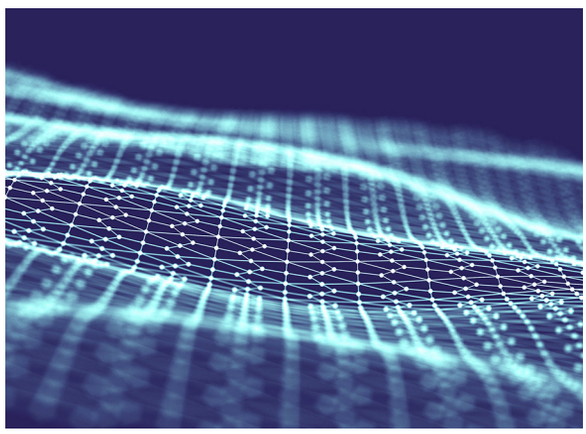
Fredrik Heintz,
Linköping University

RECOMMENDATIONS

Based on the needs expressed by academia, industry and the public sector during the WASP AI4X events and the critical role that AI will have for Swedish innovation, we can see a number of efforts important for the future:

Ensure AI knowledge

Ensure that Sweden has adequate scientific and technical AI knowledge. AI is a broad topic including reasoning, learning and interaction, and Sweden will need researchers with deep knowledge on the scientific forefront in all of these areas. We need several strong, relatively large, and well funded research environments.

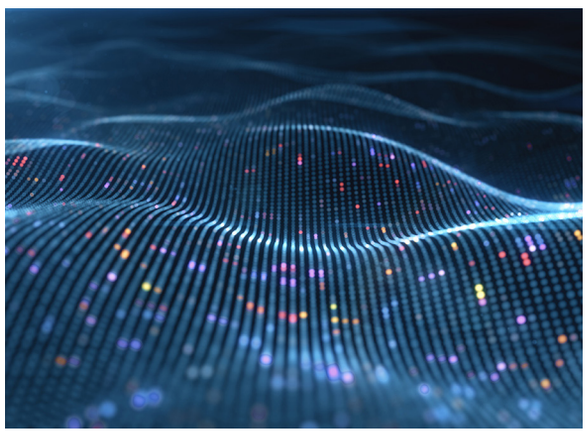


Ensure high quality multidisciplinary research

AI is a multidisciplinary area. It will both continue to draw from and be applied in medicine, law, economics and social sciences. We therefore believe that even those not directly developing or utilizing the technical aspects of AI can have an important role in supporting the research in this area.

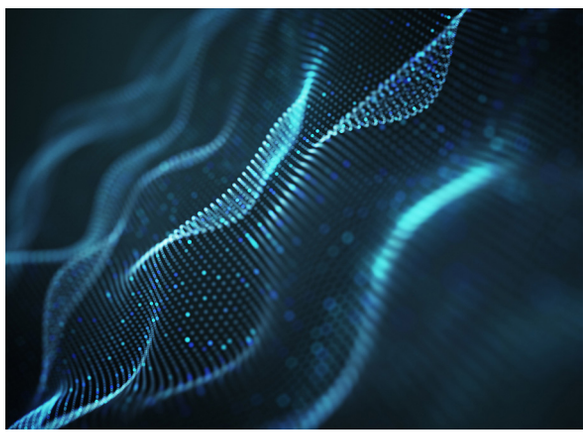
Ensure a strong ecosystem

Ensure a broad base of people with AI knowledge in industry and society. Sweden needs to achieve critical mass and to build a strong ecosystem of universities, institutes, and companies committed to developing and utilizing AI technologies. To achieve this we need both educational and professional development and knowledge transfer through collaborative efforts.



Make data and testbeds available at all levels

Make Sweden a country that welcomes and supports testing and evaluating AI technologies at all levels. Sweden is a geographically large but population wise relatively small and homogeneous country with a high trust in society and digital maturity. We should work to make data and testbeds available to researchers and industry to evaluate AI techniques at scale.



Develop a national AI research agenda

Develop a national AI research agenda for a coordinated large-scale long-term research effort, which leverages strengths and existing resources, and makes sure that results will be used in Swedish society.

Make way for an active public discussion

Make sure that Sweden has excellent lifelong competence development opportunities and an active public discussion around AI and digitalization. These areas will have a profound influence on society, and we need to prepare our citizens for it.

4 BRIEF QUESTIONS

Four brief questions was given to the speakers as a framework for the presentations. The duration of the presentations was limited to five minutes. Four images in a slideshow could be displayed.
The invitation to the five days was open and free of charge to anyone who wanted to sign up for a presentation or attend just to listen to the presentations.

All in all 195 presentations was given on the five different themes.

AI4X Industry
February 12, 2018
45 presentations
(Industry 25, Universities 20)

AI4X Education & Entertainment
February 27, 2018
26 presentations
(Industry 9, Universities, 17)

AI4X Health
March 13, 2018
60 presentations
(Industry 26, Universities 34)

AI4X Services & Finance
March 27, 2018
29 presentations
(Industry 21, Universities 8)

AI4X Society & Environment
April 11, 2018
35 presentations
(Industry 19, Universities 16)

#1
What do you expect to use AI for in the future?

#2
What AI techniques do you use?

#3
What AI applications do you use?

#4
What challenges and needs do you foresee?

On the following pages you can see answers that was given to the four questions. Below are examples of what was mentioned.

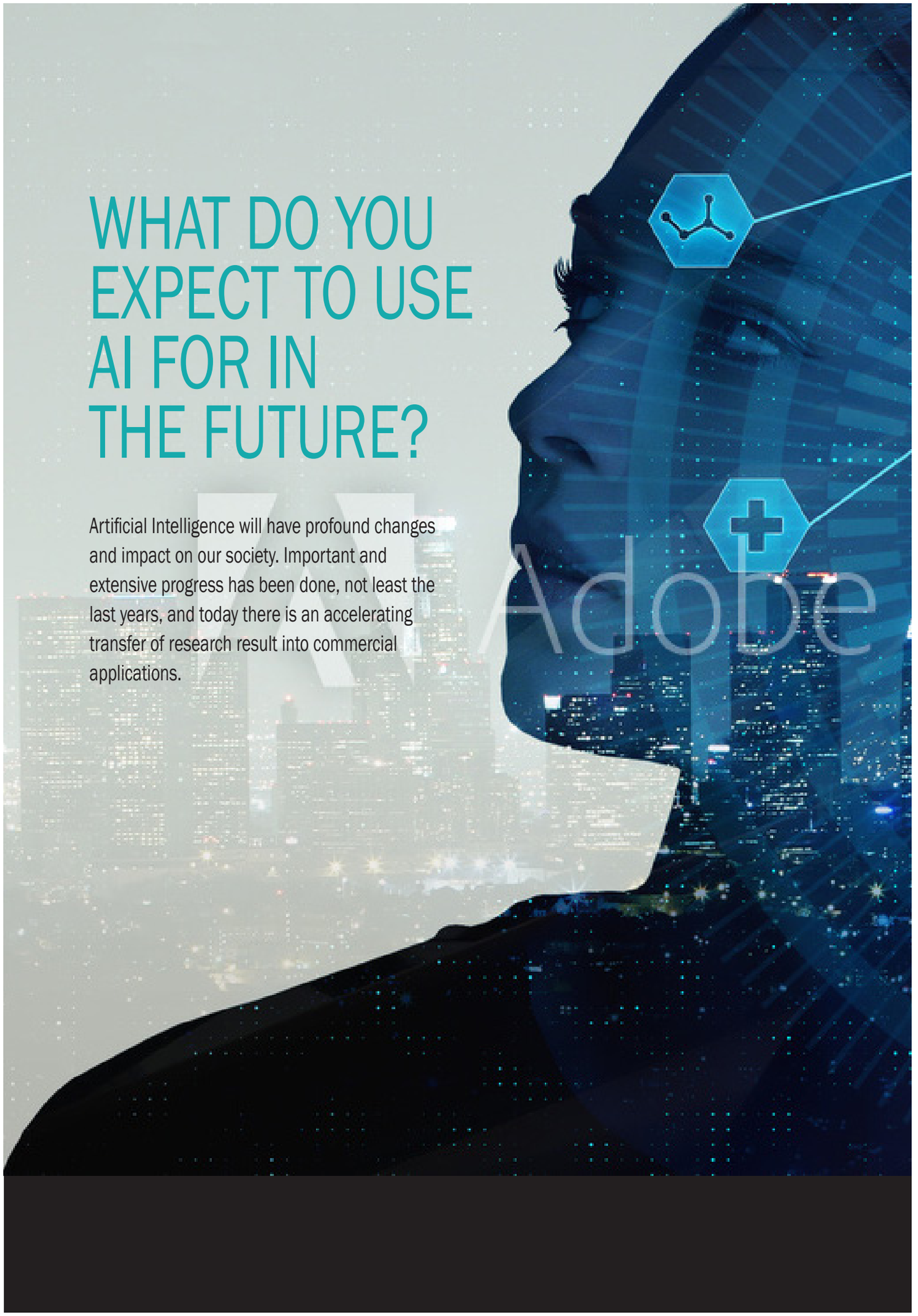
On the question “What do you expect to use AI for in the future?” a long list of areas where mentioned such as autonomous driving, chatbots and online coaches, data analysis, data collection, human-machine collaboration, image recognition, personalisation, predictions, product design, productivity, recommender engine, reliability and robustness, security, sustainability, system optimisation, and teaching and learning.

Examples of challenges and needs in the future was competence, collaboration, costs, data collection and analysis, funding, human-AI collaboration, Integration of models, privacy and legal issues, societal and ethical AI, and trust.

All in all, a total of 195 presentations were held, of which 100 from industry and companies, and 95 from universities. Below are some of the speakers.

WHAT DO YOU EXPECT TO USE AI FOR IN THE FUTURE?

Artificial Intelligence will have profound changes and impact on our society. Important and extensive progress has been done, not least the last years, and today there is an accelerating transfer of research result into commercial applications.



Based on the question “What du you expect to use AI for in the future?” all speakers at WASP AI4X got the opportunity to discuss what´s next in Artificial Intelligence and give a brief answer on their thoughts on the future.

A number of areas and fields were highlighted during the five seminar days. Some issues were unique for one or maybe two speakers on a particular subject, but several topics that the participants struggle with turned out to be in common and recurring for many of them.

Below are some of the most distinctive and frequent answers that the speakers left on the question of AI expectations. The ranking in this list is alphabetical, and should not be considered as a grading of importance or frequency. The listing gives a picture and a frame of the issues that many are struggling with today.

Quotations and speakers’ answers have been anonymised.

Autonomous driving

“We cannot achieve this without a huge amount of AI.”

Artificial Intelligence for autonomous and connected electric vehicles is no longer a distant dream. Even if they still are some time away as an everyday reality, cars that drive themselves are not far away. Several speakers at WASP AI4X presented techniques and solutions that already are implemented in pilot projects.

With more advanced assistance systems, autonomous driving will be an area where Artificial Intelligence is a prerequisite step towards development of self-driving vehicles. The demands of new solutions and applications are huge, speakers at WASP AI4X mentioned image processing and object classification, localization, free-space detection, collision avoidance, path planning, decision-making, driver support, parking assistance and vehicle control, just to note some of the aspects and prime attentions.

During the talks it was clarified that future vehicles have to be connected, some of them with ability to collect more than hundreds of different types of data and measurements, from both sensor readouts from the internal state of the vehicle and from the surrounding traffic environment. This is technology that already is proven and in line for implementation.

“We have intelligence in the vehicles that is something more than just finding bananas in a picture.”
The huge amount of data from connected vehicles can be sent wireless to so called off-board cloud infrastructures for analysis based on machine learning and deep neural networks. The process will be necessary for anomaly detection, vehicle diagnostic and maintenance planning.

However, as one speaker pointed out, the limitations in using off-board analysis is both critical and time depended with a risk that the decisions of the vehicle can be delayed. Therefore AI also has to be used for networked quality predictions for connected vehicles and many of the analysis has to be done on-board, internal in the vehicle.

“We cannot achieve this without a huge amount of AI,” says one vehicle manufacturer and explains that they are very much depended in AI, which in itself is a result of the rapid progress in the area of AI.

Chatbots and online coaches

“Chatbots is by enlarge underexplored. It is just in the beginning of this game.”

Chatbots are already a common feature on many websites, in customer services and in phone support of different kinds. It is a huge trend with messaging apps, more and more seen in e.g. shopping online, health services and banking. Many of these chatbots have a long way to go before they can be considered as driven by Artificial Intelligence technologies, but with further development, they will eventually be more sophisticated.

At WASP AI4X chatbots as online health coaches was noticed to be more common in health care. Many companies and health organisations have already started using chatbots or are in the process of developing such services. One example mentioned at WASP AI4X was chatbots as therapists for behavioral change and stress load reduction. Another example was chatbots that motivate healthier choices in life or guiding youth to self-help and self-care when mental distressed.

Consistent, reliable high-quality care for patients with complex needs is also a service awaited for chatbots and online coaches.

Besides supporting individuals with chatbots one main goal with these services is also to reduce manual administration with decision support systems in health care, as one speaker noted.

"The prime mission is to reduce time at the doctor. The chatbot is collecting data and combines different sources of healthcare data such as FASS, phone gadgets, apps, patient data, and journals."

Also in banking and finance, there is an expectation on chatbots. Similar to health coaches, banking chatbots are described as a sort of "financial PT", a personal trainer, which can help bank customers with e.g. savings.

Data analysis

"We need analysis to say something ahead of time."

It is not only a matter of collecting right data. It is also important to use effective methods to analyse data collected from machines and other sources. Analysing data is a key factor for almost every segment and industry. Several speakers made remarks on this in their presentations at WASP AI4X.

They stressed that data collected from machines, sensors and industrial processes is not always of excellent quality or cleansed. It is therefore a great need for capability to extract information out of diluted data, often in real time. There is also a need for more research, e.g. mathematical research, into AI and data analysis.

"We need to have robustness and analysis to say something ahead of time."

Analysing data is essential in big industrial processes.

"The processing in a mining ore is very complex with many different factors having impact on the final product. Analysis of the collected data will give us deeper understanding of how the process works."

Another example came from the banking and finance sector where there is a need for developing analytics for risk management, customer support, trend reports or other financial reports. Also in retail, there is need for analysing data as a tool for shop owners.

"One of our big challenges has always been data quality. I really believe that using smarter algorithms will improve the data quality and consistency of what we are doing."

Data collection

"Our biggest challenge is access to data."

Before analysing data, there is a big challenge to gather and collect it. When great amount of data is available from sensors and sources in every pump, compressor, turbine, conveyor belt and industrial process the need of an effective generation and collection of data is growing.

Accelerometers, gyros, magnetometers, thermometers, photo sensors, radars, lidar, surveillance cameras, and other sensors are today commonly in use to collect data. Industrial processes, mining, shipping, retail, logistics, almost every sector of modern society are heading towards more and more data collecting.

"Our biggest challenge is access to data."

"There is not enough data."

Yet another speaker stressed that data is a necessity for a good life for humankind. If the data is collected in a coherent way, and training sets of data is available in certain categories than

"we could build intelligence for humanity".

But collecting data is not enough. The data has also to be of high quality, confidence in quality is critical. Or as another speaker says: *"How can we determine which data have a good enough quality?".*

So the data has to be cleansed and of good quality. With huge amount of data collected, there is still a need for having the right data. Annotated and right labeled data is therefore of much need.

"We are building a big team around training data and the challenge of annotated data; we are trying to build a culture around where labeling the data is the fun part. That is essential a suicide mission but we are happy about it."

Many machine learning techniques needs large amount of training data, training data that has to be annotated. In many cases, it is expensive to collect such data. One speaker underscored that it is possible instead to use simulated data that could be applied and used as real training data. But such data also has to be of good quality.

"We need to improve the simulated data to be more accurate. Then we use generative adversarial networks. We have two machine learning algorithms competing. One is trying to cheat, the other algorithm trying to improve the data to be as natural as possible. By having these two algorithm compete, we can get better data. Machine learning is very important for our applications."

Human-machine collaboration

"Will humans have trust in robots?"

"10 years ago many would have said that speech recognition of conversational speech is an unsolvable task."

Will humans accept to work together with robots and intelligent machines? That was an issue raised at WASP AI4X with an example from software developing. Artificial Intelligence has great possibilities as a tool for developing software, in particular for automatically repairing software bugs. One speaker noted this as a field where humans and robotic systems can work together. However, will the human software developers have trust in programming robots if they work on the same code base at the same time?

"We have the vision of having a swarm of human developers and a swarm of robots program interacting at the same code based at the same time. How to build trust in programming robots from software engineers?"

Image recognition

"We will see further development."

Artificial intelligence and machine learning has been a revolution for image recognition. The applications is already widely spread with techniques for detecting and classifying objects, persons, vehicles or even more specific objects. Object detection and classification, pattern recognition, automated imaging, image content indexing for information retrieval, image based information extraction, are areas mentioned at WASP AI4X.

According to many of the speakers, deep learning for image reconstructions and image transformations and computer vision for image analysis and visual tracking are fields in which *"we will see further development".*

Personalisation

"A demand for personalisation."

Personalisation is a rapidly growing area for AI tools. Healthcare is one of the fields with strong requirements for this, even for personalised accurate diagnostics of highly complex multi-symptoms states. Another example is personalised medicine based on digital biomarkers and AI.

With personalised care and prevention, reactive care can be turned into proactive care, explained several of the speakers.

Likewise, many in the financial sector are turning to tools for personalised analysis. Another field is education where there is *"a demand for products that incorporate personalisation"*.

Predictions

"We want to predict failures, not detect them after."

With all data, collected from sensors, connected devices and machines, there is a great possibility to predict failures and errors before they occur.

At WASP AI4X, several speakers highlighted predictive maintenance as one of the most crucial efforts for the industry's future. By analysing data, and not only monitor machine health, it is possible to predict what machines should be maintained or when a machine is starting to fail or malfunction.

Predictive maintenance is also expected to contribute to more cost-effective industry processes.

One example mentioned during the WASP AI4X days concerned predictions and connected vehicles.

"The automobile industry is moving towards fully autonomous connected vehicles. One enabler for this is the 5G network. The car and truck manufactures have a specific requirement for the telecom industry. They want to know in advance if the network quality goes down. With this information, the vehicle can take appropriate actions to make sure that nothing goes wrong if the connection will be down."

"The prediction processes in this case exists of three steps. First, we have to collect data from multiple sources. Second, we have to make valuable predictions using Artificial Intelligence and, third, we can deliver the prediction timely to the vehicle. That is data-driven decision supported by a large amount of data collected from multiple sources."

Predictions in health care relying on increased patient data are also becoming increasingly significant to foresee behaviors, needs and events, catch early stage issues diseases or other disorders that might need medical attention.

In banking and finance, predictions are also becoming increasingly important. One speaker mentioned machine learning models tested to predict asset valuations based on new data. There is also tests with data-driven and data-based decision as well as time series predictions.

In weather forecasts, predictions also play an important role, already widely used but even more for next generation weather and climate prediction. That may apply for road weather forecasts, retrieval of cloud top height, estimating cloud base from space or forecasting solar energy production.

"We need to understand more of our predictions so we can make good decisions based on them."

Product design

"Almost everything is about simulation and how to connect with Artificial Intelligence."

Improving product design with virtual prototyping and digital twins is something many manufacture industries are looking into as production is becoming more and more complex and demanding. At WASP AI4X simulation-based design was mentioned as an enabler of virtual testing industrial processes or even entire factories before production goes live. Digital twins by photogrammetry and machine learning is a part of the vision to use cameras in the factory to make control and maintenance.

The expected result is reduced costs and streamlining of production lines.

"Almost everything is about simulation based design and in particular how to connect physical simulations with various types of Artificial Intelligence for developing autonomous machines and systems."

Artificial Intelligence can also be linked to products such as fall detection alarm and positioning system for seniors.

In the health area, a period and ovulation tracker for women was presented.

"We use advance technology to democratise health for women."

Another product mentioned was software for improved radiotherapy for segmentation, image reconstruction, tracking, adaptation, decision support and plan benchmarking.

Productivity

"We are aiming to help our customers to be more productive."

Artificial Intelligence has potential to boost and improve productivity in industry processes and other domains. When AI are applied to understand what machines should be maintained, what machines are underperforming and when a machine is starting to fail, then there is a great opportunity to improve productivity.

"We have a good understanding of the value we want to create."

Hence, the big question raised by another speaker concern how to use right data and take right decisions to create more productivity for customers.

"What we always talk about is increasing efficiency in processes ... the main thing for us is the new business opportunities that we can create."

Recommender engine

"AI powered investment recommendations."

Artificial Intelligence is a prerequisite for recommendation engines. At WASP AI4X many presentations highlighted the necessity of developing recommender engine of different kinds and in many different industries.

A recommender engine for health care staff, mainly physicians, is a tool that may come first in line of several new potential future tools. Such a tool could be helpful for practitioners in need for recommendations based on patient data and information extraction from medical studies and journals.

A recommender engine could also be applied in preventive care for e.g. food recommendations and a more healthy life, explained one speaker.

In the financial sector, similar tools for recommendations have a given place. This could be AI-powered tools generating recommendations for best investments or decisions on how to trade. Recommender engines could also generate data-driven customer insights to drive customer proactiveness and relevancy for enhanced sales. Optimise long-term savings, mortgages and savings accounts is another use or application.

Reliability and robustness

"It is really a paradigm shift taking place."

Reliability and resilience is essential to minimise risks in industrial processes as well for the whole society. One example highlighted at WASP AI4X was power system and energy grids, many of them undergoing major changes. The complexity and transformation of power systems are increasing. That calls for more intelligent tools and methods to run them.

"It is a paradigm shift taking place in the power systems. We are going towards a system that is much more distributed [with] a vast amount of data coming from sensor systems. How can we use this data to create actual insights that is valuable for the energy system?"

Another example concerned the data center management. Data center is complex to run and intensive in operation maintenance, with high demands of cooling activity. That requires a high level of automation and autonomous data centers, *"than you are a lot into machine learning"*, as one speaker stresses.

Another speaker stresses, *"We need better*

prognostics, we need better obstacle detections, we need better automation controls."

Security

"The risk scoring is a big topic."

Artificial Intelligence has already a natural part in various security solutions, in manufacturing and healthcare, in banking and finance, as well as other industries. One example is secure private trust based social network, another is different tools for end-to-end encryption or integrated encrypted databases.

It is hardly any news that security issues are important for the financial sector. Anomaly detection, cyber security and analysis for fraud, risk and credit is a corner stone in modern banking and trading.

Security is of course of great need also in warfare, defense and counter-terrorism.

"Security threats like pirates hijack a vessel at sea, an intrusion on a nuclear plant, a vehicle used in a terrors attack, what we try is to have an early detection so we can stop them."

AI in combination with cameras and other sensors could be of great use. Image recognition is vital for surveillance cameras to identify threatening behaviors and to detect anomalies. Here is re-identification one problem.

"If you have one person seen in one camera walking to another camera we want to be sure it is the same person even if it is another day."

However, as a speaker stress, one important issue is privacy, as cameras in public spaces could be an intrusion to the personal integrity.

"We want to reduce that as much as possible, but still have the security advantage."

Artificial Intelligence for security in banking, payments and finance is another fast growing field. AI to secure customer identities, prevent and detect fraud and overall risk management is foreseen as future main applications in the financial sector.

"The risk scoring is a big topic with complex systems in banking and finance that can use machine learning to update a knowledge base which is something else than having a normal BI system."

"We work with fraud detection where you have a combination of mathematics, lots of very high frequency computations and a lot of behavior analytics to combine."

Sustainability

"We cannot solve the problems on Earth if we do not have the data."

Artificial Intelligence is a significant opportunity to save the planet Earth. That was a message at WASP AI4X from several speakers.

However, without data, there will not be any Artificial Intelligence to find solutions for sustainability, one speaker stressed. Data of everything is needed, data of weather, solar production, storms, air quality, noise, light, flowers blooming, rainwater, temperature, ocean life, insects and more.

"We cannot solve the problems on Earth if we don't have the data. And if the data is not in real time it will be even harder."

So with good quality data, Artificial Intelligence tools could be fundamental to pave the way for a sustainable planet.

"We need to be forward looking and see what grand challenge we can address with Artificial Intelligence. The UN´s sustainable goals is what we are going to be shooting for. Here we find various areas suitable for Artificial Intelligence."

One of the attending vehicle manufacturers declared they have defined a triple zero target for their customers. The ambitious goals for their vehicles are zero unplanned stops, zero emissions and zero accidents. To accomplish this, the speaker underscores:

"We need better prognostics, obstacle detections and better automation controls. We cannot achieve this without a huge amount of AI."

Speakers also noted great possibilities for AI to find new solutions for sustainability in the energy sector, the growing data center industry, real estate business, agriculture and urban planning.

Issues mentioned was data science for the power industry, power system transformation, holistic data center automation and optimisation focused on energy consumption, smart agriculture and food systems and AI-designed intelligent, connected and viable cities.

System optimisation

"If you have insights from data, but do not know how to use it, it will not create value."

Artificial Intelligence is expected to be of great importance for optimisation of entire systems. However, to optimise big industrial systems you have to pass several steps, one speaker explained.

"You need to collect the data. Than you need to distill it and take away the waste components. You than need to transform your data into information. But information is not enough, you need to transform that into insights, which could be the prediction step."

But the road to system optimisation does not stop there, the speaker stressed. The insights from data collection and analysing still cannot create value, if there is no action decisions.

Another domain with great expectation on Artificial Intelligence is healthcare systems. A cloud based eHealth system for disruptive addiction care and automatic treatment planning are part of the expectations. The expected results are improved health care effectiveness.

Teaching and learning

"Great opportunities for improved learning with the support of AI."

In education, there are *"great opportunities for improved learning with the support of AI"*. AI could have positive impact on educational applications and administrative tools for teachers, for classifying and interpreting messages, evaluate courses, predict response or extract sentiment and topics.

One area explicitly mentioned was methods for detecting and measure readability based on science and AI technology. In order to detect reading and writing difficulties at an early stage, AI can be significant.

Even in sectors that do not directly belong to the school area, AI can create new learning opportunities. This applies, for example, to education and skills training of heavy machinery and vehicle operators. With the support of AI, the training of, for example, crane operators can be more efficient, safer and cheaper. Also for operators in work, AI can facilitate through supported and unattended operations, observing and learning the operator and predicting the next action.

Another sector mentioned was the financial industry where AI could create intelligent learning paths for directors and officers in banking and insurance.

WHAT AI TECHNOLOGIES DO YOU USE?

The field of Artificial Intelligence is vast and truly expanding. When the attendees at WASP AI4X was given a chance to mention techniques and technologies they use for research and developing of applications a long list came out. Just to give a picture of the huge area AI already has become to be, a sample of the techniques and technologies mentioned can be find below.

- Abstraction based state space reduction
- Applied CSP
- Answer set programs
- Artificial neural network
- Bayesian methods
- Big data analytics
- Cloud computing and virtualisation
- Cloud-based robotics
- Cluster analysis
- Collaborative systems
- Components for training neural networks
- Computer vision
- Convolutional neural networks
- Data analysis
- Data mining
- Deep learning
- Delegation framework
- Deviation recognition
- Distributed information systems
- Distributed machine learning
- Gaussian processes
- Generative adversarial networks
- Generative networks
- Graph mining
- High-performance MCP solvers
- Image recognition
- Incremental learning
- Kernel methods
- Knowledge representations
- Learning for dynamical systems
- Logistic regression
- Machine learning
- Machine learning for vision
- Machine vision
- Model-based reinforcement learning
- Multi-agent behavior
- Multi-agent systems
- Multi-criteria decision making
- Multi-purpose physics engine
- Multicore computing
- Neural networks
- Nonsmooth multibody dynamics
- Optimisation
- Pattern recognition
- Probabilistic analysis and learning
- Random forests
- Recurrent neural networks
- Reinforcement learning
- Representation learning
- Semantic interaction
- Semantic knowledge and reasoning
- Semantic perception
- Semantic web
- Simulated training data
- Social network analysis
- Spatial reasoning
- Specialized networks for various applications
- SPOOK stepper
- Statistical unsupervised models
- Stochastic simulation
- Stream reasoning techniques
- Supervised learning
- Time series algorithm
- Temporal logic planning and decision making
- Unsupervised learning

WHAT AI APPLICATIONS DO YOU USE?

Applications used by the attendees at WASP AI4X was as wide and broad as the list of techniques and technologies they use. Some of the mentioned applications was chatbots, applications for image and video recognition, voice applications, activity applications, predictiv applications, applications for decision support, robotics, health care, finance, vehicles, transport and testbeds. Below is just a sample highlighted in the presentations.

- Abnormality detection using deep learning
- Activity recognition
- Advanced driver assistance systems
- Aerospace applications
- AI applications related to ECG diagnostics
- AI to determine equipment break down
- Applications in intelligent well being and intelligent hospital
- Automated investment advice
- Autonomous driving
- Autonomous driving cancellation
- Biological systems
- Biomedical imaging
- Chatbots for health care
- Chatbots in education for course evaluations
- Chatbots for multilingual document
- Chatbots as a complement to manual coaches
- Cyber security
- Dialogue app
- Drones for inspection
- Embedded systems
- Estimation of asset's remaining useful life
- Eye movement recordings
- Face recognition
- Financial application of machine learning
- Fund analysis tool
- Head gestures
- Image analysis and treatment plan
- Optimisation image recognition
- Image reconstruction
- Industrial testbed for AI
- Machine learning prototypes for raystation
- Molecular imaging
- Natural language
- Neckband wearable
- Object detection
- Obstacle avoidance
- Personalised medicine based on AI
- Pharmaceutical industry and clinical diagnostics
- Platform for development of image-based AI
- Platooning
- Prediction of asset health and process status
- Prediction of process parameters
- Predictive analytics and modelling medical diagnostics
- Power systems
- Radiation treatments
- Robotic loading trained on synthetic data
- Robot programming
- Scientific information in journals and notebooks
- Talk to your data
- Tele-operated driving
- Tough robotics challenge
- Video recognition
- Virtual trucks in the cloud
- Virtual twins
- Voice 2 text
- Voice commands
- Wheelchair control
- Wheelchair settings to determine environment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WHAT CHALLENGES AND NEEDS DO YOU FORESEE?

What challenges and needs do academia and industry foresee in the field of AI? That was one question the speakers at WASP AI4X was asked to give examples on. Below are some of the answers.

Competence

"It is a fierce competition for talent."

One big issue that several speakers wanted to lift up was a scarcity of relevant competencies and a lack of Artificial Intelligence and machine learning researchers in Sweden.

The need for new skills and access to AI experts is something that many highlight. Several describe it as a fierce competition for talent and that it is difficult to find AI specialists. Finding staff with in-depth knowledge with the right competence is recognized as a top issue for many.

"We have a vast amount of data through our production and supplier chain. What we don't have is a good domain competence in AI. We have started with the low hanging fruits and implementing machine learning in our processes but we are now accelerating that journey. We have the data, we have the problems, what we need is good researchers, so please take contact."

Collaboration

"We cannot do it alone."

Multi-level collaboration to build ecosystems around Artificial Intelligence were emphasised by several speakers at WASP AI4X. Many pointed out collaboration as a necessity both for the industry and for research in the field of Artificial Intelligence.

Ecosystems built in collaboration between startups, experts, researchers and small and large companies are a necessity to tackle all issues raised by AI. But it is also a necessary to collaborate with customers and partners in order to fully exploit the opportunities that Artificial Intelligence provides.

One speaker emphasis that there are many mathematics and computer science questions in what they try to do. They would probably succeed on their own but if they could increase collaboration with academia, the speaker thinks they could create much more robust algorithms and interesting research.

"Collaboration could really improve the insights that we are looking for."

"We try to work very interdisciplinary."
"The requirements of AI is sky high. It is a challenge and we cannot do it alone. We need good research collaboration."

"We need to collaborate with customers aiming to co-create the benefits of innovative Artificial Intelligence."

Costs

“We need to become faster and cheaper.”

Cost-effective solutions are an important part of the industry’s perspective on AI. It’s all about keeping down the costs of increased computing power, but also looking at the possibilities of reducing production costs. One challenge mentioned is the need to reduce industrialisation costs when computing power is expensive and research and development takes time.

Several pointed out that it is very expensive to collect data. Simulated data used as real training data could be cost saving, according to several speakers.

Data collection and analysis

“Creating high quality data is hard.”

“The first challenge is getting the data,” one speaker at WASP AI4X underscored.

Collecting data is one of the biggest issues and crucial for processes and applications, something that many speakers stressed at WASP AI4X. In many domains, there are a lack of clean, understandable, annotated and labeled data. Furthermore, it could also be an uncertainty if the data that is collected has the right quality. All in all, it means it is a challenge with both collecting data, and analysing the data that is collected.

“Labeled data can tell us what is actually happening.”

Sometimes, as one speaker explained, the problem could be even bigger if the data belongs to someone else.

“We don’t own the data, it is our customers that own the data.”

“How can we determine which data have a good enough quality?”

Confidence in quality data is critical. It is an effort to find robust analysis capability to extract information out of diluted data in real time or analyse data from machines and other sources to improve productivity, to understand what machines should be maintained, and when a machine is starting to fail and needs service.

Funding

“Not enough funding.”

Not enough funding for publications and conferences, theoretical foundation and applications was mentioned by some speakers.

Human-AI collaboration

“AI to learn what the user wants.”

As Artificial Intelligence is increasing its impact on daily life and in workplaces, we see a demand for true cooperation of humans and robots in industrial settings and better interaction between humans and AI technologies. That is obvious with AI technologies for speech recognition, natural language understanding and chatbots, but also as autonomous driving will change people’s behavior in traffic or customers experiences in retail and shops, to set out two examples.

Integration of models

“It is a challenge to apply information technology to a traditional field where other methods are used.”

AI as an enabler of innovation, new applications and to increase efficiency in workflows needs models integrated with practice and production planning. There is a challenge in the balance of not underestimating Artificial Intelligence as well as not underestimating the need for clinical evidence. Integration of clinical knowledge and practices into models are therefore of great necessity. One challenge is *integration of system knowledge and data driven modelling*.

Privacy and legal issues

"Optimising images of the faces may be against the GDPR."

Issues relating to personal integrity and legal prerequisites for privacy protection were highlighted at WASP AI4X. Data protection, transparency and the need to develop systems for anonymisation were issues raised by several speakers.

Legal issues in the wake of GDPR was also discussed, for instance concerning self-driving vehicles and data protection regulation. One speaker noted that to avoid accidents the vehicle camera has to scan people close to the vehicle.

"Then you want to analyse their faces, to know in which way they are looking. Are they looking at the car, are they looking the other way? That may indicate where they will go next. But optimising images of the faces may be against the GDPR regulation. Things like that are challenging."

Societal and ethical AI

"Who is responsible when AI becomes expert?"

"We aim to design and develop robots that learn to interact socially with humans and bring benefits to the society we live in, for example in application areas such as education, healthcare and assistive technology."

Ethical and responsible AI is a growing part of the Artificial Intelligence area. One challenge that was raised was ethical and privacy issues versus knowledge discovery. How to know what is safe to share?

AI in health could know us better than we do ourselves – who has control over our data?

A need for privacy and transparency-enhancing technologies was highlighted. Privacy of personal data will be a major challenge.

Other issues raised was: Who is responsible when AI becomes expert? How do we make sure superintelligent AI is friendly? Which moral should guide the behaviour of a driverless car? And how do we settle such issues? Will Super AI change evolution from slow-pace biological to rapid technological?

Trust

"Society trust in AI systems"

"Establishing trust, not only for one user to one system, but we also have this society trust in AI systems in general."

Some of the speakers stressed how limited network capacity and latency can be a challenge. Another issue was how to build trust in programming robots from software engineers, and in the society.

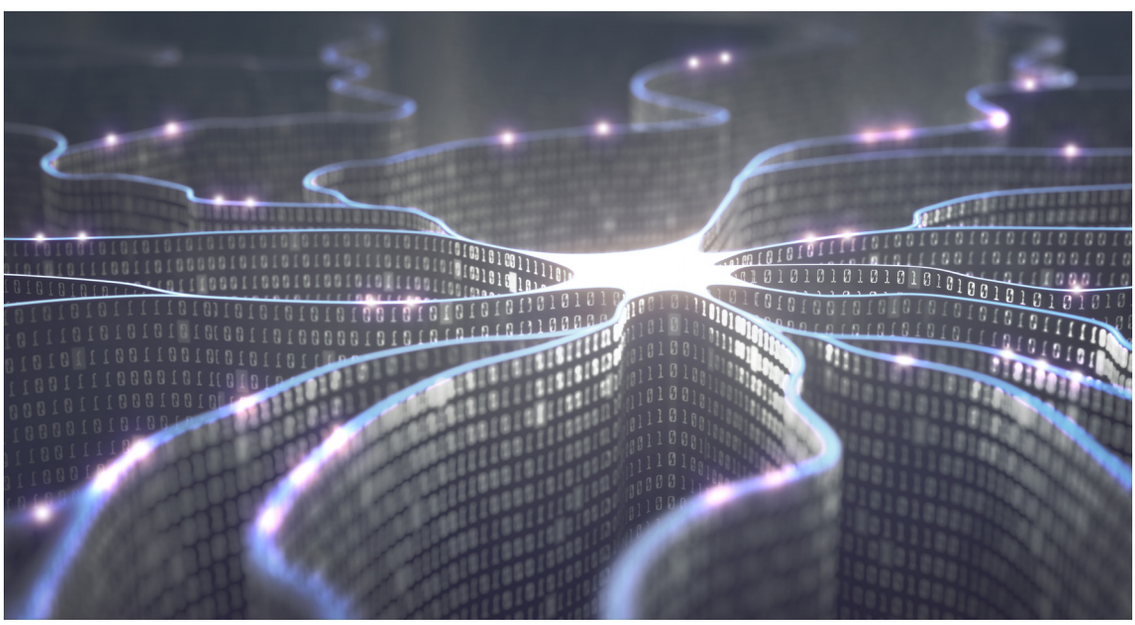
ATTENDING COMPANIES, ORGANISATIONS AND UNIVERSITIES

WASP invited organisations in different sectors to give short pitches of the application and development of AI in their organisation. The sectors was expected to be interpreted broadly and inclusively. Presentations were awaited from participants who either develop, apply or plan to apply AI in their organisation. 195 presentations and talks were presented to all participants followed by a poster session with more in-depth discussions.

Below is a list of companies, organisations and universities that were presented.

ABB
Acando Design Studio
Adivo
Algoryx Simulation
Almi Invest
AppOkey
Aptomica
Ascend
AstraZeneca
Atea
Atelier Futur
Ayond
B3 Cyber Security
BillerudKorsnäs
Bizzfuel
Blekinge Institute of Technology
Boliden Mineral
Boost Thyroid
Brainpool
Brunswick
Bygg&Inredning
C More Entertainment
CareChain
CEDITECH
Chalmers University of Technology
Codemill
Combient
CultureAi
Cybercom Group
Detective Marketing
Digital Verksamhets-utveckling
Dirac Research
Doberman
DoubleStrand Analytics
Dovii
Dynetics Invest
EA DICE
Eatit
Elastisys
Embassy of France
Engelbrekts & partner
Epiroc Rock Drills
Ericsson
Euclidica
FAM
Ferrologic Analytics
Flow Neuroscience
Freelancers 4U International
Försvarets materialverk
Försvarshögskolan
Governo
Greenlytics
H2 Health Hub
HiveStreaming
Huawei
Hubert.ai
HudVy
Husqvarna
IBM
ICT Sweden
Industry Commons
Ingenjörsfirman Crona
Inkonova
Innovation 360 Group
Innovation Norway
Inovia
Irish government / Enterprise Ireland
ITE
Iteam Solutions
Jönköping University
Jordbruksverket
Karolinska institutet
Kent Ola Andersson
King
Knowit Insight Management
KTH Royal Institute of Technology
Learnify
Learnster
Lexplore
Life-Stats
Lilsis
Linköping University
Luleå University of Technology
Lund University
MK AB
MTM

Mälardalens Högskola
nAbleGrowth
Nagoon
Netlight
Node Pole
Nordea
Nordic AI Institute
Nordic Makers
Northvolt
NVIDIA
Nya moderaterna
OHB Sweden
Opti
Peltarion
Permobil
Pfizer
Playcentric Industries & Institute
Qamcom Research and Technology
Quantified Planet
Region Skåne
RFEmb
Riksdagen
RISE
Rosenqvist & Desai
Saab
Sana Labs
Scania
SEB
Semcon
Sensor Cooling Nordic
SIS
Skepparhagen
Smarketing.ai International
SMHI
Snabbfoting
SNAFU Records
SoftRobot
Softronic
Sony Mobile Communications
Stairway
Stockholm Makerspace
Stockholm University
Swedish Maritime Technology
Swedish Research Council
Svenskt Näringsliv
Sveriges Ingenjörer
Tacton Systems
Telia Company
Tieto
Totalförsvarets forskningsinstitut
Truth
TwentyBN
Umbilical Design
Umeå University
Unionen
University of Gothenburg
Univrses
Uponor Corporation
Uponor Group
Uppsala University
Wallenberg Foundations
Vattenfall & New Bridge Founders
Veckans Affärer
Weinhandl Holding
Veoneer
Verisure
Vinnova
Vironova
Visionists
Voltium Security
Volumental
WSP Sverige
Zapiak
Zenuity
Örebro University



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