

NorwAI

ANNUAL REPORT 2020

Norwegian Research Center
for AI Innovation



Summary

The Norwegian Research Center for AI Innovation (NorwAI) is the largest academic initiative on AI innovation in Norway. Hosted at NTNU in Trondheim, the center coordinates research and innovation activities among three universities, two research institutes and 11 companies. With its long and impressive history of research on Big Data and AI and its experience with commercializing these technologies, NTNU is well positioned to lead this center of research-based innovation (SFI). Some of the largest and technologically most ambitious companies and research institutes in Norway have joined the consortium and promise to turn the center into a real powerhouse for AI-driven industrial innovation.

Internationally, NorwAI will do its best to consolidate and strengthen the Scandinavian applied AI communities. We believe that a closer collaboration among Scandinavian parties will be beneficial to us all and help us accelerate the use of sustainable and trustworthy AI across our industries.

After five years in preparation, NorwAI started its operations on 1 October 2020. We are looking forward to some very exciting years with groundbreaking AI research and innovative AI-driven solutions that will change Norwegian industry for ever.

Professor Jon Atle Gulla,
NorwAI Center Director,
Trondheim, 2021-03-26



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Objectives

The objective of the NorwAI research center is to provide a strong and robust arena for industry, research and academic institutions to collaborate on the development of AI ideas and techniques, share results, and iteratively explore how technology can transform existing businesses and enable entirely new business avenues.

The primary objective – or mission – of NorwAI is to:

Accelerate the innovation of sustainable and trustworthy artificial intelligence solutions across Norwegian industries.

This primary objective is further broken down into objectives and secondary objectives, as shown on the next page.

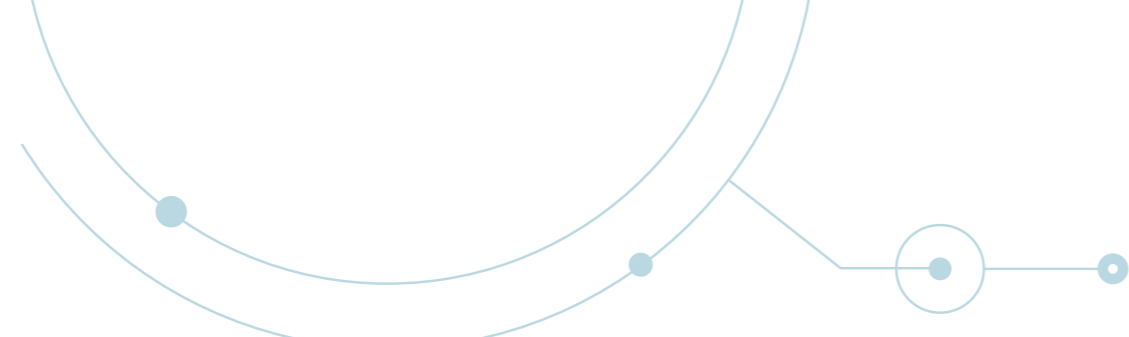
Artificial intelligence constitutes a paradigm shift in computer science, enabling substantially shorter development cycles, extremely powerful solutions, and immediate transfer of technologies from one domain to another. The innovation cycles become very dynamic, representing both challenges and opportunities at the same time. New systems may completely transform existing practices, render old value chains worthless, or open for brand new business opportunities. NorwAI supports innovation as a platform for continuous interaction between industry and academia, and will act as an

ecosystem for creating alliances, joint venturing and building synergies among all partners. NorwAI will thereby enhance the ability of the business sector to innovate and create value through a greater focus on long-term research.

NorwAI acknowledges that the deep impact of AI makes it necessary to ensure efficient sharing of knowledge and enable businesses to adapt their innovation processes to this new situation and provides the skills for business transformation. At the same time, it is critical that the technology is applied with care and with respect for the needs of individuals and societies. The objectives of true personalization of services by providing data and platforms for AI innovations address the AI research needed to implement, deploy and evaluate companies' use case innovations. Finally, the overall quality and reputation of the research center will affect the center's ability to help companies develop and deploy research-based innovations and establish NorwAI as an international leading AI research and innovation center.

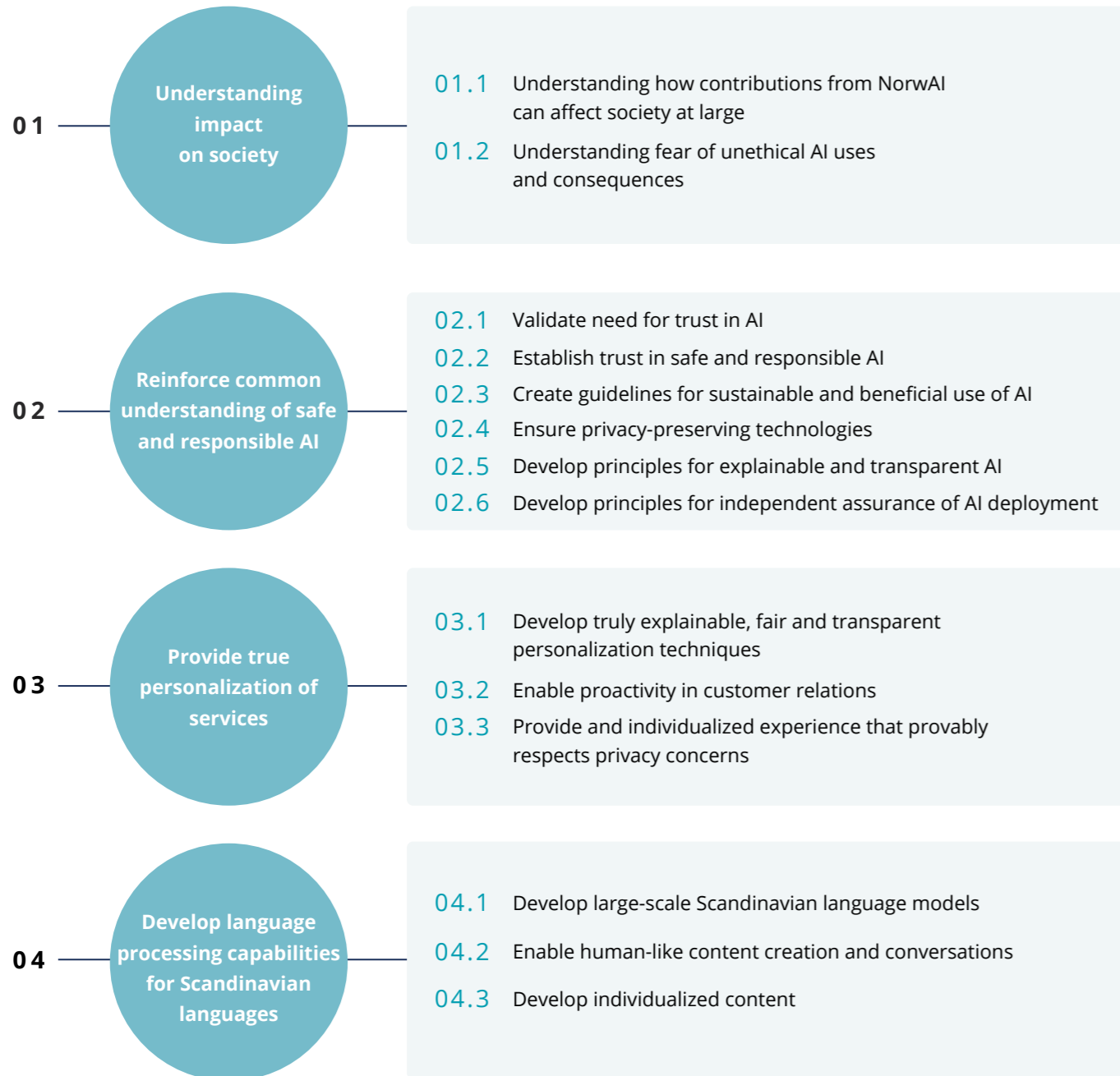


NorwAI objectives



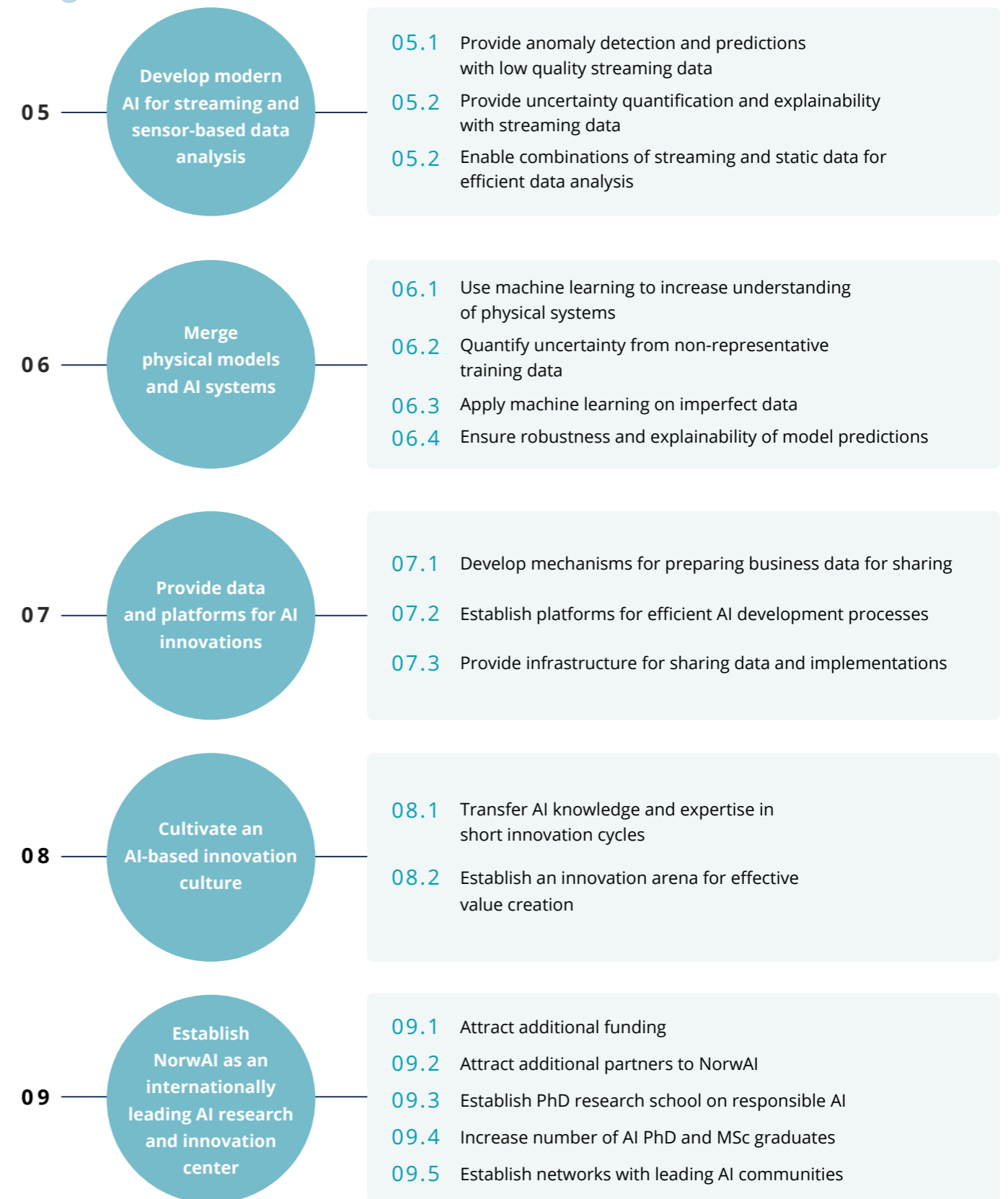
OBJECTIVES

SECONDARY OBJECTIVES



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SECONDARY OBJECTIVES



A powerhouse: some of the largest and technologically most ambitious companies and research institutes in Norway have joined the consortium.

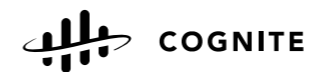
Consortium

RESEARCH PARTNERS

NTNU, the Norwegian University of Science and Technology, Department of Computer Science is host for the center, the other research partners are Norwegian Computing Center (NR), SINTEF, University of Oslo, and University of Stavanger.

INDUSTRIAL PARTNERS

The group of industrial partners in NorwAI consists of Cognite, Digital Norway, DNB, DNV, Kongsberg Digital, NRK, Retriever Norway, Schibsted, SpareBank 1 SMN, Telenor, and TrønderEnergi.



KONGSBERG



Research activities

Visions and plans



AI creates opportunities but also opens for digital risks and poses trust gaps.

Asun Lera St.Clair, Program Director,
Digital Assurance DNV - Group Research
& Development

What are your thoughts on NorwAI from your perspective?

I have big expectations for this Centre for Excellence in AI Innovation. AI technologies are being rapidly deployed in society by both governments and industries creating new opportunities, but also opening new digital risks and posing important trust gaps. The interdisciplinary design of the Center, with two transversal work packages focused on the impacts of AI in Society and a second one exploring the trustworthiness of AI solutions is key. This design can help us in identifying and mitigating not only issues related to the social licence to operate of industries innovating in AI, but also important ethical and societal challenges. We all want AI solutions to be beneficial for industry and society but this means we must look at both the technical and the non-technical elements of these digital assets. Trust

in AI is a precondition for the scalability of any AI solution and thus critical for innovation.

What are your gains from participating in the NorwAI effort?

DNV is a risk management and quality assurance actor. For us it is of fundamental importance to cooperate with research organisations and students to mature ways to identify and mitigate risks related to AI solutions, to ensure these solutions are fit for purpose and of high quality, and to ensure we understand what it takes to be able to determine a particular AI system as trustworthy. At our Research and Development Department we have started this work, but the collaboration with academia is of fundamental importance, and the technologies move at a very high speed. Also important for us is to collaborate with other industries and customers, to better understand their needs.

Going forward, what are your expectations for NorwAI?

My key expectation is that the joint collaborations of industry and academia, with a focus on the trustworthiness of AI systems leads to better, safer, socially beneficial and ethically conscious maturing and deploying of AI systems. Paraphrasing Virginia Dignum, a scholar specialized in responsible AI, I expect all of the partners collectively to understand how to implement “ethics in AI design”, “ethics by design”, and “ethics for designers” as a key elements of trustworthy AI systems.



Industrial transformation through AI solutions



We have the opportunity to define the next decade of Norway.

John Markus Lervik, CEO and Co-Founder at Cognite

As the world began closing down, the digital world that we've built, has proven itself to be fundamental in keeping our societies and economies up and running.

Our experience has also shown us that we have a lot of work to do when it comes to ensuring that our technologies not only help us persevere, but actually allow us to continue to build and innovate through times of crisis. The single greatest and still largely untapped resource to do this, is data.

Data can be a supercharger for lasting, sustainable transformation.

Consumer product industries, media, marketers, and individuals have gained the most ground in the data revolution, and asset-intensive industries like oil & gas, manufacturing, renewables, and power & utilities, can learn a lot their advances.

Data can be a supercharger for lasting, sustainable transformation for them. Data is a prerequisite for advanced AI and analytics, optimized and remote operations, predictive maintenance, and seamless reporting & accountability of industry waste, emissions, and sustainability metrics.

Asset industry is closer to its "iphone-moment".

These feats are all proven and happening in pockets around the world. But unlike the wider consumer world, there hasn't yet been an "iPhone moment" for these heavy industries.

To get to a place where AI and other advanced technologies can usher in that moment for industry, we need to cut through the buzzwords, and build a strong data foundation. Without better ways to extract, contextualize and make industrial data useful, AI innovation within Norway's largest, biggest impact industries will have no fuel.

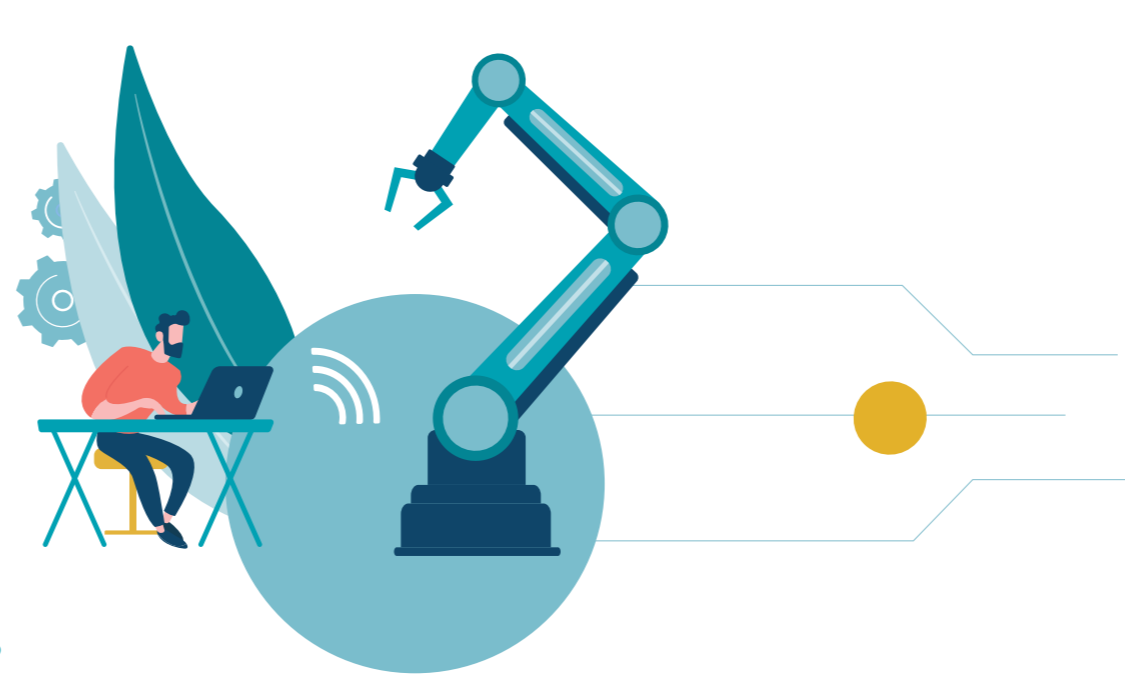


FOTO | COGNITE

We need to undertake the steps of liberating the data, connecting it together, building a foundation for advanced analytics and AI so we can ultimately reimagine how minds and machines work together.

I think it's important for us to take in the full picture of what's happening out there in the industries: We are living through the first stages of probably the largest transformation of industry in history.

Economically, geographically, technologically, this is the biggest leap we'll make in our lifetimes when it comes to the asset-intensive industries that power our lives.

This is bigger in terms of the global capital being tee'd up, in terms of the number of people potentially impacted, the way it'll shape our environment, and in terms of the opportunity cost for those who do not put themselves at the forefront of this change. It's important that we look at this with a really, really wide lense.

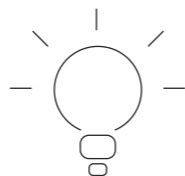
Most importantly, at our fingertips we have data and technology that can define the next decade for our societies, industries and most importantly, for our planet. There's no green future with a red bottom line.

AI and broader innovations in technology, powered by data, will not only bridge the gap between legacy and new industries – it will also accelerate the development of more sustainable and renewable energy. And it can do it while maintaining the profitability of the companies making the biggest, hopefully greenest bets.

So now more than ever it's important for Norwegian companies to invest in their data foundation, in liberating data from the silos and making it available for mass AI applications that we've just started to scratch the surface of. These investments and sense of urgency is not only crucial for the transformation of the Norwegian industries. They are equally important for the transformation of Norway.

We have an opportunity to define the next decade for Norway.

But Norway's leadership -- in terms of climate, in terms of technology, and specifically in AI innovation, depends on the successful data-driven transformation of our legacy industries. I know that many of the people involved today are - and will continue to play pivotal roles in this transformation to come.



Research activities

Visions and plans



Aiming for deep personalization and a trustworthy AI.

> *Karl Aksel Festø, Head of CoE
Advanced Analytics, DnB*

What are your thoughts on NorwAI from your perspective?

I believe that NorwAI will be foundational for developing industrial AI solutions in Norway the forthcoming years. NorwAI combines participation from major industrial players and research institutions so both skills, data, relevant use cases and trust are in place. There will be a need for solving some foundational research problems, but hopefully we will manage to put the main effort into applied research and problem solving. A key outcome will be to educate talented professionals and expose them early for the challenges being seen from various industries in Norway.

What are your gains from participating in the NorwAI effort?

Our customers move into digital solutions and we need to be able to reconnect in a digital

setting. DNB is investing heavily in digitalization and improved customer services. Our digital channels and offerings are being even more important going forward and inputting AI will be key to succeed. DNB is in this research initiative focusing on improving our abilities to enhance NLP-capabilities for Nordic languages and deep personalization. This, in combination with trustworthy AI will be a cornerstone in our digital offerings for the future.

Going forward, what are your expectations for NorwAI?

My expectation is that we are able to share our knowledge and findings both internally in NorwAI but also to a broader audience. With this SFI we are able to move from talking about AI to actually implementing it. I look forward to see AI applications in production, serving our customers built on the knowledge from NorwAI.



A vibrant showroom for talents and innovations



Aim to bring corporate partners together with researchers in their joint pursue of unlocking the AI possibilities.

Rolf Dyrnes Svendsen
Head of NxtMedia Lab and affiliated to NTNU,
Communications Manager

One of NorwAI's ambitions setting out for its planned eight-year journey, is to launch a popular tech conference for AI related research and innovations in the Nordics. Technologies related to artificial intelligence is a possible "time machine" providing a trip to the future and see where things are going.

A center for research -driven innovations is also fueled by next generation talents from leading educational institutions that are one of the backbones of NorwAI.

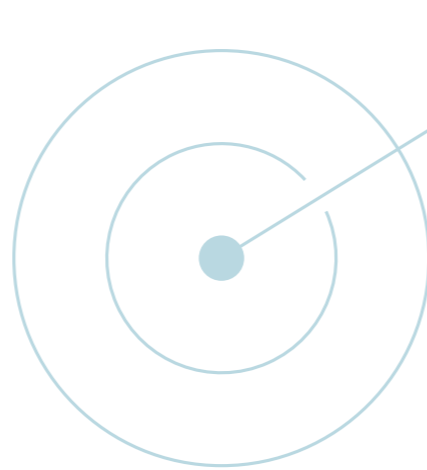
We believe in sharing. It is our intention to organize a Norwegian arena for people to connect, to collaborate and to innovate.

By calls for papers, project presentations and case studies, we will invite students, upcoming

researchers and company professionals to presentsomeoftheirwork. We believe in sharing. It is our intention to organize a Norwegian arena for people to connect, to collaborate and to innovate. In addition, our industrial partners and conference guests will be able to recognize the quality of some of the best brains soon to be available for hire.

The strong presence of corporate partners coming together with researchers in their joint pursuit to optimize the AI potential, will give energy to the future NorwAI event as an unique showroom for what to expect from this research center.

Conferences used to be valuable halts in daily routines offering an opportunity to refresh competence and relations. At their best, they provided cross discipline exchange and a technology transfer between players across borders.



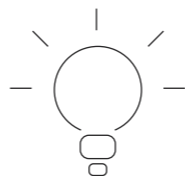
The pandemic has reduced our possibilities for these events. NorwAI's wants to contribute to a rebirth in the post-covid society in the second half of 2021.

NorwAI supports innovation by providing an arena for continuous interaction between industry and academia. As such, close contact between academic researchers and industry partners will identify and unlock AI technologies. Our intention is not only to contribute to the international AI research and innovation networks, but to create one of our own.

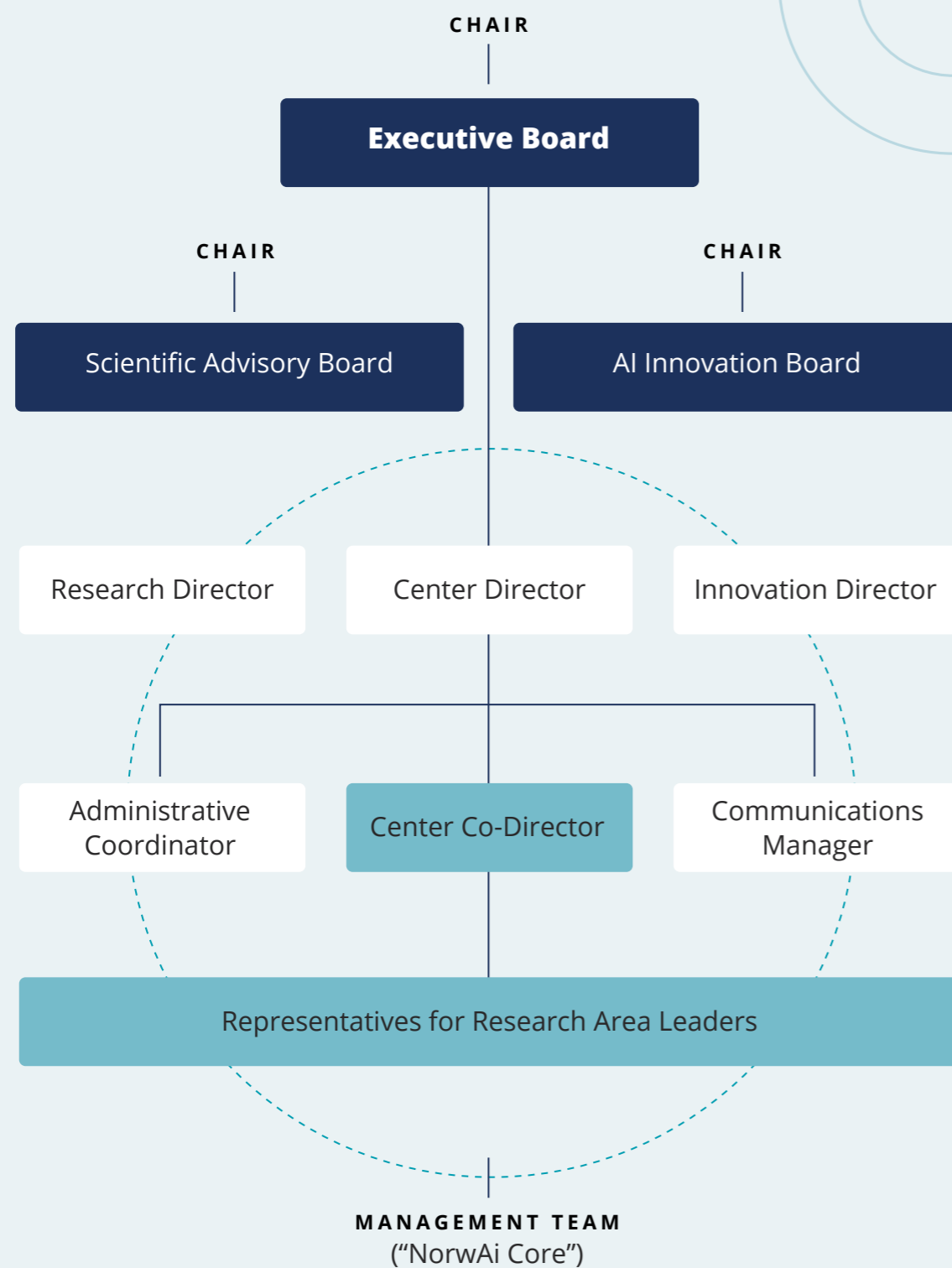
To invite colleagues from the emerging Nordic AI industrial and academic communities is worthwhile given the close relations in Scandinavia between companies and universities. Hopefully it will earn its interest by

attracting Scandinavian Applied AI professionals to the future Symposium.

NorwAI may provide compelling future developments for media, finance and telecom as well as for asset-intensive industries, mixed with a search to identify societal and ethical impacts of technologies. The visions and the tangible results of NorwAI's ambitions need to be communicated, both to the professional world as well as to tech interested audiences. Gathering people to interact on the supercharger of change in our times, namely data, is one of the inspirational objectives of NorwAI.



Organization



Center management team

The Center Management Team is responsible for the day-to-day operation of the center and consists of:



Jon Atle Gulla
Professor at NTNU,
Center Director



Karolina Storesund
Administrative
Coordinator at NTNU



Kjetil Nørvåg
Professor at NTNU,
Research Director



Rolf Dyrnes Svendsen
Head of NxtMedia Lab
and affiliated to NTNU,
Communications Manager



Arne Jørgen Berre
Chief Scientist at SINTEF,
Innovation Director



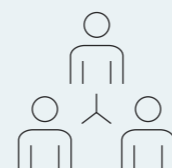
Helge Langseth
Professor at NTNU,
Research Area Leader (WP4)



Heri Ramampiaro
Professor at NTNU,
Co-director



Anne Marthine Rustad
Research Manager at
SINTEF, Research Area Leader
(WP7)



My return to old halls



Mobilizing the scientific powers for competing industries.

Sven Størmer Thaulow, Chairman of NorwAI
EVP Data & Tech, Schibsted ASA

It's been an honor to be a part of the establishment of NorwAI - one of Norway's largest efforts within AI. AI is truly a transformative technology long in the making, that now is impacting consumers and societies every day, every hour - many times without us knowing it.

It's easy to identify when you add a cool Snapchat filter on a Friday evening - but really difficult to identify when a bank is parsing your transaction records for fraudulent activities. And we've just seen the beginning.

flowing to subjects previously known by the few. An international environment working on solving the problems tomorrow - relentlessly fueled with coffee in paper cups from the SIT canteen.

As a former computer science student from NTNU, it's been great to return to the same halls.

For me personally, as a former computer science student from NTNU, it's been great to return to the same halls again. See young students

What is especially interesting with NorwAI and the SFI setup, is that we focus on getting innovations into production together with our partners.



Matching the needs and ideas of the industry partners with the scientific power of NTNU and the greater scientific community in Norway, is essential for Norway's ability to compete in an increasingly technology dependent market for all industries. And for a small country like Norway - some of these are problems that are impossible to solve alone.

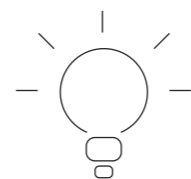
We need compute power yet to be activated on Norwegian soil.

An example is building a really good Norwegian language model. We are planning to gather data from the companies that produce large amounts of Norwegian content - Schibsted, NRK and its likes - and utilize Norway's super-computers to generate a GPT-2 language model.

It's not done overnight - and we need compute power yet to be activated on Norwegian soil. But as for all our activities, we will do it in NorwAI together - the industrial partners and NTNU - with the support of Forskningsrådet.

2020 was the beginning of a journey for NorwAI - we're all looking forward to the first results!

NorwAI FTW!



Executive board

All partners are represented in the executive board, by the following:

CHAIRPERSON OF THE BOARD



Schibsted Media Group
Sven Størmer Thaulow, Chief Data and Technology Officer/EVP

MEMBERS OF THE BOARD



NTNU
Ingrid Schjøberg, IE dean



SINTEF
Trond Runar Hagen, Research director



Telenor
Bjørn Taale Sandberg, Senior Vice President Telenor Research



DNB
Karl Aksel Festø, Head of CoE Advanced Analytics



Cognite
John Markus Lervik, CEO



NRK
Heidrun Reisæter, Director of technology



SpareBank 1 SMN
Astrid Undheim, Executive director



Norwegian Computing Center
André Teigland, Research director and Deputy Director



Retriever Norway
Claes Lyth Walsø, CIO



DNV
Asun St. Clair, Program director



Kongsberg Digital
Michael Link, Vice President SW Development



TrønderEnergi
Gøril Forbord, EVP Technology



Digital Norway
Liv Dingsør, CEO



University of Oslo
Stephan Oepen, Head of Department



University of Stavanger
Tom Ryen, Head of Department



Center director Jon Atle Gulla attends the board meetings, representing and reporting for NorwAI.

The Scientific Advisory Board



The overall goal of the Scientific Advisory Board of NorwAI is to provide external scientific reviews of research activities, evaluate plans and progress, and contribute to shaping the center's research ambitions. The Scientific Advisory Board meets with the NorwAI Management Team once a year and will report to the Executive Board. The chairperson of the Scientific Advisory Board is Professor Christian S. Jensen (Aalborg University), and the members are:

- **Professor Concha Bielza** (Technical University of Madrid)
- **Professor Maarten de Rijke** (University of Amsterdam)
- **Professor Virginia Dignum** (Umeå University)

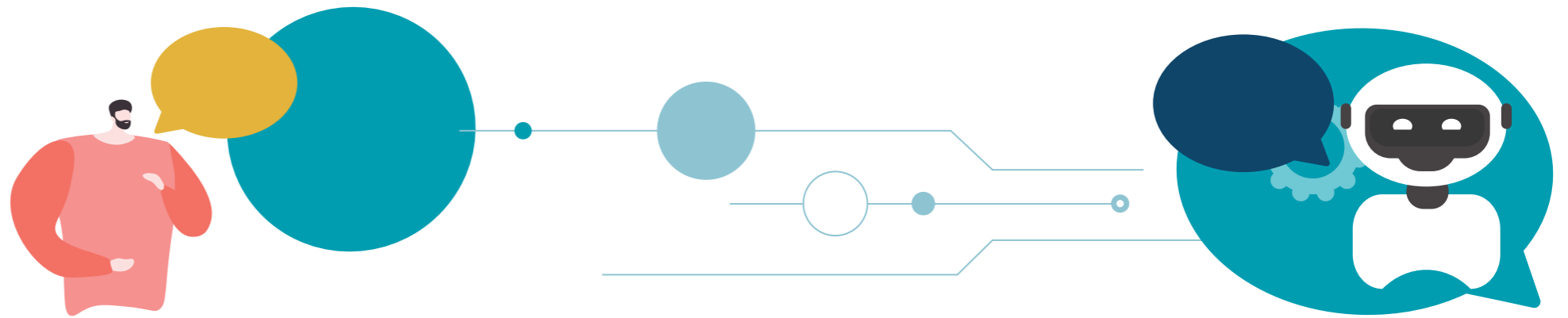
The AI Innovation Board



The AI Innovation Board plays an important part in the exciting and playful field of new ideas and innovations. The board provides advice on how to create AI innovations from research for the NorwAI partners. The board follows up on the innovation results and help to monitor the overall progress according to predefined success criteria for innovation. The board meets regularly with the Center director and the Innovation director. The Innovation Board is led by Ieva Martinkenaite, Vice President, Analytics & AI at Telenor.



New Language Models in NorwAI



Language models aiming to be the first big results signed NorwAI.

> Jon Atle Gulla,
Professor at NTNU, Center Director

Recent advances in natural language processing depend on the availability of large-scale language models that help applications interpret, analyze and generate natural language text with high precision. A language model learns to predict the probability of the next word by analyzing the text in a sentence.

Some of the most famous language models are smartphone keyboards that suggest the next word based on what you have currently typed.

In the last few years, language models have proven very useful in popular applications like Google Assistant, Siri, and Amazon's Alexa.

Unfortunately, since the publicly available models for a small language like Norwegian are based on rather small data sets, Norwegian applications tend not to be at the same level as their English counterparts. NorwAI's consortium includes some of the best computational

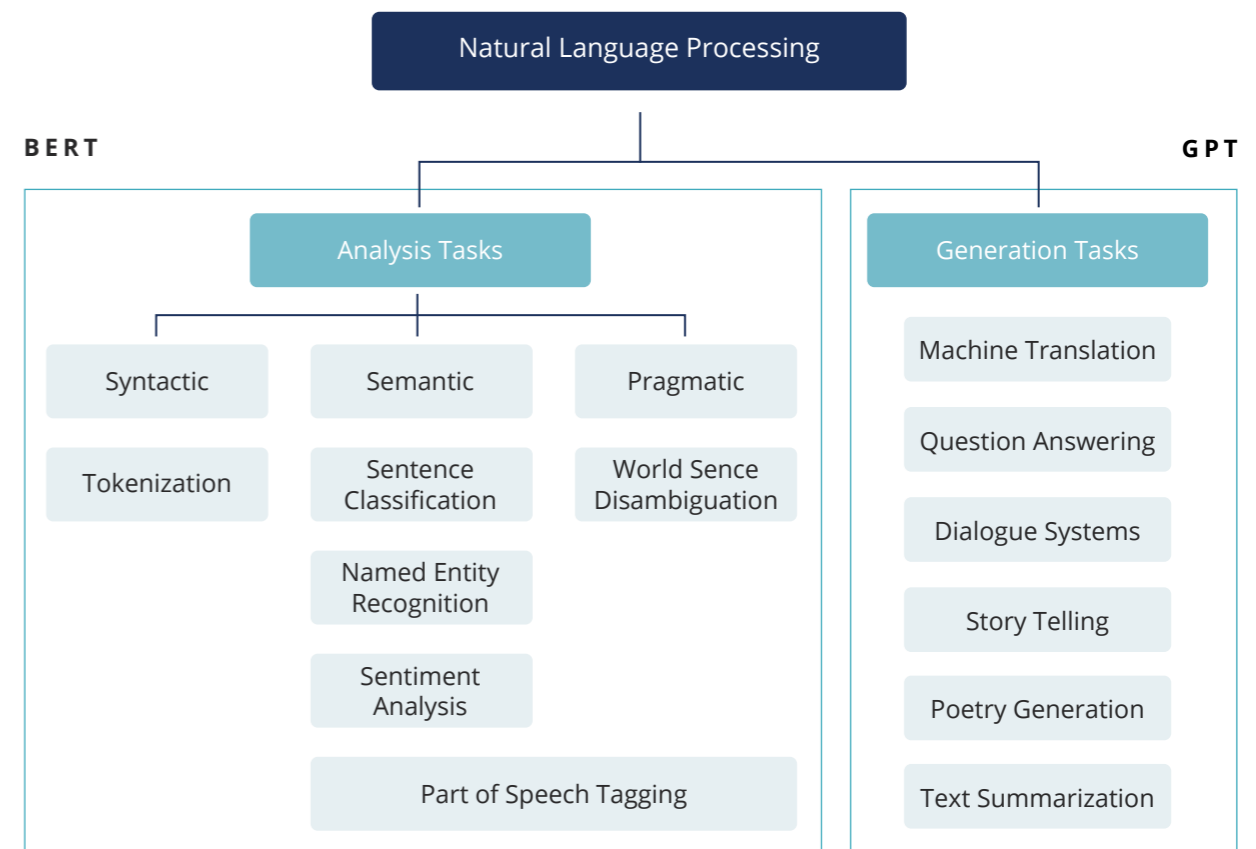
linguists in Norway, and the center is determined to provide new Norwegian language models that are significantly larger and better than what is available today and can easily be employed in advanced Norwegian NLP applications.

One of the main challenges in NLP is the availability of sufficient training data. With large-scale deep learning language models, huge amounts of training data are necessary, though both large specific training data and good human annotations are often lacking. A solution to this is to pre-train the model on large, noisy and unannotated general text data first, and then fine-tunes the pre-trained model on smaller-sized and well-annotated specific training data afterwards. Two well-known examples of such pre-trained language

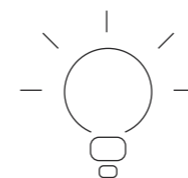
models are BERT and GPT. They are both trained on massive data sets, provide a good basis for general language understanding, and have improved the performance of many NLP applications significantly.

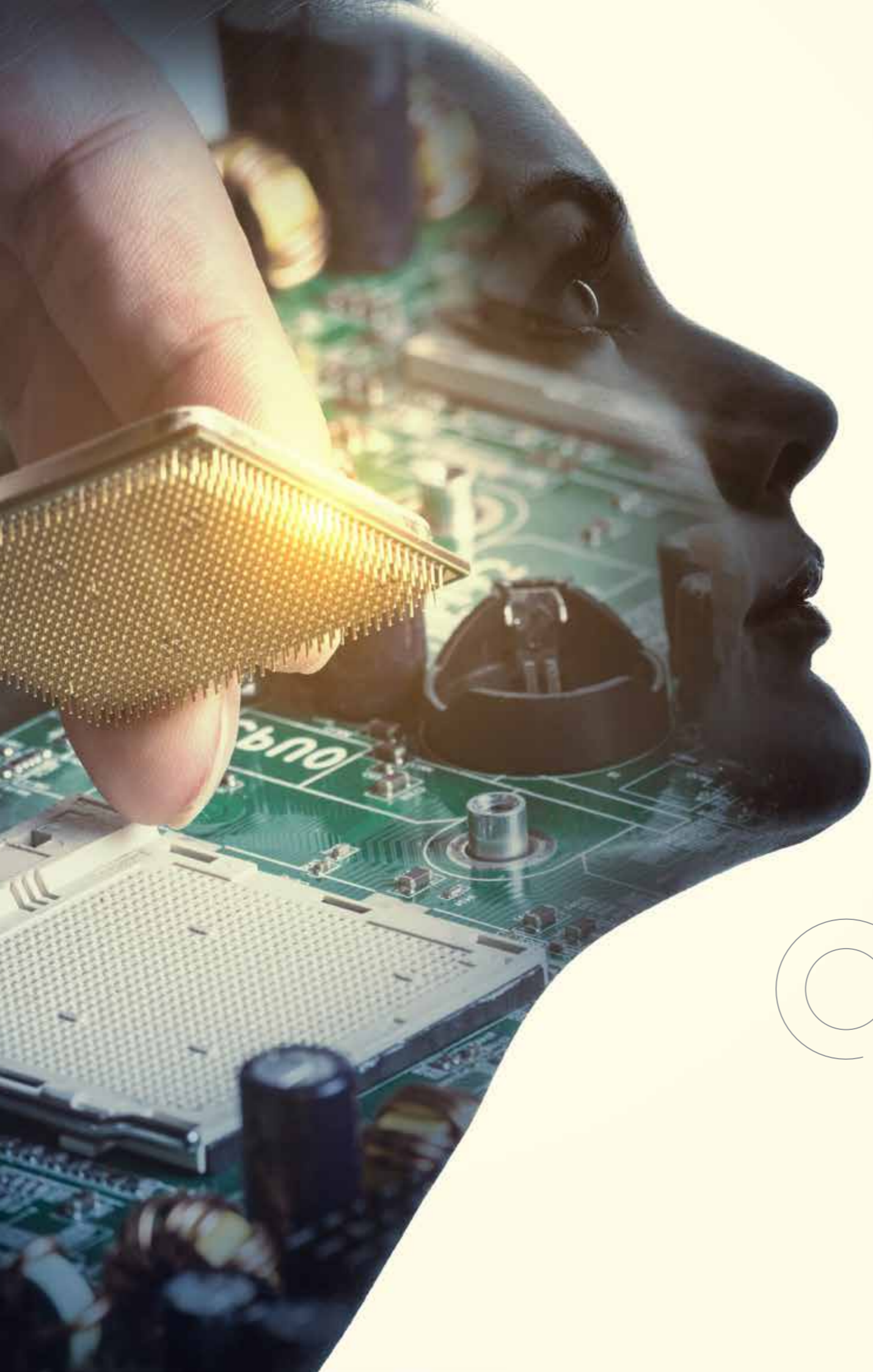
BERT and GPT are different in their structures and training tasks and tend to be suitable for different purposes. Whereas GPT has a traditional unidirectional structure and is trained to predict "the next word", BERT has a

bi-directional structure that helps us predict a randomly masked word. Making use of the full context of the sentence to predict a word, BERT is normally to prefer for analysis tasks like sentence classification, sentiment analysis and named entity recognition. GPT, on the other hand, is more used for generation tasks like machine translation, summarization and conversation generation. Both BERT and GPT are today widely used in both research and business applications.



BERT and GPT target different NLP tasks.





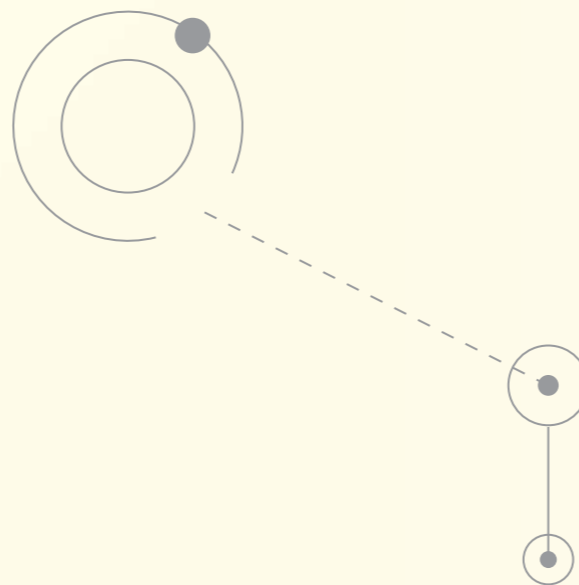
New Language Models in NorwAI

NorBERT, released by the University of Oslo this year, is a BERT deep learning language model trained from scratch for Norwegian.

Its training corpora consist of Norwegian Wikipedia and a Norwegian news corpus from Språkbanken - Norsk Aviskorpus, roughly equivalent to two-billion-word tokens. The vocabulary for NorBERT is about 30 000 and has a substantially higher coverage of Norwegian than the multilingual BERT models from Google. The model was trained on the Norwegian academic HPC system Saga with four compute nodes and 16 NVIDIA P100 GPUs over a three week period.

NorwAI is now in the process of training a GPT-2 language model for industrial use. To train the GPT-2 model, apart from NorBERT

training data sets, we plan to use recent news articles published by Norwegian media houses and subtitles from NRK productions. Computationally, the generation of GPT-2 language models is extremely demanding, and we are working together with Sigma2, an organization responsible for managing the national e-infrastructure for computational science in Norway, to allocate the necessary computing resources. Supercomputers are needed to build these language models, but in the end, we will have models that are comparable to the best English language models and NLP applications that are able to communicate properly with humans in Norwegian.



The vocabulary for NorBERT is about 30 000 and has a substantially higher coverage of Norwegian than the multilingual BERT models from Google.

Research activities

Visions and plans



Given the AI complexity, we can reap the benefits of collaborating.

> Gøril Forbord, EVP Technology, TrønderEnergi

What are your thoughts on NorwAI from your perspective?

In the consumer world, much information is already digitized. For industrial applications, the first step is digitization. TrønderEnergi is largely digitized. Next step is to automate these parts using AI methods. For example, all electricity produced by wind farms is handled automatically by AI. Parts of the energy trade already take place in real time by an AI “algotrader”. The technologies are thus already in use but can be further developed. Given the complexity, we can reap the benefits of collaborating with other industries and support each other scientifically.

What are your gains from participating in the NorwAI effort?

TrønderEnergi is involved in work packages dealing with data streaming, transparency and hybrid solutions.

Two examples illustrate possible benefits: Wind power is non-adjustable, which means that hydropower must be used when wind power is low. In addition, power usage for charging electric cars and for freezer counters can be optimized using electricity when the demand for electricity is low elsewhere.

Use of data can improve maintenance. It should only be performed when required. Thus, we ensure being ready to replace parts that are worn out or stop working. Reduced maintenance time gives increased power production as wind and water turbines are not left idle due to repairs and maintenance.

Many physical models are available for wind and hydropower plants. Combining such models with data from the specific equipment to improve predictions of service life and power production, will gain our business.

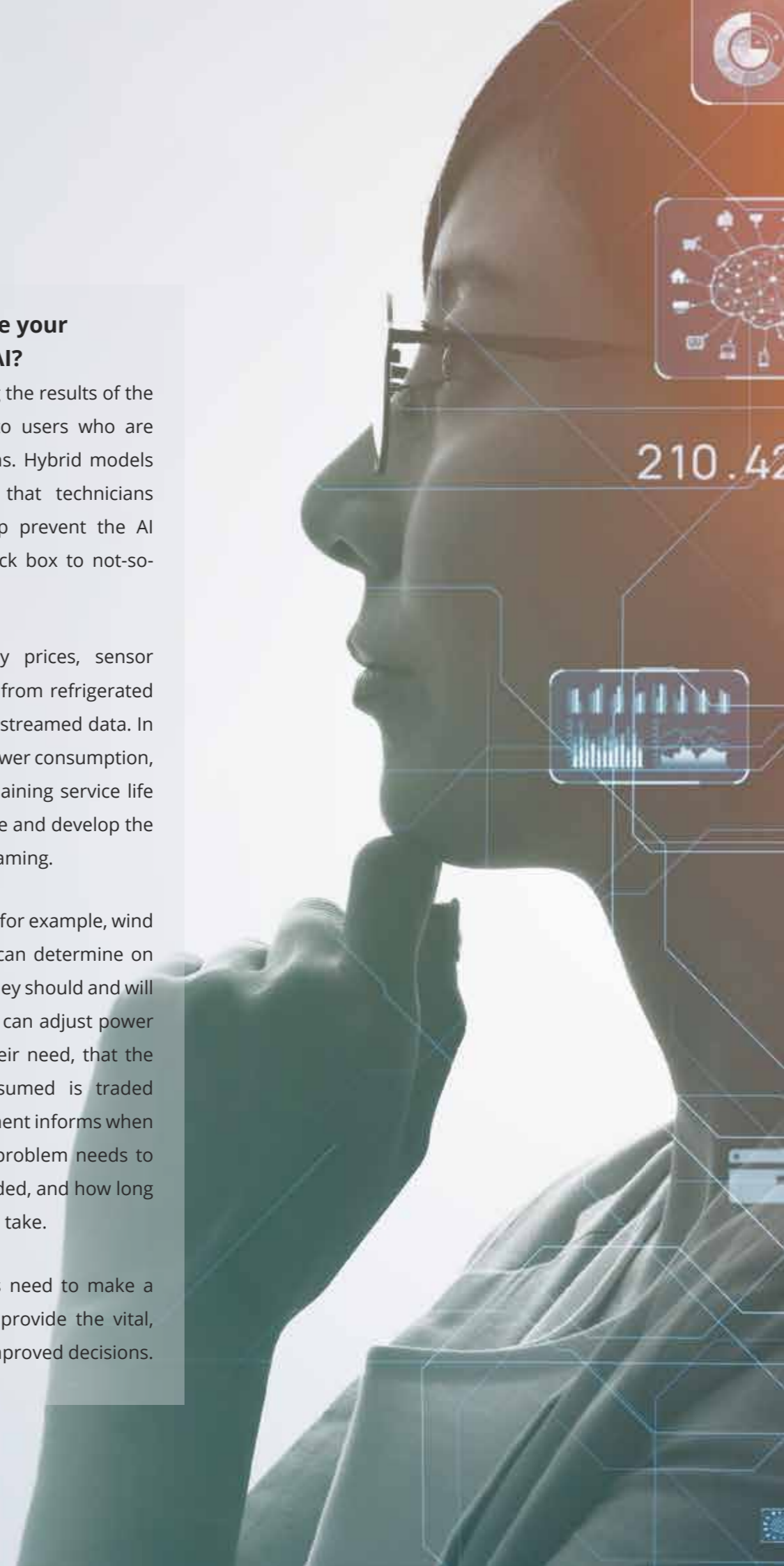
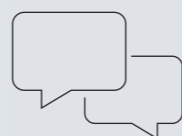
Going forward, what are your expectations for NorwAI?

Transparency is about making the results of the AI systems understandable to users who are unfamiliar with the AI systems. Hybrid models based on physical models that technicians already understand, will help prevent the AI system from becoming a black box to not-so-skilled.

Weather forecasts, electricity prices, sensor data from wind turbines and from refrigerated display counters are forms of streamed data. In order to be able to forecast power consumption, power production or the remaining service life of a wind turbine, we must use and develop the correct methods for data streaming.

We have several goals. One is, for example, wind and hydropower plants that can determine on their own how much energy they should and will produce. But also, that shops can adjust power consumption according to their need, that the electricity produced or consumed is traded automatically, that the equipment informs when it needs maintenance, what problem needs to be solved, what parts are needed, and how long the repair or maintenance will take.

When technicians and others need to make a decision, the system should provide the vital, data-driven information for improved decisions.



Ultimately it all leads up to industrial innovations



The AI Innovation areas aims at coordinating all innovation activities in the research center.

Arne Jørgen Berre, Chief Scientist at SINTEF, Innovation Director

Being an SFI, the focus of NorwAI is research-based innovation on data-driven AI. Our main objective is to develop theories, methods and technologies for successful and responsible exploitation of data-driven artificial intelligence that ultimately leads to industrial innovations. This work package aims at coordinating all innovation activities in the research center.

The main research problems to be addressed by NorwAI are motivated and identified by real industrial needs, as evident from the following set of innovation areas:

AI Innovation in Media and Finance – with a focus on:

User modeling and behavior prediction

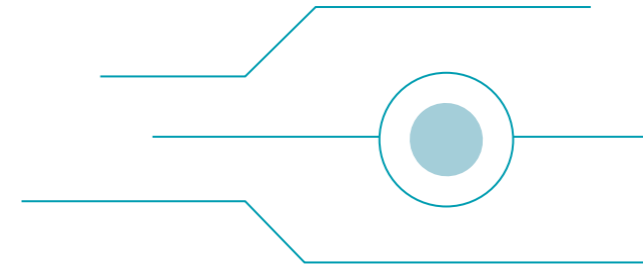
User data, collected and analyzed, using provable privacy-preserving and unbiased techniques, is fundamental to understand the user, and thereby provide relevant, personalized services and adapt well to a diverse set of user groups. From an industrial perspective, user modelling is important to, e.g., improve customer satisfaction and reduce churn. Also, successful user models

and behavior predictions will enable the industry to provide improved recommendations and other personalized services and products.

Personalized and Contextualized content creation

Providing personalized and context-aware content is important for the user experience, e.g., by offering personalized advice and services. Furthermore, in many cases the provided content should be adapted to the user's context. For text data, this amounts to providing relevant text summarizations relevant for a user in her context.

These AI Innovation areas are linked to the Research areas of AI for Personalization and AI for Language Technologies.



AI Innovation in Energy, Maritime and Telecom with a focus on:

Predictive maintenance and operational availability

Maintenance is important for efficient operation and to avoid unplanned downtime. Predictive maintenance utilizes real-time data to optimize maintenance scheduling. Operational availability extends traditional system availability to predictive resource allocation.

IoT sensor anomaly detection

The availability of low-cost sensors for collecting data is instrumenting the physical world. Sensor data can, e.g., be used for automation and decision support. In this IA, the focus is on innovations on anomaly detection.

Hybrid digital twins

A digital twin is virtual representation of a physical system, fed with sensor information in real time. NorwAI will innovate on the use of hybrid AI techniques to handle scarce or low-quality sensor data

These are linked to the Research areas of AI for Streaming & Sensor-based Data, and Hybrid AI Analytics.



Cross domain AI Innovations on Explainable AI and Data Quality – with a focus on:

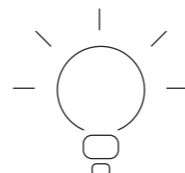
Explainability and verification

Explainability and AI verification aim at remedying problems with lack of transparency and interpretability, lack of robustness, and inability to generalize to situations beyond their past experiences by developing methods for understanding how black-box models make their predictions and what are their limitations. The call for such solutions comes from the research community, the industry and high-level policy makers, who are concerned about the impact of deploying AI systems to the real world in terms of efficiency, safety, and respect for human rights.

Data quality analysis and enhancement

High quality data is the fuel of data-driven AI. NorwAI will study how data quality can be measured and assured in order to enable critical decisions to be made based on AI models. Furthermore, data enhancement techniques will be used to increase data quality.

These are linked to the Research areas of AI in Society, Trustworthy AI and Data and Platform for AI.



DigitalNorway is focusing on intersecting research-based insight, future studies and innovations within the service sector.



Bringing assets to the table



An overall goal to accelerate the digitalization of Norwegian businesses.

*Annita Fjuk,
Head of academic partnerships and research,
Digital Norway*

DigitalNorway holds expertise in both technology transfer as well as data infrastructure tailor-made for Norwegian industry. DigitalNorway operates as a Digital Innovation Hub, and will in particular support AI Innovation for SME's, ensuring a wider spread of results from NorwAI.

DigitalNorway will further develop and offer training and courses on AI in collaboration with NorwAI.

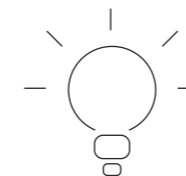
There is a demand to learn and know more of AI technologies. These are valuable tools to strengthen business.

As DigitalNorway's "liason officer" for relations to academia, focusing on intersecting research-based insight, future studies and digital

innovations within both private and public sector, I see NorwAI offers an unique possibility to connect to Norway's most advanced research professionals in AI technologies.

DigitalNorway is a non-profit business started in 2017 by 15 committed business players to accelerate the digitalization of Norwegian businesses, with a special focus on small and medium-sized companies (SME's).

Furthermore, DigitalNorway is developing the Data Factory in collaboration with the Norwegian Digitalisation Agency, which will be a source of valuable data suitable for AI Innovation. The DataFactory will provide small and medium-sized companies, academia and small public enterprises with quick and easy access to data and expertise to be able to develop new services and new industries. The DataFactory will cooperate with NorwAI's Data Management Plan.





Learn from the labs the value of proven AI

To recommend fresh deployment approaches, costs and benefits are within our reach.

Partners of NorwAI will, by introducing AI methods in their ongoing businesses, generate fresh and proven experiences from their “living labs”.

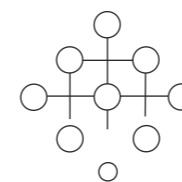
NorwAI plan to disseminate insight courses on how to implement technology and innovation from these experiences.

The first mapping of potential cases was performed during the fall of 2020, and the first collection of cases and tutorials is planned to

take place within the 3rd quarter of 2021. A framework for AI-based digitalization and its success formulas is among the approaches likely to be introduced.

Artificial Intelligence still evokes more myths associated with threats than the possibilities that technology brings to the table. AI experts are perceived as speaking a foreign language when communicating to their organization, and most managers lack sufficient understanding of data driven business-models. The knowledge gap between AI experts and their colleagues with less skills in this area poses an important challenge in advanced data analytics dissemination.

The AI Innovation Ecosystems work package is the vehicle to provide small and medium size businesses with the new knowledge generated through the NorwAI project. To be able to target our audience, we are working both with our partners’ AI experts and with HR personnel. Lectures will be presented in a form where the knowledge can be practicable applicable and the aim is to present the gained knowledge in a way so that people without AI-expertise can understand it. It will however be an advantage for course attendees if they possess some elementary AI knowledge beforehand.



International cooperation

AI will affect economies, societies and cultures profoundly at a national, international and global level. Achieving the global benefits of artificial intelligence will require international cooperation.

Already there is a global AI network of relations, cooperations and partnerships, both academically and in business. Companies, institutions, professionals, professors and students are all, either individually or via projects, connected to the international ecosystem of AI communities.

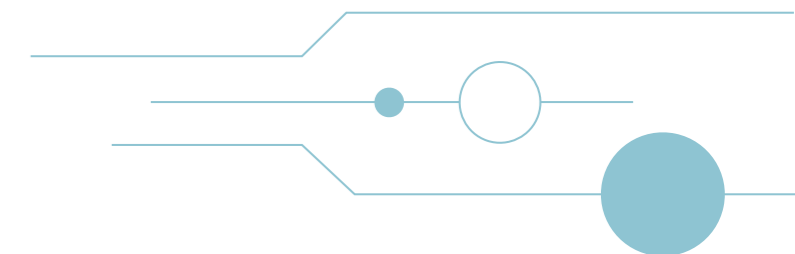
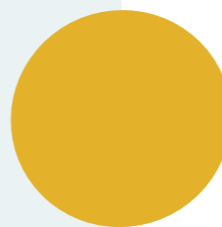
NorwAI is positioned to further extend these relations. The research partners of NorwAI already have a high degree of international collaboration. Our goals are active cooperation between innovative industries in Norway and prominent research communities abroad, as well as facilitate contact between the Norwegian

partners of the center and leading innovative companies abroad. In order for the project to benefit from the international partners, a number of actions are under way.

NorwAI will emphasize its cooperation and participation in the growing Nordic scientific and business AI ecosystem.

Parallel to establishing the NorwAI consortium itself, the initiators harnessed opportunities to strengthen relations within Scandinavia to prepare for a future benefit for NorwAI. In addition, a majority of NorwAI's business partners have international ambitions and are already active in the Nordic region. NorwAI will emphasize its cooperation and participation in the growing Nordic scientific and business AI ecosystem.

Also beyond the Scandinavian borders, the NorwAI consortium is well connected to outstanding research communities worldwide, and with Europe as a center of gravity.



Academically, selected researchers, which are among the leaders in their fields, will cooperate on tasks in the project, and our planned extensive exchange program will enable researcher exchange between NorwAI and their research groups.

Together with strong European and American universities we plan to establish an international PhD school on Data-Driven AI. All PhD students in NorwAI are expected to have a research stay abroad for 6 months, funded by NorwAI. Countrywise NorwAI is especially well connected to universities and research centers throughout Europe and also in US and China. NorwAI's scientific and innovation boards have attracted international experts within their domains.

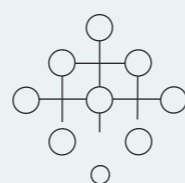
Europe is paving its own way for AI research and innovations. The EU ranks among global leaders in AI Science. In the Commissions' own words its innovation performance in AI could be revamped. At the same time, the EU has been leading in promoting trustworthy, ethical and human-centric AI – values deeply integrated in NorwAI's goals as well. The launching of Horizon Europe program by the end of 2020, investing a stimulus of 95 billion Euro anchored in the pillars of excellent science, European industrial competitiveness and innovation, invites ambitious researchers and entrepreneurs to

join forces to unlock unprecedented digital achievements. NorwAI looks into these possibilities.

NorwAI partners NTNU and Telenor are among participants to AI4EU with a goal of mobilize the entire European AI community to make AI promises real for European society and economy, and nurture economic growth. NorwAI partner SINTEF has the technical lead of Norwegian Committee for AI; a national mirror to the European standardization committee.

NorwAI partners have contributed to the recent AI SRIDA – Strategic Research, Innovation and Deployment Agenda for AI, Data and Robotics (with the 5 European organisations BDVA, CLAIRE, ELLIS, EurAI and euRobotics) – and will continue to be involved in the new ADR – AI, Data and Robotics Private Public Partnership (PPP) related to these topics for the new Horizon Europe and Digital Europe programs from 2021 to 2028.

The vision of this partnership is to boost European competitiveness, societal wellbeing and environmental aspects to lead the world in researching, developing and deploying value-driven trustworthy AI, Data and Robotics based on fundamental European rights, principles and values.



Research Strategy

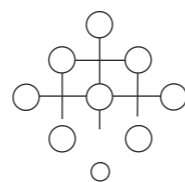
Our approach to research at NorwAI is fundamentally multi-disciplinary, consisting of both technical-oriented and socio-economic research. Current research on AI is diverse and reflect many disciplines or perspectives covering theoretical contributions from a wide range of disciplines together with more applied work from system designers and application developers working with data from many different domains.

Our research is partner-driven and rooted in a strategic and systematic approach towards innovation to create lasting value and impact. The consortium represents considerable breadth on the problem owner side with respect to business needs, experience with artificial intelligence and capabilities for commercializing technological research results to capture value. Sensitivity towards this variety necessitates tailoring of

the innovation processes for each user partner. We will adopt a user driven innovation process both with respect to needs common to several partners and needs that are unique to a single partner. The foundation for our approach is dynamic and continual collaboration between partners to iteratively understand strategic needs, research and design solutions and test resulting technologies, tools and methods. It is simple yet effective.

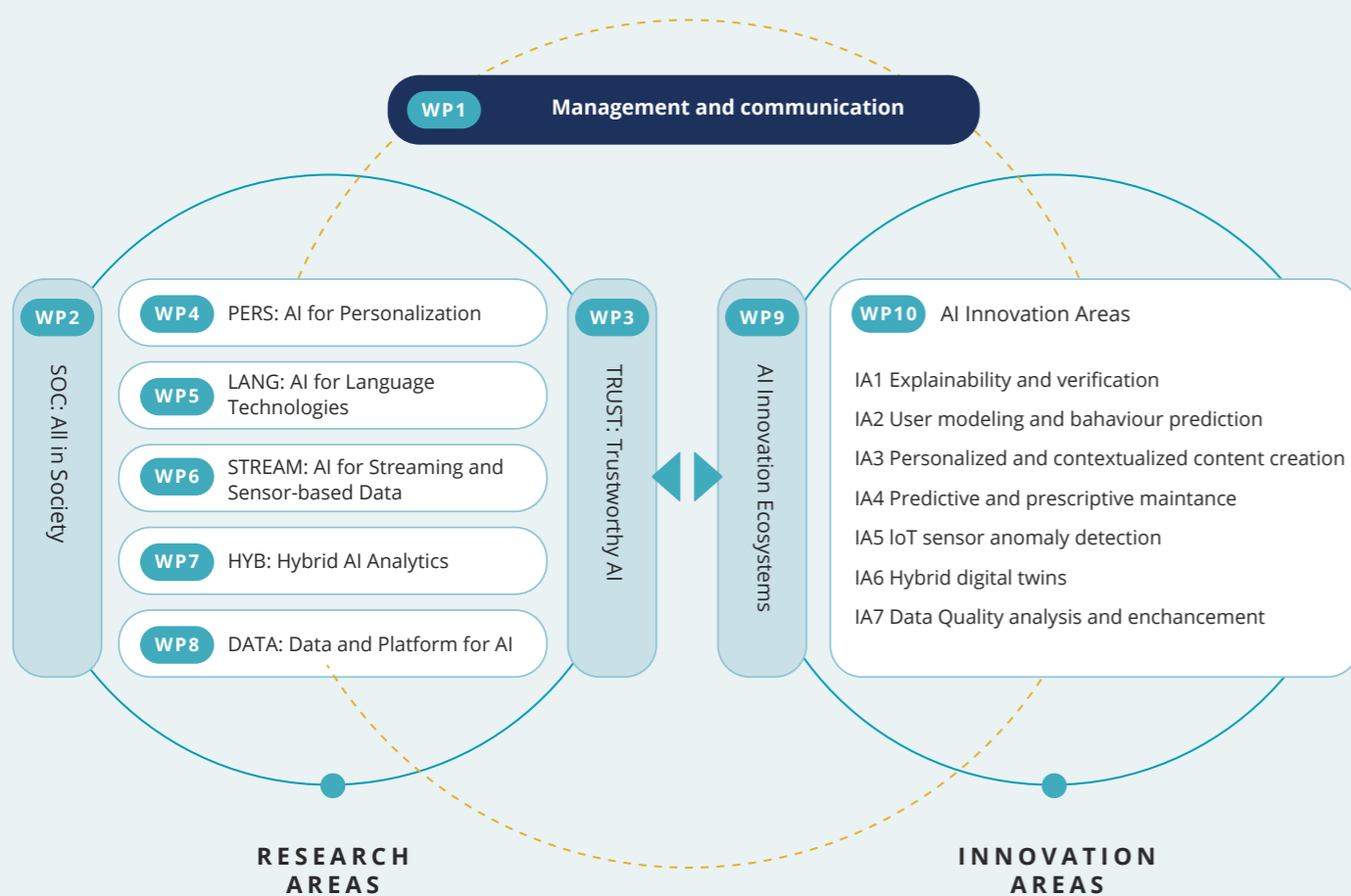
Research in NorwAI will focus on generic research areas within AI that can support the innovation activities in the center. We expect the research areas to be evaluated every year in the center's lifetime, making sure new areas will be added based on research needs from future innovation areas, current research areas can merge or conclude and come to an end.

Our research is partner-driven and rooted in a strategic and systematic approach towards innovation to create lasting value and impact.



The workpackages

NorwAI consists of 10 workpackages, which are organized as described in this figure:



NorwAI's work package structure.

WP1: MANAGEMENT AND COMMUNICATION

Work package 1 concerns communication and dissemination, as well as the day-to-day operations of the center.

Work package leader: [Jon Atle Gulla](#)



WP2: AI IN SOCIETY (SOC)

The purpose of work package 2 is to:

- Understand AI technologies in their societal aspects as they are implemented across domains
- Examine the social shaping of AI technologies within ongoing valuation and standardization processes
- Study emergent AI infrastructures together with their publics



This work package investigates broader societal challenges that arise with development and implementation of AI technologies. It combines close-up case studies of selected AI devices and examines the societal stakes, as AI technologies shape problem solutions and enter everyday lives. We will follow how AI technologies are implemented in automation, predictive modeling, and machine learning and examine how they configure societal relations more broadly. By opening up AI matters to broader publics, we will enable transdisciplinary engagements and deliberation.

Work package leader: [Susanne Bauer, University of Oslo](#)

WP3: TRUSTWORTHY AI (TRUST)

The purpose of work package 3 is to reinforce a common understanding of safe and responsible AI, specifically:

- Establish trust in safe and responsible AI
- Ensure privacy-preserving in AI technologies
- Create guidelines for sustainable and beneficial use of AI
- Develop principles for explainable and transparent AI
- Develop principles for independent assurance of AI deployment



Trust in AI is a necessary condition for the scalability and societal acceptance of these technologies. Without trust, innovation can be stalled. This research investigates, from an interdisciplinary perspective, the multiple dimensions of trust raised by the deployment of AI and builds tools, methods, and a framework for assuring the safe and responsible deployment of AI in industry and society. This work package aims to answer the question: How can such tools address the safety and needs of individuals, organizations and society at large, addressing both non-technical and technical issues? The research will address issues related to safety, explainability, transparency, bias, privacy and robustness, as well as human-machine interactions and co-behavior all in the context of industry regulations and societal expectations.

Work package leader: [Elizabeth Traiger, DNV](#)



WP4: AI FOR PERSONALIZATION (PERS)



The purpose of work package 4 is to:

- Build AI systems that can adapt to an individual user's interests while still respecting user's need for fairness, transparency and explainability
- Enhance these systems to utilize diverse data sources across different services and products without violating the users' privacy.

Personalization and contextualization have been successfully employed in diverse applications over the past decade, and currently see an extended usage, for instance in proactive interaction with customers and individualization of news stories. WP4 will contribute to developing such systems while ensuring that the system usage will be ethical and respecting users' requirements for privacy, fairness and accountability.

Work package leader: [Helge Langseth, NTNU](#)

WP5: AI FOR LANGUAGE TECHNOLOGIES (LANG)



The purpose of work package 5 is to:

- Build robust natural language processing for Scandinavian languages
- Provide conversational search and recommendations in natural language
- Develop natural language summarization of content, user preferences, and recommendations

Building Scandinavian language models requires the compilation of large-scale reusable language resources, including general-purpose corpora from public sources (e.g., news and social media) as well as industry- and domain-specific text collections. We will address the scarcity of the latter by pre-training on the former and developing transfer learning methods. These large-scale language models will then be utilized in real-life scenarios by formulating a number of specific summarizations, explanation, and conversational tasks based on our partners' use-cases. WP5 will develop appropriate evaluation methodology with user-oriented evaluation measures and objectives. It will thus contribute to providing measurable quantification of the amount of domain-specific training material needed in order to provide a language service that is of sufficiently high quality.

Work package leader: [Krisztian Balog, University of Stavanger](#)

WP6: AI FOR STREAMING AND SENSOR-BASED DATA



The purpose of work package 6 is to develop modern AI for streaming and sensor-based data analysis. This will be done by:

- Providing anomaly detection and predictions with low quality streaming data
- Providing uncertainty quantification and explainability with streaming data
- Enabling combinations of streaming and static data for efficient data analysis



Streaming data can be used for automation, recommendations and decision making. Often this involves predictions and anomaly detection in multivariate time series, as well as providing explanations for the conclusions drawn. IoT sensors are increasingly instrumenting the physical world, and efforts have been made to use AI for solving these tasks also in low-quality data regimes. This research area will identify robust techniques for analysis of streaming data within several domains (including telco network, industrial IoT), with a particular focus on improving interpretability for cases with multivariate time series with low quality data.

Solving the research problems in WP6 is crucial to successfully innovate how IoT data can be fully used in anomaly detection and contribute to breakthrough in applying AI in predictive maintenance and operational availability. [Work package leader: Kenth Engø Monsen, Telenor](#)

WP7: HYBRID AI ANALYTICS (HYB)



The purpose of work package 7 is to:

- Develop robust, stable and explainable data-driven models for physical systems
- Constrain models to enforce meaningful predictions
- Transfer data-driven models from simulations to reality
- Characterize and quantify uncertainty of data-driven models

This work package will develop methods to predict and reduce the uncertainty of data-driven models. The models will be constrained by existing knowledge, allowing to interpret the model (explainable AI) and reducing the amount of required training data. Applying these methods on real world applications will allow the industry partners to better predict the behavior of their facilities and improve their simulations, e.g. for condition monitoring, predictive maintenance, optimal utilization.

Work package leader: [Anne Marthine Rustad, SINTEF](#)

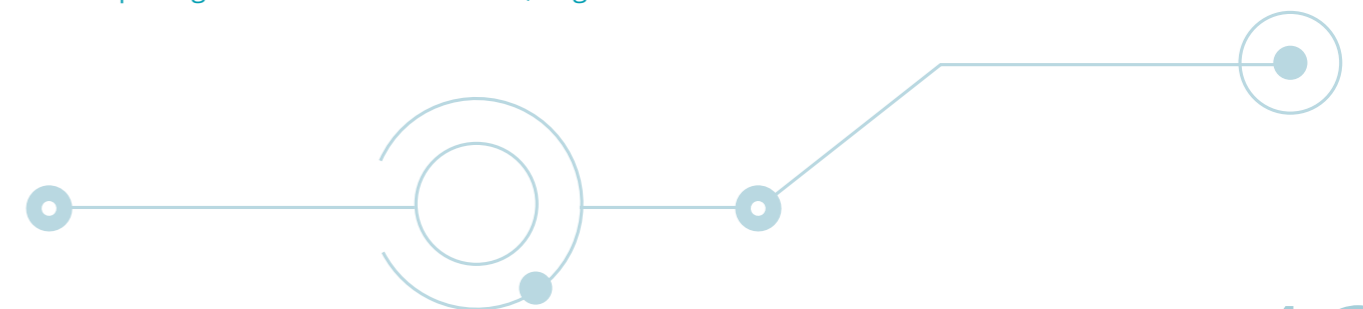
WP8: DATA AND PLATFORM FOR AI (DATA)



The purpose of work package 8 is to develop techniques and tools for the automatic creation and management of knowledge graphs.

Real impact of data-driven AI depends on the availability of live data of sufficient quality and quantity in an automatically discoverable format that both humans and machines can understand. WP8 will investigate how the semantics of data, through automatic creation and mapping of suitable knowledge graphs, can be leveraged to scale AI models from one situation to all similar situations and how complex graph-based structures can be efficiently stored and processed.

Work package leader: [Alexander Gleim, Cognite](#)



WP9: AI INNOVATION ECOSYSTEMS



The purpose of work package 9 is to:

- Create an Innovation Ecosystem among NorwAI partners for sharing both research findings, innovations, business solutions and change models within the AI domain.
- Share this knowledge to a broader audience, emphasizing small and medium sized businesses.

WP9 will contribute to narrowing the existing gap of understanding of what AI can do in terms of business solutions, by many non-AI experts by conveying state of the art knowledge in a way so that those without AI background can understand it. This will be obtained this by producing cases, hold presentations, conferences, and course spanning from limited tutorials to university courses. The following topics will be covered: what AI is, its business opportunities, its limitations, its strategic impact, and HR-change issues. To achieve these objectives both AI and HR experts will be embraced in the work. [Work package leader: Endre Sjøvold, NTNU](#)

WP10: AI INNOVATION AREAS



Work package 10 is focusing on achieving research driven AI Innovation among the NorwAI partners in the following areas.

AI Innovation in Media and Finance – with a focus on:

- User modeling and behavior prediction
- Personalized and contextualized content creation

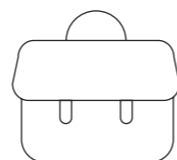
AI Innovation in Energy, Maritime and Telecom with a focus on:

- Predictive maintenance and operational availability
- IoT sensor anomaly detection
- Hybrid digital twins

Cross domain AI Innovations on Explainable AI and Data Quality – with a focus on:

- Explainability and verification
- Data quality analysis and enhancement

These are linked to the Research areas of AI in Society, Trustworthy AI and Data and Platform for AI. [Work package leader: Arne Jørgen Berre, SINTEF](#)



Key Figures

Communication and dissemination activities



Kickoff meeting

NorwAI arranged the kickoff meeting on November 12th. Because of restrictions related to the pandemic, the meeting was arranged as a combination of physical meeting and online meeting, so that some of the partners participated in person, while many attended online.

Web and social media



WEBPAGE
norwai.org



LINKEDIN
www.linkedin.com/
company/norwai

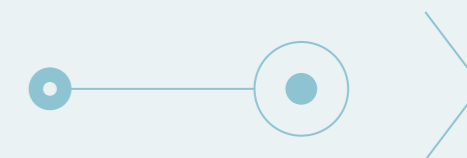


TWITTER
@SFI_NorwAI

NorwAI presentations

TITLE	PRESENTER	EVENT
En samtale om forventninger og ambisjoner for forsknings-senteret Norwegian Research Center for AI Innovation	Jon Atle Gulla, NTNU Astrid Undheim, Sparebank1 SMN Sven Størmer Thaulow, Schibsted	Next Media Conference, Trondheim/Online, 12.11.2020
Pairing theory of AI Excellence	Sven Størmer Thaulow	Next Media Conference, Trondheim/Online, 12.11.2020

NorwAI in the media



Dagens Perspektiv, 25.06.2020,
SINTEF: - Dette er områder hvor Norge kan ta en lederposisjon

Dagens Perspektiv, 15.10.2020,
Bøndene leder an i norsk datarevolusjon

NRK Trøndelag, 12.11.2020,
Nytt forskningscenter åpnet

Pressemelding Schibsted, 12.11.2020,
Schibsted steps up research-based innovation within AI

Pressemelding SINTEF, 12.11.2020,
NorwAI skal smi data til verdier

Pressemelding DNV GL, 12.11.2020,
NorwAI skal smi data til verdier

NTNU Nyheter, 12.11.2020,
Med kunstig intelligens gjør NorwAI data til verdier

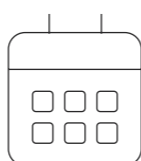
MN24, 12.11.2020,
Nytt forskningscenter for kunstig intelligens i Trondheim

Kampanje, 13.11.2020,
Schibsted dropper Sørlandet i jakten på kunstig intelligens - satser i Trondheim og Bergen

Elektronikknett, 16.11.2020,
Nytt forskningscenter for kunstig intelligens skal skape verdier

Cyprus shipping news, 16.11.2020,
New Norwegian AI centre ready to shape the future

Universitetsavisa.no, 17.11.2020,
Kunstig intelligens: Kunsten å ikke forsvinne i vrømmelen



Publications

As the center started on 1. October, there were no scientific publications within the NorwAI framework in 2020.

Recruitment

As the center started on 1. October, the work with recruiting PhD Candidates was initiated but not completed in 2020. The first candidates are expected to begin during fall 2021.

One postdoctoral researcher has been recruited and is receiving financial support from the center budget: Peng Liu, Male, China. Topic: Language models for natural language processing, Conversational systems. Period 07.12.2020-06.12.2023.

Annual Account 2020

	FUNDING	COSTS
The Research Council	399	
NTNU (host institution)	884	884
Research partners		580
Private partners	1052	871
SUM	2335	2335

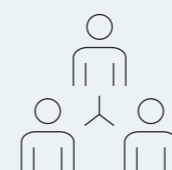

All figures in 1000 NOK.



Personell

Key researchers with reported activity in NorwAI in 2020.

NAME	INSTITUTION	MAIN RESEARCH AREA
Jon Atle Gulla	NTNU	NLP, Personalization
Kjetil Nørvåg	NTNU	Database systems, Big Data, information retrieval
Helge Langseth	NTNU	Machine Learning, Probabilistic AI
Heri Ramampiaro	NTNU	Information Retrieval, Machine Learning
Anne Marthine Rustad	SINTEF	Hybrid Analytics, Cybernetics
Arne Jørgen Berre	SINTEF	AI Innovation, Semantics and Standardization
Signe Reimer-Sørensen	SINTEF	Hybrid Analytics
Anders Løland	Norwegian Computing Center	Machine Learning, Statistics
Michael Link	Kongsberg Digital	Hybrid Analytics
Lars Westvang	Schibsted	NLP, Personalization
Øyvind Holmstad	NRK	NLP, Personalization
Alexander Gleim	Cognite	Big Data
Odd Erik Gundersen	TrønderEnergi	Machine Learning
Karl Aksel Festø	DNB	NLP, Personalization
Elizabeth Traiger	DNV	Trustworthy AI
Sigmund Akselsen	Telenor	Machine Learning
Ieva Martinkenaite	Telenor	AI Innovation
Annita Fjuk	Digital Norway	Innovation processes
Lars Ivar Hagfors	SpareBank1 SMN	Machine learning





Norw**AI**

Norwegian Research Center
for AI Innovation



sfi = Centre for
Research-based
Innovation

 NTNU