MARCH 2019

THE DANISH GOVERNMENT

National Strategy for Artificial Intelligence

Ministry of Finance and Ministry of Industry, Business and Financial Affairs

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Indhold

1 Vision and goals

Denmark is to be a front-runner in responsible development and use of artificial intelligence.

Over the years, the use of new technology has led to many advances, and globally, technological development has forged significantly better living conditions for many people.

Denmark has been quick to grasp the opportunities brought by new technology to generate economic growth and welfare for everyone.

There have been rapid developments within artificial intelligence in recent years. The major breakthrough with artificial intelligence is that it enables computers to learn without human intervention. Artificial intelligence uses data and algorithms – mathematical formulae – to mimic the way humans learn, make decisions and solve problems. The technology is already available in Danes' lives, for example when they are navigating in traffic, listening to music on their mobiles or searching the internet.

Today, artificial intelligence is primarily used for simple tasks in a single limited area, e.g. image recognition. On the other hand, the task is usually carried out at a speed and precision that far exceeds human ability.

In the slightly longer term, artificial intelligence is likely to be able to learn to perform more tasks within different areas. For example, this could be a housekeeping robot that can learn to vacuum and clean up without necessarily having to be programmed to perform the individual tasks.

There is currently intense work being undertaken aimed at achieving this broader form of artificial intelligence, as there are great potentials in the technology. In order to influence this development, it is vital that we strengthen the development of artificial intelligence in Denmark.

What is artificial intelligence?

Artificial intelligence is systems based on algorithms (mathematical formulae) that, by analysing and identifying patterns in data, can identify the most appropriate solution. The vast majority of these systems perform specific tasks in limited areas, e.g. control, prediction and guidance. The technology can be designed to adapt its behaviour by observing how the environment is influenced by previous actions.

Artificial intelligence is used in a number of areas, e.g. search engines, voice and image recognition, or to support drones and self-driving cars. Artificial intelligence can be a crucial element to increase productivity growth and to raise the standard of living in the years to come.

Source: The OECD and the European Commission, 2018

In the long term, artificial intelligence that resembles human intelligence could be developed. Today, there are still large differences between the human ability to learn new things and reflect, and a computer's ability to do the same with artificial intelligence. It is impossible to say for certain when – or whether at all – we will reach a point where computer technology can reason at a human level.

This government strategy takes its outset in the current level of development of artificial intelligence. The strategy paves the way for how we can get the most out of the potentials in this technology within a foreseeable number of years. As the technology develops, there will be a need for new approaches and initiatives that we cannot necessarily predict today.

It is important that Denmark exploit the opportunities in artificial intelligence, so that we support the competitiveness of Danish businesses, so that Denmark can remain one of the wealthiest countries in the world, and so that the public sector can provide world-class services.

For example, the technology can help **the individual citizen** to translate and read texts in different languages, navigate in traffic, and reduce and tailor energy consumption at home according to individual needs.

With regard to **businesses**, artificial intelligence could help create new and more efficient business models, e.g. by planning transport routes, thereby reducing time spent on logistics, and by identifying errors in reports to banks, insurance companies and pension companies.

In the **public sector**, artificial intelligence can support improved services, e.g. quicker diagnoses of illnesses; it can develop better and more accurate traffic control systems, and it can provide citizens with smarter and simpler communication with the public sector.

Artificial intelligence will change the way in we work. It will place new demands, but it will also provide opportunities to learn new things and perform tasks more efficiently. Denmark has have a flexible labour market and a well-educated and agile workforce with a positive attitude towards new technology. This is a good basis for getting everyone on board.

The Danish population has a high degree of trust in each other, and we are generally positive towards digital and technological development. However, the rapid development may make some feel insecure about the future. Therefore the government considers it crucial that Danes continue to feel secure and to be confident that developments in society and in the use of artificial intelligence will centre on **our shared values** of freedom, liberty, security and equality.

The government's vision

Denmark is to be a front-runner in responsible development and use of artificial intelligence.

When artificial intelligence supports people, e.g. in making a decision, it is vital that we ensure that our values are in focus at all times. We have to place the same requirements on algorithms as we do on an employee.

The algorithms must ensure equal treatment by being objective, fair and impartial of personal conditions. This means that artificial intelligence must not reflect prejudices or biases against gender, disability or ethnic origin. Furthermore, it is important to ensure that the data used by artificial intelligence is correct.

Artificial intelligence should help us to analyse, understand and make better decisions. However, the technology cannot, and should not, replace people or make decisions for us. For example, a physician should still make the final diagnosis for a patient. Trust grows between people, and new technologies must not be allowed to change this. Artificial intelligence must be used responsibly.

Therefore, the government will promote the use of artificial intelligence as a supplement to human decision-making, in order to exploit the benefits without compromising our social values.

Denmark is one of the world's most digitised countries. Denmark will use this stronghold to attract knowledge and technologies as well as influence the development of responsible artificial intelligence in close cooperation with the other Nordic and European countries. If Denmark and Europe fail to act quickly and with care, we will lose both our competitive edge and influence on developing artificial intelligence.

In December 2018, the European Commission presented an action plan for artificial intelligence. The government will work to generate support from the other EU Member States to exploit the potentials in the technology responsibly to benefit European citizens and businesses.

Europe and Denmark should not copy the US or China. Both countries are investing heavily in artificial intelligence, but with little regard for responsibility, ethical principles and privacy.

Denmark will focus on responsibility and ensure a good framework to exploit the growth potential in artificial intelligence in the sectors in which Denmark already has international strongholds so that Denmark can remain at the forefront.

Objectives for artificial intelligence

The government sets four objectives in this *National Strategy for Artificial Intelligence* for how Denmark can be a front-runner in responsible development and use of artificial intelligence.

1. Denmark should have a common ethical and human centered basis for artificial intelligence

Artificial intelligence must be developed and used within the relevant legislation, and with respect for the rights of citizens. This means that businesses and the public authorities must have strong focus on data ethics, which, among other things, include responsibility, security and transparency in the use of artificial intelligence.

The goals of the government are that:

- Ethical principles are incorporated in the development and use of artificial intelligence to secure respect for individuals and their rights, and for democracy.
- Denmark attracts knowledge and projects by being among the best in the EU at exploiting opportunities to develop and use responsible artificial intelligence.
- Internationally, Denmark works actively to ensure that responsibility is a guiding principle in the use and development of artificial intelligence.

2. Danish researchers should research and develop artificial intelligence

In order to support the development of artificial intelligence, Denmark must strengthen research efforts further. Researchers in Denmark will research artificial intelligence through basic research and more application-oriented research to pave the way for development of useful technological solutions for the individual, businesses and the public sector. Enhanced research efforts will also help ensure that Denmark can influence the development of artificial intelligence in the long term so that it is shaped according to Danish values.

The goals of the government are to:

- Prioritise research into digital technologies such as artificial intelligence further in the years to come.
- Establish better access to high-quality data for researchers in artificial intelligence.
- Support a good framework for attracting, developing and retaining research talents within artificial intelligence in Denmark.

3. Danish businesses should achieve growth through developing and using artificial intelligence

Realising the potentials in artificial intelligence also requires that Danish businesses invest in the technology and have access to the right resources and competences. There is also an ambition for Danish businesses to exploit the focus of the strategy on responsible use of artificial intelligence in their business models, so that this can be a competitive advantage both nationally and internationally.

The goals of the government are that:

- Denmark is among the best in the world at exploiting data and new business models based on responsible development and use of artificial intelligence.
- Businesses increase their investment in responsible artificial intelligence.
- Danish businesses have better access to employees with digital skills, to data and to the latest research within artificial intelligence.

4. The public sector should use artificial intelligence to offer world-class services

Artificial intelligence will be used to improve public services with outset in the needs of citizens. The public sector will also use artificial intelligence to support faster and more efficient case processing.

The goals of the government are that:

- The public sector will be among the leading countries in Europe in using data and artificial intelligence to improve and target public services.
- The public sector works systematically on a framework and methods to support responsible use of artificial intelligence so that investments and solutions are utilised as well as possible.
- The authorities have a good framework to utilise data to develop artificial intelligence.

Examples of the benefits of using artificial intelligence in the short term

For the individual

- More individualised treatment of the sick, e.g. through identification of citizens with heart attack by using advanced voice recognition for emergency calls
- Better search for information and route planning.
- Better technical aids helping citizens to write, read and hear (intelligent hearing aids, reading aloud etc.).
- Better service for citizens and case support in public administration, e.g. at Udbetaling Danmark (the Danish authority for payments of benefits etc.), in the employment area and at citizen service centres in Danish municipalities.
- Better digital customer experiences, e.g. help to check prices or to pay bills.

For businesses

- Less time wasted by transport and logistics firms because they can predict when consumers will buy products and thereby prepare the products for shipping even before consumers order them.
- Identification of errors in reportings from customers at e.g. banks, insurance companies and pension funds.
- Development of intelligent conveyor belts to predict maintenance needs at production companies.
- Development of new digital business models, e.g. within the sharing economy, such as rental housing, car-share schemes and travel booking and planning.

For the public sector

- Intelligent environmental monitoring, prediction of flooding during cloudburst events and management of drainage systems.
- Quicker and better diagnosis as well as more targeted treatments for diseases.
- A more efficient tax system and better possibilities to combat fraud in VAT, tax and social benefits.
- Higher quality and more citizen-centered care through better ressource management, e.g. optimising the operation of public hospitals to free-up more beds.
- Quicker case processing and more efficient administration, e.g. through digital sorting of citizens' inquires, ensuring that citizens receive quicker replies.

2 Good starting point – but challenges as well

Denmark has a good starting point – but other countries are moving rapidly up the digital agenda. If Denmark is to remain among the most digitised countries in the world, there are a number of challenges to address.

Artificial intelligence is already being used in many of the products and services that are part of everyday life in Denmark. E.g. in apps, search engines, image recognition, diagnosis and facial recognition, as well as for automation in industry.

Several public institutions in national, regional and local government also use artificial intelligence, e.g. for application forms, customer service calls, invoicing, etc. The first experiences from using artificial intelligence for faster and better treatment are also now being seen in the healthcare sector.

In the private sector, there is also work on artificial intelligence in industry and transport as well as in the financial and insurance sectors. Several start-up businesses are using artificial intelligence, e.g. to automate customer services, so that customers' problems can be identified more quickly. This means that customers can immediately get into contact with the relevant service staff, and this prevents telephone queues and waiting times.

There are considerable potentials to generate further growth and better public services through greater use of artificial intelligence.

An analysis by McKinsey estimates a significant growth potential in using artificial intelligence as we already know it today. It is hardly possible to realise the full potential, but the analysis indicates that there is great potential for more growth and prosperity in the Danish economy.

Denmark has a good starting point

There is a good outset for exploiting artificial intelligence. We are already well underway, and Denmark is the most digitised country in Europe. Denmark has a number of elements already in place for work with artificial intelligence.

Danish businesses, particularly the largest businesses, already use digital technologies extensively, and historically Danish businesses have been extremely good at implementing new technologies. This means that Denmark has many global digital business successes.

The Danish public sector is one of the world's most digitised. Denmark has a well-developed digital infrastructure, e.g. mobile-phone network and broadband, Digital Post (digital mailbox for messages and communications from public authorities) and NemID (eID solution), as well as high-quality public-sector data and a population with good IT skills. Denmark has also been good at digitising the public sector without compromising the confidence and trust that characterise Danish society.

Denmark has high priority on research. Denmark is among the countries in the OECD with the highest public investment in research and development, measured in relation to GDP, and there are strong research environments within artificial intelligence. The total public research budget for 2019 is DKK 23 billion (EUR 3.1 billion). Danish research enjoys international recognition, and it is high on international rankings of e.g. scientific impact.

Examples of artificial intelligence

Early diagnosis of cancer at Odense University Hospital saves lives

The Region of Southern Denmark is working on using artificial intelligence to diagnose cancer more quickly. By analysing pictures of cancer cells, artificial intelligence can see whether a cell is cancerous with a high degree of certainty. Early diagnosis makes it possible to commence treatment faster, and thereby improve patients' chances of survival. The work is part of a larger initiative in the area at Odense University Hospital.

Optimisation of the drinking water system in the City of Aarhus

Production, treatment and distribution of drinking water demands a lot of energy, which is expensive and bad for the environment. Using artificial intelligence, the CHAIN project being funded by Innovation Fund Denmark will analyse large volumes of water-consumption data (from sensors etc.) to minimise energy consumption on pumping water. This could also reduce the environmental impact of operating the water system.

Baggage at Copenhagen Airport

In 2018, 30.3 million passengers went through Copenhagen Airport. This was an increase from 21.5 million in 2010. More passengers means more baggage. Therefore, since 2016, Copenhagen Airport has been using artificial intelligence to optimise baggage handling. Among other things, artificial intelligence is used to predict where staff can probably best empty aircraft and put cases on conveyor belts. Focus is on time optimisation. This has resulted in fewer queues and better passenger experience.

Artificial intelligence will help beer tasting at Carlsberg

1,000 different beers are screened every day at the Carlsberg laboratory in Valby near Copenhagen. It is a difficult and time-demanding process. Therefore, researchers at the laboratory have launched a project to measure taste aromas before the beer is brewed. The laboratory will use chemical sensors to test thousands of different types of yeast. Data from the yeast types will be analysed using artificial intelligence, and then researchers will be able to predict whether a yeast has the right quality. In the future, it is likely that the technology could also be used to measure other food, air pollution, etc.

Research and innovation are the foundation for future solutions to the challenges facing society. And they are the key to grasping the huge opportunities in artificial intelligence.

Denmark has a flexible labour market, making it possible to adjust rapidly to changes in technology and to ensure that employees can change quickly between positions. Danish experience shows that new technology does not lead to lower employment levels, but it shifts employment between sectors and job functions.

Finally, in an international context, the Danish population is well-educated, almost all Danes use the internet on a daily basis, and there is a high degree of mutual trust and confidence. This means that Denmark is adaptable, and there is a good basis for implementing artificial intelligence.

All in all there is a good foundation for developing and using artificial intelligence.

But there are challenges as well

A good outset is not enough. To realise the full potential in Denmark, it is necessary to take action in a number of areas.

Challenges for the use of artificial intelligence in Denmark

- **Need for common guidelines and an ethical framework for artificial intelligence:** Artificial intelligence entails a new way of making decisions. It raises a number of ethical issues relating to the relationship between advantages from using new technologies on the one hand, and consideration of people's basic rights, due process, and Danish social values on the other hand.
- **Need for more data in Danish for artificial intelligence:** There is a demand for more data to train algorithms, and Danish is a small linguistic area. This constitutes a barrier to developing solutions that use language understanding or voice recognition in Danish, for example.
- **Lack of employees with the right skills:** 60% of businesses report that they face challenges recruiting IT specialists. At European level, there is an estimated demand of 600,000 specialists within IT programming, and this is expected to increase in the years to come.
- **Low level of investment:** Denmark ranks lower than comparable countries with regard to private investment in artificial intelligence.

Need for a common ethical framework for artificial intelligence

Artificial intelligence entails an entirely new way of making decisions, in which computers and algorithms play a larger role. For example, the introduction of self-learning algorithms on social media creates uncertainty regarding the extent to which we can rely on recommendations from intelligent systems.

This raises a number of questions regarding responsibility and security that need to be addressed. Furthermore, artificial intelligence raises a number of ethical issues relating to the relationship between, on the one hand the advantages from using new technologies, and, on other hand, consideration of people's basic rights, due process, and fundamental social values.

Demand for more data in Danish for artificial intelligence

A prerequisite for using artificial intelligence is access to high-quality data. Incomplete datasets are a challenge for public and private organisations and researchers who want to work with artificial intelligence.

Denmark is also a small linguistic area, and this makes it less attractive to develop artificial intelligence that operates in Danish and understands Danish text and speech. Developments are often in English, and special efforts are required to ensure that digital solutions are developed in Danish.

This is a problem for businesses, public authorities and researchers. A solution to this challenge will improve the possibilities for all parties to develop new solutions in Danish and for the Danish market.

Lack of employees with the right skills and more high-quality research

Artificial intelligence entails an increasing need for people with technical and digital skills. Many enterprises are facing challenges with regard to recruiting and retaining employees, particularly IT specialists. As many as 60% of Danish businesses were unable to find IT specialists in 2017 (Statistics Denmark, 2018).

New research is helping develop new solutions and products, and therefore, high-quality research is crucial if Denmark is to be among the leading countries in the area. Even though Denmark has a strong research position in general, and strong research environments in artificial intelligence, there is a need to further intensify research in artificial intelligence.

Few investments in Denmark

The US and China are clear front-runners in investment in artificial intelligence. More than 90% of global investment and patents over the past decade have come from companies in the US and China. In the US, this trend is driven by the technology giants and many start-ups, while in China developments are to a great extent promoted by the central government.

The position of the US and China is in part due to the size of their populations. However, even after taking into account the size of the population, Denmark is still below comparable countries such as Israel, Finland and Sweden regarding private investment and number of patents applied for in artificial intelligence (McKinsey 2019).

The US and China, but also Finland and Israel have developed ambitious plans for using artificial intelligence, and these will increase total investment in the technology. In Denmark, only few businesses and public authorities have strategic priorities for artificial intelligence (McKinsey 2019).

Cohesive initiatives

With this strategy, the Danish government is paving the way for Denmark to take the lead in responsible development and use of artificial intelligence.

The government will implement targeted efforts within four focus areas:

Four focus areas

1. A responsible foundation for artificial intelligence
2. More and better data
3. Strong competences and new knowledge
4. Increased investment

In order to ensure that specific experience from relevant areas of society is gathered immediately, the government will set goals for work on artificial intelligence within specific priority areas. These areas are:

Priority areas

- Healthcare
- Energy and utilities
- Agriculture
- Transport

Objectives will take their outset in the areas' own ambitions and contribute to ongoing follow-up and work on artificial intelligence.

The focus areas as well as the priority areas are based on the government's other work on future-proofing Denmark. For example, the government has started several initiatives to help establish a better framework for development and use of artificial intelligence in Denmark.

Disruptionrådet (a partnership for Denmark's future) has discussed the impacts on the labour market and the changes artificial intelligence will entail for many jobs, and it has spotlighted data ethics as a competition parameter. Moreover, several initiatives have been launched to strengthen education and training, and to attract talent.

The *Strategy for Denmark's Digital Growth* and the Digital Hub Denmark initiative have put focus on the opportunities for businesses in big data and artificial intelligence.

Furthermore, the framework for using artificial intelligence was further strengthened with initiatives for a good digital infrastructure, including a modernised telecommunications agreement and a *5G action plan*.

With the *World-class digital services* in the Cohesion in the Public Sector Reform, the government has paved the way for how the public sector is to provide better and more cohesive digital services for citizens, including through increased use and dissemination of new technology. The Reform will ensure that people have access to services based on their needs by accelerating e-government efforts and contributing to better and more cohesive welfare.

The research and innovation policy strategy *Denmark – ready for the future* and implementation of the research reserve for 2019 will strengthen research in digital technologies. There are also efforts to enhance digital competences, including the STEM action plan (Science, Technology, Engineering, Mathematics), *Teknologipagten*, and trials in primary and lower secondary schools to promote understanding of technology.

The initiatives mean that Denmark has a good foundation to exploit artificial intelligence, with good research, good framework conditions and a digital public sector.

The aim of the strategy is also to support Danish cooperation on artificial intelligence with other countries, in particular in the EU, the OECD, the Council of Europe and the Nordic Council of Ministers. If Denmark is are to succeed in promoting responsible development and use of artificial intelligence, not only in Denmark, but also internationally, coordinated efforts at European level are vital.

International cooperation on artificial intelligence

The EU action plan for artificial intelligence *Made in Europe*

The European Commission has established a common European framework for collaboration on artificial intelligence. In the upcoming budget period, the EU will invest in European development of artificial intelligence through Horizon Europe and the Digital Europe Programme. This provides opportunities for Danish businesses, authorities and research communities.

Nordic-Baltic cooperation on artificial intelligence

With their declaration *AI in the Nordic-Baltic region,* the Nordic and Baltic countries have agreed to cooperate on artificial intelligence to secure digital skills, access to data based on common standards, ethical guidelines for artificial intelligence, and to promote development of the technology in Europe.

This strategy is a first step

The strategy contains 24 initiatives. The government has earmarked DKK 60 million (EUR 9.2 million) for 2019-2027.

This is a supplement to the DKK 295 million (EUR 45.4 million) allocated in the Finance Act 2019 from the research reserve for research into new technological possibilities and digital technologies and for a national centre for research into digital technologies.

The government has also proposed a new investment fund to expedite the dissemination of digital welfare solutions. Together with initiatives already launched, the investment fund will have a total investment budget of DKK 410 million (EUR 63.1 million) for 2018-2022.

This strategy sets a direction, and a number of specific projects will be launched to help Denmark reap the full benefits of the opportunities artificial intelligence will provide over the years to come. However, this is only one step on the way. Sustained efforts are required if the vision is to be realised. New challenges will arise, and it will be necessary to adjust initiatives along the way. And there will be needs for new initiatives as the technology develops.

Therefore, the government will monitor developments and evaluate the strategy annually. The government will also regularly receive input from professional networks, decision makers, researchers, political stakeholders, etc.

With a strong focus on ethics, better use of data, and the importance of competences and research, the government is also sowing the seeds for Denmark to play a role in developing artificial intelligence in the long term. Several of the research projects currently being launched around the world and in Denmark, are aiming to break new scientific ground, the significance of which could take 50 years to become apparent. With Denmark's strong research communities, there is a good basis to influence developments in the very long term.

Central initiatives in the strategy

Principles for responsible development and use of artificial intelligence

The development and use of artificial intelligence. These principles will be supplemented with initiatives to strengthen cyber security, creating legal clarity as well as ensuring responsible and transparent use of artificial intelligence in the public sector.

Common Danish language resource

A common Danish language resource will be established to support and accelerate the development of language-technology solutions in Danish. The language resource will be freely available, enabling suppliers to build on existing knowledge to create new solutions within voice recognition and language understanding to benefit citizens, authorities and businesses.

More open public-sector data for artificial intelligence

In collaboration with businesses and research communities, the government will identify five public-sector datasets during 2020 and 2021, which can be made available for businesses, researchers and public authorities and contribute to the development of artificial intelligence. The datasets will not contain personal data, but rather environment and climate data from the transportation sector.

Signature projects in the public sector

There is a lack of experience in use of artificial intelligence in the public sector. Therefore, the government will launch a number of signature projects within health, the social and employment areas, and cross-sector case processing.

Stronger investment in Danish businesses

It is proposed to launch a pilot project in the form of an investment pool of DKK 20 million (EUR 3.1 million) over four years targeting at companies with a business model based on artificial intelligence. The prerequisite for this is a 50 percent financing from the private sector amounting to a total investment pool of DKK 40 million (EUR 6.2 million). The fund will be managed by the Danish Growth Fund.

Focus areas

A responsible foundation for artificial intelligence

There must be a responsible ethical and legal framework for the use of artificial intelligence.

Artificial intelligence holds a great potential for growth, innovation and better public services. However, increased use of artificial intelligence also raises a number of ethical and legal issues in both the public and private sectors.

Many of these issues are well-known from previous work with data. Others are new issues regarding the responsibility for decision-making, transparency and discrimination, for example.

Stronger confidence

Denmark has performed well when it comes to digitisation, both in the public and private sectors. Denmark has also managed to preserve high confidence in the public sector from both individuals and the business community. A total of 83% of Danes have confidence in the management of personal information by the public authorities (Statistics Denmark, 2017). In *World-class digital services*, the government has set a goal to increase this to 90% before 2024.

Realising this goal and the potentials in artificial intelligence requires a common ethical basis for development and use of artificial intelligence. This will also support confidence in work by both the public sector and by businesses on data and new technologies.

Therefore, the government has set up six ethical principles, and these will form the framework for future development and use of artificial intelligence. A number of initiatives to promote a strong focus on data ethics will also be launched.

Development and use of artificial intelligence must be within the relevant legislative framework. Use of personal data should always respect the basic principles in the General Data Protection Regulation.

The legislative framework is in the General Data Protection Regulation, administrative law, etc., and these regulate work with artificial intelligence, through among other things

requirements in connection with processing personal data. In the future, the use of technology is expected to raise new legal and ethical issues.

Therefore, the government will monitor developments closely and regularly assess the need for guidelines on interpretation of the current legal framework as well as the need for new legislation, as more experience is obtained with the technology and its possibilities.

The government's initiatives should also be considered in the context of international developments in the area, where there is an increasing interest to ethical use of artificial intelligence both at the EU level and globally.

By taking the lead, Denmark can influence developments, and help ensure that the public and private sectors focus on responsibility when using artificial intelligence. This will improve the conditions for providing services closer to citizens based on their needs, and it will give businesses a competitive edge.

Security is paramount

Security is also crucial to ensure responsible development and use of artificial intelligence. Individuals, businesses and employees must be confident that data and algorithms have been safeguarded against manipulation and attack, and that the results produced by artificial intelligence are reliable.

On the one hand, the spread of artificial intelligence entails a risk of exacerbating existing cyber threats and creating entirely new risks. At worst, technologies using artificial intelligence could be influenced for malicious use. For example, artificial intelligence could be used to automate cyber attacks on critical infrastructure and on Danish companies.

On the other hand, artificial intelligence will provide opportunities for Danish businesses to develop advanced IT security solutions that exploit the potentials in the technology. For example, the new technology makes it possible for systems to automatically reveal unknown viruses and attempts at incursion never seen before.

Case: Intelligent cyber security

The American company IBM has launched the QRadar program. Using artificial intelligence, QRadar can examine billions of pieces of information in a short period of time and look for signs that a network or system has been compromised by malicious players. In this way the program can help IT specialists find breaches of security that would be hard for a human to detect.

New IT security solutions based on artificial intelligence can potentially create new export opportunities **and increase IT security**. However, wherever these new IT security solutions are used, they will also entail potential risks if they are manipulated.

The government will ensure that data, for example personal data on citizens, continues to be managed appropriately, and that artificial intelligence, its algorithms and results are trustworthy.

Government initiatives

The government will implement the following initiatives:

1. Ethical principles for artificial intelligence
2. Establishment of the Data Ethics Council
3. Security and artificial intelligence
4. Legal clarity on development and use of artificial intelligence
5. Transparent use of algorithms by the public sector
6. Ethically responsible and sustainable use of data by the business community
7. Danish imprint on standards for artificial intelligence

The initiatives supplement existing efforts:

- World-class digital services
- Danish Cyber and Information Security Strategy, including strategies for sectors critical for society.
- Strategy for Denmark's Digital Growth

Initiative 1.1: Ethical principles for artificial intelligence

Work on artificial intelligence raises a number of ethical issues. For example, is it possible to secure the basic rights of citizens, due process and fundamental societal values when using artificial intelligence?

Therefore, the government has prepared six ethical principles to set a common framework for development and use of artificial intelligence. A common ethical framework is a precondition for maintaining the high level of confidence and trust in Denmark.

The ethical principles aim at authorities, businesses, research institutions and others working with artificial intelligence. The principles reflect Danish values and have been prepared on the basis of the recommendations from the Expert Group on Data Ethics set up under the Danish *Disruption Council*, and the draft EU ethical principles and guidelines for artificial intelligence.

The government will regularly follow up on the principles, among other things after discussions with the Data Ethics Council. The follow-up will take into account the differences between the public and private sectors. The public sector is subject to the Danish Public Administration Act and the Danish Access to Public Administration Files Act, for example, whereas businesses may need to protect trade secrets.

Six principles for artificial intelligence

1. Self-determination
2. Dignity
3. Responsibility
4. Explainability
5. Equality and justice
6. Development

1. Self-determination

People's autonomy should have priority in development and use of artificial intelligence. Like today, people should be able to make informed and independent decisions without artificial intelligence removing their self-determination.

2. Dignity

Human dignity should be respected in development and use of artificial intelligence. Artificial intelligence should not cause injury, it should support due process and it should not unjustifiably place people in a worse position. Artificial intelligence should respect democracy and democratic processes, and it should not be used to infringe fundamental human rights.

3. Responsibility

All levels should be responsible for the consequences of their development and use of artificial intelligence, i.e. developers, cooperation partners, users, authorities, businesses, etc. In decisions and decision-support based on artificial intelligence, it should be possible to place responsibility on human beings.

4. Explainability

Explainability means that you can describe, control and restore data, underlying logics and consequences of the use of artificial intelligence, e.g. by being able to trace and explain decisions and decision support. Explainability is not the same as full transparency of algorithms, as there are business interests in the private sector, for example. However, the public authorities have a special responsibility to ensure openness and transparency in the use of algorithms.

5. Equality and justice

Artificial intelligence should not reproduce prejudices that marginalise specific population groups. There will be active work to prevent unwanted bias and promote designs that avoid classification discriminating on ethnicity, sexuality and gender, for example. Demographic and professional diversity should be guiding parameters in working with artificial intelligence.

6. Development

Artificial intelligence can help forge great progress for society. Technical and organisational solutions should be developed that support ethically responsible development and use of artificial intelligence in order to achieve the greatest possible progress for society, e.g. by contributing to better public-sector services and to growth in the business community.

Initiative 1.2: Establishment of the Data Ethics Council

The government will establish the Data Ethics Council in 2019 to make recommendations and support broad public debate on issues regarding data ethics, including artificial intelligence. The council will monitor technological development and help to ensure that ethical issues are taken up so that the many advantages of using data can be supported in an ethically appropriate manner.

The council will discuss how to ensure that technological opportunities are exploited such that they serve the shared values of Danish society in the future.

Initiative 1.3: Security and artificial intelligence

Solutions based on artificial intelligence must be secure and tested to confirm they can withstand systematic attacks. The government will therefore launch an initiative to support secure development and deployment of artificial intelligence. This will ensure that confidence in digital solutions is preserved, and this is an important precondition for realising the societal benefits of more digitisation and wider use of artificial intelligence.

The initiative will analyse the security risks that may arise for authorities and businesses from increased use of artificial intelligence. Existing risks and threats will be exacerbated, for example if cyber attacks are automated, or intelligent malware is used. At the same time, entirely new and previously unknown risks will arise, e.g. if the data basis for smart solutions is compromised.

This initiative will also involve preparation of guidelines to assign specific initiatives to strengthen work by the authorities and businesses on IT security and data protection. For example, there will be specific examples of contractual requirements concerning security that the authorities can impose on suppliers of artificial intelligence.

Another part of the initiative will involve implementing initiatives to enhance the development and implementation in Danish businesses of IT security solutions based on artificial intelligence.

Together, these activities will forge a safe and secure framework for introducing artificial intelligence in the public sector and in businesses. The initiative will also help ensure that the technology can be used proactively in cyber security in Denmark.

The initiative should be seen in the context of the government's 2018 *National strategy for cyber and information security.* In the years to come, DKK 1.5 billion (EUR 200 million) will be invested in work by the Ministry of Defence on cyber and information security. Furthermore, six targeted strategies have been drawn up for work in the most critical sectors on cyber and information security in accordance with the principle of sector responsibility.

Initiative 1.4: Legal clarity on development and use of artificial intelligence

Greater use of artificial intelligence raises a number of legal issues. For example, who is responsible if a self-driving car is involved in an accident? Is it the 'driver' because they should have intervened? Is it the manufacturer or developers of the self-learning intelligent system? Driverless cars have not yet been developed commercially, but the introduction of artificial intelligence is already showing that there is a number of questions about legal responsibility to be addressed in more detail.

Therefore, the government will set up an inter-ministerial working group to examine whether the issues in using artificial intelligence can be managed within the existing legislative framework. The working group will identify the need for guidelines on the regulations that apply in relation to the use of artificial intelligence, and there may be a need to launch legislative initiatives at national or EU level. The work of the working group could also form a basis for dialogue with the European Commission on any need for regulatory measures.

Initiative 1.5: Transparent use of artificial intelligence by the public sector

Citizens and businesses must have confidence in artificial intelligence whenever it is used by the public authorities, so that artificial intelligence does not undermine public confidence in the public authorities generally. This applies in particular when the authorities use artificial intelligence to support decision-making.

On the basis of the ethical principles, the government will ensure that common public-sector methods and guidelines are drawn up which support the statutory requirements for transparency etc. As part of this work, a pilot project will be initiated to develop and test methods for how public authorities actually ensure the statutory requirements for reasonable, responsible and transparent use of artificial intelligence as a basis for making decisions.

Initiative 1.6: Ethically responsible and sustainable use of data by the business community

As a follow-up to the recommendations from the government's expert group on data ethics, the government will launch a number of initiatives targeted at the business community. The expert group has looked at how work by businesses on responsible use of data can be supported so that it becomes a competitive advantage for Danish and European businesses.

Among other things, the government will prepare a toolbox with specific tools such as guidelines to help enterprises in their routine work with data responsibility. The government will also present a proposed legislative amendment to the Danish Financial Statements Act so that the largest Danish companies have to report on their data-ethics policy.

Furthermore, a data-ethics label will be introduced for businesses that comply with the ethical principles for data utilisation, to display on their website, for example. This will make it easier for consumers to navigate between businesses, services and products and choose the data-ethically responsible alternative.

Preparation of the toolbox, amendments to the Financial Statements Act and the data-ethics label will be carried out on the basis of ethical principles.

Finally, the government will make active efforts for relevant initiatives to be introduced in the EU in order to ensure equal competitive conditions for Danish businesses in the EU single market.

Initiative 1.7: Danish imprint on standards for artificial intelligence

The international race is on to influence the development of new standards within artificial intelligence. As far as possible, the government wants the forthcoming international standards to be prepared on the basis of the needs of Danish businesses, as the standards will form the basis for future regulation of artificial intelligence at European and international levels.

In order to gain real influence on European standardisation work, the government has successfully acquired responsibility for the secretariat of the upcoming European focus group that is to identify the needs for standardisation within artificial intelligence. With the secretariat in Denmark, Danish businesses will be able to make a strong imprint on the work.

In parallel, the government will initiate work to develop national technical specifications based on the specific needs of Danish businesses. This work will take its outset in the six ethical principles for artificial intelligence.


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II More and better data

Data is the prerequisite for artificial intelligence. The Danish point of departure is good, but we can go even further.

Data is the raw material of the future and it is an essential prerequisite for the use of artificial intelligence. The quality and volume of data determines how far it is possible to go with artificial intelligence.

Businesses, public authorities and researchers need large datasets that can be linked across areas to develop new solutions with artificial intelligence. For example, data on water consumption can be used by waterworks to develop solutions to provide better and more stable water supply by finding and predicting leaks in pipes. Data on consumers' online purchases and locations can help shops predict when consumers will buy a given product.

Municipalities can collect and analyse data on education and age to develop targeted employment measures for the individual. In the healthcare area, data on sickness and hospital discharges could form the basis for solutions to ensure better and more cohesive treatment for patients. This is good; for the individual citizen, for businesses and for the economy.

Good access to public data

Several initiatives have already secured better access to public data. These include the Basic Data Program, which, since 2012, has made available data on real property, addresses, roads and areas, water and climate, geography, persons and businesses.

And this work is continuing. In 2018, the government decided to release weather and climate data from the Danish Meteorological Institute. Up to 2023, a large number of datasets on weather observations and forecasts will be made freely available for everyone. This will make it possible for electricity plants, for example, to develop solutions that adjust production of electricity to wind and weather conditions, or for businesses to develop new apps for consumers. With its Health Data Programme, the government has also earmarked DKK 250 mill. to ensure better data quality and data bases and to strengthen cross-sectoral cooperation on health data.

Through membership of the European Space Agency (ESA) and the two EU space programmes, Copernicus and Galileo, Denmark is also helping to gather and process large amounts of weather, environment and climate data. Most of this data is freely available for citizens, businesses, public authorities and researchers.

If Danish businesses are to exploit the potential in artificial intelligence and strengthen Denmark's position as a digital frontrunner, it is vital that they have access to data.

Uncertainty about the rules should not constitute a barrier to using and sharing data as a source of innovation and growth in the Danish business community. Therefore, as part of the *Strategy for Denmark's Digital Growth*, the government has prepared guidance materials for businesses about the rules for ownership and rights in connection with the use and sharing of data. This will ensure clarity about the rules for businesses and their use of data.

As a result hereof, the Danish point of departure is very good, but we can go even further. There is still low use of data, e.g. big data by Danish businesses, and several public datasets are still not available for researchers and businesses. Moreover, there is still too little use of the datasets that are available to develop new, smart solutions.

Better opportunities for Danish solutions

With this *National Strategy for Artificial Intelligence*, the Danish government is launching a range of initiatives to release more and better Danish non-personal data, and to make businesses' frameworks for the use of data even better. However, more use of data also places more demands on businesses and the public sector. The government will ensure that citizens are involved when data is made available. Citizens should be no doubt that both businesses and the public authorities use and store data responsibly.

Among other things, this requires that the public authorities have access to good and secure solutions to store data. The government will launch an initiative to give government authorities access to secure environments for data storage, as well as access to develop and test artificial intelligence by examining access to cloud technology. Furthermore, there will be work to give businesses better access to closed, secure environments, where this is permitted by legislation.

Many of the technological solutions we know today have been developed in English, and the goal has to be, that solutions developed and used in Danish are of equal quality. In line with increasing internationalisation of society, it is important to ensure that the Danish language remains strong if individuals and businesses are to have access to up-to-date digital solutions in Danish.

Therefore, the government will enhance opportunities to develop solutions in Danish by establishing a freely available Danish language resource. The language resource will enable businesses, researchers and public authorities to securely and efficiently develop solutions using voice recognition and language understanding in Danish.

Finally, the government will also focus on how the EU can establish better access to public-sector data across countries and how sharing data between businesses can be strengthened.

Government initiatives

The government will implement the following initiatives:

1. Common Danish language resource
2. Better access to public-sector data
3. More data in the cloud for artificial intelligence
4. Improved access to data outside Denmark for Danish businesses and researchers

The initiatives supplement existing efforts:

- The Basic Data Programme
- Business data from Virk.dk
- Clear guidelines for businesses and their use of data.
- Free access to weather, climate and marine data from the Danish Meteorological Institute
- The Health Data Programme
- Participation in European cooperation on space data, particularly on the weather, environment and climate

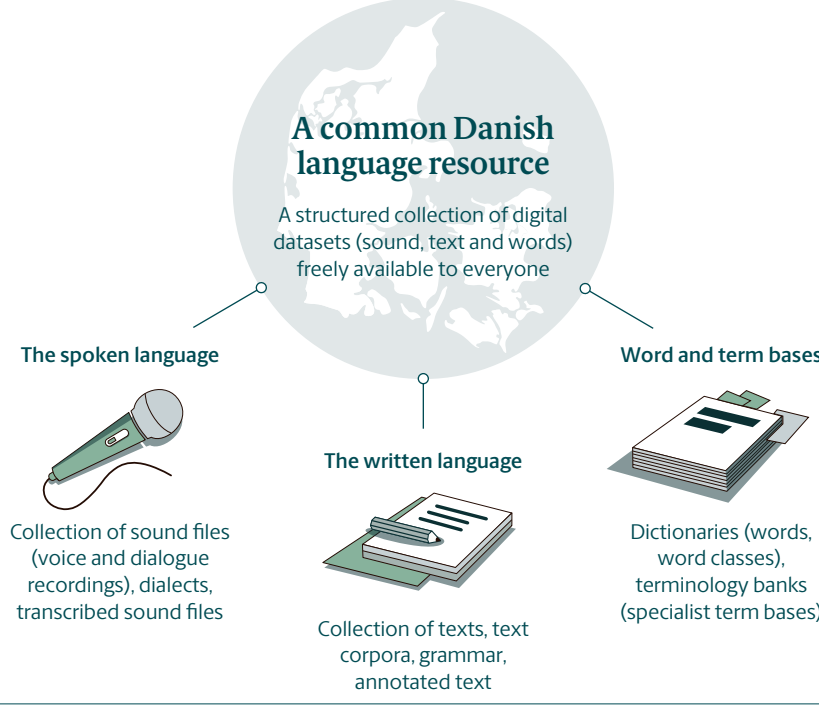
Initiative 2.1: Common Danish language resource

Danish is a small language area, and this means that the majority of language-technology solutions do not work optimally in Danish. This is a challenge, because language technology is often an integral part of the digital solutions we use every day. Language-technology solutions are used to speak with virtual assistants, e.g. to read out bus stops over speakers in busses and to translate between languages.

In step with the development of ever more advanced digital solutions in English that people can interact with, there is a risk that interaction could be increasingly in English rather than Danish. If citizens and Danish businesses are to continue to have access and possibilities to develop good solutions in Danish, Danish must continue as a strong language in international competition.

Language technology in the form of voice recognition and language understanding is a pivotal precondition for the development and use of artificial intelligence in Danish. It enables us to analyse, recognise and reproduce language within reading aloud and translation for example. Sweden, Norway and other countries comparable to Denmark are also prioritising and investing in the area.

For example, language technology can be used to help people with sight disabilities or people who find it difficult to read and write by reading texts aloud or record messages. Language technology also helps physicians to make diagnoses quicker because physicians can dictate observations instead writing them down later. This saves time that can be spent with patients instead.



Today, a significant barrier to developing Danish language technology is that developing digital language resources requires large investments for individual players. This is a problem for Danish competitiveness, knowledge-development, and future digitisation of Denmark – in businesses, in the public sector and in research.

An open and shared language resource will provide new research opportunities and strengthen development of solutions in the public and private sectors within artificial intelligence. For example, solutions will be developed to help companies transcribe phone calls so that customer enquiries can be answered faster. It will also be easier for the public authorities to develop solutions for citizen service centres, for example high-quality chatbots to help citizens more quickly and easily.

Therefore, in collaboration with both private and public players, the government will start development of a language resource that will be freely available for everyone. This will ensure that businesses, researchers and public authorities have access to a high-quality shared language resource.

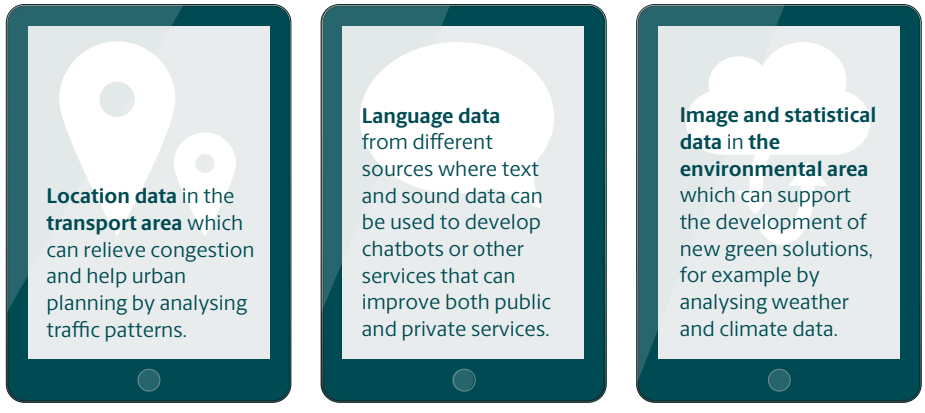
The language resource will build on existing initiatives in the public sector and private sector as well as in research communities. This will be in collaboration between public and private players.

Initiative 2.2: Better access to public-sector data

Denmark has public-sector data of high quality. We need to exploit this and turn it into an international competitive advantage.

Therefore, in collaboration with the business community and research communities, the government will identify five public-sector datasets during 2020 and 2021, which can be made accessible for businesses, researchers and public authorities as non-personal data, thereby contributing to the development of artificial intelligence.

Examples of datasets which can be released



In parallel, the government will ensure that, through test projects, businesses and researchers are given the opportunity to test and develop new innovative solutions using public-sector data.

The initiative's work on access to public-sector data will contribute to resolving societal issues like climate challenges and congestion. This work will also inspire more innovation, new thinking and use of artificial intelligence across businesses, research communities and public authorities.

This *National Strategy for Artificial Intelligence* will launch initiatives to ensure that more non-personal public-sector data is made available. However, there is also a need for more strategic initiatives, so that, in the longer term, Denmark can fully exploit the potentials of Denmark's good public-sector datasets. Therefore, with *World-class digital services*, the government has taken initiative to prepare a strategy for data in the public sector.

This strategy will help the public sector become better at using data to provide citizens and businesses with more cohesive and targeted services. As part of this, public authorities will work together to create a cohesive high-quality data basis that provides a digital foundation for good, correct and efficient services for citizens and businesses.

The strategy will set a clear framework for the use of public-sector data to ensure and increase public confidence in public-sector work with data.

Initiative 2.3: More data in the cloud for artificial intelligence

It should be easier for public authorities to develop and work with artificial intelligence. Cloud technologies can be a precondition for working with artificial intelligence, as these technologies give cheap access to massive computational power and storage capacity. At the same time, cloud technologies make it easier to work together across datasets. In future, the government therefore wants to provide authorities with a basis for taking an active position on whether data should be stored in the cloud.

The government will launch a number of activities addressing the challenges and opportunities of using cloud solutions.

What are cloud technologies?

Cloud technologies is an overall term for solutions for servers and applications, that can be accessed via the internet. Cloud technologies are advantageous, as they can quickly be scaled up and down according to user needs. By storing data in cloud solutions, authorities can buy access to the (processing) power necessary to work with artificial intelligence.

An analysis will be conducted of how to make it easier for authorities to start using secure cloud solutions. Guidelines will also be prepared for public authorities that are to decide on the use of cloud solutions.

Moreover, the government will promote central government use of cloud technologies by establishing secure cloud environments for government authorities linked to *Statens IT*. Cloud environments will be offered to public authorities wanting to explore how they can quickly get started with work on artificial intelligence or data analysis.

Initiative 2.4: Improved access to data outside Denmark for Danish businesses and researchers

It should be easier for Danish businesses to access data abroad, particularly in the EU. At the European level, efforts are being made to ensure better access to data, among others, for businesses and research communities.

New European frameworks for making available public-sector data create an opportunity for Danish businesses to deploy data-based business models across the whole of the EU. The government will work to ensure that the data that EU Member States are obligated to make available is of value to Danish businesses, authorities and researchers.

Towards a common European data space

The EU Coordinated Plan on Artificial Intelligence states that more data from public authorities and businesses should be shared and made available across national borders. The first step towards a common European data space is the PSI Directive, which will ensure that all EU Member States make certain spatial data, environmental data, weather data etc. freely available at the European level. The next step is to review the European frameworks for re-use of business data and the ongoing trials of data pools. In the research area, efforts are being made to improve frameworks for sharing and re-using research data across Europe through the European Open Science Cloud, where Denmark is participating in governing bodies. The initiative entails harmonisation of access principles, infrastructure and data management.

The European Commission will also carry out a review of the European framework for re-use of business data, including copyrights, display of data, as well as guidelines for data transfer in connection with changes of service providers. Denmark will influence this work to improve the possibilities of access to data, whilst complying with the principles of responsible use of artificial intelligence. This will benefit the competitiveness of businesses.

Finally, Denmark will work to ensure a good framework for sharing data between businesses in the annual review of the EU Plan on Artificial Intelligence. This applies in particular to the European Commission's proposal on data pools, which the government will monitor closely.

III Strong competences and new knowledge

Digital competences are key to using artificial intelligence.

In order to make the best use of the opportunities offered by artificial intelligence, businesses and the public sector must have access to employees with the right competences.

This applies in particular to IT specialists with experience in developing and using artificial intelligence. IT specialists typically use their technical expertise – for example computer scientists develop algorithms. However, this also applies to employees with more general digital and technical competences, who can apply the technology in their day-to-day work. For example, an administrative employee who has to understand and act on recommendations from an IT system.

Technology only adds value in its interaction with people. This means that artificial intelligence should not replace people, but instead be used by people to improve conditions for individuals and for society. Therefore, there is a need to improve digital competences and digital understanding in the entire population, so that we can benefit from the possibilities of the technology.

This means that it is important to train more young people with the right competences to use artificial intelligence. However, it is also important to upgrade the skills and qualifications of existing employees, so that they can carry out their tasks in new ways and with new technological devices.

Today, IT specialists constitute just over 4% of the employed in Denmark. In a survey of Danish businesses, 60% of businesses that have tried to recruit IT specialists state that they are facing challenges with regard to recruiting IT specialists (Statistics Denmark, 2018). At the European level, there is an estimated demand of 600,000 IT programming specialists. This demand is expected to increase in the years to come (EU, 2018).

On some parameters, things are going in the right direction. The intake to higher education IT programmes in Denmark rose by 50% in the period 2009-2018 (coordinated enrolment system, 2018). Denmark ranks fourth out of 35 OECD countries in terms of training young

individuals within information and communications technology (OECD, 2016). However, focus must be maintained for Denmark to become a frontrunner in development and use of artificial intelligence.

Case: New education programmes on artificial intelligence

New programmes on artificial intelligence are constantly being set up. For example, in 2018 the Technical University of Denmark set up a new BSc programme on artificial intelligence and data. In 2019, the University of Copenhagen will set up a new BSc programme on machine learning and data science. On Danish artificial intelligence programmes, students not only work with large amounts of data and algorithms, they also discuss the ethical choices that will often be part of programming and designing algorithms.

Strong research culture

There is a global race within research in artificial intelligence, in which countries such as the US and China are investing massively in research in the technology.

Even though Denmark does not measure up to large nations in terms of scope of research, Denmark stands strong as a research nation with good research environments within artificial intelligence. And Denmark is proportionally among the largest global investors in public research.

In order to help support development of artificial intelligence, Denmark must strengthen research efforts within the area. Denmark must ensure that future research talents have good conditions to provide useful technological solutions for individual, businesses and the public sector. This will fulfil the potentials offered by artificial intelligence in the short term. But it will also pave the way for scientific ground-breaking results, contributing to the fundamental development of the technology in the long term.

Enhanced research efforts will also help ensure that Denmark can influence the development of artificial intelligence according to Danish values. Strong focus on responsibility and ethics is already a consistent feature in Danish research into the technology.

As a small country, Denmark cannot build the necessary infrastructure on its own. On the other hand, the EU will be investing massively in building research infrastructure within artificial intelligence in the years to come. In this context, Denmark needs to ensure easy access to the most recent technological facilities for Danish researchers and businesses. For example, in 2018 Denmark joined the European High Performance Computing Joint Undertaking (EuroHPC), which is to develop a future European supercomputer that can process huge amounts of data for use in climate-change and cyber-security research, for example.

The government will act on several fronts, which together will establish a solid basis for developing and using artificial intelligence. A number of initiatives will support strong research efforts while at the same time strengthening employee competences and understanding of technology to maximise Denmark's new technological possibilities in the long term.

A solid foundation

The government has already launched several initiatives to improve the frameworks for strengthened digital competences and understanding of technology as well as research into new technologies, including artificial intelligence. The new initiatives should therefore be seen in the context of existing initiatives.

Teknologipagten (Technology Pact) and the future STEM action plan will raise the skills of the workforce, and it is important that more young individuals are encouraged to take digital and technological education programmes focusing on artificial intelligence, for example. In *Teknologipagten*, the government has set a goal that in 10 years Denmark will have about 10,000 more people with higher or vocational qualifications within the so-called STEM disciplines.

The government has launched a talent programme to provide the most talented and motivated students with better opportunities and greater challenges, so they become even more skilled within their fields. The government will set aside a pool of DKK 190 million (EUR 25 million) to cover all technical fields, including new technologies like artificial intelligence.

As part of the government's *Strategy for Denmark's Digital Growth*, a trial programme has been launched to enhance understanding of technology in compulsory programmes at municipal primary and lower-secondary schools. The objective is to ensure that all students learn to reflect critically about technology and shape it rather than use it.

As part of the follow-up to recommendations from the Expert Committee on Quality in Higher Education in Denmark, in the coming years the universities will work on integrating into programmes competences such as coding, data analysis and understanding of technology. The aim is that students be trained in reflecting on, and being critical about, ethical and societal consequences of technological developments and that they gain a better understanding of the digital technologies and possibilities of individual education programmes.

Based on the work by *Disruptionrådet* (Disruption Council), a number of projects will also be carried out to improve the digital competences of teachers on relevant higher education programmes. This will put teachers in a better position to use digital solutions and to link understanding of technology with their academic core competences as well as strengthen their understanding of, and critical position on, digital technologies such as artificial intelligence.

Denmark currently has innovation centres in eight cities to build a bridge to some of the strongest partners within research, higher education and business development in some of the world's leading innovation communities. The centres also support collaboration on artificial intelligence between Danish and international researchers and businesses. For example, the innovation centre in Silicon Valley and the Danish Academy of Technical Sciences together offer an "Applied AI Academy"; an exclusive and intensive training course for Danish technology leaders from knowledge institutions, public authorities and businesses.

Moreover, partnership agreements with American elite universities have been entered into through the innovation centres in Silicon Valley, which each year offer up to 20 Danish PhD students and researchers within, for example artificial intelligence, a place at Massachusetts Institute of Technology (MIT) and at the Center for Information Technology Research in the Interest of Society (CITRIS) at UC Berkeley.

In the 2019 State Budget, the Danish government has allocated DKK 215 million (EUR 27 million) to Innovation Fund Denmark to conduct research into new technological possibilities. The Budget also allocates DKK 80 million (EUR 10.7 million) to the Independent Research Fund Denmark to conduct research into digital technologies, including artificial intelligence. In the years ahead, the government will continue to prioritize research into digital technologies, such as artificial intelligence.

As part of the funds allocated for research into new technological possibilities under Innovation Fund Denmark, DKK 100 million (EUR 13.4 million) will be earmarked for a national centre for research into new digital technologies. The centre will help build the talent pool in the area, so that, in the future, Denmark will have an even better basis for influencing the development of artificial intelligence.

Furthermore, Innovation Fund Denmark's implementation of funding for strategic and challenge-driven research will also be based on the FORSK2025 catalogue. One of the four overall themes in the catalogue – *New technological possibilities* – provides a natural focus on new technology and digitisation in research investments.

Case: Artificial intelligence provides better food safety

Today, X-ray inspection requires unique solutions for each product to be tested. For example, one solution is used to find out whether a potato is rotten, whereas another solution is used to find out whether cold cuts have been contaminated with metal chips. Innovation Fund Denmark is supporting a project to develop quality control of food, for example, using X-ray inspection. The aim of using artificial intelligence is to eliminate the need to develop unique software solutions for each individual product, allowing the system automatically to learn to distinguish between good and faulty products.

Artificial intelligence requires access to large amounts of data. Full exploitation of the possibilities in the development of data requires a supportive digital research infrastructure that can handle transport, processing and storage of data. A strategy for national collaboration on digital research infrastructure has therefore been prepared to provide the best possible digital tools.

Government initiatives

Artificial intelligence places new demands on the labour market and competences. Consequently, the government has already launched a number of initiatives in the area. The government will continue its work and at the same time implement further initiatives focusing particularly on artificial intelligence.

The government will implement the following initiatives:

1. Dialogue with research funding foundations on artificial intelligence.
2. Stronger digital competences in central government
3. Strong Danish participation in the EU Framework Programme for Research and Innovation
4. Stronger digital competences through adult, continuing and further education

The initiatives supplement existing efforts:

- Teknologipagten (Technology Pact): More young people on technological and digital education programmes
- Talent programme for the most talented students on higher education programmes
- Improved digital competences and better understanding of technology in primary and lower secondary schools and in higher education
- Priority of more funding for research into new technological possibilities and digital technologies
- National centre for research into new digital technologies
- Stronger digital research infrastructure

Initiative 3.1: Dialogue with public research funding foundations on artificial intelligence

The public research funding foundations implement funding for research projects in open competition on the basis of a professional assessment of quality and relevance. Some research communities are, however, experiencing that research into artificial intelligence and data science does not always fit into the programmes and application categories of the foundations.

The government will therefore engage in dialogue with the foundations to clarify whether there are appropriate and clear support options for research projects within artificial intelligence and data science, including inter-disciplinary research.

Initiative 3.2: Stronger digital competences in central government

The need for employees with technological understanding and competences is increasing in line with more authorities using artificial intelligence. One of the ambitions of the government in the *Strategy for ICT Management in Central Government* is to enhance digital competences in central government. For example, the government will establish a digitisation academy offering continuing training courses to generalists in central government.

In order to improve the competences of government IT specialists, the government will engage in dialogue with Danish universities working with artificial intelligence at a high level with a view to developing courses aimed at IT specialists. The courses will include the latest research results and be based on specific experience and projects from relevant authorities.

Initiative 3.3: Strong Danish participation in the EU Framework Programme for Research and Innovation

The EU Framework Programme for Research and Innovation has increased focus on artificial intelligence. The government will work for strong Danish participation in the area. This work will help ensure that potential Danish applicants have a clear understanding of their possibilities within artificial intelligence in the Framework Programme (both the current Horizon 2020 and the future Horizon Europe), and it will forge better conditions for applicants through guidance.

Initiative 3.4: Stronger digital competences through adult, continuing and further education

As a result of technological developments, there is a constant need to be able to offer opportunities for upgrading skills. The tripartite agreement from October 2017 put focus on creating a vocational adult education and training system that is better geared to strengthening digital competences of the entire work force and to adapting to the changing needs of the labour market. In order to support this, a transition fund of DKK 95 million (EUR 12.7 million) annually was set up. In addition to the transition fund DKK 8 million (EUR 1.1 million) is allocated to additional activities.

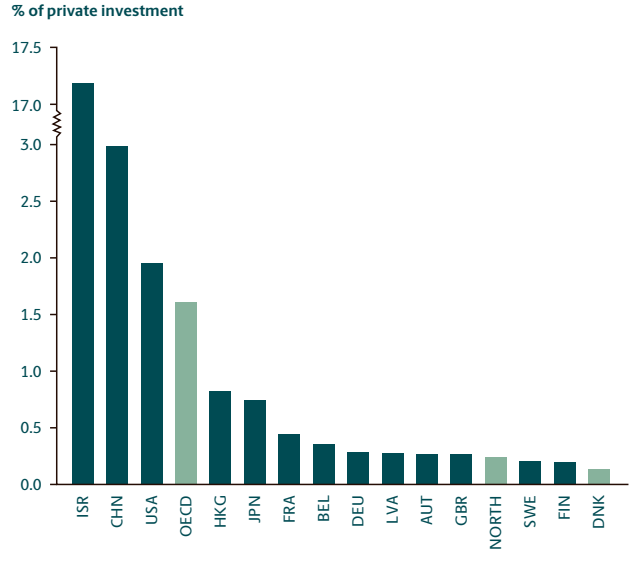
In collaboration with the social partners and representatives from higher education institutions, the government has set up a vocational adult education and training working group which, among other things, will advise on the competence needs of the labour market in the light of technological and digital developments. As part of this *National Strategy for Artificial Intelligence*, the working group will examine whether there is a need to launch initiatives on the basis of the development of artificial intelligence, for example in the form of new education programmes, analyses and development projects. An annual amount of DKK 5 million (EUR 670,000) has been allocated for initiatives by the working group.

IV Increased investment in artificial intelligence

Access to risk capital and more experience with artificial intelligence are crucial for businesses and authorities to develop, test and start using the technology.

Investment in both the private and the public sector is necessary if the growth and prosperity potentials from artificial intelligence are to be realised in Denmark.

Few Danish investments in artificial intelligence, 2008-2018



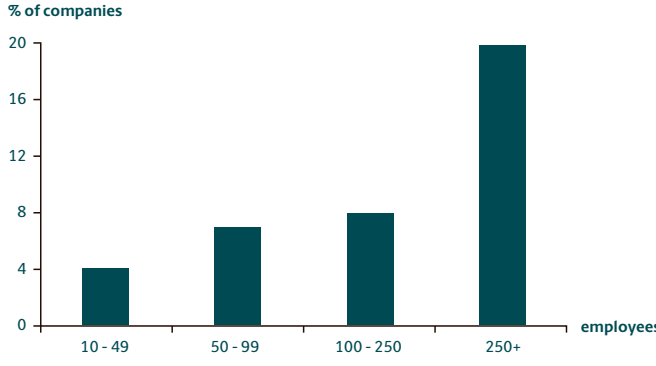
Note: The figure shows venture capital, private equity and M&A investments in artificial inte lligence and big data companies in the period 2008-2018 in relation to total private investments. The leading position of Israel is driven by a strong start-up community within artificial intelligence. The level of investment for 2018 was calculated in November 2018. The figure does not cover internal investments in businesses. Nord indicates the countries Finland, Sweden, the UK and Germany.

Source: The Impact of Artificial Intelligence in Denmark, McKinsey 2019.

Denmark is currently lagging behind comparable countries such as Finland, Norway and Sweden with regard to private investment in artificial intelligence. In the long term, this may challenge the competitiveness of Danish businesses.

Even though some Danish businesses are at an advanced stage with artificial intelligence, the level of use in Denmark remains relatively low. Only 5% of businesses are currently using the technology. Of all large Danish businesses with 250 or more employees, only one in five uses artificial intelligence. There is thus still a large untapped potential.

Large businesses use more artificial intelligence, 2018



Note: Data only available for businesses with more than 10 employees. Artificial intelligence is measured as the use of machine learning.
Source: Statistics Denmark 2018.

A similar picture exists for the public sector. A survey of Danish municipalities shows that only 3% of municipalities are currently using artificial intelligence to improve their services. However, as many as 55% expect to have implemented the technology in some areas within the next three years (KMD Analyse, 2018).

In order to stimulate investment in artificial intelligence in both the public and the private sectors, it is therefore necessary to generate, gather and disseminate experience with the technology and its uses. This will increase the knowledge of employees and leaders about what artificial intelligence can and cannot be used for. At the same time, this will promote a more well-established market for consultancy and services within artificial intelligence.

The government will therefore launch a number of initiatives to promote investment in the public sector and among businesses developing Danish solutions. The initiatives are to help boost development, testing and use of artificial intelligence by improving access to capital, consultancy services and experience in the area.

Pilot project on digital inquiries in the education sector

The Danish Ministry of Education is an example of a public authority that receives many inquiries from both institutions and citizens. Therefore, a pilot project will be launched as part of the National Strategy for Artificial Intelligence on use of chatbots by the Ministry of Education. A chatbot could be used in direct contact with citizens, but it could also serve as a support tool for employees who engage in dialogue with citizens.

Furthermore, the government will work to attract to Denmark international businesses with core competences within artificial intelligence. This will attract specialist knowledge and labour to Denmark and create an entrepreneurial environment for artificial intelligence in Denmark.

The initiatives will support implementation of artificial intelligence in the public sector. The ambition of the government is to allocate with the municipalities and the regions DKK 200 million (almost EUR 27 million) to establish an investment fund to test and deploy new technologies and digital welfare solutions in municipalities and regions. Together with initiatives already launched, the fund will have a total investment budget of DKK 410 million (EUR 55 million) up to 2022.

Especially businesses are dependent on being able to test new products and solutions. Therefore, performance contracts have been set up with seven Danish GTS institutes (approved technological service institutes) to test new solutions. More than DKK 600 million (EUR 80.5 million) have been set aside to develop technological services for Danish businesses for the period 2019-2020. This will supplement the funding that has been set aside under Innovation Fund Denmark, which also promotes new technological solutions, see focus area 3.

Government initiatives

The government will implement the following initiatives:

1. Signature projects
2. More investment in Danish businesses
3. Exploration of the possibility of an investment agreement with the EU
4. Increased knowledge-sharing across public authorities
5. Denmark as an attractive growth environment

The initiatives supplement existing efforts:

- Investment fund for new digital technologies and digital welfare solutions
- Performance contracts with GTS institutes (approved technological service provider)
- Strategy for Denmark's Digital Growth

Initiative 4.1: Signature projects

Using artificial intelligence holds great potential to offer better and more effective treatment in the healthcare system, more targeted case processing in the social sector, as well as quicker case processing at citizen service centres and in many other areas.

With *World-class digital services*, the government has launched a new investment fund aimed at municipalities and regions to boost the use of artificial intelligence and dissemination of digital welfare solutions.

However, there is a lack of experience. The government will implement a number of signature projects as quickly as possible to gather experiences of the use of artificial intelligence in the public sector.

The projects will test the technology in areas with a potential to enhance the quality and productivity of public-sector core tasks; however, specific experience in these areas is currently insufficient. Experience from these projects will contribute to mature solutions that can be used in all of Denmark.

The signature projects will be based on a public operating task, in which a solution with artificial intelligence that can provide better services for citizens has been developed in collaboration between the public sector and the private sector.

The government has selected three areas where signature projects will be launched: healthcare, the social and employment areas as well as cross-authority case processing. Common for the three areas is the large volume of tasks, and using artificial intelligence can

thereby benefit many citizens. At the same time, due to the abundance of data, these three areas provide a good basis for testing artificial intelligence.

Within each area, projects will be selected in collaboration with municipalities and regions in connection with the annual budget agreements. The projects selected will receive funding to test the use of artificial intelligence. Signature projects will be followed up and new signature projects will be launched in the strategy period for 2019-2022.

All signature projects will be implemented in accordance with the ethical principles that constitute the common framework for development and use of artificial intelligence.

Healthcare areas

Artificial intelligence can help improve the healthcare sector by improving patient treatment and optimising hospital operation. In addition to signature projects, objectives for healthcare will be set (see the chapter on priority areas) which support the proposed healthcare reform and a stronger, close and cohesive healthcare system, and thus have a structural and long-term perspective.

Example of a signature project: Healthcare areas

Artificial intelligence for quality development in primary healthcare:
In primary healthcare, the technology can be used to support the work of general practitioners. With help from the technology, physicians will be able to notify the normal test results and identify abnormal test results more quickly. Artificial intelligence can also serve as decision support and, for example by assisting physicians in common tasks and diagnosing rare diseases.

Within healthcare, artificial intelligence is likely to help quicker and better treatment in areas such as planning cancer treatment, predicting the course of diseases, time-critical diagnostics in the acute area as well as decision support for general practitioners regarding rare diseases.

Social and employment areas

In the social area, artificial intelligence can contribute to more individualised efforts, so that citizens are referred to the right place from the very beginning. Case officers can receive decision support for preventive and individualised efforts on the basis of knowledge from previous cases.

Example of a signature project: Social and employment areas

Artificial intelligence for targeted employment efforts
Using artificial intelligence will potentially shorten unemployment periods. Analysing patterns in historical data on successful efforts will make it easier for case officers to target employment efforts to the individual citizen.

Artificial intelligence can be used in the employment area to better match citizens and businesses on the basis of job ads and applications. Artificial intelligence can potentially customise an optimal course for the individual citizen to get a job quickly, and better target programmes for citizens. Moreover, artificial intelligence can screen for possible long-term unemployed individuals in order to offer preventive measures.

Cross-authority case processing

Each year, the public administration processes millions of cases and it is contacted millions of times by citizens and businesses. Artificial intelligence can utilise data in new ways to improve the quality of citizen service centres, make problem-solving more efficient, and increasing confidence in the public administration.

Among other things, the technology can automate sorting inquiries and prepare inquiries for processing. This means that case officers can concentrate on the most critical cases.

Optimisation within case processing is relevant across several professional areas, including the technical and environmental area, the citizen service centres, the benefits area, the subsidies administration area, etc.

Example of a signature project: Cross-sector case processing

Artificial intelligence for better and quicker case processing in building projects
Artificial intelligence is likely to be used to reduce processing times when citizens or businesses need to get a building project processed. For example, in connection with screening applications, comparison with similar projects, categorisation of projects and decision support in case processing.

Initiative 4.2: More investment in Danish businesses

The government will launch a pilot project in the form of an investment pool of DKK 20 million (EUR 2.7million) over four years, and this will be targeted at enterprises with a business model based on artificial intelligence. The fund will be managed by the Danish Growth Fund.

The aim of the project is to build a bridge between investors and Danish businesses within artificial intelligence and thereby nurture the Danish market for artificial-intelligence solutions. The Danish Growth Fund will therefore enter into dialogue with potential private investors about co-investing in innovative businesses within artificial intelligence.

There will be requirements for private co-investment from private investors in businesses funded by the Danish Growth Fund with the investment pool, for example. The pool can be implemented as loans or equity, depending on the specific need in the individual business.

Given the requirement for private co-financing, the initiative will have a leverage effect, as private capital is also invested in the businesses. If the private level of funding is assumed to be about 50%, about DKK 40 million (about EUR 5.4 million) will be invested in the development of Danish businesses based on artificial intelligence.

The effect of investments will be regularly reviewed and the project will be adjusted accordingly.

Initiative 4.3: Exploration of the possibility of an investment agreement with the EU

The Danish Growth Fund assesses that almost 4% of the businesses in which the Fund is currently investing have a business model based on artificial intelligence and big data.

In order to promote further investments in artificial intelligence, the Danish Growth Fund will examine the possibility of establishing an investment agreement with the upcoming EU artificial intelligence foundation in areas that are a natural extension of current investments by the Danish Growth Fund.

The investment agreement will potentially be able to help businesses and entrepreneurs in Denmark to gain easier access to funding more risk capital from the EU.

Initiative 4.4: Increased knowledge-sharing across public authorities

The National Centre for Public Sector Innovation (COI) will support more effective deployment and use of new technologies, including artificial intelligence, across the public sector. This is done by disseminating experience from research and specific testing and deployment projects.

COI will also help strengthen public-private collaboration, so that the public sector incorporates private sector competences, resources and experience to a greater extent when developing services.

Initiative 4.5: Denmark as an attractive growth environment

Under the Strategy for Denmark's Digital Growth, the government has allocated DKK 110 million (EUR 15 million) for the Digital Hub Denmark initiative, which, among other things, is to market and strengthen Denmark's position as an attractive growth environment for artificial intelligence.

In this connection, initiatives will be launched to promote Danish solutions for global tech events and trade missions, to present Danish solutions, to initiate a digital campaign on responsible use of artificial intelligence in Denmark, etc.

At the same time, Digital Hub Denmark will help increase focus on attracting foreign investment in the digital area.

In 2019 , Digital Hub Denmark will also spend up to DKK 7 million (EUR 930,000) to develop public-private collaboration models to, among other things, improve the possibilities for life-science businesses to use, for example artificial intelligence in connection with research into health data.

Priority areas

To lift the work of artificial intelligence in Denmark goals are set out within priority areas.

Artificial intelligence is developing rapidly, and the possibilities are increasing across sectors, industries and functions.

Artificial intelligence will affect all of society. However, in some areas, Denmark has particularly good preconditions for using artificial intelligence, for example good data. The government has therefore selected four areas where special measures will be implemented for work on artificial intelligence.

These areas are healthcare, energy and utilities, agriculture and transport. The areas have been selected as the preconditions for using artificial intelligence are good, for example both businesses and authorities have access to high-quality data. Similarly, the EU points to the same areas as important in realising the potential of artificial intelligence in Europe.

On this basis, the government will formulate objectives for how these areas can exploit the opportunities within artificial intelligence to strengthen Denmark's position internationally. The objectives will be formulated by the responsible ministries and involving relevant stakeholders. The work will be coordinated across ministries and with initiatives that have already been launched.

The objectives will take their outset in the areas' own ambitions and experience with digitisation and work on artificial intelligence.

The government wants to follow-up artificial intelligence work in the sectors. As part of the ongoing work on the *National Strategy for Artificial Intelligence*, the objectives will therefore be followed up to ensure that Denmark reaches the full potential in the areas. The government will ensure that the strategic sectors have access to expertise and consultancy in connection with preparation and coordination of action plans.

Priority areas

Healthcare
Artificial intelligence in healthcare can help physicians to diagnose diseases quicker, prioritise patients with the most acute needs and contribute to better capacity utilisation at hospitals. Similarly, there is potential in supporting more targeted efforts in the local healthcare system.

Energy and utilities
Businesses within green energy technology and environmental technology can use artificial intelligence to develop new products, services and business models. The products can help other businesses as well as consumers to optimise their energy consumption and thereby reduce their costs and carbon footprint.

Agriculture
Artificial intelligence can be used to support the development of precision agriculture in order to continue sustainable agriculture in Denmark. By combining data from fields and weather data, artificial intelligence can predict which fields need water and fertiliser, and make adjustments accordingly. This will benefit the environment as well as agriculture.

Transport
In the transport area, artificial intelligence can be used in self-driving cars and to ensure better and more timely public transport. Furthermore, new solutions can be developed to optimise traffic management to benefit users of both public and private transport.

5.1 Healthcare

The healthcare sector is an area in which expertise and technology are developing, and changing the way in which we provide services. The healthcare system has regularly transformed technological advances into new opportunities within diagnostics and treatment. This provides better results for patients.

Artificial intelligence is a logical step in this development. The technology can contribute to creating a more effective healthcare system offering treatment based on the needs of the individual patient. Smart solutions can contribute to improved quality and coherence in patient treatment and also help healthcare staff in their tasks. A modern and effective healthcare system should therefore take a position on how staff can use artificial intelligence as a tool to add value for patients and relatives.

The healthcare system is currently facing a number of challenges: A population where the percentage of elderly is increasing, chronic diseases are becoming more challenging, and hospitals are having to provide targeted diagnoses as well as high-quality treatment. To deal with these challenges, the healthcare sector needs to collaborate closer with the primary healthcare sector and municipal care.

At the same time, there are increasing expectations concerning treatment and procurement of new medicine, and there is a growing need to monitor side effects and the effects of pharmaceuticals. This stresses the importance of continuous innovative thinking. New, more accurate and effective tools must be found to carry out the tasks and deal with the challenges that the healthcare system is currently facing and will continue to face in the years to come.

The government has already set a direction for the healthcare system of the future with the *Digital Health Strategy 2018-2022* and with the health data initiative *Health in the future,* where utilisation of new technologies, such as artificial intelligence, is a common theme. In addition, with *World-class digital services*, the government has allocated funds to deploy and test new technologies in the health area, for example.

For patients, artificial intelligence will lead to better, quicker and more customised diagnosis and treatment. The technology can also help earlier prediction and prevention of diseases.

For hospitals, artificial intelligence means that new opportunities arise for managing the logistics behind patient treatment more efficiently and accurately. This will ultimately benefit patients and healthcare professionals as it frees resources for patient contact.

For physicians – in primary healthcare and at hospitals – artificial intelligence can help them make the right decisions. This again means better opportunities for quick and accurate diagnosis and better opportunities to focus on patients who require special attention.

Project with artificial intelligence in healthcare

Identification of heart failure

Together with Corti, the emergency medical services at the Capital Region of Denmark have developed a solution which, by listening in when a citizen calls the emergency number, can help healthcare staff identify symptoms of heart failure which would not otherwise be detected over the phone. In these situations, the healthcare staff will receive recommendations or alarms on their screen to help them react quicker and correctly in the situation. In 84% of cases, the solution can identify situations of heart failure. This is quicker and more precise than the healthcare staff, who could only identify 73% of the heart failures correctly.

Artificial intelligence helps analyse CAT and MRI scans

One in six Danes will suffer a coronary thrombosis or brain haemorrhage, and this figure will increase as the population gets older. Aarhus University has developed a solution which saves time by using artificial intelligence to 'read' CAT or MRI images and to identify how much brain tissue can be saved for a given patient, and how much has already been permanently injured. The technology also enables smaller hospitals to offer state-of-the-art treatment. This will shorten transport time, thereby increasing the possibilities of minimising brain injury for many patients.

In this development, it is vital that we do not jeopardise the confidence of citizens and healthcare staff. Responsible development and use of artificial intelligence is a mandatory principle, particularly for patient treatment by the healthcare sector.

Therefore, citizens, patient associations and Danish businesses should help set the course in close collaboration with the health authorities. Clearly, these developments must also be within the legislative framework set by the Danish Parliament (the Folketing) regarding balanced and responsible use of health data.

In order to ensure cohesive efforts, the government will coordinate efforts and signature projects in the healthcare area, including funding from Investment Fund Denmark, with the parties within the framework of a more long-term plan for utilisation of new technology and innovation in the healthcare area.

5.2 Energy and utilities

Denmark is at the forefront with regard to ensuring sustainability, green development and sustainable energy. This benefits the environment and is a competitive advantage for Danish businesses in a time when green technology is in great demand throughout the world.

Artificial intelligence can help maintain our leading position and strengthen the green transition, for example by ensuring better coordination of production and transport, so that only the energy required is produced. This requires a more flexible and integrated supply system than today, and that we start using artificial intelligence to a greater extent.

The potentials are huge for data and the increasing digital transformation of the energy and utilities sector. Therefore, with the *Energy Agreement*, the government has launched initiatives to ensure a continued green transition in the energy and utilities sector, for example energy-efficient buildings. Data and use of artificial intelligence are key in achieving this goal.

The action plan for smart energy will examine how smart solutions can couple energy consumption closer to energy production. The government will also establish regulatory free zones that will make it easier to test smart energy solutions.

The initiatives have added direction and focus to the area. However, it is important to maintain this focus if Denmark is to remain at the very forefront. Several countries are currently investing and using artificial intelligence to support their green transition.

Project with artificial intelligence within energy and utilities

Better maintenance of electricity stations
Energinet has installed a number of sensors at selected electricity stations throughout Denmark. Artificial intelligence can be used to develop solutions that can recognise patterns, for example in sounds, vibrations or temperatures at the installation. The data collected can then predict when something at the station deviates from the norm and should be maintained or replaced. This releases resources and provides better and more effective monitoring for electricity stations.

More flexible and secure electricity supply
Danish electricity consumption fluctuates depending on time of year and time of day. By analysing consumption patterns, utility companies can adjust production according to demand, thereby saving resources. In the UK, the UK National Grid and DeepMind have developed a solution which can reduce energy consumption by up to 10%.

An important precondition for increasing the use of artificial intelligence in the energy and utilities sector is access to good data. For example, consumption data from electricity and water meters and from sensors in pipes, pumping systems and thermostats makes it possible to develop solutions which can optimise production and supply according to demand.

Release of consumption data in the utilities sector is one of the recommendations that has just been made by the growth team for green energy and environmental technology. In the Energy Agreement, the government has set up a secretariat for digitised public-sector services in the utilities sector, which, among other things, is to look at how utilities data can be made more accessible.

In addition to contributing to the green transition, better geodata can also help the business community to develop new and innovative solutions. For instance, good data can help telecommunications operators when new underground cables are to be laid, or the insurance sector where up-to-date data is necessary to calculate fair insurance premiums in the event of flooding and storm damage.

In order to create conditions for efficiency improvements and good growth opportunities in the business community, it is vital that geodata, including maps is up-to-date.

Today, mapping is carried out using aerial photographs, and the photos are then partly processed manually. This is expensive, and it takes a long time. Production time is particularly determined by how long data processing takes.

The government will therefore launch a **new project entitled "Automatic photo recognition GeoDanmark"** to provide access to better and up-to-date map data. A pilot project will be carried out on automatic identification of changes to buildings using artificial intelligence. This will make it easier to access map data and develop new solutions, for example to plan routes.

Up-to-date map data will also help in the public sector. It will make it easier for municipalities to prepare local development plans and follow up on flooding.

In the long term, the ambition is to automate the entire process of mapping Denmark, and the possibility to make the underlying algorithms available to the business community will be examined.

5.3 Agriculture

The agricultural sector has been a cornerstone of Danish society for centuries. Danish farms are some of the most efficient in the world. This is because the sector has kept up with the times and has continuously embraced new technologies. This is a competitive advantage that Denmark must maintain by continuing to develop its agricultural sector with new technology.

More use of new solutions that can increase efficiency in Danish agriculture is necessary. The agricultural sector is currently not only under pressure financially, but also in terms of access to qualified labour. Climate change demands new forms of production and efficient

exploitation of manure and pesticides. Finally, agricultural land is increasingly overloaded and it is being degraded by heavy machinery.

In agriculture, artificial intelligence enables farmers to spray exactly where weeds are growing and fertilise exactly where the yield can be increased, whilst protecting the areas with the highest runoff risks. Better use of resources will save the individual farmer money and benefit the environment.

In this way, using new technology can support the development of precision agriculture, so that sustainable agriculture can continue in Denmark.

Developing the agricultural sector will be on the industry's own terms and initiative. However, the government will provide the required framework in order to seize the opportunities for growth and improved competitiveness brought by artificial intelligence.

In partnership with the agricultural sector, the government has initiated a number of pilot projects. One project is examining how the amount of manure can be varied according to the needs of crops. This is possible by using data collected from sensors in the soil.

Irrigation is another area in which smart solutions can contribute to more intelligent and sustainable development. There is no reason to irrigate more than necessary, and field irrigation of sandy soils in correct doses can increase yields by up to 40%.

The government will also initiate **a new "Intelligent irrigation" pilot project** using artificial intelligence to develop a solution for intelligent crop irrigation. A system will be developed to predict irrigation needs and manage field irrigation. By creating new algorithms and combining weather data from weather stations and field data, the project will develop a system to predict which fields need irrigation and register where, when and how much has been irrigated. The possibility to adjust the level of irrigation to the actual needs for individual fields will benefit everyone. It will protect the environment, make work easier for farmers and enhance the competitiveness of Danish agriculture.

Project with artificial intelligence within agriculture

Agrointelli
This year, the Danish company Agrointelli launched their self-driving Robotti robot. The robot can be used for seedbed preparation, sowing, mechanical cleaning or to add nutrients. It navigates via GPS and optimises its own route in the field using artificial intelligence.

The Swiss Ecorobotix
Ecorobotix makes autonomous weeding solutions by combining robots and artificial intelligence. The solution can reduce pesticides use by up to 90%.

Herd Navigator
Herd Navigator is a fully automatic solution developed in Denmark to monitor the reproduction and health of cows. The solution conducts online analysis of data from sensors and cows and this provides farmers with information about animal health, reproduction and nutrition, etc.

5.4 Transport

Artificial intelligence has the potential to improve Danes' mobility and at the same time help make transport in Denmark safer, cheaper and greener. Advances within artificial intelligence can improve self-driving transport, enable delivery by drones, and optimise digital mobility solutions. Common for these advances is that they are largely based on effective access to, and analysis of, data.

The *Mobility for the Future* expert group (2018) sees great benefits from exploiting the capacity of the transport system through optimised traffic management and use of real-time data about traffic.

The transport sector has many private and public players on the market. Through more extensive data exchange, new solutions and business models based on artificial intelligence are likely to be developed.

Due to the high level of digitisation, Denmark is in a favourable position to utilise transport data. For example, increased exchange of data on timetables and real-time updates of operations and delays in public transport will prepare the ground for new public mobility services and business models.

At the same time, driver-assist technologies, and in the long term, driverless technologies, will be able to utilise real-time data to optimise route planning and improve safety. In September 2018, the *Easier Public Transport* policy initiative was launched. It contains a number of initiatives to promote the development of digital mobility services linking planning, payment and ticketing across private and public modes of transport.

For example, an initiative will be launched to ensure that transport data from public transport operators, including statistical and selected dynamic transport data, is shared and made freely available. It is also proposed that public transport operators enable resale of selected tickets through a third party, and this will support the market's possibility to develop new digital and innovative mobility solutions.

Project with artificial intelligence within transport

Fuel-efficient routes

Independent Research Fund Denmark is supporting a research project on the use of artificial intelligence that can guide transport operators to choose the quickest and most fuel-efficient route using big data on how traffic is moving at different times during the day. In collaboration with researchers from the US and Australia, researchers from Aalborg University will develop algorithms that can manage systems associated with great uncertainty. Independent Research Fund Denmark has granted DKK 5.8 million (EUR 800,000) to the project.

Artificial intelligence can also help prevent congestion. By analysing anonymised location data for mobile phones, it is possible to predict traffic flows and design better urban spaces and infrastructure.

The government will initiate a **new "Better use of location data for mobile phones" pilot project** in collaboration with the telecommunications industry. This initiative will support Denmark as a data-ethical frontrunner that also develops new innovative databased technologies. The pilot project will clarify the legal and data-ethical frameworks for displaying and using location data, and it will test the commercial possibilities of using location data for artificial intelligence. The data used in the pilot project will be aggregated and anonymised ensuring that only non-personal data are used.

Under the pilot project, the government will establish a closed 'sandbox' with anonymised and aggregated location data. This will provide a secure environment in which the authorities control access to data. Trials aimed at businesses will be initiated as 'challenges' and 'hackathons', where selected businesses will have access to data in the closed 'sandbox'. Among other things, the trials will identify aggregation levels of data that secure the anonymity of individuals, and at the same time trials will enable development of intelligent solutions to benefit citizens, businesses and authorities.

Initiatives in the strategy

Focus areas

I. A responsible foundation for artificial intelligence

1.1 Ethical principles for artificial intelligence
1.2 Establishment of the Data Ethics Council
1.3 Security and artificial intelligence
1.4 Legal clarity on development and use of artificial intelligence
1.5 Transparent use of artificial intelligence
1.6 Ethically responsible and sustainable use of data by the business community
1.7 Danish imprint on standards for artificial intelligence

II. More and better data

2.1 Common Danish language resource
2.2 Better access to public-sector data
2.3 More data in the cloud for artificial intelligence
2.4 Improved access to data outside Denmark for Danish businesses and researchers

III. Strong competences and new knowledge

3.1 Dialogue with research funding foundations on artificial intelligence.
3.2 Stronger digital competences in central government
3.3 Strong Danish participation in the EU Framework Programme for Research and Innovation
3.4 Stronger digital competences through adult, continuing and further education

IV. Increased investment in artificial intelligence

4.1 Signature projects
4.2 More investment in Danish businesses
4.3 Exploration of the possibility of an investment agreement with the EU
4.4 Increased knowledge-sharing across public authorities
4.5 Denmark as an attractive growth environment

Priority areas

- Healthcare
- Energy and utilities
- Agriculture
- Transport

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