DRIVE SWEDEN

AI as an enabler for safe and sustainable mobility

Strategic review of Drive Sweden with regard to Artificial Intelligence

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ABOUT DRIVE SWEDEN

Drive Sweden is a Swedish Strategic Innovation Program co-funded by Vinnova, the Swedish Energy Agency and Formas. Drive Sweden´s vision is to help Sweden taking a leading role in creating future mobility systems for people and goods that are sustainable, safe and accessible for all. The task is to drive the development towards sustainable mobility solutions by creating and demonstrating efficient, connected and automated transport systems.

Drive Sweden provides a platform and an ecosystem of leading experts from all sectors of society, where the partners work together across organisational boundaries. The work is structured around five thematic areas, all necessary components in the transformation ahead of us; digital infrastructure, policy development, business models, society planning and public engagement.

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DRIVE SWEDEN

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SUMMARY

In 2019, Vinnova gave all Strategic Innovation Programs a possibility to develop an AI strategy. Drive Sweden's vision is to help Sweden taking a leading role in creating future mobility systems for people and goods that are sustainable, safe and accessible for all. In this work, Drive Sweden has investigated how AI could support the vision. The aim of the work was to identify challenges, both for mobility of people and goods, where advanced data analytics or AI can be an enabler to solve the challenges. The work should also identify where measures may need to be taken to counteract the unwanted effects of AI. The review focused on the partners' needs and interest in the area of sustainable mobility solutions and AI. Data was collected by questionnaires, interviews and analysed in several workshops. The results are presented in detail in this report.

The review has resulted in both general results and a number of focus areas that could develop into new research and innovation projects. In the general perspective it is important to increase general knowledge of AI, to ensure trustworthy AI in the work ahead, and to emphasize the system perspective for the mobility system.

As a response to increase general knowledge, it would be beneficial to set up a strategic collaboration between stakeholders within Drive Sweden and AI Innovation of Sweden. The aim would be to increase the general knowledge and the potential of AI, share good examples of how to apply AI in mobility projects and networking to develop more concrete cooperation possibilities and projects. The collaboration should include regular meeting possibilities.

To ensure trustworthy AI, i.e. complying with all applicable laws and regulations, ensuring adherence to ethical principles and values and being robust from both a technical and social perspective, it is important that there is a work process built into every project starting. The EU report Ethics Guidelines for Trustworthy Artificial Intelligence[1] can be applied in doing so. In this work, collaboration with other Strategic Innovation Programs and AI Innovation of Sweden would be welcome.

In the work ahead with AI within Drive Sweden there is a need to focus even more on the system view of mobility and transport. This need has been particularly identified within in the following specific focus areas:

- Planning and maintenance of physical and digital infrastructure
- Traffic management for both national and urban roads
- Forecasting of transport needs
- Planned and real-time route optimization
- Support to users to make transport mode and route decisions

The necessary and relevant actors need to gather and together formulate concrete projects around the identified challenges. The priority of the cases depends very much on the response of the stakeholders to take ownership of solving the challenges. Therefore, one suggestion is to identify the interest by creating challenge-driven innovation activities that should answer to the focus areas presented in this report.

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PROJECT SET UP

2.1 BACKGROUND

Drive Sweden's vision is to help Sweden taking a leading role in creating future mobility systems for people and goods that are sustainable, safe and accessible for all.

Our task is to drive the development towards sustainable mobility solutions by creating and demonstrating efficient, connected and automated transport systems. It is also to provide a cross-functional collaboration platform to enable this. Drive Sweden functions as competence node and facilitator for networking, experience exchange, initiation and running of demonstration projects and to find gaps and challenges that need to be tackled in cooperation.

Drive Sweden is structured around five thematic areas, all necessary components in the transformation ahead of us; digital infrastructure, policy development, business models, society planning and public engagement.

During 2019, Vinnova gave all Strategic Innovation Programs the opportunity to develop an AI strategy for their respective areas. The question of how AI, digitalisation and automated transport systems can create value for societies is in the core of the program, and therefore, the initiative was warmly welcomed.

2.2 PURPOSE

The purpose of the work was to review ongoing and planned initiatives within Drive Sweden to identify areas where AI should be applicable to stimulate and strengthen the development towards sustainable mobility solutions for people and goods. The work should also identify where measures may need to be taken to counteract the unwanted effects of AI. As a result of the review a number of specific new initiatives with a major emphasis on AI should be identified, which are in line with the overall objectives of the program.

2.3 PROJECT PERIOD

The work took place from May 2019 until March 2020.

2.4 PARTNERS

The bulk of the review work was performed by Drive Sweden's program management together with RISE. Ericsson, Volvo Cars, Halmstad University and the Royal Institute of Technology has also participated in the project group.

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METHOD AND ACTIVITIES

Drive Sweden´s partnership is large and multidisciplinary (145 partners in March 2020) and the review focused on the partners' needs and interest in the area of sustainable mobility solutions and AI. The aim of the work was to identify challenges, both for mobility of people and goods, where advanced data analytics or AI can be an enabler to solve the challenges. The challenges should form the basis for new project initiatives with a scope that defines a specific mobility challenge, data sources and analysis methods.

To create interest in the area and identify AI-related challenges relevant for the Drive Sweden partners, a questionnaire was sent to all partners. At the time 111 organisations were partners and 22 responded. To complement the questionnaire, interviews were performed with 20 organisations, including private companies, research organisations and authorities. In total 29 partner organisations have contributed with input through questionnaires and interviews. See the interview questions in Appendix 1.

The results from the questionnaire and interviews have been analysed and boiled down to five focus areas. Further, the focus areas have been exemplified by cases where more detailed challenges are described.

Finally, the results from the review were presented and further developed during a workshop where Drive Sweden partners as well as some partners from AI Innovation of Sweden and Closer were invited. The overall results from the review as well as five focus areas are presented in chapter 4.

4

RESULTS AND DELIVERABLES

The review has resulted in both general results as described in chapter 4.1 and a number of focus areas described in chapter 4.2.

4.1 GENERAL RESULTS

In the general perspective it is important to increase general knowledge of AI, to ensure trustworthy AI in the work ahead, and to emphasize the system perspective for the mobility system.

Increase general competence

The review showed that some of Drive Sweden's partners have competence and are actively working with AI today. However, for many of the partners, the experience in the area is limited although the interest is growing. There is a general opinion that raising the level of competence is needed within AI and specifically of how AI or advanced analytics can be applied in the development towards sustainable mobility solutions.

Ethics and AI

Ethical work methods in applying AI and using personal or in other ways sensitive data has been brought up as key to ensure trustworthy AI. There is a need to define work processes that can ensure that the trust, not only between collaborating partners within Drive Sweden, but also in society as a whole.

On 8 April 2019, the High-Level Expert Group on AI presented Ethics Guidelines for Trustworthy Artificial Intelligence. It summarises that:

"Trustworthy AI has three components, which should be met throughout the system's entire life cycle: (1) it should be lawful, complying with all applicable laws and regulations (2) it should be ethical, ensuring adherence to ethical principles and values and (3) it should be robust, both from a technical and social perspective since, even with good intentions, AI systems can cause unintentional harm. Each component in itself is necessary but not sufficient for the achievement of Trustworthy AI. Ideally, all three components work in harmony and overlap in their operation. If, in practice, tensions arise between these components, society should endeavour to align them."

The guidelines presented in the report can be used in future activities to develop, apply and assess the trustworthiness of AI.

Photo by Jonas Jacobsson

Emphasize the systems perspective

The review identified in different ways the need for a systems perspective related to AI and mobility. For example, there is a lack of AI algorithms for complete system decision making in Sweden and digital twins are not available for complete systems.

Drive Sweden, as a Strategic Innovation Program, should use its wide network and support the development of AI for sustainable mobility solutions with a systems perspective. The transport system, for both people and goods, is complex and requires interaction between many different stakeholders. Priority in the analysis has therefore been on system challenges where several actors, data sources and competences are needed to develop efficient solutions.

4.2 FIVE FOCUS AREAS BASED ON IDENTIFIED CHALLENGES

As a result of the analysis, and the need for a systems approach to be taken into account, the following five prioritized focus areas were identified.

1. Planning and maintenance of physical and digital infrastructure
2. Traffic management for both national and urban roads
3. Forecasting of transport needs
4. Planned and real-time route optimization
5. Support users to make transport mode and route decisions

Examples of cases that could be further developed are described for each area.

4.2.1 PLANNING AND MAINTENANCE OF PHYSICAL AND DIGITAL INFRASTRUCTURE

The planning and maintenance of physical and digital infrastructure is central for ensuring the day-to-day function of the modern transport system. While the planning and maintenance of much infrastructure has previously been based on coarse-grained estimates of use and wear, more fine-grained data and sensors can allow for better maintenance decisions. An example is predictive maintenance, allowing for service and repairs in good time before something breaks, yet not being done unnecessarily early.

Data also allows for making better decisions in planning stages. The capacity and placement of roads and public transport lines are examples of this, as is the development of charging stations for electric vehicles. As the availability of fine-grained mobility data becomes available, advanced predictive models can be leveraged to improve traffic flow and robustness, while avoiding bottlenecks and brittleness.

An integral part of modern vehicles is communication. The digital infrastructure is important both for autonomous vehicles and for vehicles supported by advanced driver-assistance systems (ADAS). The development of communication technology, such as 5G cellular networks, V2I, V2X, and the exploration of how best to utilize this in modern vehicles is a question that needs to be explored as this holds substantial promise for vehicles that rely increasingly on automated decision systems. Hybrid approaches to computation may need to be developed where the limited computation power of in-vehicle devices can be relieved when possible.

Example case: Maintenance of road infrastructure

Large efforts are put into road maintenance to ensure its quality. With the collection of finer-grained data, the maintenance can be set as a predictive maintenance problem. Sensors in vehicles and stationed at and around the roads will collect up-to-date data about the state of the road, and models can be trained to help make decisions of when to perform service and repairs.

Road maintenance is largely a task that is done using a schedule. When the schedule fails, roads may deteriorate, and problems arise for road users. Potholes, debris, or snow and ice may soon become hindering for traffic. Predictive maintenance is the use of data and predictive models to determine the right time for a particular service. Scheduled maintenance may fail in one of two ways: either the maintenance is done too seldom, or it is performed more often than necessary, leading to unnecessary costs. Performing the service at the right time is key to success.

By collecting the required data and learning to predict the right time for maintenance, costs may be saved from alleviating both these conditions. Funds can be used to further improve the maintenance, and the end result is a road system of higher quality for the road users.

Data sources

Road user movement data (e.g. from mobile phones) provides a signal about the wear of the roads. While this may be enough as a proxy for the expected wear, more fine-grained sensors such as cameras or vibration sensors in cars or close to the read could give a better signal of the magnitude of the actual wear of the road.

Photo by Peter van der Meulen

Analysis & AI methodology

Machine learning techniques will be required to make good predictions about the service needs. Deep convolutional neural networks provide a solid platform for the components working on image data. Further work is required to determine useful classes of machine learning models and algorithms, and to determine what data will be useful for the task.

Possible stakeholders

- Swedish Transport Administration
- Transport Administrations in cities
- Vehicle OEM and suppliers
- Technology providers within infrastructure sensing and analysis
- Universities and research institutes
- End users

4.2.2 TRAFFIC MANAGEMENT FOR BOTH NATIONAL AND URBAN ROADS

Traffic management is important to increase efficiency in the use of road infrastructure and to improve traffic flow. However, it is challenging due to the number and complexity of variables influencing the actual traffic flow and of their stochastic nature. The increasing amount of data made possible by connected travelers, vehicles, and goods transporters makes it feasible to search for models that can reflect some of the relationships between different variables and the resulting flow. Their ability to predict in real-time what will happen in the future coupled to traffic management and traveler actions is key to manage traffic flows efficiently.

One area of interest is dynamic speed advice, i.e. giving vehicles speed advice in real-time that is based on the current road conditions. Adapting speed to current conditions could increase road safety and improve traffic flows. A system that gives speed recommendations based on previous experience, predicted risks and benefits coupled to present status has a great potential.

Models that can predict the risk of accidents is a way to accomplish improved safety. Several factors and variables including built environment, traffic situation such as vulnerable road users, flow, surrounding vehicle locations, speeds, directions and density, as well as weather, sight, road surface condition, speed limits, vehicle efficiency and emissions, accidents, road work, and traffic management actions should be considered.

User acceptance of the data collection and the advice is crucial. Self-regulation should be one approach studied, as well as variable speed limits and feedback of compliance.

Example case: The Local & Live Speed Advice (LLSA) case

Today there is a general rule that vehicle speed shall be chosen in a safe way in relation to actual circumstances within specified speed limits. In some new vehicles, Intelligent Speed Adaptation is available, a system that supports the driver to stay within existing limitations. An implementation is underway of geo-fenced zones giving a finer geographic division for speed limits related to special needs at e.g. schools, sensitive infrastructures, etc. Zones within which maximum speeds can be varied within short notice (< 1 min) are under development.

To deploy this, road operator processes must be digitalized. There is also an ambition to introduce feed-back to drivers, vehicle operators, and other road users. The speed adaption to actual circumstances is still not good enough. Therefore, a service is envisioned which continuously supplies best estimated speed in every location. For the LLSA use case the general idea is to develop tools that take a system perspective and digitalizing necessary traffic management operations.

Benefits in general includes more relaxed drivers, reduced number of traffic accidents improved traffic flows and reduced congestion. Dynamic speed advice also has the potential to enable autonomous vehicles.

Due to complexity and efforts needed to collect data, a stepwise approach for the model and service function development is proposed. Possible steps for introduction are:

1. In geo-fenced zones based on historic data coupled to predicted traffic density, weather, road friction, sight, etc.
2. For actual positions on roads and crossings, also considering speed, position and paths of surrounding vehicles
3. Considering predicted over-all traffic flow in vicinity and surrounding areas
4. Considering predicted driver behaviors

Data sources

There are different data that are needed in traffic management e.g.
- Maps with recommendations of maximum speed, emission, access, capacity
- Status of weather, road friction, congestion, density of vehicles and road users
- Traffic signals, incidents/accident, and compliance with regulations
- Positions of people, goods units, vehicles, etc.

Photo by Luke Insoll

These data can be obtained in different ways from e.g.

- Road users and travelers
- Vehicles and load carriers
- Back offices of logistics and/or transport operators

A proper digital infrastructure for transferring and sharing this data need to be available.

Analysis and AI methodology

To develop models and prediction of safety risks and traffic flow [2,3,4,5,6,7,8,9,10,11,12,13,14] there is a need to use large amounts of data with well-defined semantics. Often there is a need to fuse and integrate data from different sources in a balanced way. AI-methods may be applied to interpret the signatures of the patterns, images, etc. monitored.

Predictive models of safety risks related to different input variables such as speed, distance between vehicles, objects in the roadway, driver, sensor and vehicle capabilities can be built with machine learning approaches including e.g. artificial neural networks and decision trees. Initially, supervised learning methodology can be used to train the models. Due to the low frequency of accidents, incidents and patterns that are typical before accidents should also be searched for in the data streams. High-risk locations, such as crossings, road sections where queuing often starts is in focus in order to reduce the amount of analysis. Having these patterns and incidents for a number of variables with enough data annotated, can be the base for the learning of the algorithms. To test the ability of the algorithms to predict incidents, data not used in the learning process should be used.

Reinforced learning approaches are envisioned to improve algorithms. An open system approach with sharing of algorithms and data between all actors can be a base for the harmonization of interfaces and cooperative behavior.

Possible stakeholders

Possible stakeholders for further development of the case are:

- Swedish Transport Administration
- Transport Administrations in cities
- Vehicle OEM and suppliers
- Technology providers within infrastructure sensing and analysis
- Universities and research institutes
- Transport service providers
- End users

Photo by Marcin Jozwiak

4.2.3 FORECASTING OF TRANSPORT NEEDS

Accurate predictions of transport needs allow mobility actors to correctly plan transport routes, determine the need for vehicles and drivers. The need to improve predictions and optimize transport flows exists for many different purposes. Planning of public transport routes, freight transport routes, transport needs of customers of car sharing services, bike sharing, e-scooters, and taxis are some examples.

The data used to make predictions are in some cases unique to the type of transport considered, but there is also data that is valuable for many different transport purposes. Specific data needed to predict freight transport needs could be input on the production planning of a factory. If the freight transport provides components to the factory it is important to plan the transport according to that specific need. More general data sources that could be used for varied purposes is e.g. information about travel patterns of people in a city. This kind of data can be used to predict the capacity need for various types of transport services.

The forecasting of transport needs can be done for a specific type of transport. However, to improve a system of e.g. transport services for personal transport, different options such as public transport, personal vehicles, cycling can be optimized to complement each other.

Predictive models can be trained using historical data and can further incorporate information about the current status of the transport system.

Example case: Predictive vehicle placement system

For many taxi companies, each taxi driver manually determines their own position while not in use. How well the position is optimized is based on the experience and knowledge of the driver. People working with dispatch can order cars to pick up locations.

Using predictive models, a system that has information about taxi locations can schedule a globally optimal placement scheme that takes historical travel patterns into account as well as current conditions: traffic state, event information, the availability of drivers and vehicles and their current locations.

E-scooter companies' way of working is an example of where data-driven predictions for the need of electric scooters are used and could be an inspiration to optimize a system of vehicles. Scooters are collected for recharging batteries and placed according to where they are expected to be of most use.

Photo by Robin Aron

In this approach, we employ a system-centric view. A solution that optimizes the vehicle location problem will be agnostic of modes of transportation. Placement of taxi cars will be optimized for their specific use and strengths, while electric scooters will be positioned with their use and strengths in calculation. Rental bikes and rental cars/carpool will also be taken into account. Extending the system to incorporate driverless autonomous vehicles should be considered.

Some work has been done to improve taxi dispatch using data-driven approaches [15]. These techniques could be further explored and extended for the tasks discussed in this section. Vehicles that will be positioned at the right place and time. Predictive data-driven systems allow for positioning vehicles in the right time before they are needed.

Data sources

- Road user movement data
- Event information
- Road works or other traffic disturbances

Analysis & AI methodology

Machine learning models that can train on historical data should be evaluated and developed for the task of predicting situations and locations of interest for the placement of vehicles.

Possible stakeholders

- Transport Administrations in cities
- Vehicle OEMs
- Transport service companies such as taxi, carpools, shared bikes and e-scooters
- Technology providers within transport analysis
- Universities and research institutes

Example case: Planning public transport lines

The planning of public transport lines is often done using statistics about the movement of people, in combination with utilization statistics for current public transport lines. These statistics are often of low resolution and infrequently updated, leading to suboptimal planning in the public transportation system. The planning of lines is often done manually or semi-manually [16 17].

In an improved way of working, the availability of fine-grained personal mobility data is assumed. The data could be gathered using smart phones of people who has opted in. The goal is to optimize a whole public transportation system based on real movements. This would entail minimized travel time, and fewer vehicle changes with shorter waiting time. Solutions that may be tried out during this study would rely on the availability of such fine-grained mobility data from individual travelers. The data would be processed using a system-view, with the goal of making the whole transportation system as efficient as possible.

Along with detailed data and predictions come detailed planning. A well-planned public transportation system has shorter waiting times and fewer changes of lines for the average trip of the general user of the system, but it will also mean that line operators get more detailed information about how to scale the transport so as to maintain a good fill-rate.

Data sources

High-resolution movement data. The data could be collected from smart-phones belonging to users of the transport system, after the users have downloaded a travel planning app and agreed to the data collection.

Analysis & AI methodology

Possible AI-related techniques to look into would be machine learning solutions to estimate the expected movement of people at any given time [18] [19] [20]. Furthermore, simulations and reinforcement learning approaches could be applied to estimate the system-level efficiency, and to perform updates of routes and lines based on the current use of the system. The optimization problem should not be viewed as a one-time offline task but should rather be viewed as a system where changes in the routes/lines may lead to changes in people's transportation patterns. Thus, the solution needs to adapt to a dynamically changing traffic system.

Photo by Jonas Jacobsson

Possible stakeholders

- Public Transport Authorities
- Transport Administrations in cities
- Transport service companies such as taxi, carpools, shared bikes and e-scooters
- Technology providers within transport analysis
- Universities and research institutes
- Construction companies within infrastructure and buildings

4.2.4 PLANNED AND REAL-TIME ROUTE OPTIMIZATION

Optimizing transport routes using advanced analytics and AI has the potential to save time in transports, decrease congestion and reduce emissions. Freight transports, public transport, personal transport with cars, bikes etc., transports for emergency vehicles and automated vehicles all have the need to optimize routes. The optimization needs to consider each transport mode, e.g. planning delivery tours for freight vehicles and re-routing them in case of traffic disturbances such as roadworks, accidents etc. but should also consider the optimization on a system perspective.

The system optimization should consider all transport modes, their specific conditions of operations and priority on the roads. Using more advanced AI, the potential to use data about intentions of the transport, the conditions such as vehicle size and accessibility can define better solutions for both planned and real-time route optimization. Re-routing advice may be a response to an accident or congestion build up.

Predictive flow models integrating several factors and variables, built up based on historic as well as actual status data, are needed. System optimization for traffic routing would be based on input from road authorities, goods transporters, public transport, and personal transport. This is a complex task and it is necessary to take on the task in steps, to manage the complexity.

Example case: Predictive and interactive re-routing of traffic

Traffic congestions may arise quickly due to accidents or over-utilization of road capacity. Applying predictive models to get quick insights before problems arise could improve the traffic flow in dense areas.

When congestion occurs in urban areas, drivers of private cars are often left without support. Vehicles in the public transportation system may get information from traffic control. In the vision, a system would be explored that detects load on city roads, and alerts people in real time to choose alternate roads or transport modes. The detection would be based on predictive models that monitors the current state of road usage and can detect risk of upcoming disturbances.

The *rerouter* would be a service of use to many different actors in the traffic. One use-case would be emergency vehicles that would get special treatment with highest priority in the rerouting system. But the system would also help other traffic users so that the system flows as good as possible given all circumstances. With predictive models that can alert the actors in traffic, many problems can be avoided.

Data sources

- High-resolution movement data (sensors on cars, cameras, crowd sourced data from mobile phones, etc.)
- Vehicles movements of different transport modes
- Planned and ongoing traffic work, other traffic disturbances or ongoing events
- Weather forecast

Analysis & AI methodology

To solve the problems outlined above, a number of phenomena need to be modelled. Machine learning techniques have demonstrated effective to create adaptive and effective warning systems that can signal in good time when congestions and traffic problems arise. The output from the resulting models may be used as input to route planning algorithms that can adapt to the current circumstances, and make sure that the resulting routes with enough certainty will produce recommendations that allow the whole traffic to flow.

Possible stakeholders

- Swedish Transport Administration
- Transport Administrations in cities
- Public Transport Authorities
- Freight forwarders
- Transport service providers
- Technology providers within transport analysis
- Universities and research institutes
- End users

Example case: Emergency vehicle route and placement optimization

For emergency vehicle the time to arrival is important, every second can make a difference. Applying prediction of optimal position of emergency vehicles, route optimization and estimation of what resources and competence is needed for the emergency case, will or can improve the emergency service and reduce fatalities and serious accidents by improving arrival time and help patients in a more efficient way based on their specific need.

Today there are several initiatives ongoing or finished that have the scope of traffic management and route optimization [21], improve the awareness of accidents with improved communication [22] or optimize location for emergency vehicles [23].

Data sources:

- High-resolution movement data (sensors on cars, cameras, crowd sourced data from mobile phones, etc.)
- Vehicles movements of different transport modes
- Planned and ongoing traffic work and other traffic disturbances
- Weather forecast
- SOS alarm information about position of patient and conditions on location
- SOS alarm data sources for estimation of needed competence
    - Health sensors, health journals
    - Emergency call information

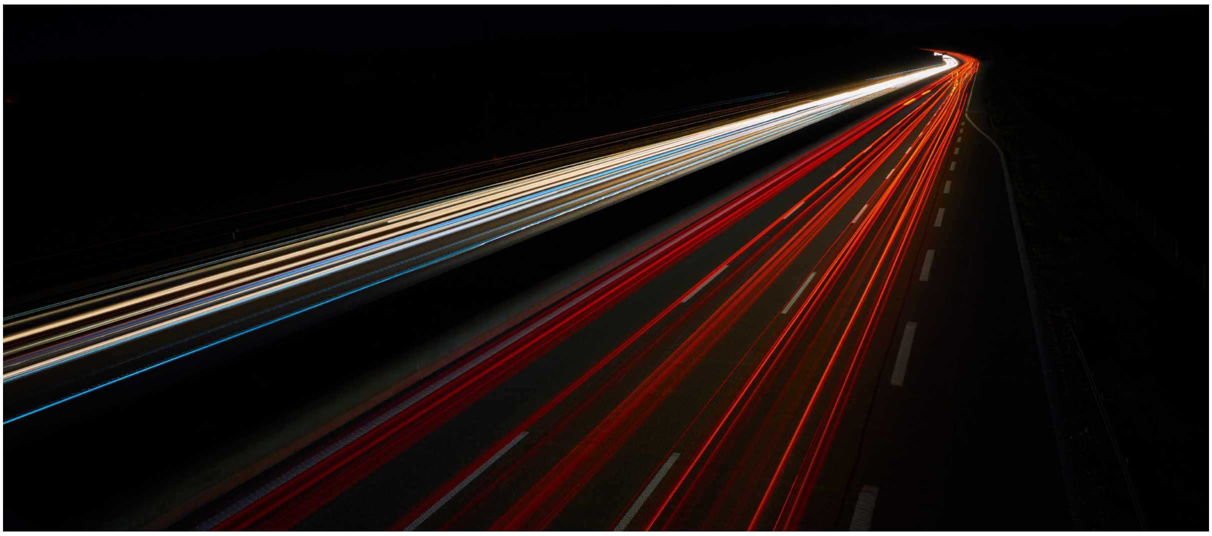

Photo by Christian Englmeier

Analysis & AI methodology

By using multiple sources of information and extended SOS alarm calls and statistics from previous emergency calls and accidents, a more efficient route optimization and placement for emergency vehicles can be made. The challenge is to get relevant information available so that machine learning or more advanced AI algorithms can be used. A possible addition to existing route optimization with increased precision in alarm handling and emergency care.

Possible stakeholders:

- SOS alarm
- Swedish regions
- Swedish Transport Administration
- Transport Administrations in cities
- Telecom operators

4.2.5 SUPPORT USERS TO MAKE TRANSPORT MODE AND ROUTE DECISIONS

To reduce the negative effects that personal mobility can cause such as emissions and congestion, and to improve the efficiency in the transport system, the development of shared mobility, or Mobility as a Service (MaaS) is important. Public transport is the foundation of shared mobility, especially in cities. As a complement to public transport, other services e.g. shared cars, shared bikes, e-scooters and new players in taxi services are entering the market.

With the development of MaaS, the options of both public transport services as well as private transport services are increasing and also becoming increasingly inter-connected. Compared to e.g. having and using your own car or bike, using shared mobility with a multitude of options is more complex and requires that information about the transport services is available and that the options are accessible to users. With this development there is a need to not only provide transport services to people that meet their needs but to also ensure that the development contributes to more sustainable mobility. Not only more mobility.

For shared mobility or MaaS to develop in an efficient and sustainable direction, it should be possible to find and access optimal transport modes easily. There is a need to take into consideration travel time and cost of different options, but also to understand how sustainable the different options are. To make daily travel decisions and e.g. choosing between taking the car, bus, bike or a combination of transport modes, a multi-modal travel planner where travel time, costs and sustainability (e.g. climate footprint) are considered would be beneficial for users.

As an example from Gothenburg, several different travel planners can be used for different purposes making travel mode decisions. At trafiken.nu there is a travel planner for the city Styr & Ställ rental bikes. At vasttrafik.se there is a travel planner for public transport. At google.com it is possible to compare travel options and times for walking, cycling, public transport and driving a car. Different service providers, e.g. for e-scooters and shared cars, have their own apps where it is possible to see the availability of the services. It is a challenge for users to consider and compare all options, which creates an obstacle in the use of them.

In Stockholm, Nobina has developed the travel app Travis [24] that collects travel options for public transport, several taxi providers, e-scooters from Voi and travel times by walking and using privately owned bicycle. It includes travel times and costs of the different options. It is a step forward to collect information of several different transport modes in one app.

Photo by Rodion Kutsaev

Example case: The pro-active travel mode planner

To predict possible transport alternatives and inform the user of the service options both in advance of travel and in real time would make it easier to use shared transport services. It has the potential to prevent congestion, optimize the traffic flow but also help the commuter to optimize the day to day travel. Just to give a suggestion of changing departure time from home or leaving the work can reduce the congestion and travel time for the commuters.

By using data about availability from transport providers as well as transport needs from users, it is possible to match the need to the options available. Based on the users' specific needs, e.g. disabilities, restrictions in time or cost, the planner could be able to adapt the options. Data from providers and users can also be used to analyse the system efficiency and give input to improve it. The transport system needs to balance the optimization between the individual users' specific needs, and the societal perspective including e.g. sustainability aspects.

Data sources

A proactive AI travel mode planner improves with the number of service option that are included and the accuracy of their respective data. Data provided from service operators would ideally include:

- Availability and conditions of use for transport services (public transport, cars, bikes, e-scooters etc.) including access and costs of service
- Environmental impact of using the service. A common and comparable method between actors and transport modes needed

Additionally, to determine travel time the following data is needed:
- Conditions of infrastructure (conditions of roads, disturbances such as road works)
- Traffic information (congestion) and statistics from previous traffic situation with similar conditions
- Weather forecast and weather information

User information and preferences:
- Users' specific needs such as disabilities, travelling with children, restrictions in time or cost the planner

Analysis & AI methodology

Predictive modelling using machine learning techniques trained on the data suggested above will be important components in the travel planner.

Possible stakeholders

Shared mobility services are both offered by public and private actors and they could potentially complement each other in a better way to meet the needs of the users. The possible stakeholder considered therefore consist of both public and private actors in the areas of transport and AI.

- Traffic administration offices in cities, e.g. in Göteborg or Stockholm
- Transport service providers (public transport providers, operators, car sharing companies, bike sharing companies, e-scooter companies)
- Map data providers
- Technology providers within transport analysis
- Research institutes and universities
- End users

5

CONCLUSIONS AND NEXT STEPS

The AI review has resulted in some general conclusions and five specific development areas. The first general conclusion is that experience and knowledge how to apply AI in solving mobility challenges is limited and there is a need to increase competence in the area. As a respond to this need, it would be beneficial to set up a strategic collaboration between stakeholders within Drive Sweden and AI Innovation of Sweden. The aim would be to increase the general knowledge and the potential of AI, share good examples of how to apply AI in mobility projects and networking to develop more concrete cooperation possibilities and projects. The collaboration should include regular meeting possibilities.

The second general conclusion is the need for clear ethical guidelines in the work ahead. As described in chapter 5.1, the work to ensure trustworthy AI includes complying with all applicable laws and regulations, ensuring adherence to ethical principles and values and being robust from both a technical and social perspective, to make sure it does not cause unintentional harm. For future projects within Drive Sweden, it is important that there is a process to ensure trustworthy AI. The EU report Ethics Guidelines for Trustworthy Artificial Intelligence can be used in projects to assess them, unless the actors already have established an alternative process to ensure trustworthy AI. In this work, collaboration with other Strategic Innovation Programs and AI Innovation of Sweden would be welcome.

The third conclusion is that in the work ahead with AI within Drive Sweden there is a need to focus even more on the systems view of mobility and transport. To make transports more sustainable and efficient it is necessary to include various and numerous actors in the system and Drive Sweden should use its wide network and established collaboration structure to drive this development. This need has been particularly identified within in the following specific focus areas:

- Planning and maintenance of physical and digital infrastructure
- Traffic management for both national and urban roads
- Forecasting of transport needs
- Planned and real-time route optimization
- Support to people to make transport mode and route decisions

To take the next steps and tackle the challenges in the identified focus areas, the need for relevant and reliable data is apparent. Looking at the areas, using data such as transport flows of people in the analysis could potentially help to solve several challenges. Considering both historical data and the present situation, it would support in the planning and maintenance of infrastructure but also in the forecasting of transport needs. An important step to take to make an impact of AI in mobility is therefore to focus on common data types and put special attention to types of data and sources that can solve several challenges. A strategic project within Drive Sweden, in collaboration with other relevant actors such as AI Innovation of Sweden, would be beneficial to investigate this area further. For that work to be successful, the involvement and contribution of many different public and private stakeholders will be crucial.

As a complement to a strategic project on prioritized data, it is necessary to continue the work with the individual focus areas and the specific cases. The necessary and relevant actors need to gather and together formulate concrete projects around the identified challenges. The priority of the cases depends very much on the response of the stakeholders to take ownership for solving the challenges. Therefore, one suggestion is to identify the interest by creating challenge-driven innovation activities that should answer to the focus areas presented in chapter 5 in this report. The set-up could be similar to the three-stage approach defined by Vinnova UDI (utmanings-driven innovation or challenge driven innovation) where funding is done in the three stages initiation, collaboration and implementation. This approach could possibly also support public sector partners in innovation procurement processes.

As a response to the latest open call within Drive Sweden, at least two projects are starting up, focusing in different ways on AI and mobility [25] [26]. Learnings from these, and other on-going strategic and open call-projects, will be presented at different occasions within Drive Sweden. Based on how the work that will follow this strategic analysis will develop, there is a possibility that the following open calls can in a clearer way target AI and mobility challenges.

6

FOOTNOTES

[1] *https://ec.europa.eu/futurium/en/ai-alliance-consultation*

[2] *https://www.researchgate.net/publication/330110260_Applications_of_Artificial_Intelligence_in_Transport_An_Overview*

[3] *https://towardsdatascience.com/live-prediction-of-traffic-accident-risks-using-machine-learning-and-google-maps-d2eeffb9389e*

[4] *https://www.researchgate.net/publication/295834239_Artificial_intelligence_techniques_for_driving_safety and_vehicle_crash_prediction*

[5] *https://medium.com/geoai/using-machine-learning-to-predict-car-accident-risk-4d92c91a7d57*

[6] *https://ieeexplore.ieee.org/document/7051936*

[7] *https://lup.lub.lu.se/search/ws/files/4434766/26516.pdf*

[8] *http://www.civil.uwaterloo.ca/bhellinga/publications/publications/trb%202003%20crash%20precursors.pdf*

[9] *http://n.saunier.free.fr/saunier/stock/saunier07probabilistic.pdf*

[10] *https://www.researchgate.net/publication/313128840_Predicting_Real-Time_Crash_Risk_for_Urban_Expressways_in_China*

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[12] *https://www.mdpi.com/2076-3417/9/13/2717/pdf*

[13] *https://www.intellias.com/machine-learning-ai/*

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[21] *https://www.drivesweden.net/projekt-3/trafikledning-av-utryckningsfordon*

[22] *https://picta.lindholmen.se/Via_Appia*

[23] *https://www.vinnova.se/p/prehospital-resursoptimering/*

[24] *https://gettravisapp.se/*

[25] *https://www.drivesweden.net/en/projects-5/intelligent-and-self-learning-traffic-control-3d-ai*

[26] *https://www.drivesweden.net/en/projects-5/stockholm-virtual-city*

APPENDIX 1

1. What parts of Drive Sweden's program area for sustainable mobility solutions does your organization focus on?

2. Are there areas where advanced data analysis could solve the challenges you have? If so, which areas?

   a. Do you work in these areas now and what could make your work more efficient?
   b. If you do not work in these areas. What is stopping you?
   c. What are factors or actions that would be possible?

3. Do you have examples of challenges where AI can be an enabler for solving problems?

   a. Could you use AI or ML today?
   b. What would make it possible or simpler to use AI or ML?
   c. Can you mention partners or organizations that you would like to collaborate with within AI applications. Why do you want to cooperate with these?

4. Do you have competence in the field of AI in your organization?

   a. Do you have requests for cooperation and which partners would be interesting?
   b. How would Drive Sweden contribute?

5. How do you think Drive Sweden, as a strategic innovation program, would best support the development of AI for sustainable mobility solutions?

   a. Describe one or more ideas for projects as well as the purpose and the partners that are important.

6. Are you familiar with other projects in Drive Sweden's areas of interest and AI. E.g. EU projects or other nations' research projects?