6GVISIBLE - INTELLIGENT MOBILITY FOR AUTONOMOUS DRIVING

Virve Karsisto [a], Marjo Hippi [a], Hannu Honkanen [a], Heikki Myllykoski [a], Kari Mäenpää [a], Seppo Pulkkinen [a], Nada Sanad [b], Etienne Sebag [a], Pertti Seppänen [b], Timo Sukuvaara [a], Anna Teern [b]

[a] Finnish Meteorological Institute, P.O. BOX 503, FI-00101, Helsinki, Finland. *virve.karsisto@fmi.fi*, ORCID: 0000-0002-5212-1002

[b] University of Oulu, P.O. Box 8000, FI-90014, University of Oulu

Summary

6GVISIBLE project's aims are to develop enhanced solutions for autonomous driving, and to validate a 6G network technologies' support for safety-critical services. The project includes several different topics: 1) Evaluation of autonomous vehicles' sensor systems sensitivity to harsh weather conditions, 2) Development of road weather services for autonomous driving, 3) Development of precipitation nowcasting web application, 4) Using knowledge modelling to do route planning, 5) Building machine learning model to quantify the effects of weather parameters on accident risk.

Introduction

Current technical solutions for autonomous vehicles already provide precision and reliability sufficient for many applications. However, there are still many limitations considering the detection of varying weather conditions and in the use of real-time observations of the environment. To improve the intelligence of autonomous systems, there is a need for a real-time dynamic information environment that includes the adaptation to weather conditions. In the 6GVISIBLE (Seeing Invisible as a 6G infrastructure Service for Autonomous Vehicles) project, Finnish Meteorological Institute (FMI) and University of Oulu are joining forces to improve intelligent traffic road weather services for autonomous driving. One of the aims of the project is dynamic real-time modelling of the environment and obstacle detection for autonomous or semi-autonomous vehicles, but here we will focus on road weather related goals. The project started in summer 2023 and will last until spring 2026.

Evaluation of sensor sensitivity to harsh weather

Sodankylä test track is located in northern Finland, and it is used as a testing and development environment for intelligent traffic, autonomous vehicles, and road weather services [1]. The test track is supplemented with a multitude of communication systems. For example, there are vehicle-to-vehicle(V2V) radios and 5G test networks. All FMIs special instrumentation and knowledge related to intelligent traffic road weather services are employed as part of the 6GVisible development architecture. In this project, autonomous vehicles' sensor systems are being evaluated for their sensitivity to harsh weather conditions. For this purpose, FMI is employing a self-built small autonomous robotic platform to study the instrumentation used on autonomous vehicles. Special focus will be on LiDAR instruments. Our goals are to study lidar vulnerability to weather, road sign recognition, identifying snow cover, snowbank height monitoring, road condition monitoring and creating a digital twin base for different test locations. The Lidar is used in multiple locations: on a vehicle, miniature autonomous vehicle platform, drones and on a shipping container when not in use elsewhere. Figure 1 shows an example of measurement on a shipping container.

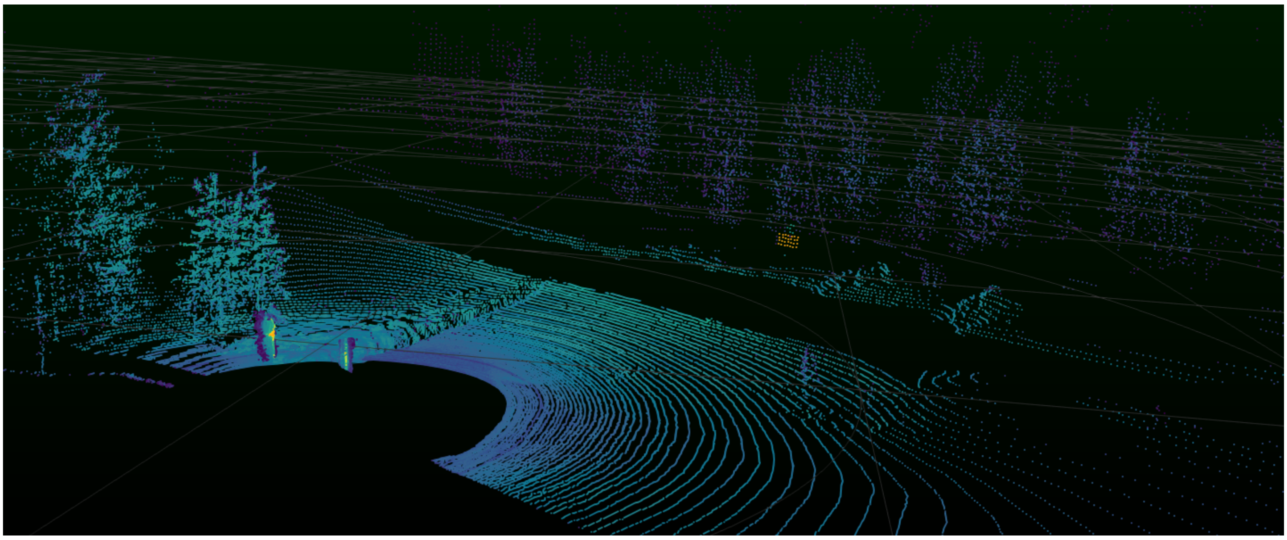

Fig. 1. Example of Lidar measurement. There is a sign with an infrared coating on it that is visible as yellow in the figure.

Road weather forecasts

FMI's road weather model RoadSurf is a one dimensional heat balance model that predicts road weather conditions [2]. It requires a forecast of atmospheric variables as input and as output it gives road surface temperature, amounts of ice, snow and water on the road, friction and road condition (wet, icy, snowy…). In this project, road weather forecasts produced by RoadSurf will be further developed for the needs of autonomous vehicles. The forecasts will consider the autonomous vehicle's sensor system and its sensitivity to weather conditions to provide more sophisticated instructions in harsh weather conditions. For example, the vehicle might be instructed to lower driving speed or stop entirely in heavy snowfall. The forecasts will be piloted in the Oulu region. Forecast points will be selected along major roads and the forecasts will be updated every hour. The forecasts will take into account the surrounding environment's effects to radiation via sky view factor and shadowing algorithm [3].

Precipitation nowcasting

Precipitation nowcasts are produced by Pysteps, which is an open-source Python library [4]. The nowcasts are based on extrapolation of radar observations along the motion field estimated from past observations. Nowcasting based on radar extrapolation provides better results than NWP based models on short time ranges, that is, 0-6 hours. Nowcasting models can produce reliable predictions of large scale stratiform rainfall up to 6 hours and convective rainfall up to the next 30-60 minutes. However, forecasting snowfall by using weather radars is still a challenging task. It is important to provide accurate information about precipitation for autonomous vehicles, as snowfall and heavy rainfall affect road conditions and the sensors' ability to observe the surroundings. In this project, we will develop a precipitation nowcasting web application to show results from a radar extrapolation algorithm in the Linnanmaa region in Oulu. The precipitation nowcast will be also given as input data to the road weather model to produce better road condition forecasts. Figure 2 shows an example of a precipitation nowcast for southern Finland.

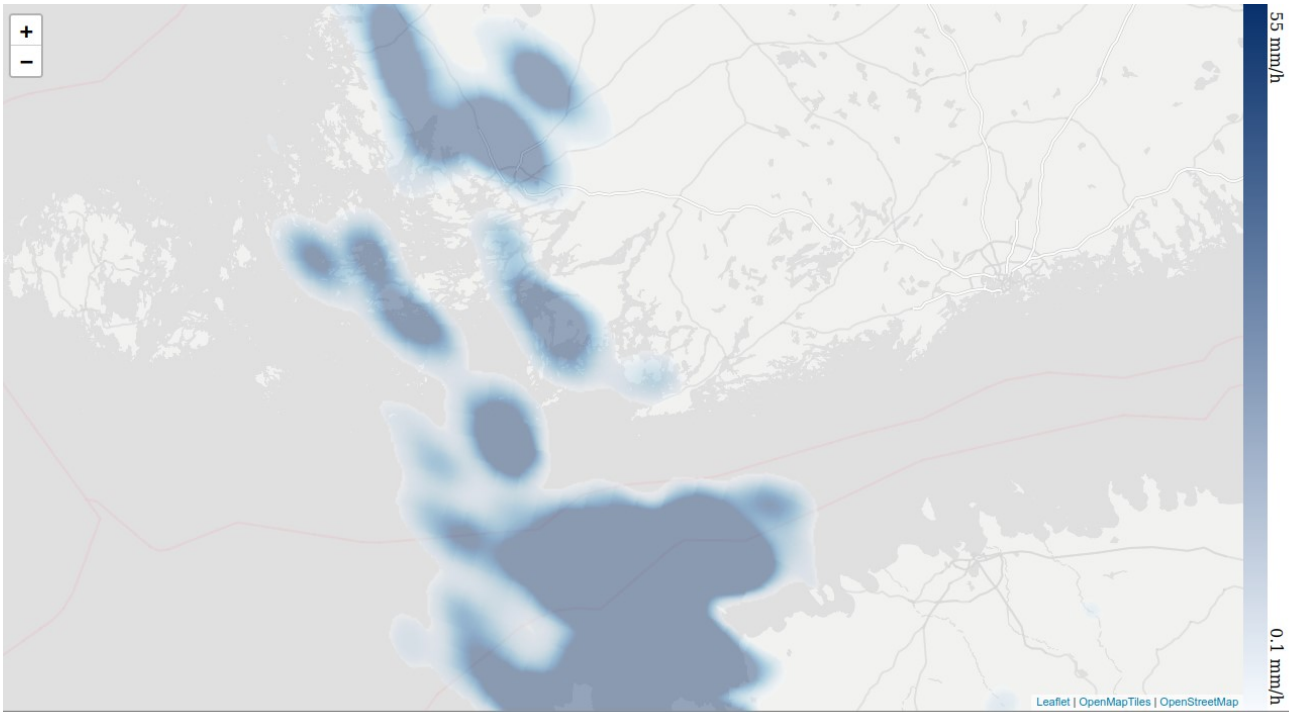

Fig. 2 Example of precipitation nowcast for southern Finland

Route planning with knowledge modelling

Knowledge graphs (KGs) are one of the driving powers for the development of Artificial intelligence (AI) [5]. They are knowledge bases composed of a large number of entities and relations between them. In this project, we investigate the use of knowledge modelling with KGs for driving. We also explore opportunities for a hybrid intelligence support system that uses KG for knowledge modelling and knowledge sharing between humans and machines.

Data based on the real environment is difficult to utilise in AI driving scenarios because the environment changes constantly. In this project, we explore opportunities to utilise and integrate near real-time data with a KG in driving scenarios, offering real benefits for automatic route planning. Knowledge modelling through ontologies is one possibility for integrating different data types from various sources. Ontology means a systematic framework for defining concepts, their properties, and relationships. Knowledge modelling through ontologies would allow multi-party collaboration between support system developers (such as vehicle manufacturers), infrastructure holders (cities) and other parties (meteorological centres). To test this kind of system, we develop a driving ontology based on data available from the Oulu area. Thus far, an initial ontology model has been created (Figure 3). Weather, map and road maintenance data of the Oulu area are integrated into the KG. The ontology will be developed further during the project. At the end of the project, we will demonstrate the support system utilizing KG, which considers changes in conditions and environmental feedback.

Predictive modelling of weather-related crashes

In this project, we are aiming to build a predictive model that can forecast the probability of a road crash in Uusimaa and Southwest Finland in a 24-hour window, using as covariates both MEPS weather data and forecasted traffic volume data. The topic is important in the context of improving impact-based warnings and to increase awareness of weather-related road safety, allowing authorities to intervene by establishing more appropriate speed limits, improving road design, and issuing timely warnings for road users. The underlying machine learning model is trained on five years of historical data (from 2017 to 2021 inclusive), and it is a generalized additive logistic regression model. Logistic regression models are useful for modelling outcome probabilities of binary variables, and in this case, it is used to forecast the probability of a road crash happening in each hour. Generalized additive models are flexible versions of generalized linear models which account for possibly non-linear functional relationships between predictors and the response variable. Besides providing short-term future road crash probabilities, another expected result of the model is to signal which meteorological covariates are statistically significant and thus associated with a heightened probability of a road crash. The results will tell us if certain areas or certain times of the day, as well as which weather factors, carry more risk for road safety. Ultimately, we wish to collapse the information from the output of the predictive model into a knowledge graph construction, outlining semantic relationships within the driving environment. The user and AI would henceforth collaborate in a data-driven decision theory framework to maximize safety on the roads once informed about weather-related driving risks.

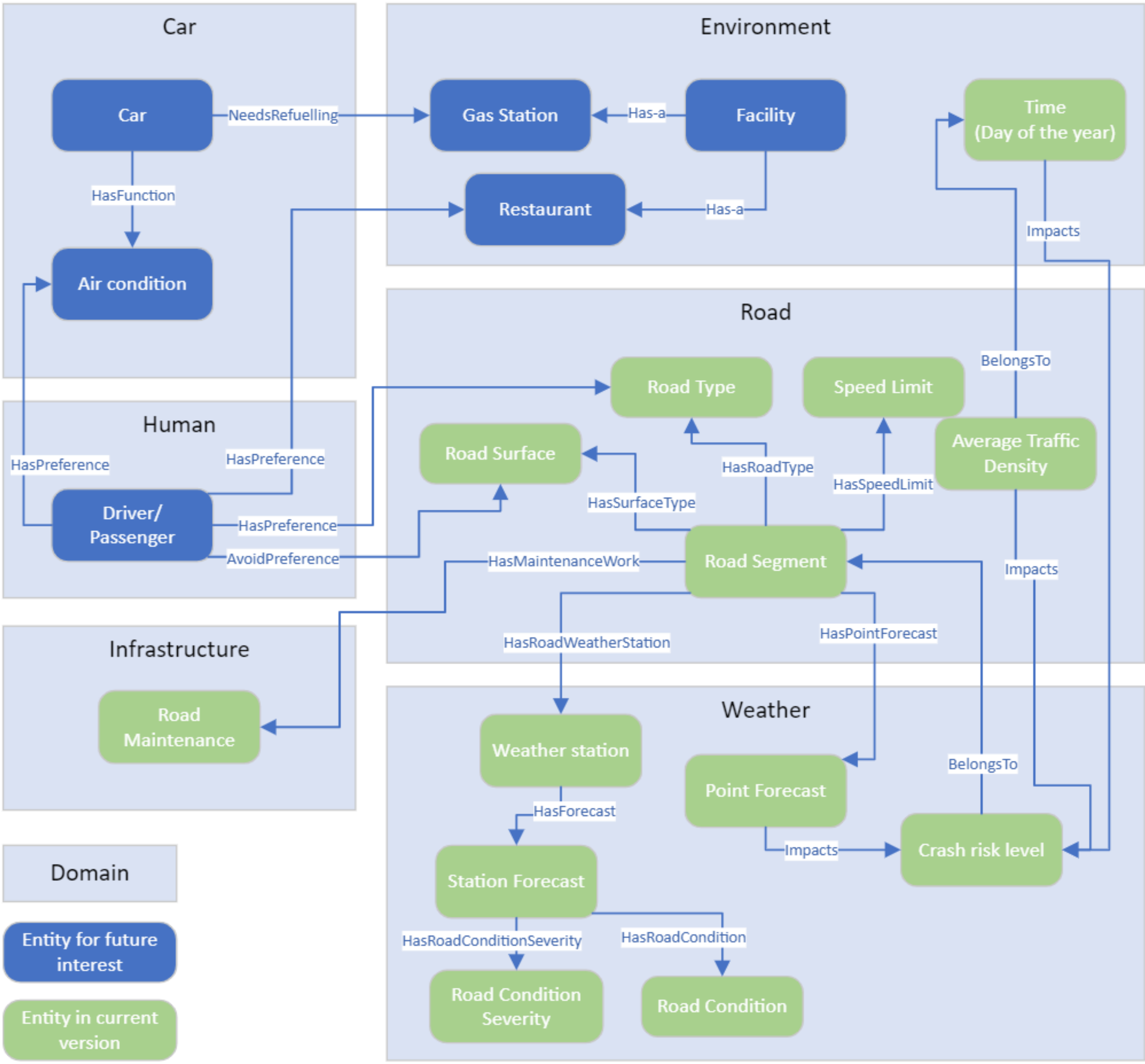

Fig. 3 Knowledge Ontology created in the project with the help of Oulu University students.

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