



Beyond connectivity – Clean Air

Air quality monitoring and decision support in Trondheim

Telenor, NTNU (Norwegian University of Science and Technology) and ITI-CERTH (Informatics and Telematics Institute, Centre for Research and Technology Hellas) have collaborated with the municipality of Trondheim (Norway) since August 2018 on the exploration of options for improved air quality services based on new technologies (AI and IoT). This collaboration is referred to as the AI4IoT pilot on Air Quality Monitoring and ran within the frame of the AI4EU project, with the objective to build a European AI on-demand platform. The services and data provided for this pilot will be part of showcasing use of this platform.

The pilot has focused on technologies for data capture, data quality, advanced analyses and visualisations, and has addressed the different parts of a value chain for a complete solution. This has included prototype development and evaluations of:

- Micro-sensor units for measuring air quality able to communicate data over NB-IoT networks
- Machine learning methods for calibration of wireless sensor networks
- Mobile and web applications for air quality monitoring with better coverage than existing services
- Machine learning applications for forecasting of air pollution
- APIs and tools for data integrations, what-if analyses and visualisations

The project has included bachelor and master students from NTNU working on the mentioned challenges (5 bachelor students in 2018; 6 bachelor students in 2019; 7 bachelor students in 2020; 2 master students in 2019 and 2 master students in 2020).

Through this project, Telenor has been able to address the challenge of monitoring air quality which is essential to human well-being and provide prototype development and evaluations to Telenor Norway's IoT development project with Trondheim municipality.

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More details are available on the [NTNU project website](#).

References



Articles in the media

Studenter laget app som måler luftkvalitet, Universitetsavisa, 3. juli 2019.

<https://www.universitetsavisa.no/student/2019/07/03/Studenter-laget-app-som-m%C3%A5ler-luftkvalitet-19239054.ece>

Selected publications from the project

Veiga, T.; Munch-Ellingsen, A.; Papastergioupolos, C.; Tzouvaras, D.; Kalamaras, I.; Bach, K.; Votis, K.; Akselsen, S. From a Low-Cost Air Quality Sensor Network to Decision Support Services: Steps towards Data Calibration and Service Development. *Sensors* 2021 (Accepted for publication)

Bach, Kerstin; Akselsen, Sigmund; Veiga, Tiago Santos; Kalamaras, Ilias. (2020) [On the Use of Air Quality Microsensors for Supporting Decision Makers](#). IoT '20 Companion: [10th International Conference on the Internet of Things \(IoT 2020\)](#), Malmø, Oct 6-9, 2020. <https://dl.acm.org/doi/abs/10.1145/3423423.3423463>

Andreas Lepperød, Hai Nguyen, Sigmund Akselsen, Leendert Wienhofen, Pinar Øzturk and Weiqing Zhang. 2019. Air Quality Monitor and Forecast in Norway using NB-IoT and Machine Learning. Paper presented at the 4th *EAI International Conference on IoT in Urban Space (Urb-IoT 2019)*, Braga, Portugal, Dec 4-6, 2019.

Ilias Kalamaras, Ioannis Xygonakis, Konstantinos Glykos, Sigmund Akselsen, Arne Munch-Ellingsen, Hai Thanh Nguyen, Andreas Jacobsen Lepperød, Kerstin Bach, Konstantinos Votis, Dimitrios Tzouvaras. 2019. Visual analytics for exploring air quality data in an AI-enhanced IoT environment. Paper presented at the 11th *International ACM Conference on Management of Digital EcoSystems (MEDES'19)*, Limassol, Cyprus, Nov, 12-14, 2019.

Sigmund Akselsen, Pontus Edvard Aurdal, Kerstin Bach, João Paulo Costeira, Ilias Kalamaras, Andreas Jacobsen Lepperød, Pedro Lima, Ieva Martinkenaite, Ole Jakob Mengshoel, Arne Munch-Ellingsen, Hai Thanh Nguyen, Dimitrios Tzouvaras, Tiago Veiga, Konstantinos Votis, Leendert Wienhofen, Weiqing Zhang, Pinar Øzturk. On the need for explanations, visualisations and measurements in data-driven air quality monitoring and forecasting. Paper presented at the 1st *International Workshop on Evaluation and Benchmarking of Human-Centered AI Systems (EBHAIS-2019)*, Milton Keynes, UK, Sep 20, 2019.

Erling Ljunggren. Deep Learning for Blind Calibration of Wireless Sensor Networks. A comparative study of convolutional and recurrent neural networks. Master Thesis, NTNU. June 2020.

Daniel Svendsen. A User-Based Look at Visualisation Tools for Air Quality Data harvested by IoT (microsensor units). Master Thesis, NTNU. June 2020.

Lepperød, A. J. *Air quality prediction with machine learning*. Master thesis, NTNU. June 2019.

Aurdal, P. E. *VisualBox - A Generic Data Integration and Visualization Tool*. Master thesis, UiT. June 2019.



Mobile applications

Lufta. Med denne applikasjonen kan du sjekke luftkvaliteten i Trondheim!

Utviklet i kurset IT2901 Informatikk prosjektarbeid II ved NTNU våren 2019 av studentene Helle van den Broek, Håkon Kjærnli, Sander Breivik, Hans Bjerkevoll, Truls Berglund, Thomas Bruvold. Studentgruppa ble veiledet av Hai Thanh Nguyen og Sigmund Akselsen, Telenor.

<https://play.google.com/store/apps/details?id=com.luftaapp.lufta>

Frisk app for personalized air quality monitoring and prediction.

Utviklet i kurset TDT4290 Customer driven project ved NTNU høsten 2020 av studentene Sunniva Block, Lukas H. Gjersøe, Mathilde H. Haugum, Espen H. Højjord, Kim A. B. Midtlid, Andreas Oksvold and Miriam V. Woldseth. Studentgruppa ble veiledet av Sigmund Akselsen, Arne Munch-Ellingsen, Ivar Sorknes, Kerstin Bach og Tiago Veiga.

Selected assignments for various NTNU courses in this area proposed by Telenor

EiT - Experts in Teamwork starting in January 2018, village on Big Data Analytics and Business Intelligence (4 challenges submitted by Astrid Undheim, Ieva Martinkenaite and Sigmund Akselsen)

TDT4290 - Customer Driven Project starting in August 2018, 1 challenge (Dashboard and API for Air Quality Monitoring) submitted and supervised by Hai Thanh Nguyen and Sigmund Akselsen

IT2901 - Informatics Project II starting in January 2019, 1 challenge (Mobile app for Air Quality Monitoring) submitted and supervised by Hai Thanh Nguyen and Sigmund Akselsen

TDT4290 Customer driven project starting in August 2020, 1 challenge (Mobile app for personalised air quality monitoring and prediction) submitted and supervised by Sigmund Akselsen, Ivar Sorknes and Kerstin Bach.