Demonstration Projects

Call for Ideas to Boost the Competitiveness of the Estonian Manufacturing Industry

Final Report

Please fill in the Final Report in English
The content of the Final Report is published also in [AIRE GitHub]
To be filled by the Lead of the Development Team

Demonstration Project Title

Testing of digitalisation and machine learning for quality control of mobile aircrete production equipment

Company

Company Representative Name *(First name, Surname)*	Jon Ender
Company name	Kodatek OÜ

Development Team

Development Team Lead Name *(First name, Surname)*	Mattias Põldaru

Objectives of the Demonstration Project

The project's goal was to test and validate the technical capability for the automatic collection and transmission of production process data to the artificial intelligence database in the required format to train the model. Necessary sensors and camera were installed on the mobile production equipment, which sends data to the control module with each production task. As a result of the project, the model and equipment have recorded data from the process for the initial training of machine learning model.

AI & Robotics Estonia (AIRE-EDIH) is co-funded by European Digital Innovation Hubs Programme of the Digital Europe Programme and the Estonian Ministry of Economic Affairs and Communications
Project ID: 101083677

Activities and results of the Demonstration Project

Challenge addressed (i.e. whether and how the initial challenge was changed during the project, for which investment the demonstration project was provided)

Today the operator is controlling the production process manually. Since the properties of foamed concrete is affected by several factors, taking them all into account without a good model is error prone.

Testing in production revealed that quality control relies on having reliable measurement data on important process parameters. Some of the initially chosen methods (such as weighing a line with material) for data gathering did not provide reliable feedback and the plan was revised. Some additional checks were adjusted to catch different error scenarios, which caused problems during testing.

Activities implemented and results achieved

Continuous data logging for motor controller setpoint/present value of speed and power output was tested with checks for out of bounds values.
Temperature and moisture logging of production line and humidity environment was tested.
Video monitoring of production area to identify timestamps of important ranges of time-series data of testing process was tested.
Laboratory samples were tested for the properties important from the building materials perspective.
Initial relationship between raw values and machine output was determined.
An initial model of relation between production parameters and output was tested.

Data sources (which data was used for technological solution)

Data sources used consist of time-series data of machine speeds, power, flow measurement of liquids and fresh mix, logging of compressed air state, measuring temperature of machine and curing environment.
Laboratory test results for density are linked to relevant production times and the relationship can be established later using timestamped video stream of production area.

Description and justification of used AI technology

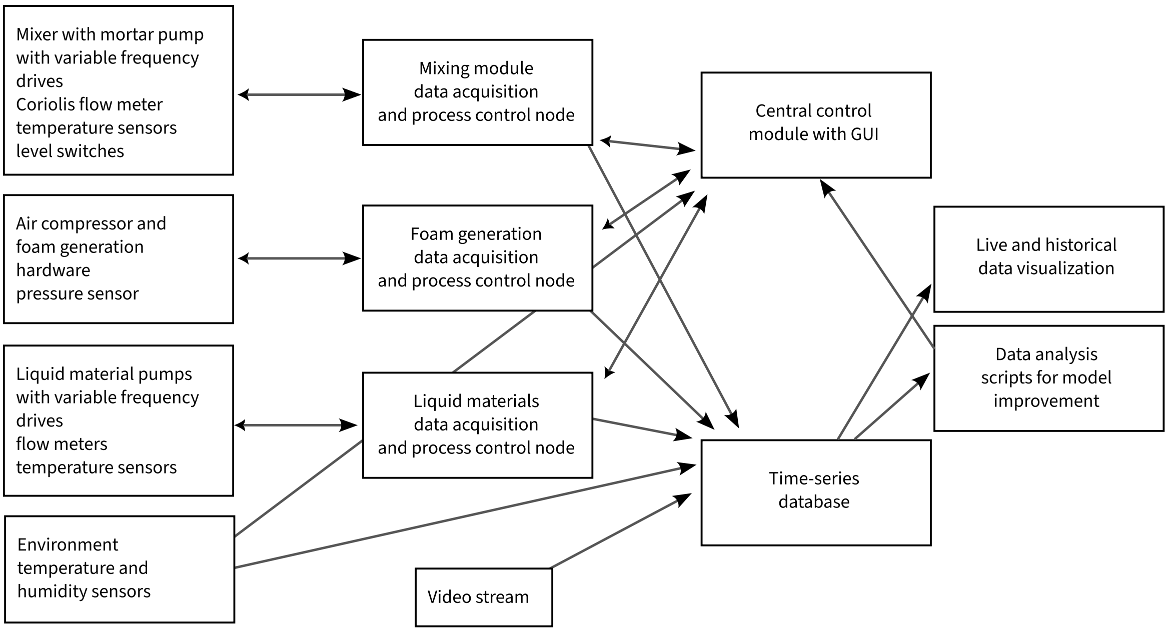
Linear regression was used to establish solid base model about the process. Since conducting tests using production-scale machine produces about a hundred litres of material per minute, the initial tests were conducted in a non-wasteful manner, using curated tests to find the core relationships of process parameters.
Real production data will continue to be acquired, which enables the model to be regularly updated. For this a script is used to find correlation between any two time series data columns and to prepare statistical summary for analysis together with laboratory data.

Results of testing and validating of the technological solution

Gathering of the process data gives relevant information about the process. Further data acquisition is needed to fine-tune the process parameters and limits.

Technical architecture of the technological solution (presented graphically, where can also be seen how the technical solution integrates with the existing system)

The following chart illustrates the data acquisition and process control module signal flows.



Potential areas of use of technical solution

The technical solution of data acquisition and process control can be used to improve aircrete production lines. It is very similar to the needs of mortar production lines for concrete 3D printing and probably other production lines with similarly continuous process.

Description of User Interface (i.e. How does the client 'see' the technical result, whether a separate user interface was developed, command line script was developed, was it validated as an experiment, can the results be seen in ERP or are they integrated into work process)

The user interface consists of three parts:
Control system with GUI to control the motors during test production runs and acquire process parameters related to motors.

Visualization of raw data for both live viewing and later analysis using Grafana dashboards.

Command line scripts to query the database for statistical profile and correlation analysis of data for chosen data columns and ranges.

Follow-up activities and plans for future (e.g. developments, potential for scalability, creation of spin-offs aso)

The system is ready to gather large-scale data for further analysis during production runs. Gathered data can then be periodically evaluated and used for further model training.

Lessons learned

i.e. assessment whether the technological solution actually solved the initial challenge

Measuring process data live and setting up error conditions to stop or block starting the system reduces the most apparent possibility of producing non-compliant material.

The initially chosen measurement methods were partly insufficient to provide reliable feedback about the density of the produced material. A Coriolis effect based sensor system was chosen as a replacement for the earlier method.

Projekti lühikirjeldus (AIRE kodulehele, eesti keeles)

Projekti pealkiri, millist väljakutset lahendati, projekti eesmärk, millist tehisintellekti tehnoloogiat valideeriti, projekti tegevused ja tulemused, kuni 10 lauset

Tehisaru abil juhitava mobiilse vahtbetooni tootmisliini ja kvaliteedi juhtimise testimine

Mobiilsel poorbetooni tootmisliinil testiti tootmisprotsessi parameetrite ja keskkonnaandmete kogumise teostatavust tootmise juhtimiseks. Automaatne tootmise kvaliteedikontroll põhineb sagedusmuunduritelt, Coriolise ja muudelt vooanduritelt ning temperatuuri- ja niiskusanduritelt saadud andmetel. Kui praeguse segu valemi standardseid kvaliteeditingimusi ei saavutata, reguleerib juhtmoodul tooraine voogu vastavalt nõutud parameetritele või peatab seadme. Esialgne mudel põhineb baasmudeli aluseks olevate kureeritud katsete andmetel. Iga seguretsepti standardseid kvaliteeditingimusi ajakohastatakse regulaarselt, kui tootmistsüklite ajal koguneb uusi andmeid.

Project description (to be published on AIRE webpage, in English)

Project title, what challenge was addressed, aim of the project, what AI technology was validated, project activities and results achieved, max 10 sentences

Testing of digitalisation and machine learning for quality control of mobile aircrete production equipment

On a mobile aircrete production line the feasibility of collecting production process parameters and environmental data for production control was tested. Automatic production quality control is based on the data input from frequency changers, Coriolis and other flow sensors, temperature and humidity sensors. If standard quality conditions for current mix formula are not reached, the control module adjusts raw material flow to meet the required parameters or stops the equipment. The initial model is based on data from curated tests establishing the base model. The standard quality conditions for each mix are regularly updated as new data is gathered during production cycles.