# Analysis of Data to Solve Problems with Humidity in Buildings

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## Abstract

The aim of this work was to solve problems with excessive humidity in buildings using data analysis. Key parameters affecting indoor relative humidity are indoor and outdoor temperature and outdoor relative humidity. The long-term measurement of the mentioned parameters was performed using the set of sensors and BeeeOn system. Measured data was used to design a system for event detection related to a humidity change. The approach to air change regulation in the room was based on natural ventilation.

## Goals

People spend about 90 % of their life indoors. Therefore it is necessary to maintain a healthy indoor environment that is significantly affected by humidity. Comfortable relative humidity ranges from 30 % to 70 %.

The common symptoms of excessive humidity in buildings:

- people can suffer from allergy or asthma thanks to airborne dust mites and mould spores that are spread in the excessively humid air,
- a big difference between indoor and outdoor temperature can cause condensation,
- interior damage, e.g. paint blisters or peeling wallpaper.

Ventilation can remove pollutants and humidity forming indoors or reduce their concentrations to admissible levels for the occupant health and comfort. It should be energy efficient, preserve indoor air quality and it should not harm the occupants or the building.

## Hardware equipment

The hardware devices used for measurement are depicted in Figure 1. The **BeeeOn gateway** receives measured data from sensors and converts it to the format specified for a given protocol. Then the data is stored on the server and it is accessible using REST API. Sensors measure data and send it to the gateway. The **BeeeOn sensor** v1.2 can measure temperature and humidity. The **Jablotron sensor** JA-83M is designed to detect the opening of doors, windows, etc.

## Data gathering

The indoor and outdoor relative humidity an temperature were measured using a set of BeeeOn sensors. Each window opening event was annotated both automatically and manually (weather, airspeed, number of people in the room). The ventilation was performed at various time intervals during the day. RapidMiner tool was chosen for data analysis. Data was used to define appropriate attributes, to create a dataset and to train and test the window opening detector and optimal ventilation length predictor.

*Figure 1: BeeeOn gateway (left), BeeeOn sensor (middle), Jablotron sensor (right)*

## Results

The window opening **detector** was trained using various classification methods, the best accuracy was achieved by Support Vector Machines (SVM). The initial accuracy of the detector was increased by an iterative learning process, where false positives were included. After the 41st iteration, the accuracy increased from 98.59 % to 99.98 %. The number of true positives (TP), false negatives (FN), true negatives (TN) and false positives (FP) also express the detector accuracy (see Table 1).

The aim of the **predictor** was to determine optimal ventilation length to decrease indoor humidity to the required level. The decision tree was used for data classification. Initial accuracy of the predictor based only on attributes created using measured data was 40.87 %.

To increase predictor accuracy, the cluster-based data model was designed (see Figure 2). The model reflects the course of indoor humidity decrease in the selected room. The accuracy of the predictor was 87.02 %. The attributes representing the distance between a certain point of the cluster and its trendline significantly improve the accuracy of the predictor. The long-term measurement was performed for approximately 1.5 years.

| Iteration | Accuracy [%] | TP | FN | TN | FP |
|---|---|---|---|---|---|
| 1st | 98.59 | 438 | 5 | 240 964 | 3 442 |
| 41st | 99.98 | 404 | 39 | 244 406 | 0 |

*Table 1: Number of TP, FN, TN and FP after 1st and 41st iteration of the SVM learning process*

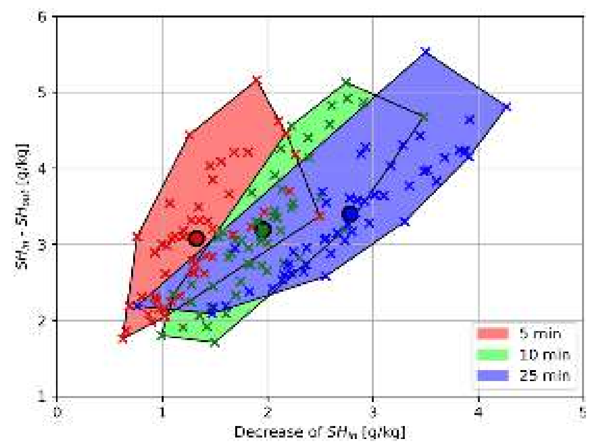


*Figure 2: Dependency of decrease of indoor specific humidity on the difference between indoor and outdoor specific humidity for the ventilation intervals of 5, 10, 25 minutes*