Domain Specific Language for Indoor Air Quality Analysis in Museums

Björn de Nijs

Middelheimlaan 1, Antwerpen

University of Antwerp[1]

Abstract

Indoor air quality plays a major role in preventive cultural heritage conservation. There are several parameters that have an influence on the degradation process. Some examples are temperature, relative humidity, visible light, UV, radiation, particulate matter and reactive gases. All these parameters are measured and stored for monitoring purposes, but the amount of data is overwhelming for caretakers. We need a method that can make an assessment of the influence on these works of art. Given the measured parameters, it would be so much easier to convert measurements into a judgment (good-mediocre-bad). This will help caretakers to improve air quality and to take steps to prevent degradation. Analysis of big data provides the answer for this problem.

Keywords: Domain Specific Language, Indoor Air Quality, Museums

2010 MSC: 00-01, 99-00 ???

1. Indoor Air Quality in general

The air we breath has a big influence on our health. A lot of attention has been paid to the air quality outdoors, with reducing the emissions of cars and factories, but the air quality indoors has not been researched so well. We spend most of our time indoor, so why hasn't there been more research regarding this subject? The construction materials used in our homes can have an effect

URL: `www.uantwerpen.be` (University of Antwerp)

on the air quality, just as combustion of fuels, think about cooking or heating our home, release gasses that infleunce the air quality. All these factors and many more can cause health issues or even endanger us. The World Health Organisation (WHO) has released a report on the dangers of indoor air quality for human health, which can be publicly viewed [1].

2. Indoor Air Quality in museums

In the previous section the effect of Indoor Air Quality on humans was discussed, but why wouldn't the Indoor Air Quality influence other materials as well? It has been proven that the Indoor Air Quality does have an effect on cultural heritage, mainly due to the degradation proces of materials. Materials degradade naturally but the quality of the air can speed up this process. The main difference between materials and humans is that humans can repair themselves, but materials do not possess such abilities. Restauration is possible, but if will always differ from the original work, and it will never be as good as the original work. That's why it's important to preserve our cultural heritage.

3. Existing tools

3.1. AirSense

AirSense [2] is an Intelligent Home-based Sensing System for Indoor Air Quality Analytics. Other monitoring techniques focus on Indoor Air Quality measurements and visualization, but the lack of information about the pollution sources as well as the intensity of the pollution causes ignorance of the polluted air at their homes. AirSense is able to automatically detect pollution, identify the source of the polution and estimate personal exposure to that pollution. It also provides actionable suggestion to help people improve the Indoor Air Quality.

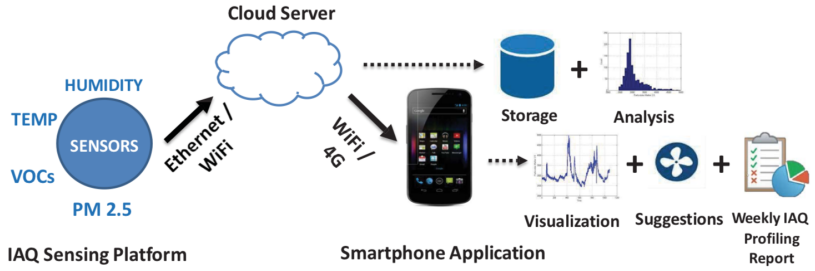
The AirSense system architecture is composed of several components. The first one is an Indoor Air Quality sensing platform that has several sensors build in to detect parameters in the air, such as temperature, humidity, particulate

matter, volatile organic compound, and more if desired. The data is collected every 5 seconds and is send to a cloud server.

The cloud server does the processing of the data and stores the results in a database and some graphs are created.

The smartphone application allows the user to view the information and get suggestions as to what parameter needs to be changed to improve the Indoor Air Quality.

The entire architecture is shown in the figure below.



AirSense system architecture

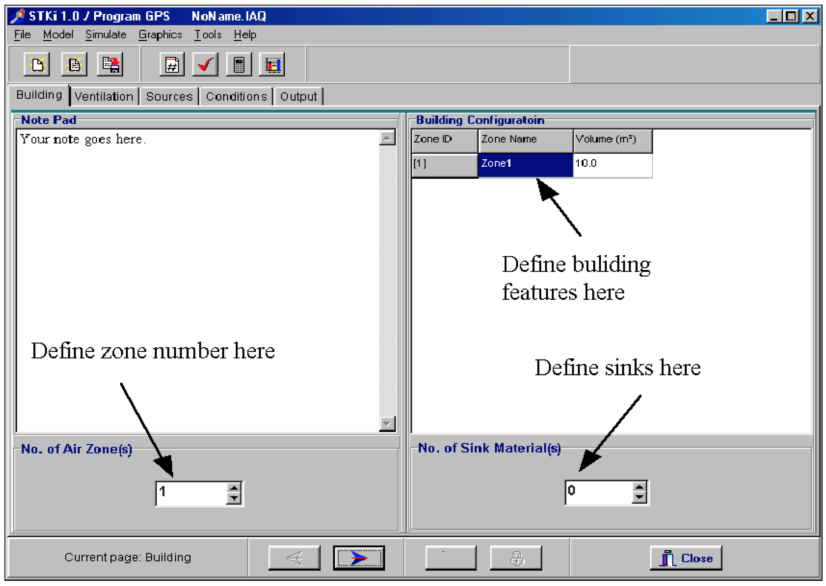
3.2. IAQX

IAQX [3] is an Indoor Air Quality simulation software package that complements and supplements existing Indoor Air Quality simulation programs. IAQX helps users analyze the impact of pollutant sources and sinks, ventilation, and air cleaners. It performs conventional Indoor Air Quality simulations to calculate the pollutant concentration and/or personal exposure as a function of time. It can also estimate adequate ventilation rates based on user-provided air quality criteria. This is a unique feature useful for product stewardship and risk management.

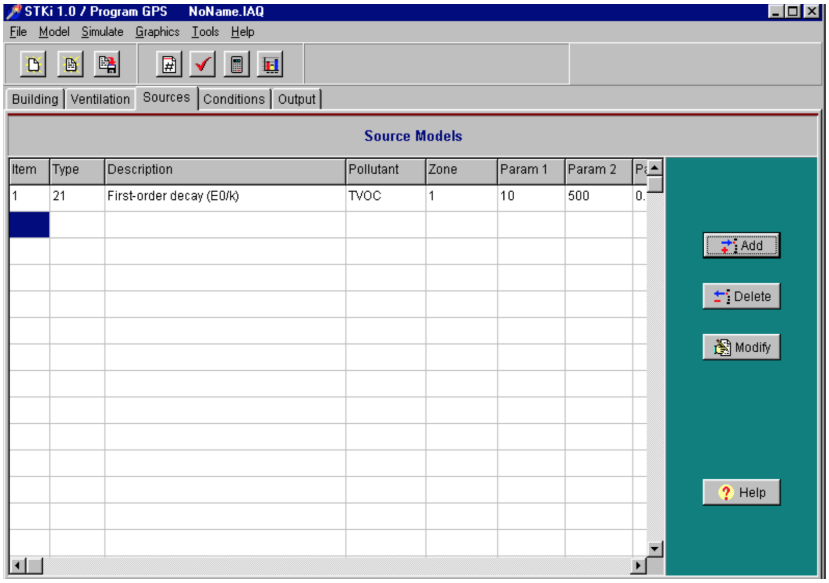
IAQX consists of a general-purpose simulation program and a series of standalone, special-purpose programs. The general-purpose program performs multizone, multipollutant simulations and allows gas-phase chemical reactions. The four special-purpose programs contain more complex mass transfer models than the general-purpose programs, including:

- Models for predicting volatile organic compound (VOC) emissions from solvent-based indoor coating materials based on product formulation
- Models for indoor solvent spills
- A model for VOC emissions from diffusion-controlled homogeneous slabs such as new carpet backing
- A model for indoor particulate matter

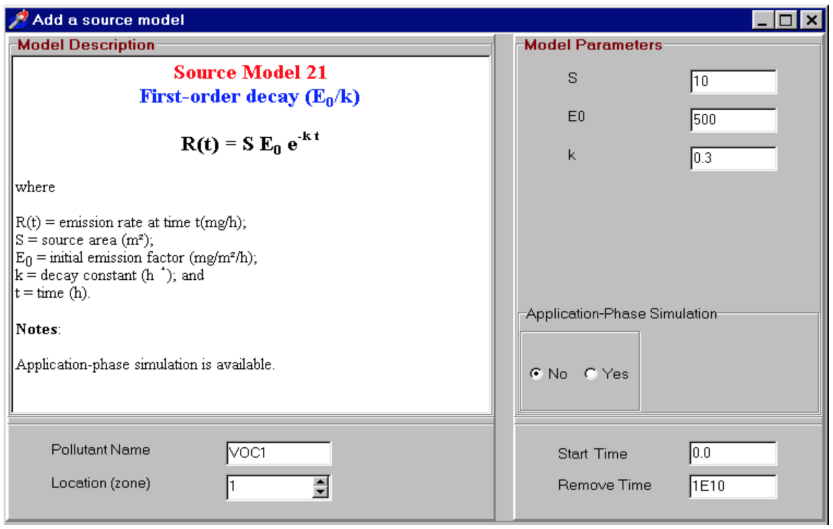
Some interesting views are shown in the images below.



The available zones within the simulation

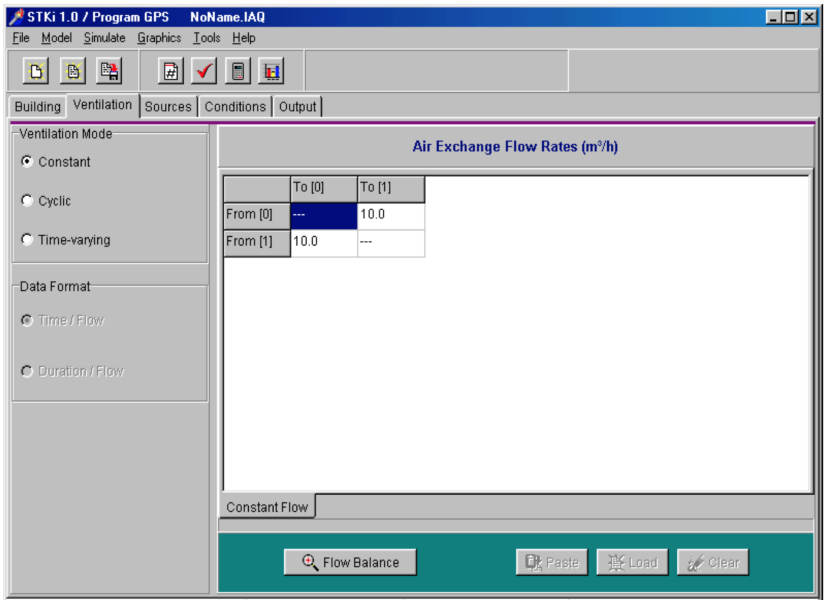


Emission sources page

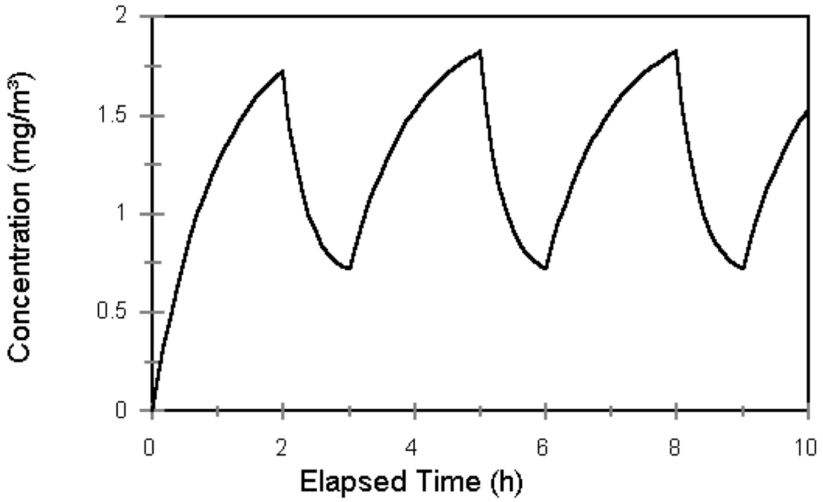


70

Emission source model page



Ventilation page to generate the airflow



Example result of concentration during a period of time

4. DSL for Indoor Air Quality in Museums

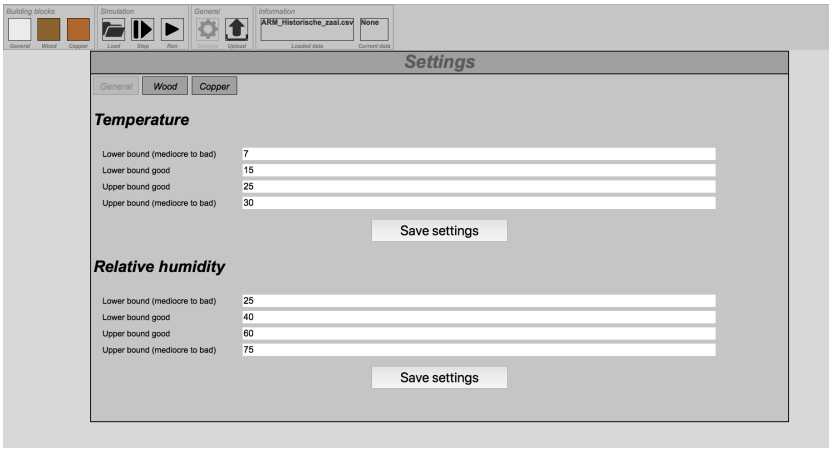
4.1. Introduction

In order to give the caretakers the ability to analyse measurements themselves, I came up with a Domain Specific Language for this problem. A web-interface gives caretakers the ability to create objects of a certain material (currently general, wood and copper materials are supported) on a plane. Those objects are called building blocks. For each building block that is created, the caretaker can change the name, delete the building block and view the simulation history to look at the evolution of the Indoor Air Quality. It's also possible to move the building block object to another location by left clicking and dragging it to another position on the workspace.

Settings of the Indoor Air Quality can be changed in the settings menu, which allows caretakers to optimise the classification of the Indoor Air Quality. A csv file can be uploaded that represents the measurements of data in an environment. This data can be loaded and the simulation takes care of classifying the building blocks that are created on the plane.

4.2. In depth look

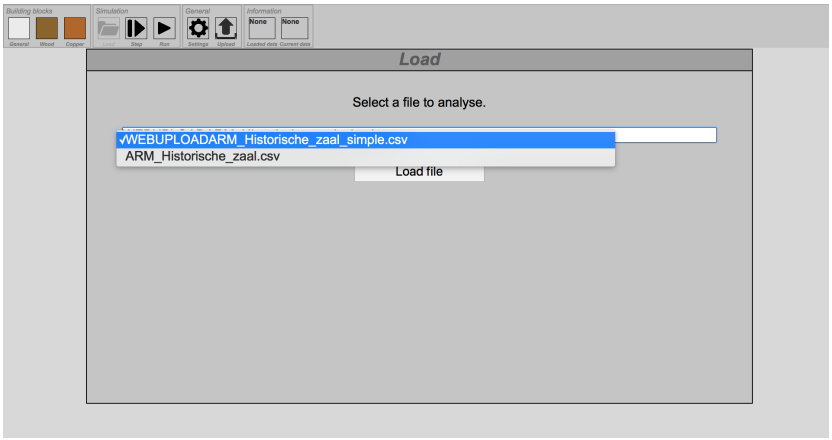
The opening of the web-interface



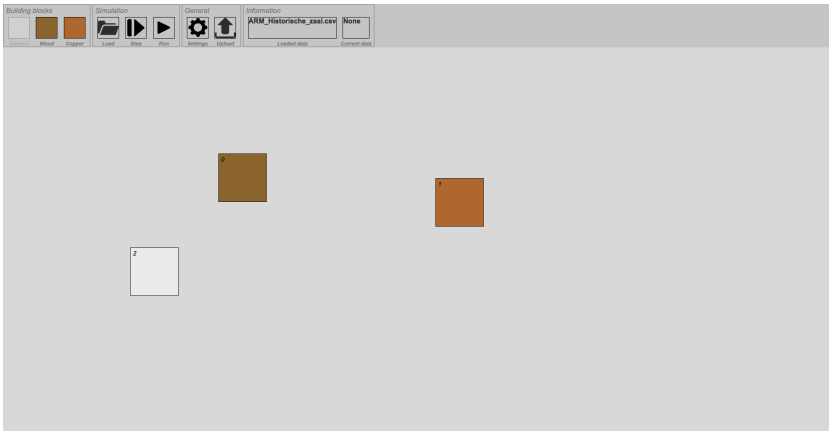
95

Various settings can be adjusted

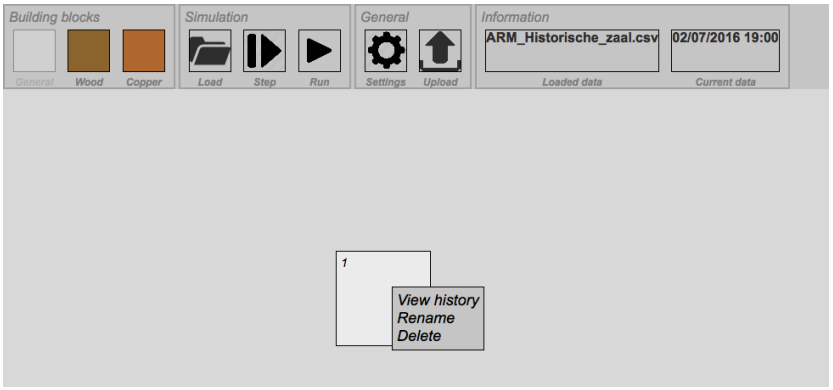
CSV files can be uploaded as data input for the simulation



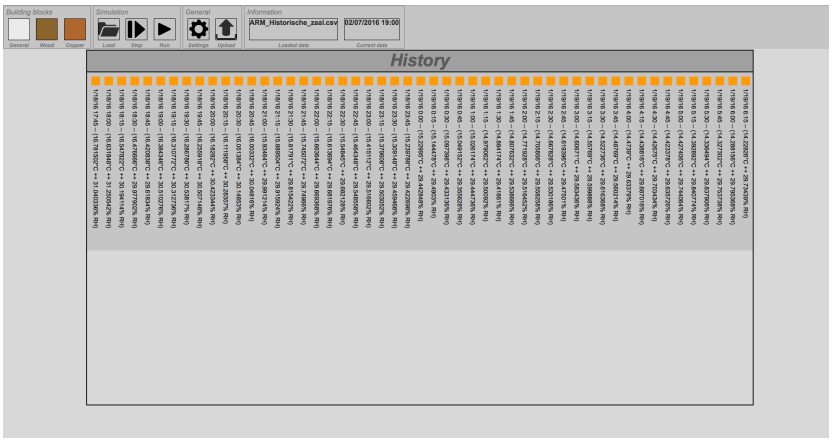
Loading uploaded data to run the simulation



Concept of the building blocks used on a workspace



Building block options made visible with a right click on the building block object



View the Indoor Air Quality history of a building block object

Give the building block object a more suitable name

4.3. Comparison to other alternatives

4.3.1. AirSense

The AirSense approach is directed at the Indoor Air Quality and its effects on the human health. My approach has the ability to determine the influence of the Indoor Air Quality and its effects on our cultural heritage. This is one of the most important distinctions that can be made between AirSense and my solution.

4.3.2. IAQX

The IAQX has an old user interface and the program is only available for windows. There are a lot of options to configure, but it takes some time to figure all of those out. A thing that IAQX has that my solution doesn't have, is the ability to create airflows between different zones. My solution doesn't use any zones, and therefor it doesn't have an airflow available.

4.4. Future work

Caretakers are able to create a workspace where they can do the analysis on, and visual aids will help them in quickly determining the influence of the Indoor Air Quality on cultural heritage objects, but at this moment in time there is no option to save the analysis and load it again. This is a very useful feature to have, especially if you want to try different settings on the same model to compare it with.

Another point that has to be done is adding more building block types. Currently only a general, wood and copper building block exist, but there are much more types of material existing in the world of cultural heritage, such as canvas, cotton, silver, lead, ... All of these materials can be added to upgrade the support for analysis of more objects in the cultural heritage.

Another thing that is needed is the adding of paging. When the history of an object is requested, it sends the history one point at a time. This isn't a problem with a small history, but if the history is quite large, the browser will freeze, because it gets so many messages from the backend server, that it doesn't have anything else to do.

References

[1] WHO, Who guidelines for indoor air quality: selected pollutants, http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf.

[2] B. F. Q. X. T. P. M. Zhang, Airsense: An intelligent home-based sensing system for indoor air quality analytics, UbiComp september 2016 (2016) 12–16. doi:http://dx.doi.org/10.1145/2971648.2971720.

[3] Z. Guo*, Development of a windows-based indoor air quality simulation software package. environmental modelling and software, https://www.epa.gov/air-research/simulation-tool-kit-indoor-air-quality-and-inhalation-exposure-iaqx 15 (2000) 403–410. doi:10.1016/S1364-8152(00)00020-7.