# VIRTUAL REALITY MODEL OF AIR POLLUTION

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**Abstract**

**The paper is devoted to the description of virtual reality model generation using the system Matlab and its Virtual Reality Toolbox. The selected possibilities of interconnection of both systems (Matlab and VRML) are demonstrated by means of visualisation of two-dimensional interpolation of air pollution data.**

## 1   Introduction

Presentation of three-dimensional data currently represents a very topical theme in many areas, and not only technical ones. Clear and intelligible arrangements of information in the 3D model is necessary for example in medicine and it is used more and more frequently in other areas. Results of information processing using complex mathematical tools can naturally lead to formulation of a three-dimensional graphical model. It has been possible to observe or process spatial data for all users of personal computers since the VRML (Virtual Reality Modeling Language) had been developed [5, 6, 7]. The most frequently used Internet browsers (MS Internet Explorer and Netscape Navigator) have a VRML viewer built in. There are also many other freeware plug-in modules available on the Internet with which one can enter the virtual world and observe it and possibly control it as well. Thanks to these facts, it is expected that areas of applications of 3D modeling will grow.

The goal of this paper is to describe the process of formulation of a 3D model of air pollution level in the Czech Republic using the system Matlab, and its export to VRML.

## 2   Real Data Description

Automation Imission Monitoring System (AIM) in the Czech Republic that includes more than 100 measuring stations [3] provides regular measurements of chosen components in the air. Concentrations of selected pollutants are measured at every station in 30 minute intervals during the whole year. These data allow to watch the air pollution level at exactly located points, and by using interpolation methods, in the whole area of the Czech Republic, as well. Graphically presented results of interpolation make the imagination faster and clearer. They could be also compared with parallelly performed NOAA (The National Oceanic and Atmospheric Administration) satellite observations and namely concentrations of dust particles in the air. The one year's time series representing current concentrations of the PM10 pollution obtained from the AIM stations has been kindly provided by the Czech Hydrometeorological Institute in Prague. The data observed at locations presented in Fig. 1 were preprocessed by means of compensation for values of measurement failures and elimination of distant values [4].
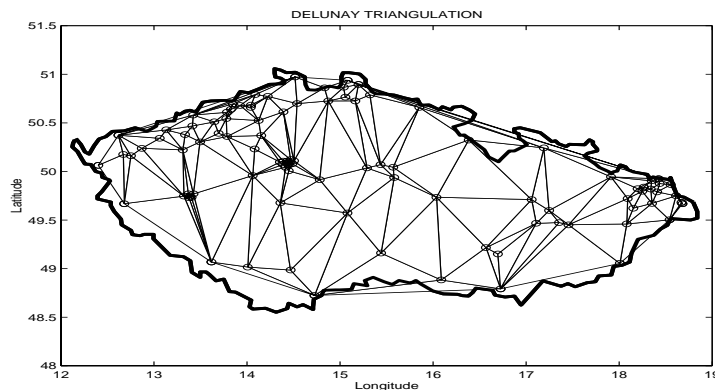


Figure 1: The AIM station layout in the Czech Republic with marked Delaunay triangulation

# 3 Two Dimensional Interpolation Methods

It is possible to use various interpolation methods for estimation of values of an observed pollutant in other non-measured points specified by a selected orthogonal net. The description and comparison of these problems has been presented in [4]. It is possible to use the simplest method of the 0-th order - the nearest neighbour method that interpolates the surroundings of a given station by the same value measured in the station. Voronoi diagrams [1] limit the surrounding borders. Related Delaunay triangulation method presented in Fig. 1 is used for higher-order interpolation (bilinear, cubic, spline). A selected method applied to the array of calculated concentration's values results in the orthogonal net defining longitude and latitude. The three-dimensional model represents a natural presentation of these results.

# 4 Three Dimensional Model in Matlab and VRML Environment

The spline interpolation method has been applied for the data PM10 (particular material up to 10 $\mu$m) measured in the AIM system of the Czech Republic at a selected time. The algorithm realized in the Matlab R12 system provides resulting model of air pollution presented in Fig. 2.
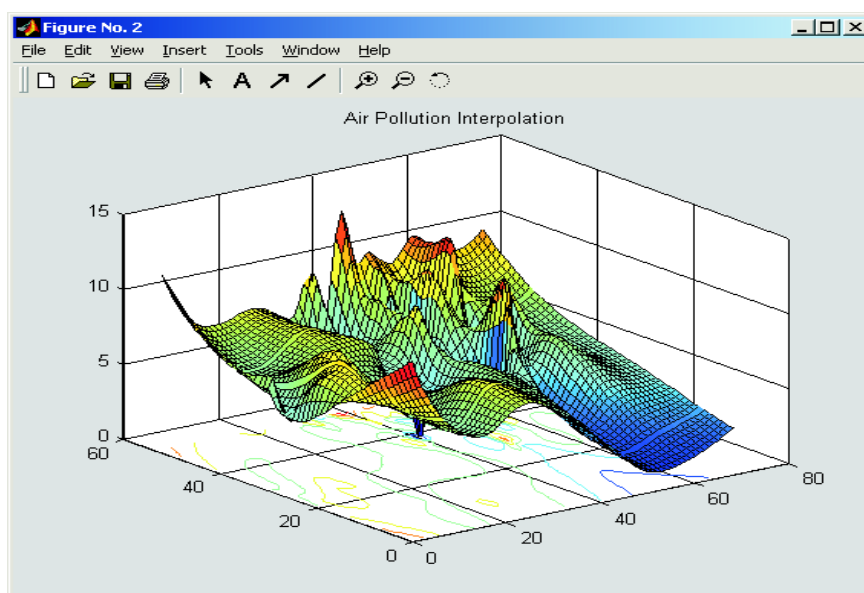


Figure 2: Result of spline interpolation of PM10 concentration realized in the Matlab system

Virtual Reality Toolbox v.2 [2] has been then used for creation of the VRML file (.wrl). Using any text editor for modification of this file it is necessary to respect the following requirements for the VRML file creation:

1. **Coordinate systems:** Both the Matlab system and the VRML use the right-handed Cartesian coordinate system, but rotated around the x-axis as given in Fig. 3
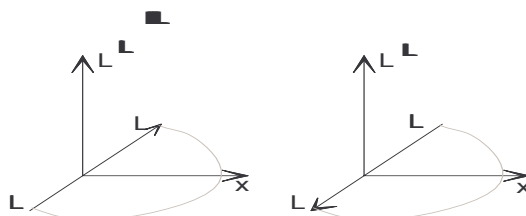


Figure 3: Coordinate systems in Matlab and VRML

2. **Units:** While in the Matlab environment it is possible to use any unit system, VRML expects that the length values are given in meters, angles in radians and time in seconds
3. **Nodes marking:** It is possible to communicate with the selected set of the VRML nodes in existing virtual world from Matlab and its Virtual Reality Toolbox provided that the nodes in VRML are named using the $DEF$ keyword

Having in mind these rules it is possible to export a 3D model created in the Matlab environment enabling visualization by *mesh* or *surf* commands to VRML environment in a very simple way using $vrml(handle, filename)$ command. Object properties defined in Matlab and given by the corresponding constant *handle* are translated into the VRML node parameters in this way.

As an example it is possible to assume the point coordinates as parameters of the node *coordinate* defined as a part of the transformation hierarchy. In the VRML environment each point must be declared by all its coordinates - x, y, z, respectively - on contrary with Matlab allowing to draw the model with missing z-coordinates as well. Further model properties are set using other nodes (*viewpoint, transform,...*). Allocation of names to nodes allowing the following modification of VRML nodes parameters from Matlab environment must be defined in the .wrl file.
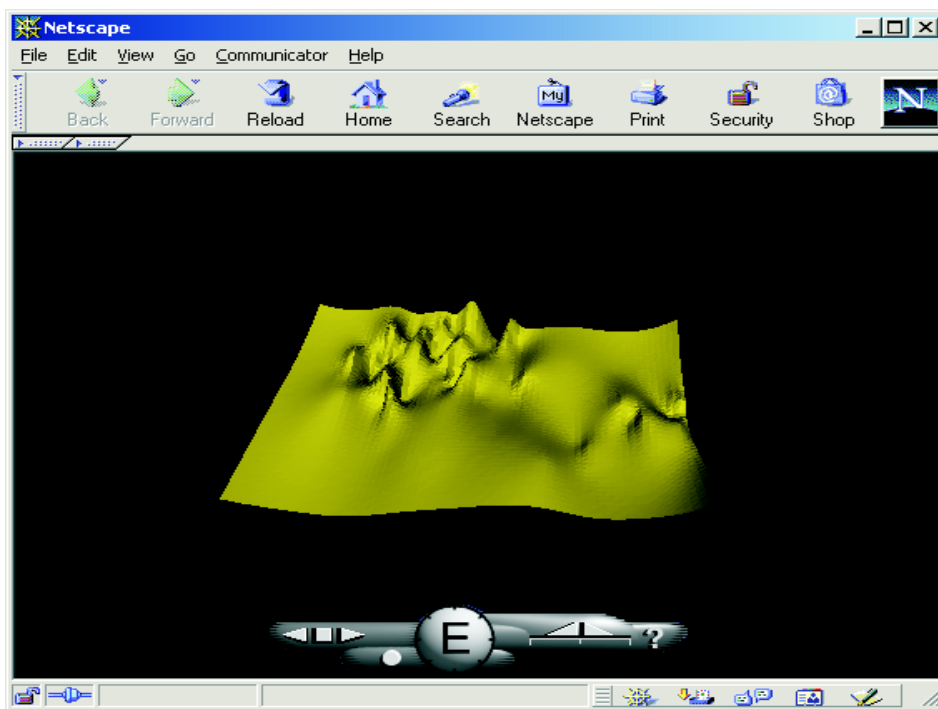


Figure 4: VRML model of the air pollution level in the selected region

The VRML model of air pollution presented in Fig. 4 has been verified in Netscape Navigator v. 4.77 with recommended plug-in module Blaxxun Contact v. 4.4. Using this software tools it is possible

- to observe VRML model
- to go through predefined points of view
- to change the way of movement in the model

Other possibilities include the virtual world control through the Virtual Reality Toolbox commands specified in [2].

# 5   Conclusion

Presented virtual model provides the possibility to view the air pollution situation in the Czech Republic. It is further easy to insert this model to Web pages. Although the VRML does not enable to solve mathematical problems by itself it can be used very efficiently to create animated three dimensional scenes driven from the Matlab and Simulink environment allowing signal or system modelling in the standard way.

The paper summarises the initial author's experiences with Virtual Reality Toolbox only. It is assumed that the presented model will be further developed in the future. As an example it is possible to mention the introduction of dynamical nodes to watch the time development of air pollution.

Proposed applications include three-dimensional models of air pollution and biomedical models based upon three-dimensional magnetic resonance observations as well. In both these cases the visualization and animation is very useful.

## Acknowledgments

## References

[1] S. J. Fortune. A sweepline Algorithm for Voronoi Diagrams. *Algoritmica*, (2), 1987.

[2] Humusoft, Praha. *Virtual Reality Toolbox - User's Manual*, 2000.

[3] a kol. J. Fiala, J. Ostatnická. *Znečištění ovzduší na území ČR v r. 1998*. ČHMÚ, Praha, 1999.

[4] M. Kolínová M. Mudrová and A. Procházka. Two Dimensional Inteprolation of Air Pollution Data. In *Process Control 2000*, Tatranske Matliare, 1999.

[5] J. Žára. *VRML97 - Laskavý průvodce virtuálními světy*. Computer Press, Brno, 1999.

[6] J. Žára. *Jazyky pro popis virtuální reality*. ČVUT, Praha, 2000.

[7] J. Zrzavý. *VRML - Tvorba dokonalých www stránek*. Grada, Prague, 2000.

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