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Hybrid Web visualization of urban GIS models with dynamic environmental volumetric data

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IK4 Research Alliance

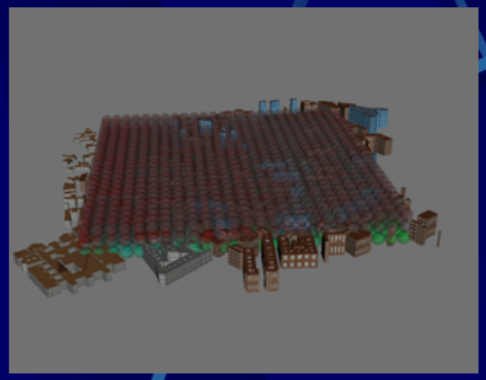
Outline

1. Motivation
2. HTML5 + WebGL
3. Volume Rendering
4. Methodology
5. Conclusions / Future Work
6. Questions

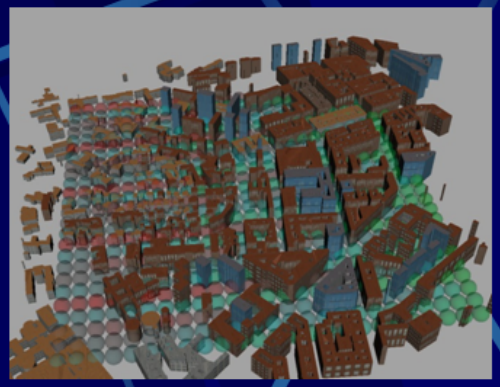
Motivation

- Air Quality Models
  - From monitoring network
  - Measure meteorological variables and pollutant levels
- … conceptualized as 2D at large scale
- But … at urban scale
  - It is essentially a 3D dataset
  - X–Y plane ~ Longitude Latitude
  - Z direction ~ Height
  - Mapping or analyzing the atmosphere
- ¿Visualization of such 3D scalar fields?

AIR POLLUTION VISUALIZATION GVSIG-3D



3 vertical levels



surface

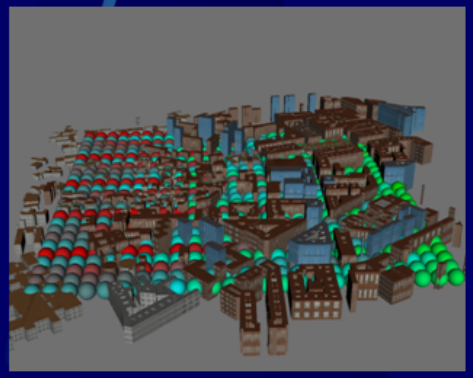
3D GRID CELL = SPHERE

COLOUR SCALE

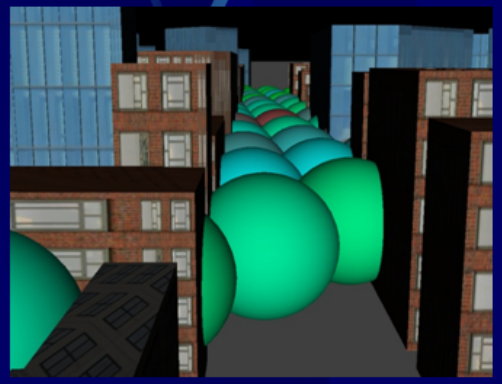
TRANSPARENCY

Temperature 3d data

1Km * 1Km Madrid



No transparency



Zoom-in

Red → Highest values

Green → Lowest values

gvSID – 3D

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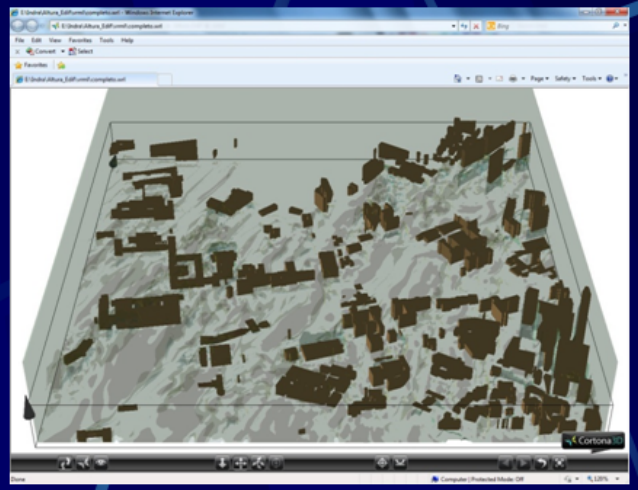
http://artico.lma.fi.upm.es

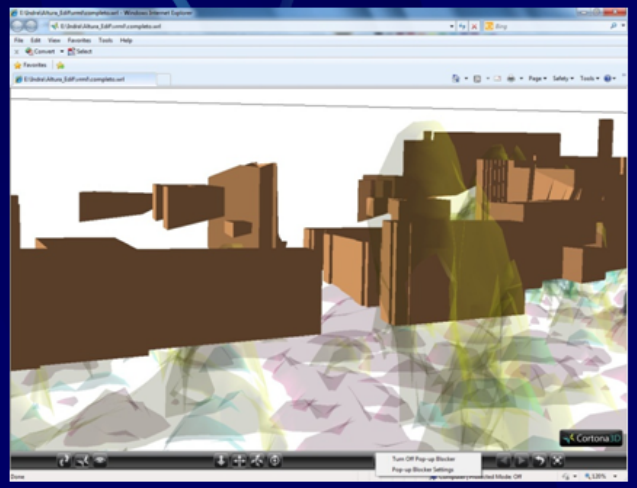
upm UNIVERSIDAD POLITÉCNICA DE MADRID

AIR POLLUTION VISUALIZATION VRML



Example of visualization with VRML of buildings and isosurfaces of temperature over Madrid area

Example of interaction of the user with VRML



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Why HTML5 and WebGL ?

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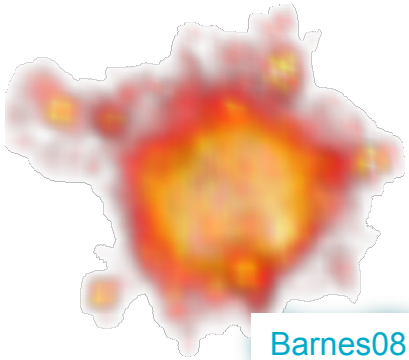
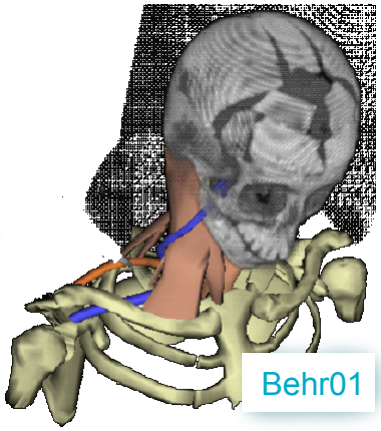
- Users can access Web application from anywhere
- No installations, just go to the web address
- Automatic and transparent app updates
- Huge amount of mobile devices and growing

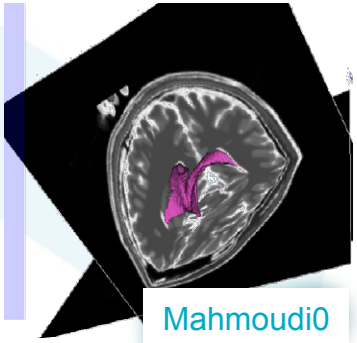
- HTML5 : **develop/write once, run everywhere**.
- WebGL: high performance 3D graphics standard like OpenGL, but in the Web.
  - Implemented natively in the latest versions of Firefox and Chrome. Also in mobile devices.

Volume Rendering (I)

- Scientific Visualization
- Medical Datasets
- Weather visualization
- Web advantages:
  - Homogeneous visualization from any device
  - No server computation


Barnes08

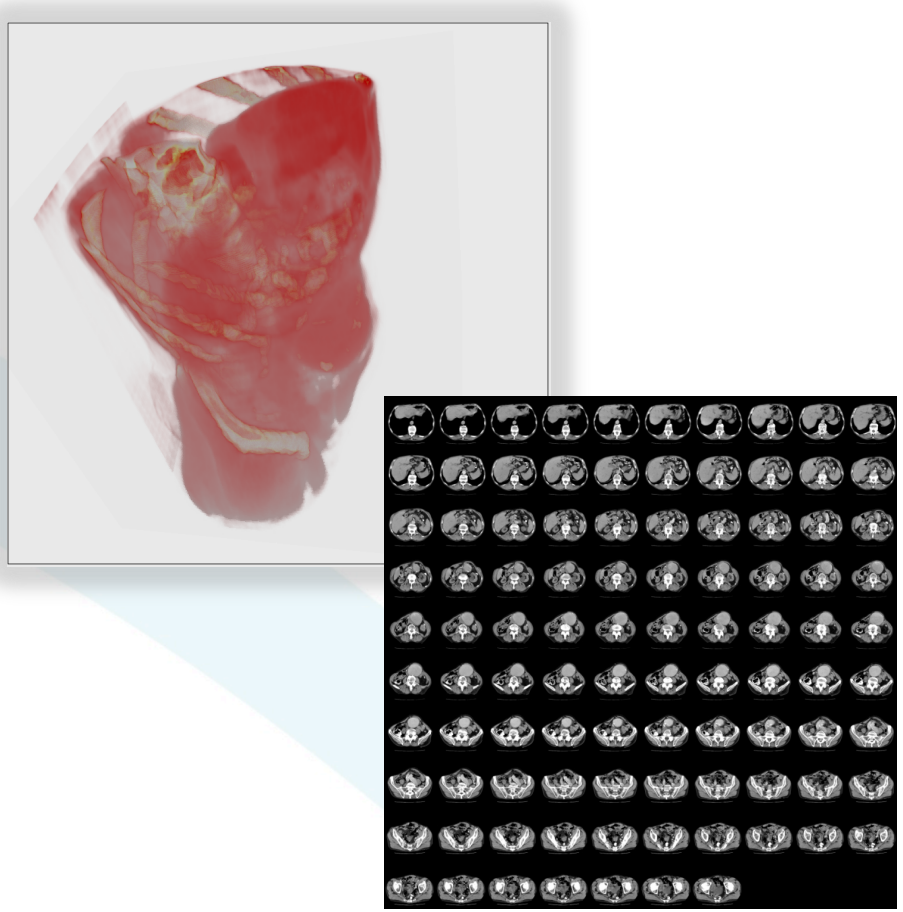

Behr01


Mahmoudi09


Settapat11

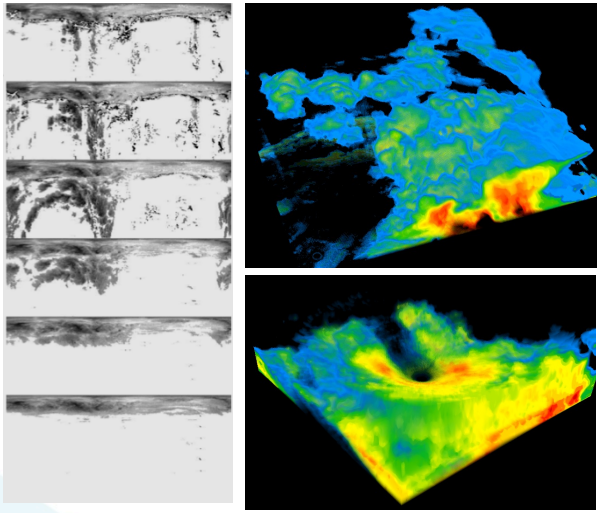
Volume Rendering (II)

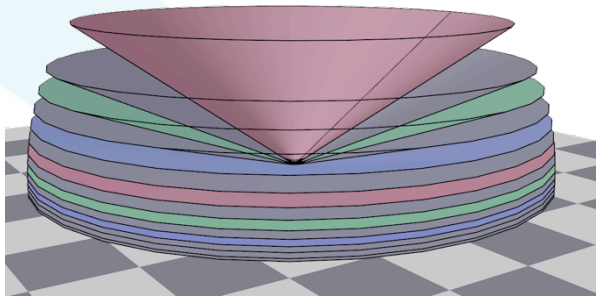
- **Ray-casting** is an expensive render algorithm for volume rendering.
- **WebGL** allows the graphics rendering pipeline be used from the Web.
- **Several proofs of concept**



Volume Rendering (III)

- Traditional Volume Rendering methods use orthogonal/cartesian coordinates
- Other scalar fields are represented with different coordinate system
  - e.g. Weather Radar datasets
  - Concentric cones, with the radar in the centre of them
    - Spherical coordinates
- What about AQM datasets at urban scale?



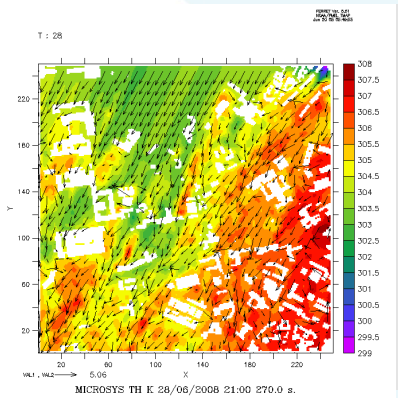


Objective

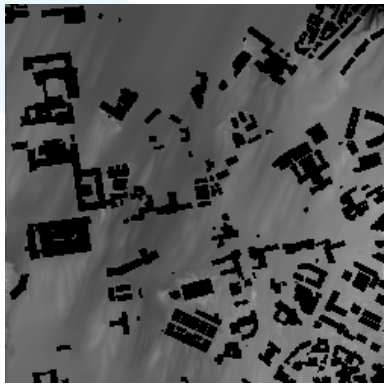
- Apply Volume Rendering techniques to AQM datasets
  - Provided by Madrid Technical Univesity (UPM).
  - Temperature at urban scale (Madrid, 1 km x 1km)
    - Obtained from numerical experiments to simulate turbulent fluxes for urban areas.
    - Modified EULAG micro scale model (CFD) used to obtain the urban atmosphere/biosphere energy exchange.
  - Each sample: 250 × 250 × 25 scalar values, in K.
    - With special values for NaN: -1.E+34

Methodology (I)

- Raw data provided in big ASCII Files (**X Y Z V**)
- Create PNG images from X-Y values
  - Map values (*float*) to (0 – 255) range (greyscale)
    - **298 K – 313 K** (~15 K) → **0 – 255** values (1 byte)
  - Defining a "good" **Window Level** is experimental
  - It depends on what the user wants to achieve

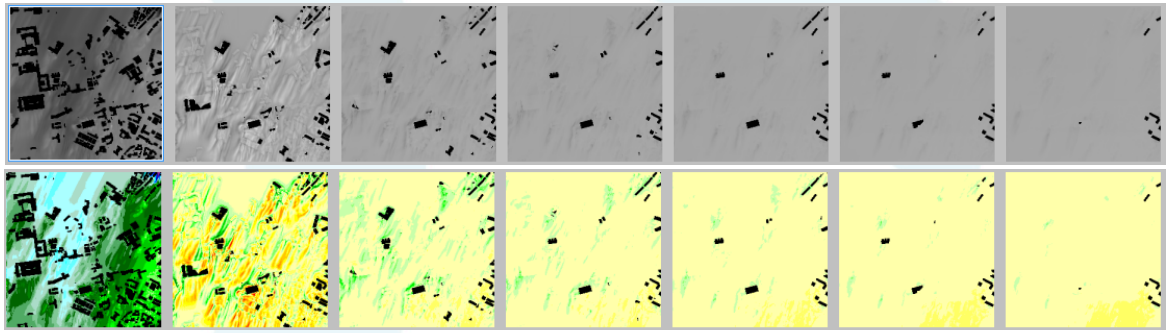



```
14   -1946.0 3102.0 2.0 304.785858
15   -1942.0 3102.0 2.0 304.828156
16   -1938.0 3102.0 2.0 304.845886
17   -1934.0 3102.0 2.0 304.831238
18   -1930.0 3102.0 2.0 304.814392
19   -1926.0 3102.0 2.0 304.909790
20   -1922.0 3102.0 2.0 -1.E+34
21   -1918.0 3102.0 2.0 -1.E+34
22   -1914.0 3102.0 2.0 -1.E+34
23   -1910.0 3102.0 2.0 -1.E+34
24   -1906.0 3102.0 2.0 -1.E+34
25   -1902.0 3102.0 2.0 305.334778
26   -1898.0 3102.0 2.0 305.313782
27   -1894.0 3102.0 2.0 305.164886
28   -1890.0 3102.0 2.0 305.115356
29   -1886.0 3102.0 2.0 305.089783
30   -1882.0 3102.0 2.0 304.923737
```



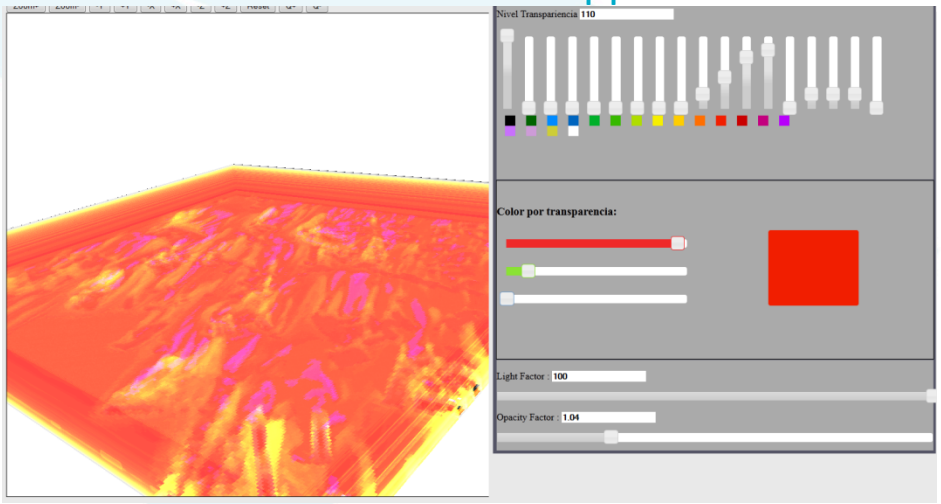
Methodology (II)

- Create set of **Z-aligned** PNG images
  - Do the same process for each Z slice
  - Without modifications of the Window Level
  - So, choosing the Window Level should take into account all the dataset values
    - As “interesting” information is near the ground, the Window Level could be biased to optimize the mapping of such layers
- Some colouring can be applied
  - Applying some Transfer Function (standard or random)



Results – WebGL AQM Volume Rendering

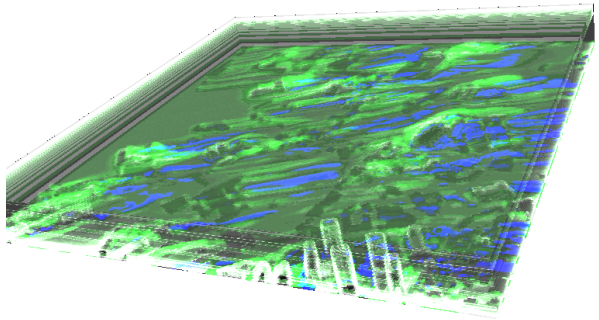
- The set of Z-aligned greyscale images is loaded into a WebGL powered Volume Rendering Web Application
  - HTML5 + jQuery for interaction controls
- Initial values for a correct visualization have to be chosen experimentally
  - Load, modify till get a good result and write down the values
  - Read values from a JSON file when the application is run

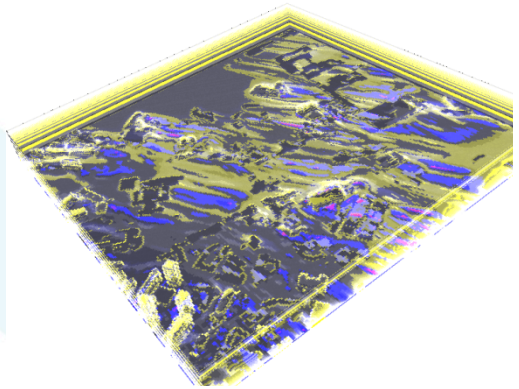


http://artico.lma.fi.upm.es/demo_TF_volren_upm/aqm-test-tf.01.html

Results – WebGL AQM Volume Rendering

- Interactively:
  - Free View - Camera Rotation
  - Dataset Inspection - Zoom Level
  - Color Mapping and Transparency
    - Set of slides
  - Global transparency and Light Factor are applied to the whole Volume
- Individual control for value 0 and 255
- Rest grouped in 16 values per slider
  - Each slider modifies the color and /or transparency of 16 values
  - More sliders more control
  - But less usable





Conclusions

- Volume Rendering techniques can be applied to AQM datasets
- Asymmetry is challenging
  - Less levels in height (250 x 250 x 25)
  - Interesting “details” are near the ground
- Better Transfer Function editor in HTML5 is required
  - Transfer classical TF editor controls to Web
- Georeferenciation has to be taken into account when working with “images”.

Future Work

- Next steps?
  - Window Level should be interactive
    - Realtime images generation from RAW data
  - Add 3D models (terrain + buildings)
  - Temporal Series
  - Extend to Vector fields (wind currents)
  - Manage several AQM variables
- ¿Different Pollutants (scalar, vector fields) + time + 3D models + “at the same time” + proper UI?
  - Usability problems
  - Further research

Volume Rendering Demos

http://demos.vicomtech.org/

http://www.volumerc.org/

Make sure that you've got the **very latest versions of the drivers for your graphics card**

and

use new versions of Firefox or Chrome

Thank you for your attention…

QUESTIONS?