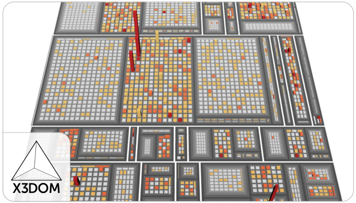
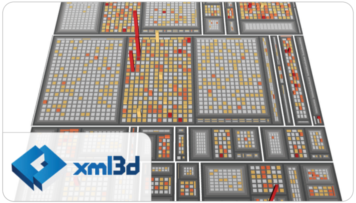
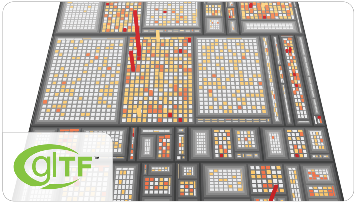
Dynamic 2.5D Treemaps using Declarative 3D on the Web







Daniel Limberger, Willy Scheibel, Stefan Lemme, and Jürgen Döllner

Treemaps are used to visualize tree-structured data.

They are applied in various domains such as visualization of financial data, sensor data, software system information, file systems, etc.

For it,

1. the usually non-spatial data is spatialized—it is given a gestalt that preserves the data's structure, e.g., rectangular treemaps use nested rectangles to depict individual nodes,
2. and data (attributes) are mapped to visual variables, i.e., properties of the rectangles (size and color).

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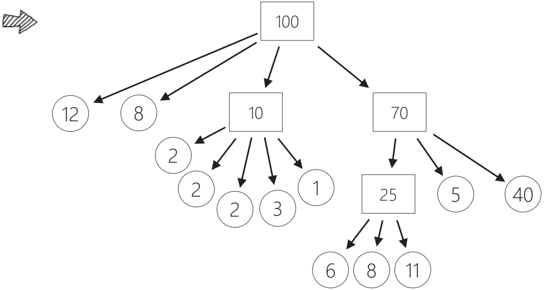
2. and data (attributes) are mapped to visual variables, i.e., properties of the rectangles (size and color).

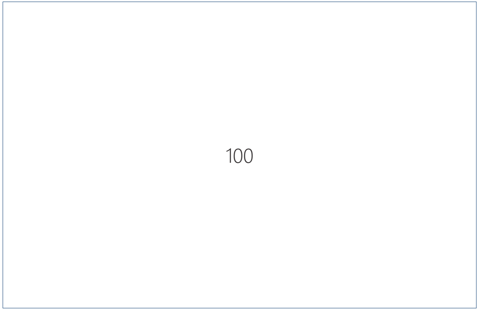
Depiction of Tree-structured Data

Leaf nodes are colored and have numerical weights, which can represent any associated attribute, e.g., file size. The weight of a parent node is defined by the sum of the weights of its child nodes.

Simple Graph



Rectangular Treemap



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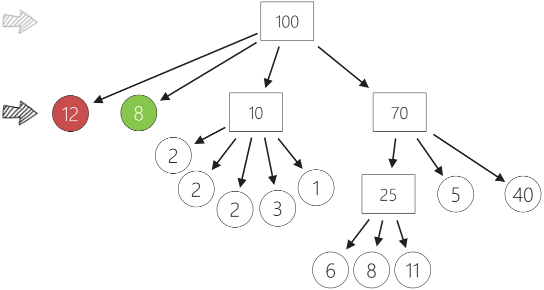

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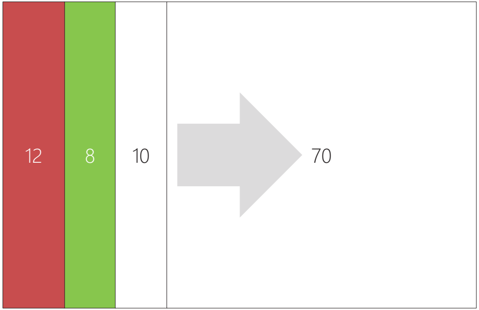

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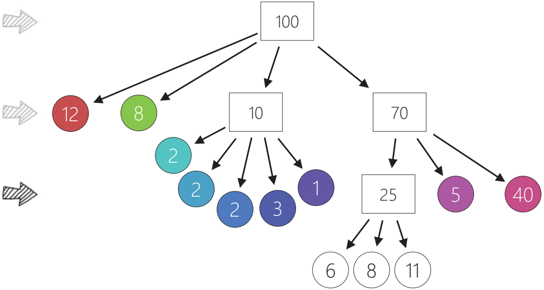
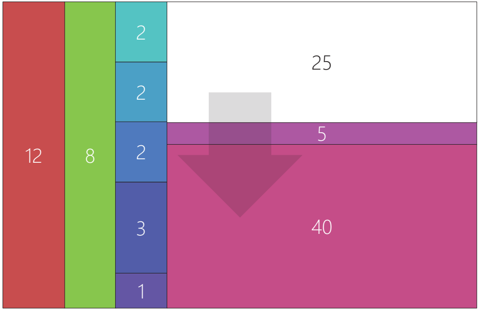


Rectangular Treemap



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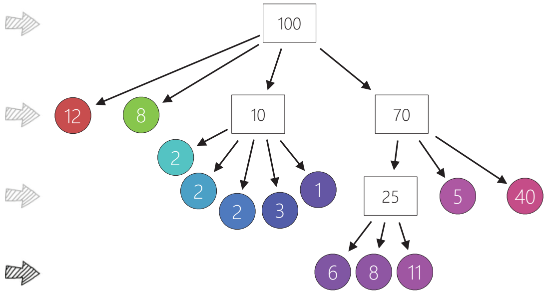
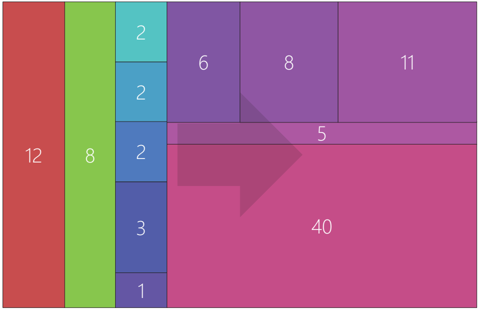


Rectangular Treemap



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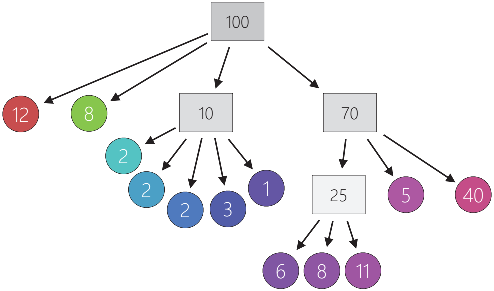
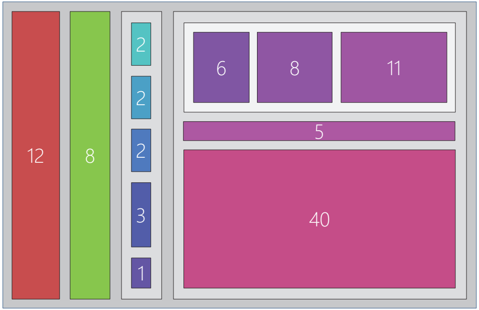


Rectangular Treemap



libmng_pixels.c
3rdparty
src
examples
double_data.h
auto
tests
demos
gui
corelib
benchmarks
qmake
project.cpp
qbig5codec.cpp
plugins
qt3support
declarative
xmlpatterns
designer
qdoc3
ts.cpp
tools
doc
epocroot.cpp
network
opengl
tools
util
config.profiles

Web-based Provisioning using Declarative 3D

Dynamic 2.5D Treemaps using Declarative 3D on the We

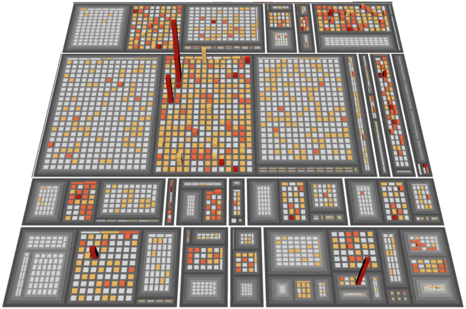
SUBMISSION ID: 32

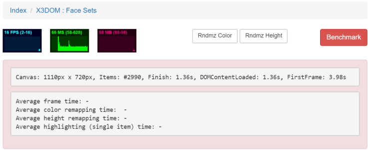
X3DOM	Instant 3D the HTML way!, X3DOM Documentation
X3DOM : Empty	/x3dom-0-empty.html
X3DOM : Boxes	/x3dom-1-box.html
X3DOM : Face Sets	/x3dom-2-faceset.html
X3DOM : Indexed Face Set	/x3dom-3-indexed-faceset.html

XML3D	Interactive 3D Graphics for the Web, XML3D Specification
XML3D : Empty	/xml3d-0-empty.html
XML3D : Mesh, Transformed Cuboid	/xml3d-1a-data-transformed-cuboid.html
XML3D : Model, Transformed Cuboid	/xml3d-1b-assets-transformed-cuboid.html
XML3D : Model, Styled Cuboid	/xml3d-1c-assets-styled-cuboid.html
XML3D : Indexed Meshes	/xml3d-2a-indexed-meshes.html
XML3D : All-in-One static Mesh	/xml3d-2b-all-in-one-no-picking.html
XML3D : Mesh with Transformed Index Buffer	/xml3d-2c-transformed-indexed-buffer.html

GLTF	GL Transmission Format, glTF Specification
glTF : Empty	/gltf-0-empty.html
glTF : All-in-One, static Mesh	/gltf-1-static.html
glTF : Separated Meshes and Materials	/gltf-2-accessors.html
glTF : Shared Mesh with Material per Node	/gltf-3-materials.html

Approaches (colored): Proposed | Feature Complete | Feature Incomplete | Template





X3DOM – Boxes

```
<transform id="parents">
  <transform id="transform-1"
    translation="-0.306478 0.0016 0.396264" scale="0.373045 0.001 0.193473">
    <shape id="1">
      <appearance>
        <material id="color-1" diffuseColor="0.329412 0.329412 0.329412"/>
      </appearance>
      <box size="1 1 1"/>
    </shape>
  </transform>
  ...
</transform>
```

X3DOM – Shared Geometry

```
<transform id="cuboid-template" render="false">
  <IndexedFaceSet DEF="cuboid" normalIndex="0 1 2 3 4" solid="true" normalPerVertex="false"
    coordIndex="0 6 5 1 -1 0 2 7 6 -1 3 4 7 2 -1 3 1 5 4 -1 3 2 0 1 -1">
    <Coordinate point="-0.5 1.0 -0.5 -0.5 1.0 0.5 0.5 1.0 -0.5 0.5 1.0 0.5 0.5 0.0 0.5 ..."/>
    <Normal vector="-1 0 0 0 0 -1 1 0 0 0 1 0 0 0 1"/>
  </IndexedFaceSet>
</transform>
<transform id="parents">
  <transform id="transform-1"
    translation="-0.306478 0.0011 0.396264" scale="0.373045 0.001 0.193473">
    <shape id="1">
      <appearance>
        <material id="color-1" diffuseColor="0.329412 0.329412 0.329412"/>
      </appearance>
      <IndexedFaceSet USE="cuboid"/>
    </shape>
  </transform>
  ...
</transform>
```

XML3D – Meshes

```
<defs>
  ...
  <data id="cuboid">
    <float3 name="position">-0.5 0.0 +0.5  -0.5 1.0 +0.5  -0.5 0.0 -0.5  -0.5 1.0 -0.5 ...</float3>
    <float3 name="normal">-1  0  0  -1  0  0  -1  0  0  -1  0  0  0  0 -1   0  0 -1 ...</float3>
  </data>
  <data id="c" src="#cuboid"> </data>
</defs>
<group id="treemap" material="#cuboid_material" ...>
  <group id="parents">
    <transform id="t1"
      translation="-0.306478 0.0011 0.396264" scale="0.373045 0.001 0.193473"></transform>
    <mesh id="1" src="#c" type="tristrips" transform="#t1">
      <float3 name="diffuseColor">0.329412 0.329412 0.329412</float3>
    </mesh>
    ...
  </group>
</group>
```

XML3D – Asset

```
<defs>
  ...
  <asset id="c">
    <assetdata name="cuboid_geometry">
      <float3 name="position">-0.5 0.0 +0.5  -0.5 1.0 +0.5  -0.5 0.0 -0.5  -0.5 1.0 -0.5 ...</float3>
      <float3 name="normal">-1  0  0  -1  0  0  -1  0  0  -1  0  0  0  0 -1   0  0 -1 ...</float3>
    </assetdata>
    <assetmesh includes="cuboid_geometry, s" type="tristrips"></assetmesh>
  </asset>
</defs>
<group id="treemap" material="#cuboid_material" ...>
  <group id="parents">
    <transform id="t1"
      translation="-0.306478 0.0011 0.396264" scale="0.373045 0.001 0.193473"></transform>
    <model id="1" src="#c" transform="#t1">
      <assetdata name="s">
        <float3 name="diffuseColor">0.329412 0.329412 0.329412</float3>
      </assetdata>
    </model>
    ...
  </group>
</group>
```

X3DOM – Pre-Baked Buffer

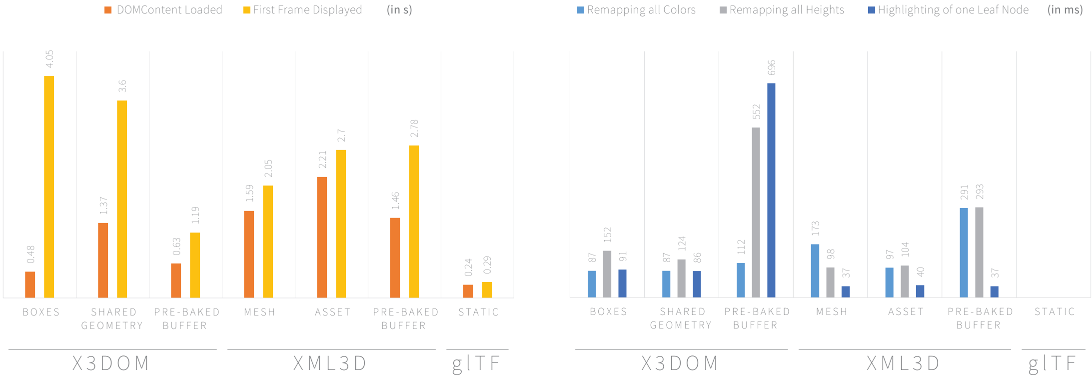
```
<shape id="parents" ...>
  <IndexedFaceSet coordindex="0 1 2 3 -1 4 5 6 7 -1 8 9 10 11 -1 12 13 14 ..." solid="true">
    <coordinate point="-0.493 0.0021 0.299527 -0.493 0.0011 0.299527 -0.493 ..."></coordinate>
    <colorrgba color="0.329412 0.329412 0.329412 1 0.329412 0.329412 0.329412 1 ..."></colorrgba>
    <normal vector="-1 0 0 -1 0 0 -1 0 0 -1 0 0 0 0 -1 0 0 -1 0 0 -1 0 0 -1 1 0 0 ..."></normal>
  </IndexedFaceSet>
</shape>

<shape id="leafs" ...>
  ...
</shape>
```

XML3D – Indexed Meshes (xflow)

```
<defs>
  <data id="cuboid">
    <float3 name="cube_position">-0.5 0.0 +0.5  -0.5 1.0 +0.5  -0.5 0.0 -0.5  -0.5 1.0 -0.5 ...</float3>
    <float3 name="cube_normal">-1  0  0  -1  0  0  -1  0  0  -1  0  0  0  0 -1   0  0 -1 ...</float3>
  </data>
  <data id="treemap-parents">
    <float3 name="center">-0.306478 0.0011 0.396264 -0.0627951 ...</float3>
    <float2 name="extent">0.373045 0.193473 0.10312 0.193473 ...</float2>
    <int name="id">1 221 291 342 614 710 814 837 889 903 1041 ...</int>
    <float name="height">0.001 0.001 0.001 0.001 0.001 0.001 ...</float>
    <float3 name="color">0.329412 0.329412 0.329412 0.329412 ...</float3>
  </data>
</defs>
...
<group id="treemap" material="#cuboid_material" ...>
  <group id="parents">
    <mesh id="1" type="tristrips" compute="dataflow['#select-box']" src="#d">
      <int name="boxid">1</int>
    </mesh>
    ...
  </group>
</group>
```

Results – Measurements



*All measurements were captured and averaged over 1.000 iterations for the same data set of 2990 nodes (358 parent and 2632 leaf nodes) with the same attribute mapping applied. All data was deployed on a server (http://hpicgs.github.io/web3d-treemaps/) and loaded/processed locally in Chrome (50.0.2661.87 64-bit) running on a Notebook (Intel Core-i7 6700HQ, 16GB RAM, Windows, Intel HD 530). For polyfill and DOM publicly available resources were used based on X3DOM 1.7.1, XML3D 5.1.4, and glTF 1.0 (with three.js r76).

Status and Future Work

Declarative 3D is capable of (tree-structured) data visualization.

However,

- massive data visualization might be possible—the bottleneck currently is DOM-processing speed
- custom buffers (e.g., ID buffers) that map data to visual properties (as xflow partially allows) by means of an arbitrary mapping function would be helpful
- remapping of attributes with Java Script is currently cumbersome—polyfills could provide helpers for that, e.g., for deriving relations between DOM objects and their associated data
- APIs might enable dynamic mapping/flexible geometry creation with upcoming WebGL releases

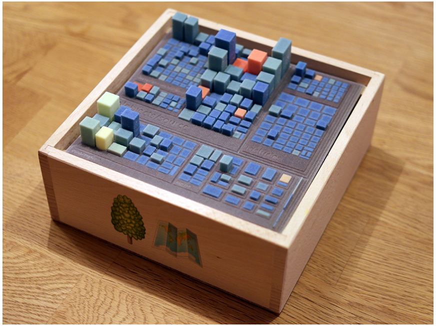
Disclaimer: latest 3D engines do NOT perform significantly better ...

Questions and Contact Information

Open-source implementation available at

hpicgs.github.io/web3d-treemaps/

- Daniel Limberger
  E-Mail: daniel.limberger@hpi.de
- Willy Scheibel
  E-Mail: willy.scheibel@hpi.de
- Stefan Lemme
  E-Mail: stefan.lemme@dfki.de
- Prof. Dr. Jürgen Döllner
  E-Mail: office-doellner@hpi.de



Backup : Performance (Table)

Benchmarks

Basis	**Approach**	DOMContent Loaded	First Frame Displayed	Continuous Rendering	Remapping all Colors	Remapping all Heights	Highlighting of one Leaf Node
X3DOM	**Boxes**	0.48s	4.05s	15fps	87ms	152ms	91ms
X3DOM	**Shared Geometry**	1.37s	3.60s	15fps	87ms	124ms	86ms
X3DOM	**Pre-baked Buffer**	0.63s	1.19s	60fps	112ms	552ms	696ms
XML3D	**Mesh**	1.59s	2.05s	30fps	173ms	98ms	37ms
XML3D	**Assets**	2.21s	2.70s	29fps	97ms	104ms	40ms
XML3D	**Pre-baked Buffer**	1.46s	2.78s	28fps	291ms	293ms	37ms
glTF	**Static**	0.24s	0.29s	60fps	–	–	–

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