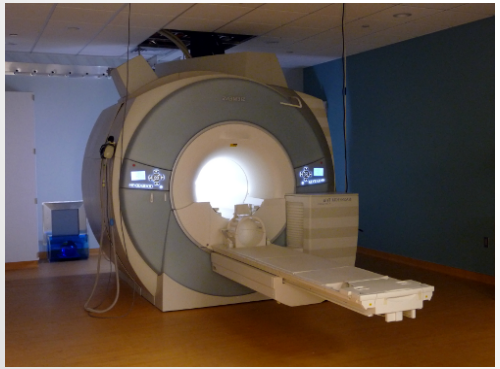
BrainBrowser

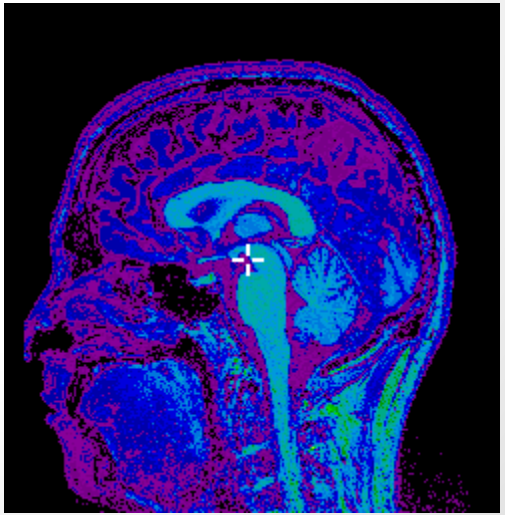
API and Architecture

Tarek Sherif
McGill University

Background

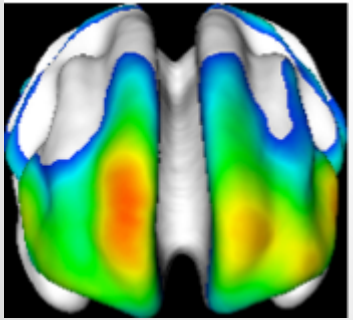
- Brain imaging is a fairly young field
  - Became widespread in the 1990s
- Magnetic Resonance Imaging (MRI) has become the most common technique
  - Low invasiveness
  - Lack of radiation exposure



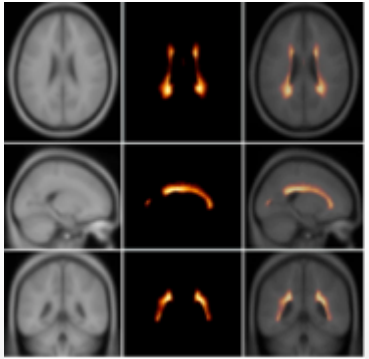


Background

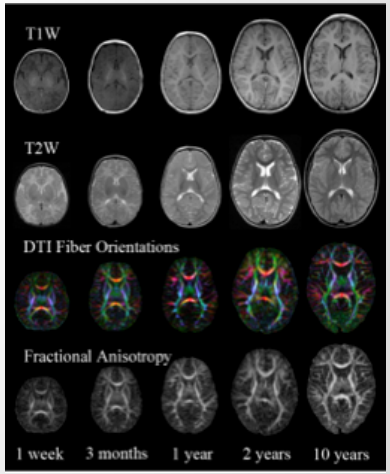
- Areas of Research:
  - Normal brain development
  - Alzheimer's Disease
  - Multiple Sclerosis
  - Autism
  - Schizophrenia



Alzheimer's Loss of Cortical Thickness



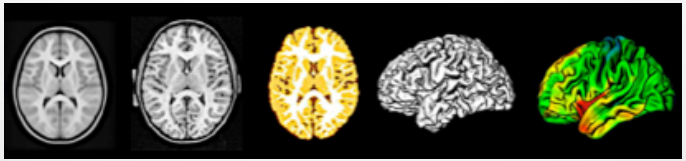
Multiple Sclerosis Lesions



Normal Brain Development in Children

Background

- Brain imaging research workflow involves:
  - Scanning
    - Get intensity data representing structural or activation patterns (structural vs. functional MRI)
  - Computational Analysis
    - Extract information of interest from the data (e.g. cortical thickness, tissue classification, gyrification)
  - Statistical Analysis
    - Determine significance of results
  - Visualization and Quality Control



BrainBrowser

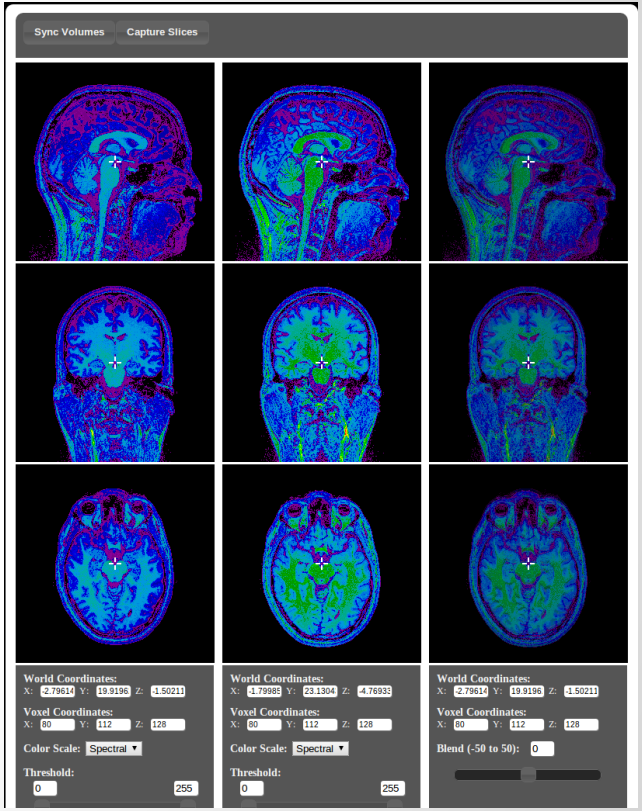
- A web-based set of tools for visualizing neurological data through modern standards-compliant browsers
  - Volume Viewer
  - Surface Viewer
    - Web Service API available

BrainBrowser

- Technologies used:
  - HTML
  - CSS
  - JavaScript
  - Canvas
  - WebGL (three.js)
  - Web Workers
  - CORS (for the web service)

Volume Viewer

- Navigate 3D MINC volumetric data
- Sagittal, coronal and transverse slices shown from a particular point in 3D space



Volume Viewer

- Entry point is BrainBrowser.VolumeViewer.start()
  - `viewer` object is passed to callback
  - manipulate it to control the app

```
BrainBrowser.VolumeViewer.start("viewer_div", function(viewer) {
  // Manipulate viewer to control the app
});
```

Volume Viewer

- Event model

```
BrainBrowser.VolumeViewer.start("viewer_div", function(viewer) {

  viewer.addEventListener("ready", function() {
    //...
  });

});
```

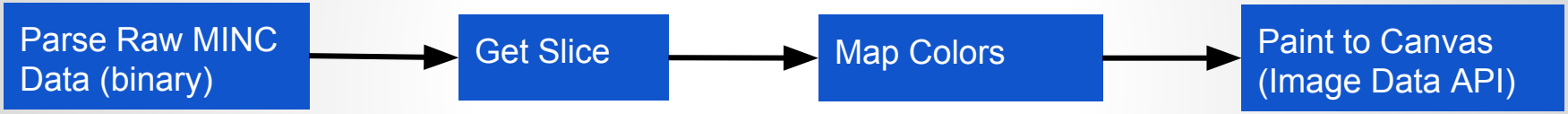
Volume Viewer

- Load your volumes.

```
BrainBrowser.VolumeViewer.start("viewer_div", function(viewer) {
  viewer.loadVolumes({
    volumes: [{
        type: "minc",
        header_url: "brain1.mnc?headers=true",
        raw_data_url: "brain1.mnc?raw_data=true"
    }]
  });
});
```

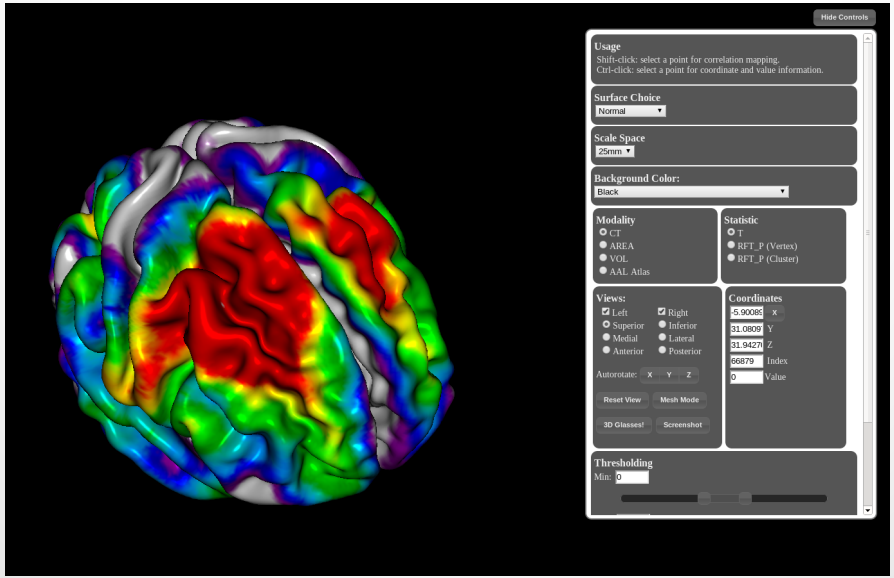
Volume Viewer

- Workflow:



Surface Viewer

- Real-time 3D visualization of surface files
- Apply color data representing different information about the surface (cortical thickness, correlations, etc.)



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```

Surface Viewer

- Event model

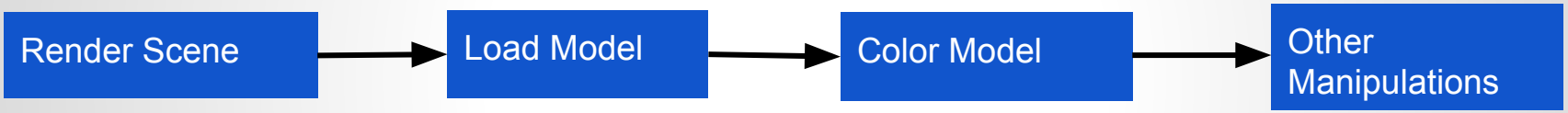
```
BrainBrowser.SurfaceViewer.start("viewer_div", function(viewer) {

  viewer.addEventListener("loadcolormap", function (color_map) {
    //...
  });

  viewer.addEventListener("displaymodel", function(model) {
    //...
  });
});
```

Surface Viewer

- Workflow:



Render Scene

```
BrainBrowser.SurfaceViewer.start("viewer_div", function(viewer) {

  viewer.render();

});
```

Render Scene

```
var renderer = new THREE.WebGLRenderer(...);
var scene = new THREE.Scene();
var camera = new THREE.PerspectiveCamera(...);

renderer.render(scene, camera);
```

Load Model

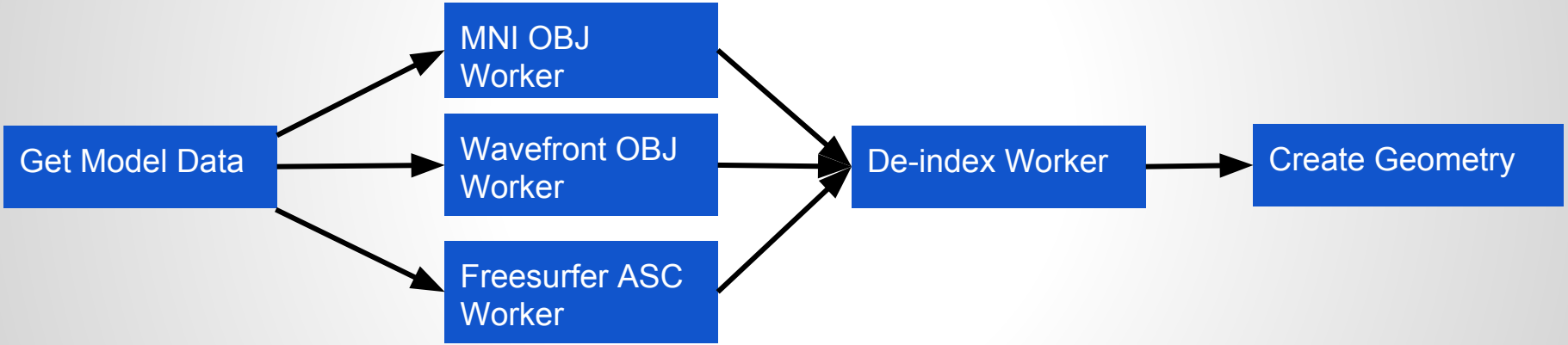
```
BrainBrowser.SurfaceViewer.start("viewer_div", function(viewer) {

  viewer.loadModelFromURL("brain.obj", {
    format: "MNIObj",
    complete: function() {
      // Do something when done
    }
  });

});
```

Load Model

- Model Load Workflow:



Load Model

- Get Model Data:
  - AJAX request for URL
  - FileReader API to load from a local file

Load Model

- Workers to parse model data:
  - A Web Worker is defined for each supported file type
    - Parse the file and return vertices, colors, indices and normals
  - Plugin architecture
    - Define a new worker and you can support a new file type
  - Currently supported file types:
    - MNI OBJ
    - Wavefront OBJ
    - Freesurfer ASC

Load Model

- De-index Models
  - Most data formats encode indexed models
  - WebGL indices can only be 8-bit or 16-bit unsigned integers
    - Limit of 65536 vertices for indexed models
  - BrainBrowser uses models that are much larger than this
  - Models are de-indexed by a Web Worker before being used

Model	Number of Vertices
Brain	81924
DTI	478750
Aeroplane	187358

Load Model

- Create geometry:
  - Was using THREE.Geometry
    - Convenience classes that manage everything: THREE.Vertex, THREE.Color, THREE.Face
    - TOO SLOW:
      - Object creation becomes a bottleneck
      - Updates have to traverse a tree-like structure

Load Model

- Create geometry:
  - Now using THREE.BufferGeometry
    - Still pretty convenient
    - Directly define the vertex, color and normal buffers that will be sent to WebGL
    - MUCH FASTER

Color Model

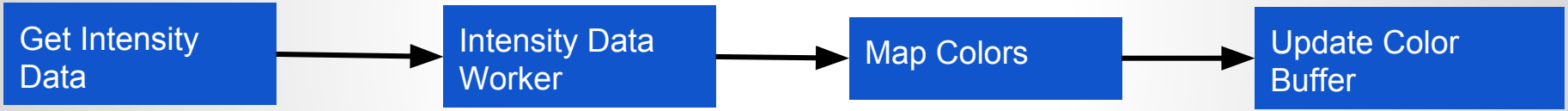
```
BrainBrowser.SurfaceViewer.start("viewer_div", function(viewer) {

  viewer.loadColorMapFromURL("spectral.txt");

  viewer.loadIntensityDataFromURL("cortical_thickness.txt");

});
```

Color Model


Get Intensity Data
Intensity Data Worker
Map Colors
Update Color Buffer

Color Model

- Get Intensity Data
  - Intensity data is the raw information we’re visualizing
    - Original scan or computation run on the original data
  - Can be loaded from a URL or a local file

Color Model

- Parse Intensity Data
  - Intensity data comes in as text
  - Web Worker parses it into array

Color Model

- Map Colors
  - Map intensities to colors based on the current color map
- Color can be tweaked based on several parameters:
  - Minimum and maximum intensity threshold
  - Clamping
  - Flipping the intensity to color map relationship

Color Model

- Update the Color Buffer
  - Write colors to the color buffer
  - Signal that the colors must be updated in WebGL

```
geometry.attributes.color.needsUpdate = true;
```

Other Manipulations

```
BrainBrowser.SurfaceViewer.start("viewer_div", function(viewer) {

  viewer.setWireframe(true);                          // Wireframe mode

  viewer.setTransparency("left_hemisphere", 0.5);  // Transparency

  viewer.setIntensityRange(0.5, 1.5);                 // Intensity range

  viewer.autorotate.x = true;                         // Autorotate around the x axis

  // AND MORE!!!
});
```

Surface Viewer Web Service

- Simple GET HTTP request for widget HTML to load into page

```
<div id="display"></div>
<script>
  $("#display").load(
    "https://brainbrowser.cbrain.mcgill.ca/surface-viewer-widget?" +
    "version=1.4.1&" +
    "model=brain.obj&" +
    "intensity_data=cortical_thickness.txt&" +
    "color_map=spectral.txt&" +
    "width=100&" +
    "height=100"
  );
</script>
```

Surface Viewer Web Service

- Request a specific version of BrainBrowser
  - Prevent widget from breaking if BrainBrowser is updated
  - Appropriate version of three.js is automatically loaded
    - (unless client requests otherwise)

Surface Viewer Web Service

- Control viewer programmatically by defining a viewer callback

```
<div id="display"></div><input id="wireframe" type="checkbox"/>
<script>
  function init(viewer) {                                    // Define callback function
    $("#wireframe").change(function() {
      viewer.setWireframe($(this).is(":checked"));           // Use viewer object
    });
  }
  $("#display").load(
    "https://brainbrowser.cbrain.mcgill.ca/surface-viewer-widget?" +
    "version=1.4.1&model=brain.obj&" +
    "viewer_callback=init"                                   // Pass callback name as
  );                                                         //   parameter to web service
</script>
```

Thanks!

BrainBrowser

BrainBrowser: https://brainbrowser.cbrain.mcgill.ca/

CBRAIN: http://cbrain.mcgill.ca/

Questions? tsherif@gmail.com

Credits:

Lead Developer: Tarek Sherif

Original Author: Nicolas Kassis

Contributing Developer: Mia Petkova

Consultant: Samir Das

CBRAIN System Architect: Marc Rousseau

CBRAIN Manager: Reza Adalat

Principal Investigator: Alan Evans

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McGill

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