GeoSVG: A Web-based Interactive Plane Geometry System for Mathematics Education

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Outline

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  – Complete Web orientation
  – Manipulative enhancement by the Web
• Implementation
• Conclusions and Future Work
Motivation

• To provide support for the WME (Web-based Mathematics Education) system
  – Online Geometry manipulative authoring and running
  – Drawing capability for different components of the WME system
    • Lesson page contents composition
    • Assessment question composition
    • Bulletin Board message posting

• Existing DGS (Dynamic Geometry Software) cannot meet all the requirements
  – Geometer’s SketchPad (JavaSketchPad), Cabri Geometry II (CabriJava), Cinderella, C.a.R., etc.
Goals of GeoSVG

- GeoSVG authoring environment can be run on the Web via a browser
- A generated manipulative can be directly embedded in a Web page
- A manipulative may contain none or all of the authoring supports
- A manipulative can be interoperable with the enclosing page
- Manipulatives can be easily shared, modified, and reused
Usage Scenarios

• GeoSite alone
  – Authoring manipulative on GeoSite
  – Learning directly from GeoSite

• Cooperation between GeoSVG and other Web sites
  – Adding drawing capability to your Web Site
  – Simple embedding of manipulative from GeoSite into your Web pages
  – Advanced embedding of manipulative from GeoSite to allow interaction between the manipulative and your Web pages
Usage Scenarios

- Adding drawing capability to your site

  • Install the GeoSVG library to your Web site
  • Include a javascript library GDrawing.js to your pages
  • GDrawing interacts with the GeoSVG library and provides several APIs:
    - newDrawing, editDrawing, displayDrawing, replaceDrawing, removeDrawing
  • Example: A math bulletin board using the GeoSVG allows users to post text along with interactive drawing.
Usage Scenarios
- Simple embedding of manipulative from GeoSite

• Add this html codes to your Web page:
  `<embed
      src="http://GeoSite-server-name
          /username/path/manipulative name.svg">
    type="image/svg+xml" width=".." height=".." />

• Pro: simple
• Con: no interaction between the manipulative and the enclosing page due to security restriction
• An advanced embedding technique will be introduced in the Conclusions and Future Work section
GeoSVG Architecture and Components

Browser
Interactive Learning (In Web page)
with SVG

Server
System Access
Manipulatives Access
File Storing
Sharing
Searching

GeoSite

Browser
Authoring
Testing
Editing
Configuring
with SVG
GeoSVG Architecture and Components (cont.)

• The GeoSVG toolkit:
  a. An SVG-coded *Plane Geometry Engine* for authoring and viewing manipulatives (creating, moving, and animating geometric objects).
  b. GUI for the authoring environment providing authoring logic, a variety of dialogs assisting authoring, publishing, and communications with the server side.

• The GeoSite ([http://wme.cs.kent.edu/geosite/main.html](http://wme.cs.kent.edu/geosite/main.html))
  • A Web site that makes the GeoSVG toolkit available as well as stores manipulatives and education pages for access, searching, and sharing.
GeoSite
GeoSVG Authoring Environment

Proof of $a^2 + b^2 = c^2$
Features of GeoSVG

• Geometry manipulative authoring support
• Complete Web orientation
• Manipulative enhancement by the Web
  – Configurable GUI for Learning
  – Input and output interface of a manipulative
  – Page composition
  – Submittable manipulative
  – Keywords and search
Geometry manipulative authoring support

- Drawing primitives
- Geometric object construction
- Measurement
- Loci and Envelops
- Animation
- Calculation
- Graphing
- Geometric transforms
- Defining Macros
- Defining GUI Operations
Features of GeoSVG

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- **Complete Web orientation**
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### Complete Web Orientation

<table>
<thead>
<tr>
<th></th>
<th>Non-Web-based DGS System</th>
<th>GeoSVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software installation</td>
<td>Per Computer installation required</td>
<td>Use through browser, no installation required for authoring or learning</td>
</tr>
<tr>
<td>Manipulative sharing</td>
<td>Difficult because manipulatives are stored on individual computers</td>
<td>Easy because manipulatives are stored and searchable on the Web</td>
</tr>
<tr>
<td>Publishing manipulatives</td>
<td>Authors need to include Java applets in Web pages which are then deployed on servers</td>
<td>Saving a manipulative automatically publishes it on the Web</td>
</tr>
<tr>
<td>Download speed</td>
<td>Applets are binary, large and slow to download</td>
<td>Files are textual, smaller and can be compressed for fast download</td>
</tr>
<tr>
<td>Open Standards</td>
<td>Use proprietary technologies</td>
<td>Use W3C standard Web Technologies</td>
</tr>
<tr>
<td>Interoperable with the enclosing page</td>
<td>No</td>
<td>Can be driven by data outside, and output data</td>
</tr>
</tbody>
</table>
Features of GeoSVG

• Geometry manipulative authoring support
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  – Submittable manipulative
  – Keywords and search
Configurable GUI for Learning

• On the Web, it’s possible to present a manipulative in two modes: authoring mode and learning mode
  – Under learning mode, any unnecessary authoring support is removed.
  – The author can decide to include as little or as much as needed authoring supports into the manipulative
Configurable GUI for Learning (cont.)
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Input and output interface of a manipulative

- Input interface can make sources outside to change a manipulative.
- Output interface defines what measurements in a manipulative can be used outside.
- APIs to access the interface are provided if the manipulative is to be embedded in a page outside the GeoSite.
- GeoSite itself also provides GUI to authors to compose education pages that access the manipulative interface (next slide).
Page composition

- A page can embed any number of manipulatives
- Quantities (shown as html text) associated with an expression can be updated instantly
- User input (from html input box) can update manipulatives or quantities instantly
- Html button can invoke the evaluation of an associated expression
- Expressions in terms of manipulative interface, quantities, and user input are created via a dynamic calculator.
Manipulative with question

Define output interface

Dynamic calculator

Paragraph composition
Features of GeoSVG

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Implementation

• Geometry Engine
  – for manipulative rendering and interaction
  – in SVG (*Scalable Vector Graphics*) from either browser’s native support (Firefox or Opera) or plug-in (Adobe SVG Viewer)

• GUI
  – menus, toolbars and a variety of dialogs
  – in XHTML, XUL & XBL (Mozilla specific)

• Math Expressions
  – to be rendered in MathML
Conclusions and Future Work

• Performance of SVG is still not ideal. Fortunately, the support from browsers such as Firefox and Opera is improving.
• More authoring support is under development, and hopefully GeoSVG will eventually be as good as existing DGS systems.
• Cooperation between GeoSVG and other sites such as WME sites is under development and test (next slide).
Usage Scenarios
- Advanced embedding of manipulative from GeoSite

- This part is still under development. The main workflow is:
  - Install the GeoSVG library to your Web site
  - Embed an svg file named view.svg from within the GeoSVG library
  - Retrieve from GeoSite the data describing the manipulative via Web service
  - The GeoSVG library will interpret the data and display the manipulative
  - Security restriction is removed and interaction between the manipulative and the enclosing page is possible now. You can use the manipulative input/output interface APIs.