Integration of *OpenGeoProver* with *GeoGebra* (ongoing project)

Ivan Petrović  
PhD student at Faculty of Mathematics  
University Belgrade  
joint work with  

Predrag Janičić  
Associate Professor at Faculty of Mathematics  
University Belgrade
AGENDA

- Short overview of OpenGeoProver
- Integration with GeoGebra – the main ideas
- Implementation details
- Future work
Short overview of OpenGeoProver

- OpenGeoProver is an improved Java reimplementation of the prover from the GCLC tool
- Only the simple Wu's method has been implemented so far
- OpenGeoProver is developed to be used in various geometry tools
- OpenGeoProver project open-source: [ http://code.google.com/p/open-geo-prover/ ]
Short overview of OpenGeoProver

- JGEX is related system (but aimed only at one tool)
- Comparison of execution times (of final reminder calculation) for Wu's method between OpenGeoProver and JGEX:

(CPU times in ms)

<table>
<thead>
<tr>
<th>Theorem</th>
<th>JGEX</th>
<th>OGP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 6 (variant of; Pascal’s theorem for circle)</td>
<td>1077</td>
<td>138</td>
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<td>Example 36 (butterfly)</td>
<td>1745</td>
<td>289</td>
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<tr>
<td>Example 133 (variant of; orthocenter is incenter of triangle formed of altitudes’ feet)</td>
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<td>Example 154 (incenter)</td>
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<td>Example 173 (orthocenter)</td>
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<td>Example 191 (Euler’s line)</td>
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<td>Example 196 (Euler’s/nine-point circle)</td>
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<td>Example 288 (Simson’s theorem)</td>
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<td>Example 336 (Gergonne’s point)</td>
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<td>51</td>
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<td>Example 346 (Desargues’ theorem)</td>
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<td>221</td>
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</tbody>
</table>
Integration with GeoGebra – the main ideas

- Adding automated geometry theorem proving features to GeoGebra in collaboration with the GeoGebra team
- The prover within GeoGebra will check relationships among constructed objects
- The prover returns NDG conditions that could be used for examination of special cases of geometry theorems
Integration with GeoGebra – the main ideas

- Design choices:
  - Java programming language – OpenGeoProver compatible with GeoGebra
  - Construction set and organization similar to GeoGebra – Construction Protocol concept
  - Easy exchange of data between the core GeoGebra and OpenGeoProver through a set of API methods
Integration with GeoGebra – the main ideas

- “Light” (flexible) integration of prover and GeoGebra:
  - Easy replacement of a prover in GeoGebra
  - Easy maintenance of OpenGeoProver code
  - Integration with other dynamic geometry tools
Implementation details

- Defining and implementation of XML format for API methods used between OpenGeoProver and GeoGebra

- OpenGeoProver currently holds the internal XML format for representation of geometry constructions and theorem statements

- OpenGeoProver can act as a standalone application, although it is mainly intended for integration with other dynamic geometry systems
Implementation details

- Example of theorem representation in OpenGeoProver's internal XML format:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE geothm SYSTEM "geothm.dtd">
<geothm name="Orthocenter of triangle">
    <!-- In a triangle ABC, let h_a, h_b, and h_c be altitudes that -->
    <!-- correspond to the vertices A, B, and C and let H be the -->
    <!-- intersection of h_a and h_b. Then, H belongs to h_c. -->
    <constructions>
        <pfree label="A" />
        <pfree label="B" />
        <pfree label="C" />
        <ltwopts label="a" point1="B" point2="C" />
        <ltwopts label="b" point1="C" point2="A" />
        <ltwopts label="c" point1="A" point2="B" />
        <lperp label="ha" point="A" baseline="a" />
        <lperp label="hb" point="B" baseline="b" />
        <lperp label="hc" point="C" baseline="c" />
        <pintersect label="H" set1="ha" set2="hb" />
    </constructions>
    <statement>
        <pointonset set="hc" point="H" />
    </statement>
</geothm>
```
Implementation details

- GeoGebra's XML format should be able to:
  - express constructions from GeoGebra
  - express statements about relationships between constructed objects
  - pass prover parameters like the time and space limits, the log level, the selected prover etc.
  - pass results back to GeoGebra – whether theorem has been proved or not, prover reports, NDG conditions
Implementation details

- GeoGebra must provide way to express relationships among geometry objects (parallel lines, collinear points, congruent triangles etc.)

- GeoGebra GUI must be enhanced to support setting prover parameters

- Processing of NDGs – only textual description will be used in the first phase
Future work

- Implementation of complete Wu's method (JGEX can be used as a reference)
- Implementation of Gröbner basis method
- Improving prover efficiency
Future work

- Implementation of special requirements from GeoGebra about usage of prover (if any)
- Real-world applications of theorem proving within GeoGebra
- Supporting theorems about parametric objects (like conic sections)
- Supporting generic XML formats for representation of theorem statements, so OpenGeoProver could be easily integrated to any geometry system that supports such XML format
Thank you very much!