Dynamic Geometry Software and the GCLC System

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Roma, Italy, November 11, 2008.

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Research interests

- Automated theorem proving and formal theorem proving, with emphasis on SAT and SMT solving and applications
- Geometrical reasoning
- Intelligent mathematical software

Agenda

- What is dynamic geometry software?
- What is GCLC?
- Demo of GCLC
- Intelligent Geometrical Software

What is Dynamic Geometry Software?

- Interactive geometry software or Dynamic geometry software or Dynamic geometry environments or Dynamic geometry tools

- DG tools allow the user "to create and then manipulate geometric constructions, primarily in plane geometry"

- The user typically starts a construction with a few points, construct new objects, and then can move the points to see how the construction changes

What Good is Dynamic Geometry Software?

- Fun and good for exploring geometry and mathematics

- Good for students:
  - to explore and understand the underlying principles of Euclidean constructions and transformations
  - to create and explore mathematical animations

What Good is Dynamic Geometry Software? (2)

- Good for teachers:
  - to demonstrate and illustrate concepts
  - to help students grasp the abstract concepts in mathematics
- Good for publishing:
  - easy producing complex mathematical figures

Some Commercial Dynamic Geometry Tools

- Cabri Geometry — since 1988
- Geometer Sketchpad (GSP) — since 1991
- Cinderella (different geometries)

Some Free Dynamic Geometry Tools

- KSEG
- Eukleides
- DrGeo
- http://en.wikipedia.org/wiki/Dynamic_geometry_software

Some of 3D Dynamic Geometry Tools

- Cabri 3D
- Archimedes Geo3D
- JavaView

Different Tools, Different Skills

- Animations, loci, ...
- Symbolic expressions, calculations, ...
- Saving constructions, saving figures, ...
- Multilingual
- Automated theorem proving, probabilistic proofs, ...

GCLC/WinGCLC

- First version released in 1996, originally, as a tool for producing geometrical illustrations for LaTeX, hence the name GCLC:

  "Geometry Constructions → LaTeX Converter"

- Command-line versions for Windows and Linux and a version with graphical interface for Windows (WinGCLC)

- Freely available from http://www.matf.bg.ac.yu/~janicic/gclc and from EMIS (The European Mathematical Information Service) servers http://www.emis.de/misc/index.html

Main applications of GCLC/WinGCLC

- producing digital mathematical illustrations
- mathematical education
- storing mathematical contents
- studies of automated geometrical reasoning

GCLC Users

- Used worldwide in a number of high-schools and university courses, and for publishing

- >20000 visitors since 2003 (>5% from Italy!), last 2000 visitors:

GCLC: Basic Principles

- A construction is a formal procedure, not an image
- Producing mathematical illustrations should be based on "describing figures", not on "drawing figures" (similarly as TEX)
- Images can be produced from descriptions, but not vice-versa!
- All instructions are given explicitly, in GCLC language
- GCLC language is like a simple programming language, easily understandable to mathematicians

Features (part I)

- Support for geometrical primitive constructions, compound constructions, transformations, etc.
- Symbolic expressions, while-loops, user-defined procedures
- Conics, 2D and 3D curves, 3D surfaces
- Log files with information on all objects
- Built-in theorem provers

Features (part II)

- User-friendly interface, interactive work, animations, traces
- Export to different formats (LaTeX— several versions, EPS, BMP, SVG), import from JavaView
- Full XML support
- Free, small in size (<1Mb), easy to use, well documented

GCLC Language

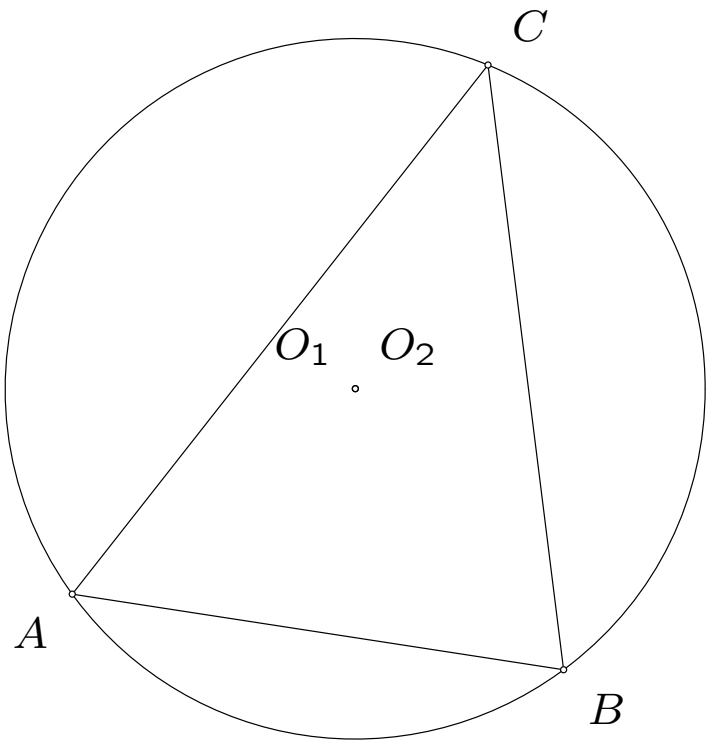
- Instructions for describing **contents**
- Instructions for describing **presentation**
- All of them are explicit, given by GCLC commands

Simple Example (part I)

```
% fixed points
point A 15 20
point B 80 10
point C 70 90

% side bisectors
med a B C
med b A C
med c B A

% intersections of bisectors
intersection O_1 a b
intersection O_2 a c
```

```
% labelling points
cmark_lb A
cmark_rb B
cmark_rt C
cmark_lt O_1
cmark_rt O_2

% drawing the sides of the triangle ABC
drawsegment A B
drawsegment A C
drawsegment B C

% drawing the circumcircle of the triangle
drawcircle O_1 A
```

Simple Example (part II)



Overview of the Language

- Basic definitions, constructions, transformations
- Drawing, labelling, and printing commands
- 2D and 3D Cartesian commands
- Symbolic expressions, loops, user-defined procedures
- Commands for describing animations
- Commands for the geometry theorem proving

Demo: Several GCLC Examples

Intelligent Geometrical Software