

Dr. Geo II

“Smalltalk Interactive Geometry in School”

ESUG 2008 Innovation Awards Technology

Software: Dr. Geo II

Developer: Hilaire Fernandes hilaire@ofset.org

Affiliation & Country: Self-supported, OFSET, France

Dialect: Squeak & Pharo

URL: <http://wiki.laptop.org/go/DrGeo>

Keywords: mathematics, geometry, teaching, micro-world, constructivism, education, K12

Licence: LGPL

What's interactive geometry?

From Wikipedia encyclopedia:

“Interactive geometry software (IGS, also called “dynamic geometry environments”, DGEs) are computer programs which allow one to create and then manipulate geometric constructions, primarily in plane geometry. One starts construction by putting a few points and using them to define new objects such as lines, circles or other points. After some construction is done, one can move the points one started with and see how the construction changes.”

Interactive geometry software is the-facto standard software for secondary school mathematics teachers.

Dr. GeoII is a feature complete interactive geometry software. It allows one to create geometric figure plus the interactive manipulation of such figure in respect with their geometric constraints. It is usable in teaching situation with students from primary or secondary level.

Why Dr. Geo II?

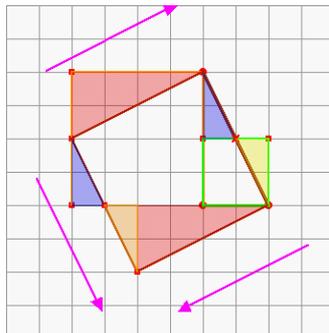
Dr. Geo II is a complete rewrite from scratch of Dr.Geo1.1, a long maintained project started in 1996 and developed until 2005. This software received the INDIRE quality label[drgeo1]. It is C++ and GTK+ based with an embedded

Scheme interpretor for scripting.

One of the motivation to restart from scratch with Squeak/Smalltalk was to take full advantage of the Morphic user interface, the Smalltalk language and its IDE environment to provide a more user friendly interface for extensibility and scripting.

The author thinks Smalltalk/Squeak is an excellent platform to develop interactive educational software. DrGeoII, as a first Smalltalk essay, was an attempt to prove it with real facts. Also the Smalltalk programming language makes DrGeoII more accessible to contribution and extension. In future, the author expects to go further in this direction with the iStoa.net learning platform[istoa].

DrGeoII development started in early 2006, it is still developed and maintained today by its author.



Interactive construction of the Chinese Gougu Puzzle to demonstrate the Pythagorean theorem.

How?

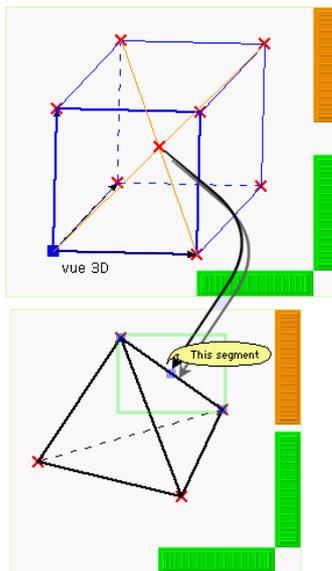
Great cares was taken to write DrGeo with today Smalltalk code standard: well factored classes, abundant use of design patterns (factory, command, mvc, flyweight, builder, template, tool & state, abstraction layers) and refactoring practices. Only unit tests were left behind. It has been rewarding as the author received several code contributions from the Extremadura Smalltalkers in Spain.

The author objective is to make DrGeo an extensible framework. Interested mathematics teachers can learn Smalltalk from it and extend it.

The integration within the Squeak UI framework

– Morph – was done to make DrGeo an integrated part of it: all the views of the geometric models (points, segment, ...) are Morphic objects. Therefore a DrGeo canvas can be integrated in any Morph (a Morph book for example). The canvas can also accept any Morph dropped or connected to its elements.

Moreover, DrGeo owns specific Etoys tiles to script “free point on the canvas” and “free point on a curve”. It allows teachers or students to graphically design interactive geometry demonstrations[Etoys].



Linking canvas with Connectors

–**style**: applied to the view of the geometric and numeric items

–**misc tools and features**: grid and magnetic grid, undo/redo, reverse dragging, experimental group function

The DrGeo features are accessible through a contextual menu, with a click in the background canvas. This menu is also available from the red handle menu, in the halo of the DrGeo canvas. For faster access to the tools, the user can stick the DrGeo menu.

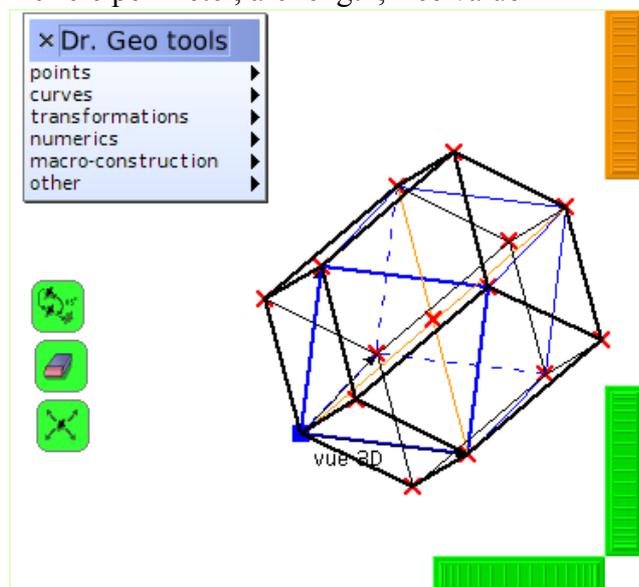
DrGeo can also give buttons, the user can then plug these buttons in the canvas or in any other convenient place. Most of the tools are accessible

Standard Features

DrGeo integrates the basic features one can expect from an interactive geometry software:

- **point item**: free on the plane, free on a curve, middle, intersection between two curves, constrained by coordinates (numeric item)
- **curve item**: segment, straight line, ray, circle, arc, polygon, locus, vector
- **transformation**: parallel and perpendicular line; axial symmetry, central symmetry, rotation, scale, translation on point and curve items

- **numeric item**: distance between two points or a point and a line, line slope, segment length, vector norm, circle perimeter, arc length, free value

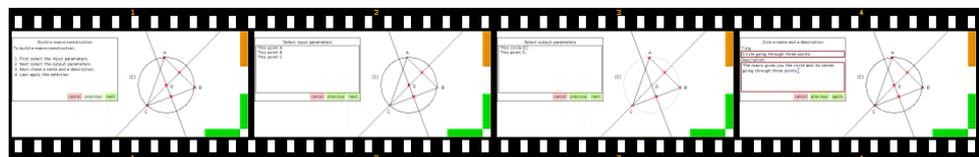


through these buttons.

Advanced features

Beside the standard features, DrGeo proposes more advanced tools:

- **macro-construction**: it is construction template depending on input items and output

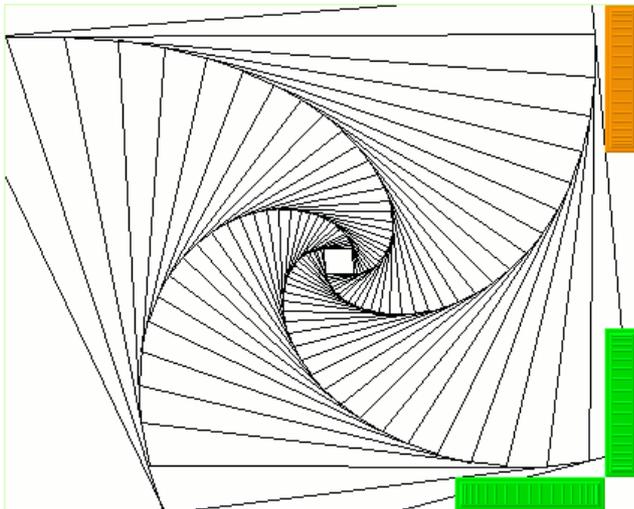


items. They are built according to a model defined by the user. Then the user can quickly repeat this construction sequence by only providing the input items.

To define a macro-construction, the user first builds once the whole construction sequence. Then he asks DrGeo to record this sequence. To record a construction sequence, DrGeo needs to know the initial items of the sequence and the resulting items (output items). Of course the output items must depend only on the input items; otherwise DrGeo would not be able to deduce the construction.

- **Smalltalk figure**: it is a tool to construct non-interactively an interactive figure! To construct the figure, the user write a small programme with a specific, user friendly API. The result is an interactive figure in a standard DrGeo canvas. With this tool the user can construct

figure which otherwise will be tedious to construct by hand. It is particularly true for any recursive construction. Although this feature may seem very strange, the author saw mathematics teacher learning programming to construct historical geometric problems or situations. See contributions from Andrea Centomo at [drgeo1].



– **Smalltalk script:** Scripts are user written with the Smalltalk language and they are used to do user computation on geometric items. They are plugged into the geometric canvas and they display the computed script value. Scripts are completely integrated in the Smalltalk environment, so the user has access to the

Smalltalk development tools to write script (browser, debugger, etc.). With script, it is possible to write awesome interactive figure. The illustrated example bellow shows the rendering of the cosines function and the tangent in any point of the curve. And of course all is dynamic. In DrGeo1.1, script were Scheme written and the user interface to edit and to debug was very poor and very cryptic for the end user. With DrGeoII it is definitely more user friendly and we hope more educators will be able to manipulate and to use scripts.

Use cases

There are probably many I am not aware of, but here a few the involved persons told me about.

- [Chao-Kuei Hung](#), professor at the CYUT university at Taiwan is an old time DrGeo1.1 user, he is moving to DrGeoII and he starts to learn Smalltalk to rewrite his scripts.
- The people from Extremadura in Spain produced a specific Squeak/Etoys image using intensively DrGeoII, [download the geometria-squeak image](#) and enjoy it.
- [Piaget, Vygotsky, Kay. De la teoria a la practica](#) article from Pato Acevedo illustrating DrGeo use for primary school students.

The screenshot shows the DrGeoII interface. On the left, a window titled "Select a script then the figure items" has a list of scripts: "coordinate", "slope:", and "cos:". The "slope:" script is selected. Below it, a description reads: "Calculate the coordinate of M', according to the slope at position M. The script expect the coordinate of the point M, a script".

In the center, a cosine function is plotted on a grid. A point M is marked on the curve, and a tangent line is drawn at that point. A point M' is marked on the tangent line. A blue dot labeled "Move me!" is also visible on the grid.

At the bottom, the coordinates for M and M' are displayed: $M = 0.59@1.66$ and $M' = 1.59@0.54$.

On the right, a window titled "Edit or create scripts" shows the "slope:" script. The script code is:


```

    | m |
    m := script valueItem.
    ^ (m x + 1) @ (m y + (m x sin negated * 2 * 1))
    
```

 Below the code, a text box says: "Calculate the coordinate of M', according to the slope at position M. The script expect the coordinate of the point M, a script".

At the bottom right, a speech bubble contains the text: "This script DrGeoUserScripts>>slope: on argument: M".

Sponsorship

- Dr. Geo II was partly sponsored by TOP, the Taiwan Open Source Project, with funding from the Ministry of Economy, Taiwan. TOP is a jointly managed project by Gjun Information Co.,Ltd., STEPS, and Software Liberty Association, Taiwan (SLAT).
- Dr. Geo II macro-construction and Smalltalk scripting were sponsored by ESUG to promote the Smalltalk language.

If you are interested to sponsor for support, maintenance or additional and custom developments, contact the author at hilaire@ofset.org.

References

- [Etoys] See an old Thales demonstration for Etoys scripting with DrGeoII <http://people.ofset.org/hilaire>
- [drgeo1] DrGeo1.1, GTK+/C++ based, is the DrGeoII predecessor <http://www.ofset.org/drgeo>
- [istoa] <http://www.istoa.net>

Thanks for your time and have a nice “16th International Smalltalk Joint Conference 2008 in Amsterdam”!

