S U R F E R 2012

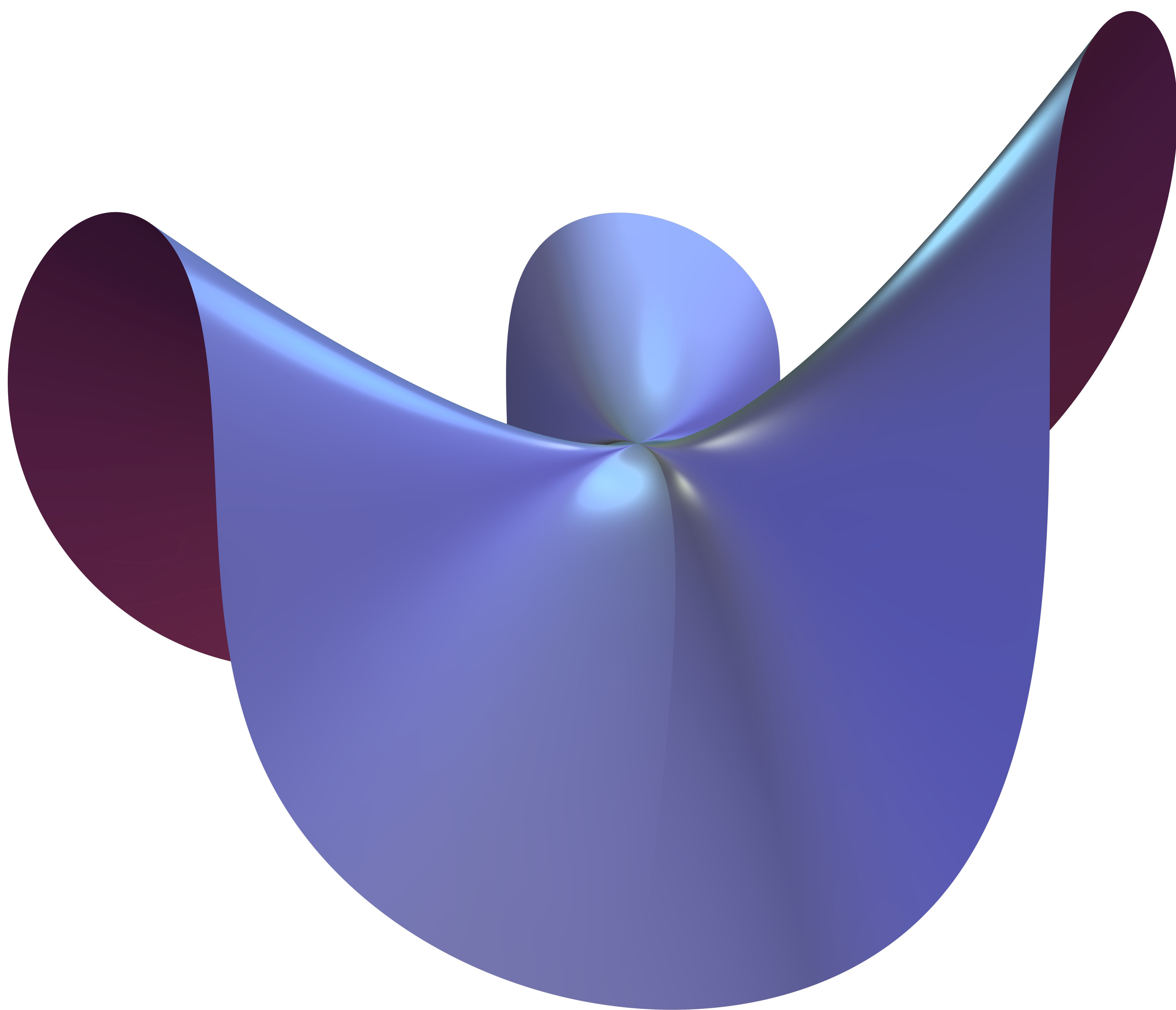## VISUALIZATION OF ALGEBRAIC SURFACES

OVERVIEW

With SURFER you can experience the relation between formulas and forms, i.e. mathematics and art, in an interactive way. You can enter simple equations that produce beautiful images, which are surfaces in space. Mathematically, the programme visualizes real algebraic geometry in real-time. The surfaces shown are given by the zero set of a polynomial equation in 3 variables. SURFER 2012 is a new Java implementation of Surfer 2008 with a new raytracing kernel. It was mainly developed for the exhibitions and museum installations by the Mathematisches Forschungsinstitut Oberwolfach for IMAGINARY and related activities.

INTRODUCTION

With SURFER you can create algebraic surfaces through equations. The polynomial equations are given in the variables x, y and z. All points in space that solve the equation are displayed and form the surface. As an example look at x^2+y^2+z^2-1=0, the equation of a sphere. You can easily see that the point (0,0,0) is not on the sphere while the points (1,0,0), (0,1,0) and (0,0,-1) for example solve the equation. Note that a polynomial is given by variables with natural exponents, real coefficients and their multiplication and sum.
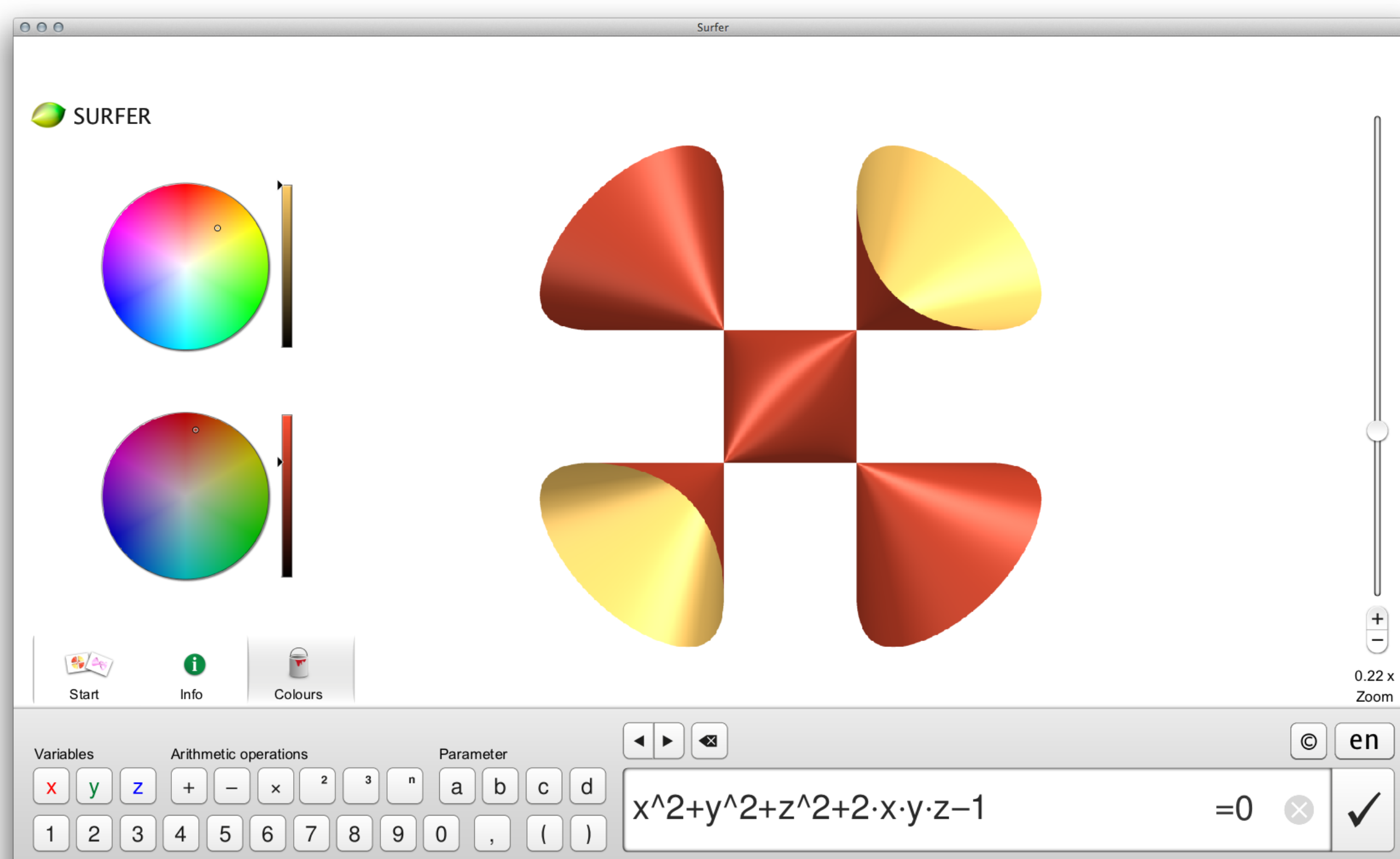
1. ENTRY OF POLYNOMIAL

The polynomial in the three variables x, y and z can be entered in the text field at the bottom right. If the formula is syntactically incorrect a red exclamation mark (!) pops up on the right hand side of the text field. The surface, i.e. the real zeros of the polynomial, are displayed immediately. Each surface is first shown in lower resolution and after a short time of calculation in high resolution.

2. ROTATION OF THE SURFACE

While holding down the left mouse button at the center of the image the surface can be rotated. During the rotation the surface is displayed in lower resolution. When the button is released it will be shown in high resolution - after a short time of calculation.
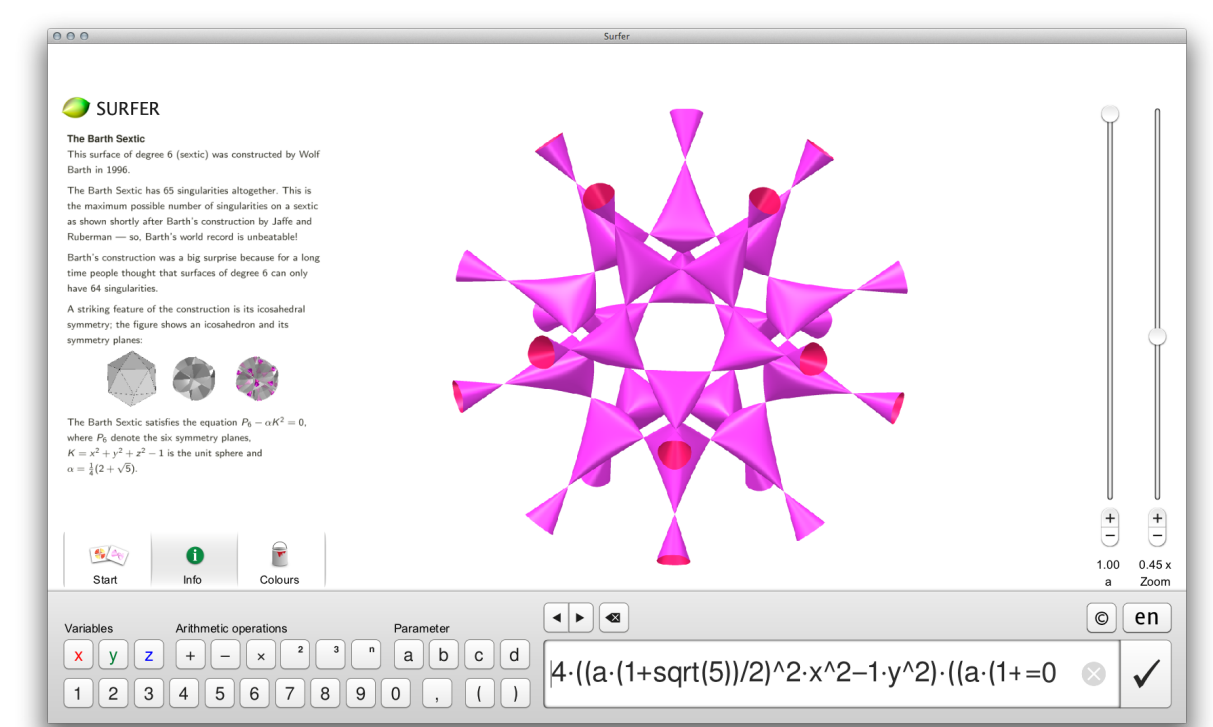
3. ZOOMING

With the zoom bar at the right of the display window you can zoom in or zoom out by changing the radius of the invisible sphere intersecting the surface. The surface is always displayed in the same overall size. You can also use touchpad zoom gestures or the mouse wheel.
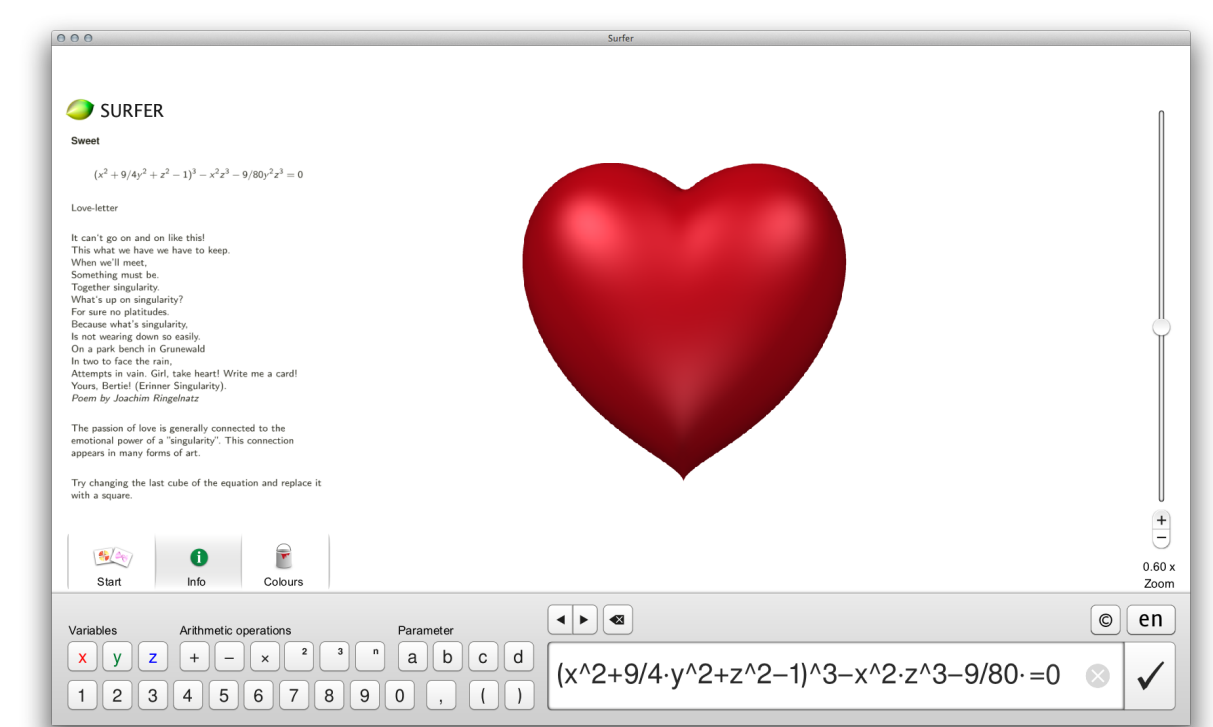
4. ENTRY OF PARAMETERS

The parameters a, b, c and d can be used in the text field. When using them slider automatically appear to change the parameters betweeen 0 and 1. The parameters can easily be changed with the mouse. The changed surface is displayed immediately.
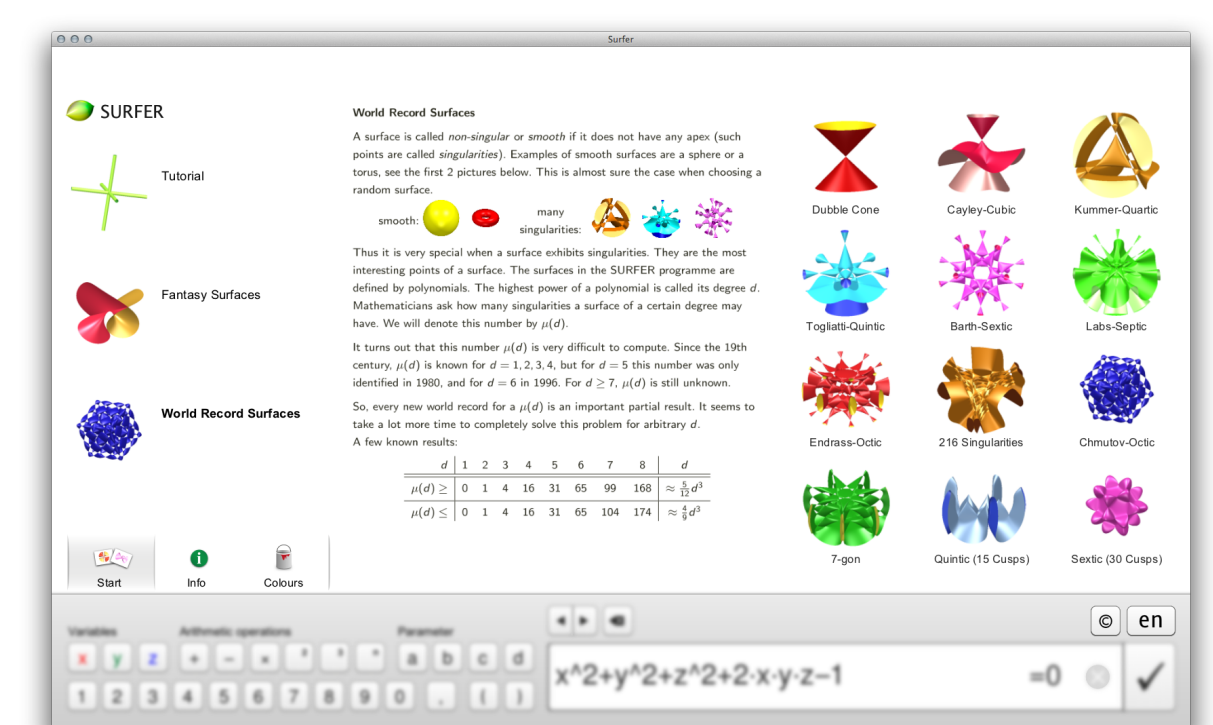
5. COLOURS

Under menu item Colours a specific colour can be assigned to the exterior or interior side of the surface. The colours are selected through a colour picker.
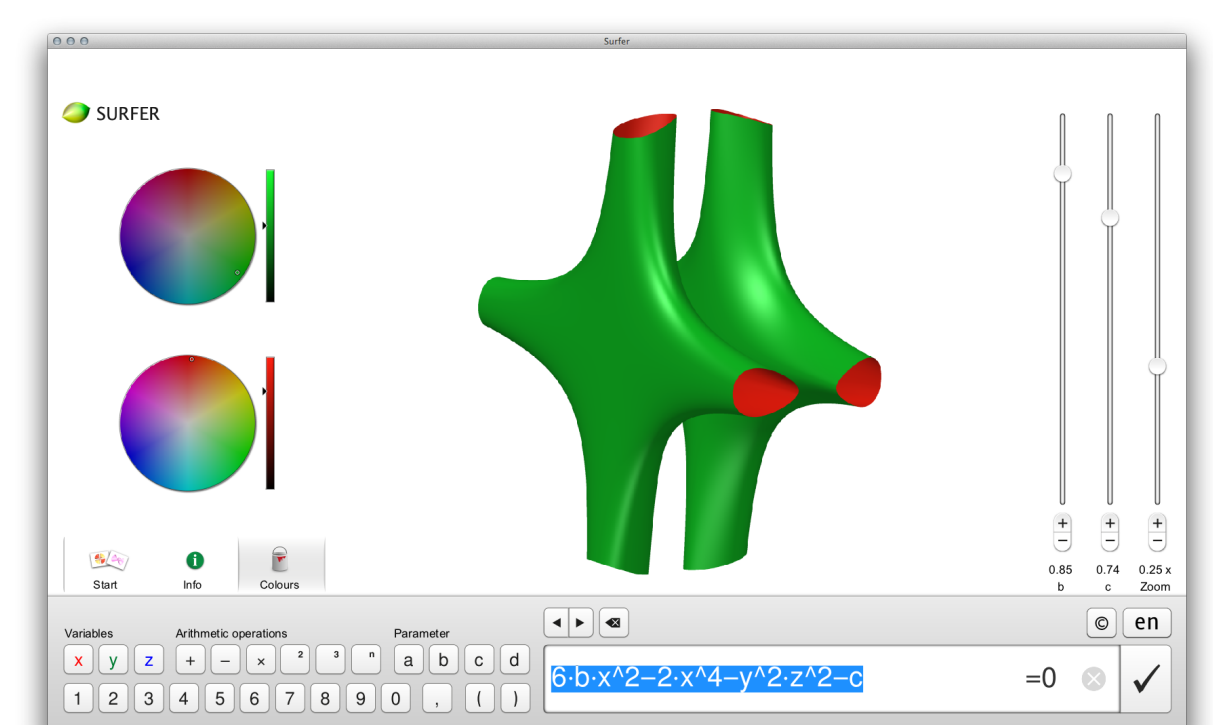
6. GALLERY AND INFORMATION

Under menu item <u>Start</u> you enter the gallery of SURFER with a great choice of surfaces available to view with options to change given parameters. All surfaces are provided with additional information. There is a tutorial gallery with an introduction to SURFER and how formulas and forms are related.

7. SAVE, LOAD, PRINT AND EXPORT IMAGES

The buttons <u>Save</u> and <u>Load</u> allow saving and loading the surface as an image in the SURFER file format (.jsurf). The file includes all settings (rotation, zoom, colours, special settings, etc.). With the <u>Export</u> button you can save your image as png file. Resolution settings can be changed in the pop-up menu. With the <u>Print</u> button the image is sent to your default printer. Please consult the technical manual for details on setting up LaTex, which is needed to display the equation at the print-out.

8. SURFER CONFIGURATION

SURFER has some configuration options that make it more suitable to use on an exhibition. These options are set on the configuration file .fxsurfer located in your home directory. You can edit this file with any text editor to change your preferences.

- Fullscreen. Switch to true to avoid users accessing to the menus of the operating system.

```
fullscreen=false
```

- Hidden cursor. If you use a touch screen, no cursor is needed. You can disable it switching to true.

```
hideCursor=false
```

- Load, Save and Export buttons. You can disable these features switching to false these options.

```
showSaveButton=true
showLoadButton=true
showExportButton=true
```

- Print button. You can set up a printer so users can bring home a poster of their surfaces. See Section 11 below. This option is disabled by default.

```
showPrintButton=false
```

- Languages. You can select the available languages for your exhibition, and the default language used at start, e.g. "`languages=pt,es`" means Portuguese (by default) and Spanish as an option. Available languages are Spanish (es), German (de), English (en), Norwegian (no), Portuguese (pt), Russian (ru), Serbian (sr) and Korean (ko). By default, all available languages are on the selector.

```
languages=*
```

- ClickMode. The click mode is useful for fine tuning button events for touch screens ("mouse click" (0), "mouse pressed" (1) or "mouse released" (2)).

```
clickMode=1
```

9. SURFER IN SCHOOL

SURFER has been used in interactive teaching. Please visit our website www.imaginary.org for ideas to use SURFER at school

10. SURFER IMAGE COMPETITIONS

We collect nice, creative, interesting, funny images generated with SURFER. Example competitions with prizes can be found on our website. Please send us your creations!

11. PRINT YOUR IMAGES

At home use, you can use the Export button to save a png image of your surface, that you can print or use in another program. For exhibitions, SURFER has the option to create a small poster with your surface and its equation, and automatically print it on a properly configured printer. The following instructions apply to a Linux(Ubuntu)/Unix/Mac installation.

1. Make sure that you can print a pdf file via command line. The following command should print without problems, otherwise please refer to your printers configuration.

```
$ lpr test.pdf
```

2. Install LaTeX on your system.

```
$ sudo apt-get install texlive-full
```

3. Create a printing folder in your home directory.

```
$ mkdir /home/USER/printing
```

4. Download the SURFER printing script for LaTeX image
   print, from the SURFER page at imaginary.org.
   http://imaginary.org/sites/default/files/printing_0.zip

5. Extract the zip file into the printing directory. This will let
   you with the following files:
   print.sh
   surfer_print.tex
   surferprintfooter.pdf
   surferprintheader.pdf
   You can substitute the header and footer with others
   adapted to your exhibition.

6. Edit the following options in the configuration file .fxsurfer
   located in your home directory:

   Enable the printing button.
   ```
   showPrintButton=true
   ```

   The location of your printing directory.
   ```
   printExportDir=/home/USER/printing
   ```

   The location of the printing script
   ```
   printCmd=bash /home/USER/printing/
   print.sh
   ```

   A message shown to the user while printing. You can
   translate it into your language, or give some instructions
   (e.g. "Take your poster on the white printer next to the
   stairs").
   ```
   printMsg=Your image has been sent
   to the printer. Please wait.
   ```

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You should be able now to print the posters of the surfaces with their equations, just clicking on the Print button.

Some remarks:

By default, the script saves a copy of the surfer file (.jsurf), the image (.png) and the poster (.pdf) with a date-time stamp as name on the sub-folder ~/printing/archive/. You can review later all printed posters.

You can change the printing script if you want to implement other functionalities, such as authorization before printing. The header and footer can be changed and translated to adapt to your exhibition. Following the license you have to mention the authors and should thus leave the IMAGINARY and MFO logo in the footer. Please contact info@imaginary.org for more information.

Klaus Tschira Stiftung gemeinnützige GmbH | KTS
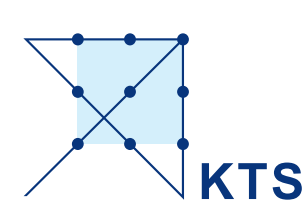
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