Maple goes GUI with Maplets – A Review of Maple 8

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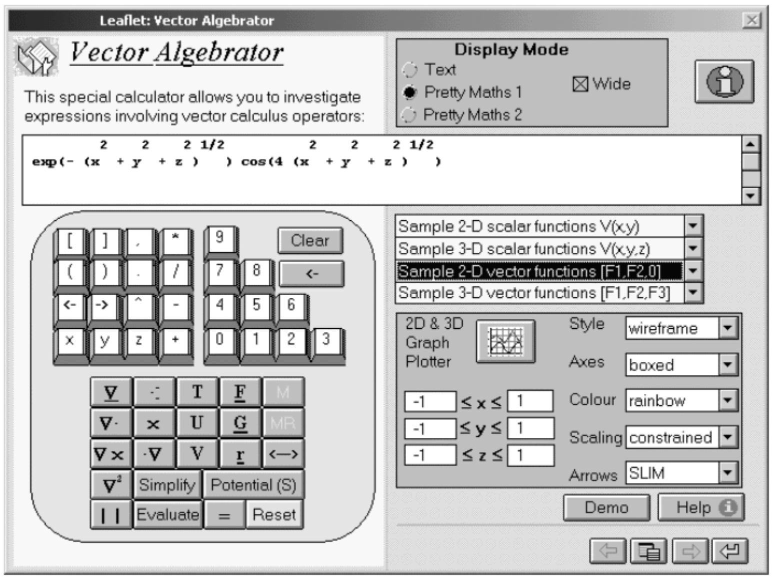
Command the brilliance of a thousand mathematicians... I read on the box as I installed Maple 8 on my home PC (2 GHz, 256 MB) without any difficulty. I imagined myself sitting at a desk on a stage with a hard problem to solve. Pythagoras … Newton … Riemann … Wiles were all there sitting in the audience to help me. Would the power of Maple 8 be equivalent to their combined brainpower?

In fact, the "revolutionary" new features heralded at the top of the list of Maple 8 developments relate more to the graphical user interface rather than mathematics. "Evolutionary" mathematical and programming enhancements are given less prominence. The headline feature is the ability to build custom graphical user interfaces, called Maplets, which access Maple computer algebra. Maplet users, e.g. students, can click buttons, drag sliders, enter values, select menu items and so on, without getting embroiled in the minutiae of Maple syntax. For many students learning to use Maple, the hassle of getting to know when to use the correct symbols can make them thoroughly *%$"{[(:';`&^..ed off and diverts attention from their mathematical understanding. The opportunity to eliminate those "Warning, premature end of input messages" is very attractive indeed…

Six years ago I developed Maple powered GUIs by using Mathedge (McCabe and Watson, 1997), essentially the kernel of Maple version 3, linked to multimedia authoring software. I could draw buttons, sliders, combo-boxes and other interface elements interactively using graphical authoring tools and then hook them up to Maple commands (Figure 1). The result was a Mathwise CBL module, which has been used in the teaching of multivariable calculus for the past five years. The module included GUIs for sophisticated algebraic calculators (or "algebrators" as I called them), computer marked self-assessment and interactive graphics. Unfortunately, Mathedge was never upgraded in parallel with later versions of Maple, so the long-awaited announcement of Maplets in Maple 8 came to me as a welcome surprise…


Leaflet: Vector Algebrator

Vector Algebrator

This special calculator allows you to investigate expressions involving vector calculus operators:

Display Mode: Text / [✓ Pretty Maths 1] / Pretty Maths 2; ☒ Wide

```
          2      2      2 1/2              2      2      2 1/2
exp(- (x    + y    + z )     ) cos(4 (x    + y    + z )     )
```

Sample 2-D scalar functions V(x,y)
Sample 3-D scalar functions V(x,y,z)
Sample 2-D vector functions [F1,F2,0]
Sample 3-D vector functions [F1,F2,F3]

2D & 3D Graph Plotter

-1 ≤ x ≤ 1
-1 ≤ y ≤ 1
-1 ≤ z ≤ 1

Style: wireframe
Axes: boxed
Colour: rainbow
Scaling: constrained
Arrows: SLIM

Figure 1a Maple GUIs Generated Using Mathedge c.1996

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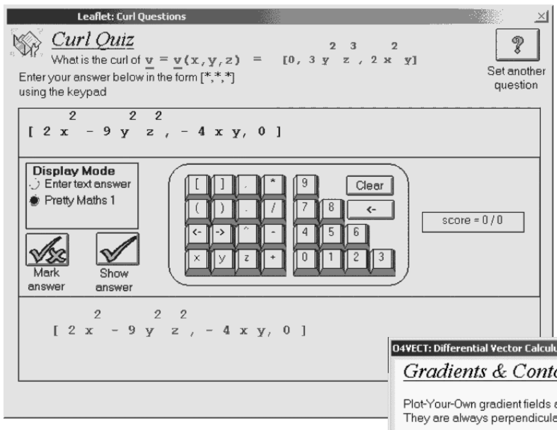


Leaflet: Curl Questions

Curl Quiz

```
                                              2  3      2
What is the curl of v = v(x,y,z)  =   [0, 3 y   z , 2 x  y]
```

Enter your answer below in the form [*,*,*]
using the keypad

Set another question

```
      2       2   2
[ 2 x   - 9 y   z , - 4 x y, 0 ]
```

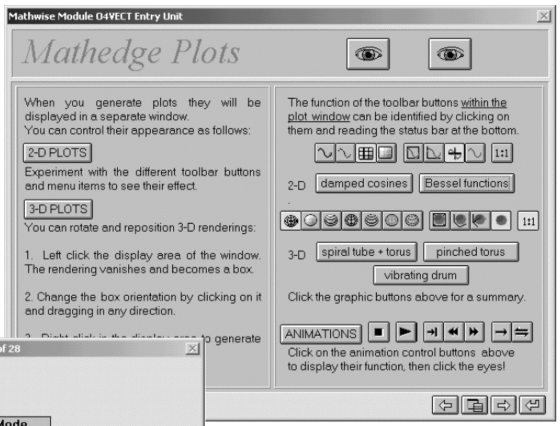
Display Mode
- Enter text answer
- ● Pretty Maths 1

Mark answer

Show answer

score = 0 / 0

```
      2       2   2
[ 2 x   - 9 y   z , - 4 x y, 0 ]
```



Mathwise Module 04VECT Entry Unit

Mathedge Plots

When you generate plots they will be displayed in a separate window.
You can control their appearance as follows:

2-D PLOTS

Experiment with the different toolbar buttons and menu items to see their effect.

3-D PLOTS

You can rotate and reposition 3-D renderings:

1. Left click the display area of the window. The rendering vanishes and becomes a box.

2. Change the box orientation by clicking on it and dragging in any direction.

3. Right click in the display area to generate

The function of the toolbar buttons within the plot window can be identified by clicking on them and reading the status bar at the bottom.

2-D damped cosines Bessel functions

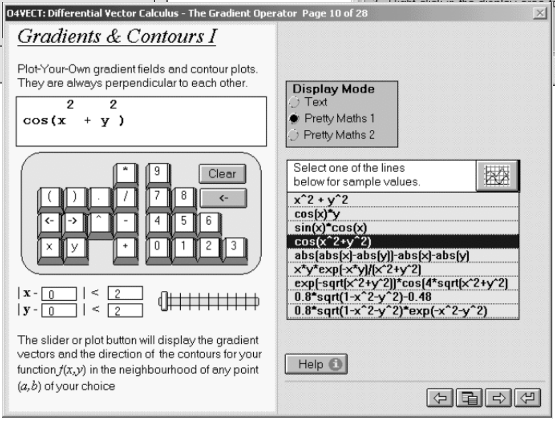
3-D spiral tube + torus pinched torus vibrating drum

Click the graphic buttons above for a summary.

ANIMATIONS

Click on the animation control buttons above to display their function, then click the eyes!

Figure 1b Maple GUIs Generated Using Mathedge c.1996



04VECT: Differential Vector Calculus - The Gradient Operator Page 10 of 28

Gradients & Contours I

Plot-Your-Own gradient fields and contour plots.
They are always perpendicular to each other.

```
      2     2
cos(x   + y )
```

Display Mode
- Text
- ● Pretty Maths 1
- Pretty Maths 2

Select one of the lines below for sample values.

- x^2 + y^2
- cos(x)*y
- sin(x)*cos(x)
- cos(x^2+y^2)
- abs(abs(x)-abs(y))-abs(x)-abs(y)
- x*y*exp(-x*y)/(x^2+y^2)
- exp(-sqrt(x^2+y^2))*cos(4*sqrt(x^2+y^2)
- 0.8*sqrt(1-x^2-y^2)-0.48
- 0.8*sqrt(1-x^2-y^2)*exp(-x^2-y^2)

|x - 0 | < 2
|y - 0 | < 2

The slider or plot button will display the gradient vectors and the direction of the contours for your function *f*(*x*,*y*) in the neighbourhood of any point (*a*,*b*) of your choice

As a MATLAB user I have also used its GUIDE (Graphical User Interface Development Environment) tool for several years to create GUIs linked to the MATLAB engine (Figure 2). I expected something similar, but was disappointed when Maplets were first demonstrated to me at ICTM2 on Crete during the summer. Instead of the interactive authoring tools that I had been expecting, I found that Maplets had to be coded by their authors, who had to master the Maplet syntax, in addition to that of Maple.

I recall that MATLAB, prior to the introduction of the GUIDE tool, also required authors to code custom MATLAB GUIs by hand. Textbooks written to support GUI programming in MATLAB (e.g. Marchand, 1996), had to be rewritten when the GUIDE tool was introduced and the code production was automated. Hopefully the effort, which has to be made in programming Maplets in Maple 8, will eventually be eliminated in the same way. Developers of complex Maplets beware!

To clarify what Maplets are about: the developer writes a series of commands to create the interface elements, specify their layout and define their behaviour. You don't need knowledge of the underlying Java to design Maplets, but you do need to understand not only Maple syntax, but also the intricate syntax of Maplets. A simple Maplet, provided for reviewers, displays and plots a user-specified function and adjusts its x-axis range with a slider. This Maplet concludes with the symbols ‘]))))))): so I baulk at thinking about a more complicated example. The scourge of the GOTO statement in the distant past seems to have been replaced by an abundance of impenetrable brackets, quotes and punctuation marks! My concern is that, like MATLAB before it, developers spend time mastering Maplet GUI programming only to find that a Maplet authoring tool is produced to automate the code generation. The time needed to reproduce Maplets equivalent to GUIs generated using Mathedge would be prohibitive. Maple 8 (pronounced Maple Late ?) still

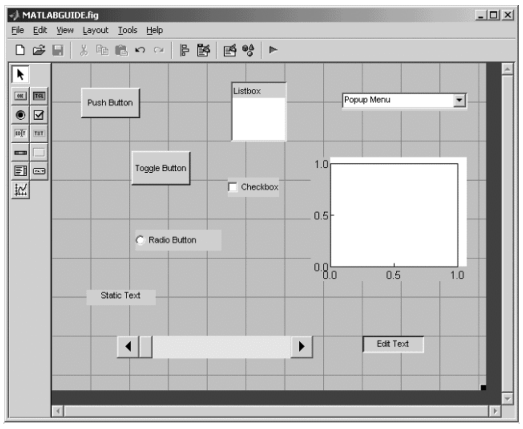
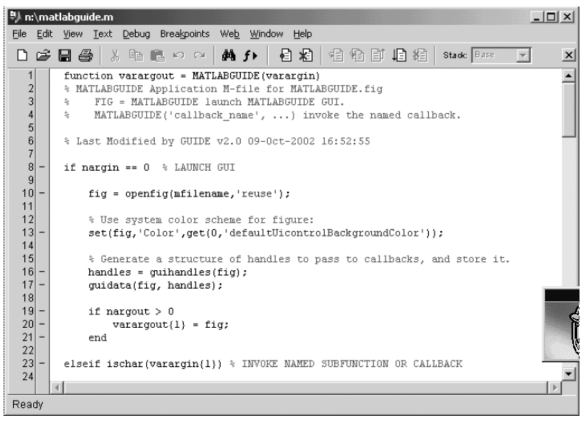


Figure 2 MATLAB GUIDE Tool - GUIs with Automatic Code Generation – No Sweat!



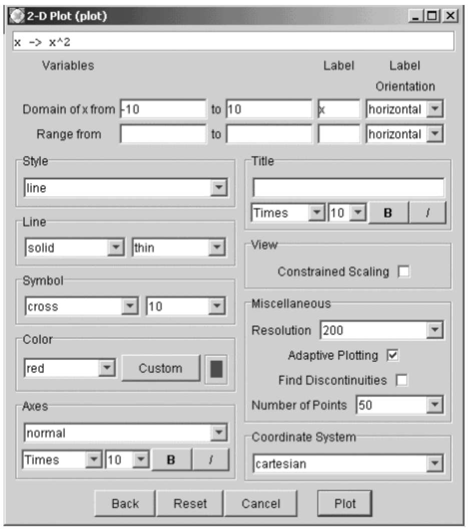
n:\matlabguide.m

```
function varargout = MATLABGUIDE(varargin)
% MATLABGUIDE Application M-file for MATLABGUIDE.fig
%    FIG = MATLABGUIDE launch MATLABGUIDE GUI.
%    MATLABGUIDE('callback_name', ...) invoke the named callback.

% Last Modified by GUIDE v2.0 09-Oct-2002 16:52:55

if nargin == 0  % LAUNCH GUI

    fig = openfig(mfilename,'reuse');

    % Use system color scheme for figure:
    set(fig,'Color',get(0,'defaultUicontrolBackgroundColor'));

    % Generate a structure of handles to pass to callbacks, and store it.
    handles = guihandles(fig);
    guidata(fig, handles);

    if nargout > 0
        varargout{1} = fig;
    end

elseif ischar(varargin{1}) % INVOKE NAMED SUBFUNCTION OR CALLBACK
```

Ready

does not allow the relative ease of Maple GUI authoring which was achievable six years ago using Mathedge and Toolbook. A Maplet authoring tool must remain on my wish list.

I tried my hand at producing a couple of simple Maplets: one for input of cubic polynomial coefficients and plotting of the resulting polynomial and another to allow the plotting of ellipses with different semi-major, semi-minor axes and eccentricities. I attempted to do this using sliders and input boxes by modifying sample Maplets and, despite initial progress, quickly got bogged down in syntax errors, which I could not easily debug. A message: *Error, ':' unexpected* at the end of a Maplet is hardly much help. After a struggle I managed to adapt a sample Maplet (Figure 3), but quickly realised that the type of Maple GUI which I generated several years ago would be extremely difficult and time-consuming to produce. I wasn't even able to reduce the width of input boxes by following the on-line help for Maplet syntax.



x -> x^2

Variables: Domain of x from -10 to 10; Label x; Label Orientation horizontal
Range from [ ] to [ ]; Label [ ]; Label Orientation horizontal

Style: line
Line: solid, thin
Symbol: cross, 10
Color: red, Custom
Axes: normal; Times, 10, B, I

Title: [ ]; Times, 10, B, I
View: Constrained Scaling ☐
Miscellaneous: Resolution 200; Adaptive Plotting ☑; Find Discontinuities ☐; Number of Points 50
Coordinate System: cartesian

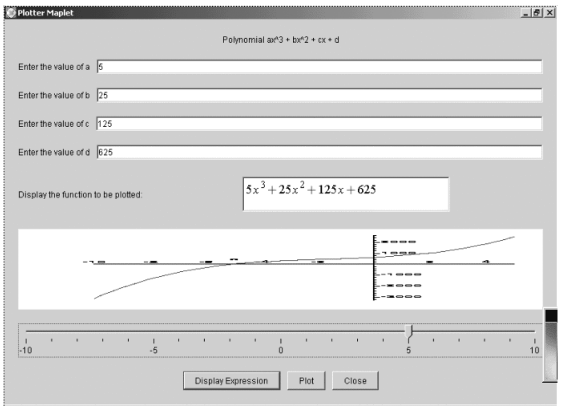
Figure 4 Plotting Made Simpler with Interactive Dialogues

Java is the programming language upon which Maplets are based, although you do not write the code in Java. This might suggest they can be run on-line as stand-alone Java applets. In fact, anyone wishing to run a Maplet standalone needs to have the free Maplet Viewer.

Fortunately there are some Maplets which you don't have to write yourself. The new interactive plot builder in Maple 8 incorporates a Maplet, which allows you to specify plotting options via a series of dialogue boxes, rather than by lengthy specification of options within command line parameters. This is a welcome addition, although I hesitate to say that I was able to generate a GUI for Maple plotting six years ago (Figure 1)!

Waterloo Maple divides the developments in Maple 8 into those which are "revolutionary" and those which are "evolutionary". Beside Maplets the other revolutionary feature of Maple 8 is the Student Calculus Package. This follows in the wake of software like Calculus Machina (Quinney, 2002) by allowing intermediate mathematical steps, eg in an integration, to be explained rather than showing a result immediately. Curiously though, the two have not been combined, ie students must enter Rule(), Hint(), Showsteps() and their associated parameters as commands, rather than via a set of student calculus Maplets. In view of my earlier comments I hesitate in generating my own!

With our daughter approaching her mock GCSEs, I hear comments from her that: "Maths is boring. It's all about rules. You either know them or you don't". Maple 8 might help her with hints, rules, steps and even clever graphics or Maplets, but it's unlikely to change her views. Now wouldn't it be great if following any expression or equation you could type Application(%) and see an interesting real-world example of its use?

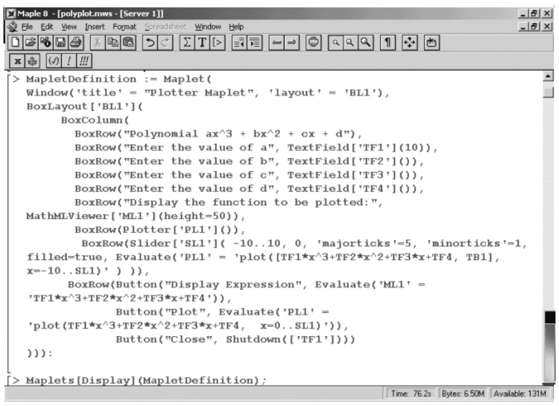


Polynomial ax^3 + bx^2 + cx + d

Enter the value of a: 5
Enter the value of b: 25
Enter the value of c: 125
Enter the value of d: 625

Display the function to be plotted: $5x^3+25x^2+125x+625$

Figure 3 Maple MAPLET - GUIs with Handwritten Code – Much Sweat!



```
> MapletDefinition := Maplet(
  Window('title' = "Plotter Maplet", 'layout' = 'BL1'),
  BoxLayout['BL1'](
       BoxColumn(
         BoxRow("Polynomial ax^3 + bx^2 + cx + d"),
         BoxRow("Enter the value of a", TextField['TF1'](10)),
         BoxRow("Enter the value of b", TextField['TF2']()),
         BoxRow("Enter the value of c", TextField['TF3']()),
         BoxRow("Enter the value of d", TextField['TF4']()),
         BoxRow("Display the function to be plotted:",
  MathMLViewer['ML1'](height=50)),
         BoxRow(Plotter['PL1']()),
          BoxRow(Slider['SL1']( -10..10, 0, 'majorticks'=5, 'minorticks'=1,
  filled=true, Evaluate('PL1' = 'plot([TF1*x^3+TF2*x^2+TF3*x+TF4, TB1],
  x=-10..SL1)' ) )),
        BoxRow(Button("Display Expression", Evaluate('ML1' =
  'TF1*x^3+TF2*x^2+TF3*x+TF4')),
               Button("Plot", Evaluate('PL1' =
  'plot(TF1*x^3+TF2*x^2+TF3*x+TF4,  x=0..SL1)')),
               Button("Close", Shutdown(['TF1']))
  ))):

> Maplets[Display](MapletDefinition);
```

Maple 8 could then really claim to "command the brilliance of 1000 mathematicians"! The visualisation component of the student calculus package does nevertheless provide a selection of routines, which will help with student motivation and understanding. Commands like Tangent, MeanValueTheorem, TaylorApproximation, ArcLength, NewtonsMethod and VolumeofRevolution allow plots and numerical results to be generated quickly and easily. "This relieves teachers of the need to write copious Maple code". Presumably the time saved can now be spent writing Maplet code!

I welcome some of the new evolutionary components of Maple 8: the VectorCalculus package and numerical solutions to PDE boundary value problems will certainly support my teaching. There are also significant improvements in solving ODEs.

I'm less excited by the ScientificConstants package. Literature states that over 13,000 physical constants are available, but the GetConstants(names) command seems to list just 70 of them: from the Avogadro_constant to the von_Klizing_constant.

Much of the other data seems to relate to properties of the chemical elements and has allowed a pretty periodic table Maplet to be written. For my astronomy teaching the mass of the Sun or the gravitational constant might come in handy, but if I want the Hubble constant I have to add it to the package myself. My real irritation is the failure of Maple to express all scientific notation correctly. With user interface issues apparently so important, why, for example, does the Planck constant h have to be displayed as $0.662606876\ 10^{-33}$ not $6.662606876 \times 10^{-34}$? (I expect to see a multiplication sign and a mantissa between 1 and 10).

Finally, amongst the evolutionary features are enhancements to programming. There is now Java code generation, allowing numeric Maple code to be translated into Java, as well as improved linking to externally written Java. I didn't test that out.

I have been a committed Maple user for almost 10 years and have included it in my teaching for almost as many years. Familiarity may therefore make me a little sceptical of "revolutionary" features, especially when they seem to have shortcomings. In fact, the newly created Department of Mathematics at Portsmouth has just purchased a full university site licence for Maple 8 under an excellent CHEST deal. Following installation during the summer, students are already "commanding the brilliance of 1000 mathematicians" … and computer programmers? Now there's an idea for an open-ended exam question: "Does Maple 8 command the brilliance of 1000 mathematicians? Discuss."

References

[1] D Quinney, *An Intelligent Tutor Providing Computer Based Support for Teaching Undergraduate Calculus* http://www.math.uoc.gr/~ictm2/Proceedings/pap120.pdf (2002) http://jws-edcv.wiley.com/college/machina/calculus

[2] P Marchand, *Graphics and GUIs With Matlab*, 1st – 3rd editions, CRC Press (March 1996 – Dec 2002)

[3] E M McCabe and J Watson, *From MathEdge to Mathwise: The Cutting Edge of Interactive Learning and Assessment in Mathematics*, Proceedings of the 3rd International Conference on Technology in Maths Teaching, Koblenz (October 1997)