Review of Maple V Release 5

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The latest release of Maple V has had little time to be installed on many University teaching networks, least of all my own! So this review is mainly a report on what the improvements and the new features may have the potential to offer for those contemplating making the upgrade from Release 4, or as a change of teaching software for those who use one of its competitors. For certain comparative purposes, I installed the package on two similarly endowed PCs, a Pentium 133 and a Pentium 166 (with MMX), both with 32 Mb of RAM, but running under Win 95 and Win 3.1, respectively. The software was sent to me on two CDs, although it can be supplied on diskettes if required. The full installation takes up about 40 Mb of hard disk space, of which about 10 Mb is occupied by the optional Share Library. I was subsequently alerted to the existence of the patch-level 1 upgrade. This can be freely downloaded from the Maple website (http://www.maplesoft.com/patchec1.html) as a 5.6 Mb self-extracting file. The manuals supplied in the box are the *Maple V5 Learning Guide* and the *Maple V5 Programming Guide.* The rather essential *Maple Handbook,* distributed with Maple V4, has apparently not been upgraded by its author Darren Redfern. Speaking personally, I do like to have a hard copy of the full set of commands and their syntax.

Release 4 (R4), reviewed by Peter Whitworth in the February 1997 issue of *Math&Stats*, was a considerable advance over earlier versions, principally in terms of the sophistication and flexibility of the new user interface. In particular, electronic worksheets could be created with active mathematics, textual annotations up to basic word processor standards, with headings and subheadings in appropriately sized typeface. In-line mathematics, in standard textbook notation as an alternative to the usual character based Maple input form, could be included. For ease of navigation, a document could be structured as a tree, by means of collapsible sections and subsections. Furthermore, multiple worksheets could be related by hyperlinks, and bookmarks placed at appropriate locations. There were also numerous mathematical enhancements.

What is New ?

In this review, being about Release 5 (R5), may I begin with perhaps the most trivial change which seasoned users of Maple will certainly need to know about. The much loved double quotes symbol " , used as an alias for the result of the last command, has been replaced by the percentage symbol %. The double quotes symbol is now used as a string delimiter. Whether one likes it or not, index fingers will need to be retrained! A brief description of this and other compatibility issues between R4 and R5 is to be found in the help file opened by the command

```
> ?compatibility ;
```

In R4, to input mathematics in standard form, it was necessary to select Maple input from the Insert menu, and then type in the required expression using Maple character form, in a text field on the context bar. For beginners in the use of Maple, this method of input may have increased the steepness of the learning curve which students with little confidence have to climb. The Maple developers have taken note of the potential uses of *palettes,* as in the latest versions of Mathcad and Mathematica, for the input of mathematics, either as live input or to be included as in-line text. There are three palettes: the symbolic palette, containing Greek characters together with symbols for
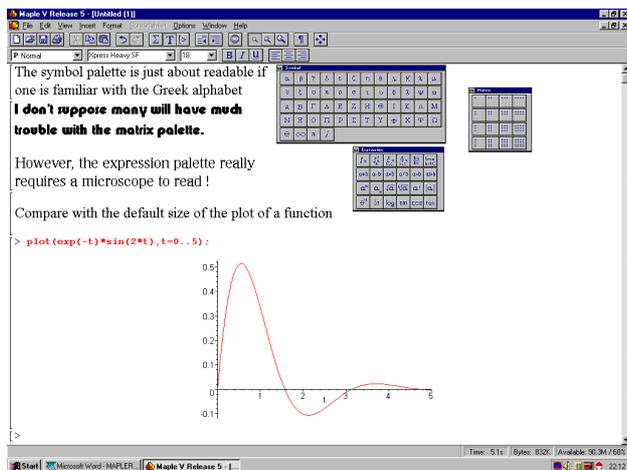
Figure 1

i, e and *infinity*; the expression palette, which allows one to enter anything from arithmetic formulae to basic trigonometric / exponential / logarithmic functions as well as integrals and summations; the matrix palette for the input of rectangular matrices with up to 16 elements. The mechanics of input via palettes is very straightforward, reducing the reliance on knowledge of the syntax of the Maple character form. Unlike Mathematica 3, however, specialized palettes cannot be created in R5 - not perhaps much of a drawback in the context of teaching, as customized palettes are probably more relevant for the production of large purpose-built packages. My main gripe, however, with the palettes, is that although they are movable, they are not resizable. The fact is that the palettes are just too small for us oldies - see Figure 1, which contains all three palettes, as well as the plot of a function at default size, for comparison.

Another new feature which will surely help the novice, is the introduction of *context-sensitive menus*. For example, the following sequence of input and output lines comes about by entering the expression on the first line and then followed by several clicks of the mouse buttons.

```
>  sin(t)*cos(t);

     sin(t) cos(t)

> R0 := combine(sin(t)*cos(t),trig);

     R0 := 1/2 sin(2 t)

> R1 := expand(R0);

     R1 := sin(t) cos(t)
```

To achieve the second input, and its resulting output, simply right-click on the first output line. This produces a menu with several items : copy, differentiate, integrate, factor, approximate, combine, constructions, conversions, plots. Moving the mouse pointer to combine, opens a sub-menu with items : trig, ln, power, radical. Left-clicking trig automatically produces the second input and output lines. Now right-click the second output. A menu appears as before, but with the addition of simplify and expand. A left-click on expand results in the third lines of input and output.

There is more to it than this. In the following example, having entered the quotient of quadratics, select the numerator, then right-click. Left-click factor from the resulting menu. This gives the second input line, but no output. Press <enter> to obtain the latter. The third input and output lines are similarly produced.

```
> (x^2+3*x+2)/(x^2+5*x+6);

          2
         x  + 3 x + 2
         ------------
          2
         x  + 5 x + 6

> (x+2)*(x+1)/(x^2+5*x+6);

         (x + 2) (x + 1)
         ---------------
              2
          x  + 5 x + 6

> (x+2)*(x+1)/((x+3)*(x+2));

          x + 1
          -----
          x + 3
```

I have seen this excellent context-sensitive menu facility described as "Click and Solve". This is a little unfortunate, as solve does not appear as a menu item! It is apparently possible to build one's own context menus, but a glance at the help file suggests that this is not for the faint hearted.

Of particular interest is the special item plots on the menu. If the original expression highlighted is a function of one or two variables, then pointing to plots produces a single item sub-menu containing either Plot, 2D-Plot or 3D-Plot. Clicking whichever of these is there, invokes the smartplot command. This simply plots the function originally highlighted. In the case of

a function of two variables, there is a further sub-menu to allow the user to choose the order of the coordinate axes. It also "knows" that functions of more than two variables cannot be plotted.

For an example of using smartplot for a function of two variables, <enter.> the following line :

```
> x*y^2/(x^2+y^4);
```

$$\frac{x\,y^2}{x^2 + y^4}$$

Now right click the output, move to 3D-Plot and then click on x-y in the sub-menu. The result is the following new input line and the plot of the surface with default axes [-5,5], see Figure 2.

```
> smartplot3d[x,y](x*y^2/(x^2+y^4));
```

There is more. If the range and/or the default domain, [-10,10] in the case of a function of one variable, turns out to be inappropriate - this is likely to happen with rapidly growing functions and functions with asymptotes - then a right click in the plot region will open up a menu which, in particular allows one to change the axes ranges. I can't help feeling that there is scope for a little bit of AI here in the automatic choice of the original plotting domain. The plotted function can easily be altered or added to.

This brings me to an exciting and impressive new development, namely the realtime manipulation of 3D plots. In R4, surfaces could be rotated to provide a different viewpoint. However, one had to wait for the plot to be rendered. Now, in R5, the plot is rendered continuously during rotation. For the technically minded, this is achieved through the use of OpenGL and a hardware floating-point array datatype which obviates the conversion to and from software floating-point representation.
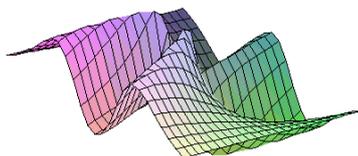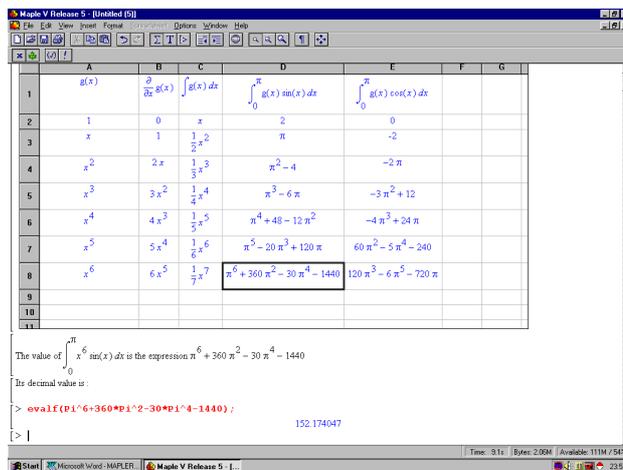

Figure 2

Figure 3

The final new feature which should appeal to those who use Maple as a teaching medium, is the Spreadsheet environment. From the Insert item on the menu bar, click on spreadsheet. This opens up a 10 by 7 portion of a spreadsheet. This can be enlarged if required to show more cells. I suppose the most obvious application of this structure, for Maple users, is in the production of tables. So for example, one could place a sequence of functions in the first column and then apply some operation, perhaps integration or differentiation, to each function simultaneously, with results in another column. Results obtained can then be copy/pasted to another part of a worksheet if required - ideally it would be nice to be able to use cell referencing from outside the spreadsheet for such an operation. In fact, by Excel standards, the Maple version is rather primitive. Still it is an interesting first attempt, which the Maple developers are keen to promote. A simple example is shown in Figure 3. Copy/pasting was used to obtain the results below the body of the spreadsheet.

Having mentioned the two new features of R5, namely smartplots and spreadsheets, here is the bad news for some users : neither feature is available in the Win 3.1 version of R5.

I have concentrated on the new interface facilities, There is, however, as one would expect after two years of R5 development, much more that is new and improved in other areas. The DEtools package, for the study of ordinary differential equations, has been much enhanced. For example, there is a useful new command called odeadvisor, which provides information on the type and method of solution of large classes of differential equations. The following lines give an example of the interrogative use of the

command. Had the help option been included in the third line, it would have opened up the relevant help pages for the type of differential equation indicated. This is potentially a very useful command in the context of teaching differential equations.

```
> with(DEtools):
> diffeqn:=
    x^2*diff(y(x),x)+2*x*y(x)^2y(x):
> odeadvisor(diffeqn);

        [_rational, _Bernoulli]

> dsolve(%%);


                    1
y(x) = ----------------------------
        exp(1/x) (2 Ei(1, 1/x) + _C1)
```

In R4, a tentative start was made on the difficult problem of solving partrial differential equations, with the new commands pdesolve and PDEplot (in the Detools package). With R5, pdesolve becomes pdsolve and there is a whole new package called PDEtools. The use of symbolic software to solve PDEs is very much in its infancy - indeed the help file for PDEtools concludes with the plea: "You are very welcome to contribute ideas for improvements. There is a great deal of scope for changing and improving things, so let us know what you think."

In most courses based on the use of symbolic sofware, once students become confident in the basic black-box interactive use of the tools, there is a need to tackle more challenging exercises. This inevitably involves the writing of programs (procedures). In this area, one new feature in R5 is worth pointing out, namely *lexical scoping.* This is something with which computer scientist are very familiar in the context of nested procedures: it allows a procedure to use the variables from any enveloping procedure. A simple example will demonstrate this. First in R4:

```
> f:=p->x->sin(p*x):
> f(q);

        x -> sin(p x)
```

Was that really what one wanted the procedure to do? Now try again in R5:

```
> f:=p->x->sin(p*x):
> f(q);

        x -> sin(q x)
```

That is much more satisfactory!

Bugs ?

With all upgraded sofware one expects old bugs to be eliminated, and hopes that no new bugs have been introduced. In Peter Whitworth's review of R4, he mentioned two bugs. I am pleased to say that his integration bug, a failure to find the numerical value of the definite integral

```
> int(x^2/(1+x^3)^(3/2),x=0..2);
```

despite being able to find the easy indefinite integral, has been eliminated. R5 correctly returns the correct answer 4/9.

The infinite summation bug,

```
> sum((-2)^n,n=0..infinity);

        1/3
```

remains as a severe warning that computer software should be used with great caution.

A curious bug, present in R4 and discovered by me during the beta testing of R5, is revealed in the following example:

```
f:=2^(2/3)*x^2-4^(3/4)*x-7^(23/8);

      (2/3)  2     (3/4)          (7/8)
 f := 2      x  - 4       x - 49 7

> solve(f,x);
Error, (in evala) reducible RootOf detected.
```
Substitutions are, {RootOf(_Z^12-4) = RootOf(_Z^6-2), RootOf(_Z^12-4) = RootOf(_Z^6+2)}

Despite my challenge : "A CAS which cannot solve a quadratic should be laughed out of town!", the developers were not able to fix this bug, which was not a problem in Release 3! Nevertheless, there is clearly some clever code working away there; it manages to cope with the following:

```
F:=x^2+7^(1/2)*x-3^(1/2);

        2
    F := x  + sqrt(7) x - sqrt(3)

> solve(F,x);

1 + 1/2 sqrt(3) - 1/2 sqrt(7), -1 - 1/2
```

```
sqrt(3) - 1/2 sqrt(7)
```

which not many of us would have spotted!

On this topic it is worth saying that users who find bugs are encouraged to let the developers know. Even if a bug is not unknown to them, if it keeps cropping up, then it is imperative that something should be done about it. Robert Israel, one of the leading exponents of Maple, keeps a database of bugs, work-arounds and useful utilities. His worksheets are freely viewable and downloadable from his web site at http://www.math.ubc.ca/~israel/advisor

Conclusions

I have referred only to some of the more obvious new and improved features in R5, which have relevance to its use as a teaching medium. I have not mentioned some other improvements, which the Maple people are very proud of : for example the Matlab link and the export to HTML facility. These have more relevance in the research and publishing world of mathematics.

Existing users of Maple will know what an immense and powerful package it is, and how little of its potential is exploited in the classroom. Its growth continues apace with R5 - now 40Mb compared to 30Mb for R4 - at such a rate that I am beginning to have difficulty forming a picture of its full extent. Hence my disappointment at the lack of a comprehensive Handbook of commands and packages.

The highlights of R5, in the teaching context, are the context-sensitive menus the associated smartplots and the realtime rotation of 3D plots. Palettes are the in-thing for inputting common commands, but they need to be made larger in size and expanded in scope. I like the spreadsheets, but users with experience of Excel, for example, will be frustrated by the primitive manipulative tools available. I believe that improving this facility is a high priority with the developers.

All in all, R5 is a very desirable package, and existing users will probably want to upgrade - perhaps only those whose Pcs run under Win 3.1 will hesitate for long.

Response from Paul Bragg (Adept Scientific plc)

Both Adept Scientific and Waterloo Maple Inc. are delighted by Nigel Backhouses's excellent review of Maple V Release 5. With respect to some specific points raised in the review:

(i) Although Darren Redfern's book is now no longer included with Maple V, the program's comprehensive on-line help system provides all users with immediate information and examples. It also includes both hyperlinks to related topics and a browser. There are now over 250 books on the use and applications of Maple V.

(ii) The Maple V Release 5 palettes are small to obscure a minimum amount of users' working space; however their exact appearance depends on the screen resolution. We believe our context specific menus provide an efficient way of developing mathematical solutions for beginners and experienced users alike. The description 'click and solve' is intended to convey that this is achieved simply using your mouse (avoiding typing and command syntax altogether), rather than referring to the contents of specific menus. We appreciate the favourable comments about our automatic plotting and also point out the 'drag and drop' facility which can be used for example to plot multiple graphs on a single set of axes.

(iii) Our unique symbolic spreadsheet environment will indeed be developing in future releases, however please contact technical support at Adept Scientific for details of how you can currently reference spreadsheet cells from elsewhere in your Worksheet or import data into these spreadsheets.

(iv) With respect to the 'bugs' we always appreciate our users pointing out unusual behaviour or bugs in Maple V to us. These are always immediately forwarded to our developers and, as evidenced from the integration example and the improvements with the Maple V Release 5 patch, are acted on as swiftly as possible. The infinite summation bug is caused by sum() using more than just the standard 'add it up' approach and here it is using something like Cesaro summation. The sum command cannot be used as a convergence test, since these techniques generalise the notion of 'convergence' in order to obtain results that are mathematically useful in many contexts. With respect to solution of the quadratic equation, numerical solutions can easily be found using the floating point solver fsolve(f, x); or by inserting a decimal point in the expression for f.

We are indeed very excited about this latest release, which offers the significant improvements in its usability and usefulness that Dr Backhouse highlights, as well as many others.