A Few Remarks About Debugging in R

Norm Matloff
Dept. of Computer Science
University of California, Davis

October 13, 2009

Where I'm Coming From

My sources of bias:

- Early career was as a statistics professor at UCD.

Where I'm Coming From

My sources of bias:

- Early career was as a statistics professor at UCD.
- UCD CS Dept. since 1983. Main research areas: probabilistic/statistical modeling of computer systems; parallel processing; computer architecture and networks; Chinese-language computing.

Where I'm Coming From

My sources of bias:

- Early career was as a statistics professor at UCD.
- UCD CS Dept. since 1983. Main research areas: probabilistic/statistical modeling of computer systems; parallel processing; computer architecture and networks; Chinese-language computing.
  (Will release my Rdsm shared-memory parallel R package to CRAN in the next couple of weeks, much improved over the α version.)

Where I'm Coming From

My sources of bias:

- Early career was as a statistics professor at UCD.
- UCD CS Dept. since 1983. Main research areas: probabilistic/statistical modeling of computer systems; parallel processing; computer architecture and networks; Chinese-language computing.
  (Will release my Rdsm shared-memory parallel R package to CRAN in the next couple of weeks, much improved over the α version.)
- I'm a longtime Linux fan/promoter. I use it for everything, both professional and personal.

Where I'm Coming From

My sources of bias:

- Early career was as a statistics professor at UCD.
- UCD CS Dept. since 1983. Main research areas: probabilistic/statistical modeling of computer systems; parallel processing; computer architecture and networks; Chinese-language computing.
  (Will release my Rdsm shared-memory parallel R package to CRAN in the next couple of weeks, much improved over the α version.)
- I'm a longtime Linux fan/promoter. I use it for everything, both professional and personal.
- Have been programming since I was 17.

Where I'm Coming From

My sources of bias:

- Early career was as a statistics professor at UCD.
- UCD CS Dept. since 1983. Main research areas: probabilistic/statistical modeling of computer systems; parallel processing; computer architecture and networks; Chinese-language computing.
  (Will release my Rdsm shared-memory parallel R package to CRAN in the next couple of weeks, much improved over the α version.)
- I'm a longtime Linux fan/promoter. I use it for everything, both professional and personal.
- Have been programming since I was 17. (FORTRAN, punched cards.)

Where I'm Coming From

My sources of bias:

- Early career was as a statistics professor at UCD.
- UCD CS Dept. since 1983. Main research areas: probabilistic/statistical modeling of computer systems; parallel processing; computer architecture and networks; Chinese-language computing.
  (Will release my Rdsm shared-memory parallel R package to CRAN in the next couple of weeks, much improved over the α version.)
- I'm a longtime Linux fan/promoter. I use it for everything, both professional and personal.
- Have been programming since I was 17. (FORTRAN, punched cards.)
- GUIs and IDEs are nice, but:
  - I didn't grow up with it. Not a "necessity" to me like it is for most new grads today.

Where I'm Coming From

My sources of bias:

- Early career was as a statistics professor at UCD.
- UCD CS Dept. since 1983. Main research areas: probabilistic/statistical modeling of computer systems; parallel processing; computer architecture and networks; Chinese-language computing.
  (Will release my Rdsm shared-memory parallel R package to CRAN in the next couple of weeks, much improved over the α version.)
- I'm a longtime Linux fan/promoter. I use it for everything, both professional and personal.
- Have been programming since I was 17. (FORTRAN, punched cards.)
- GUIs and IDEs are nice, but:
  - I didn't grow up with it. Not a "necessity" to me like it is for most new grads today.
  - I like to use the same text editor for everything I do.

My Biases (cont'd.)

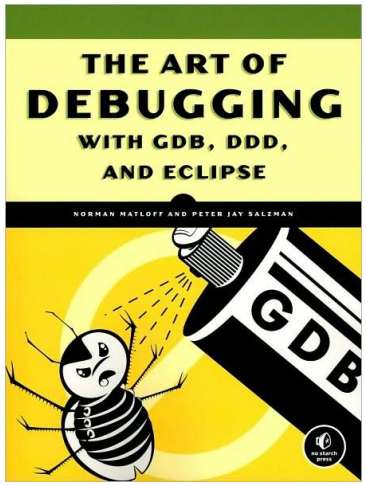
- Debugging is one of the most underrated software skills.

My Biases (cont'd.)

- Debugging is one of the most underrated software skills.
  I may not think IDEs are important, but debugging tools are crucial.

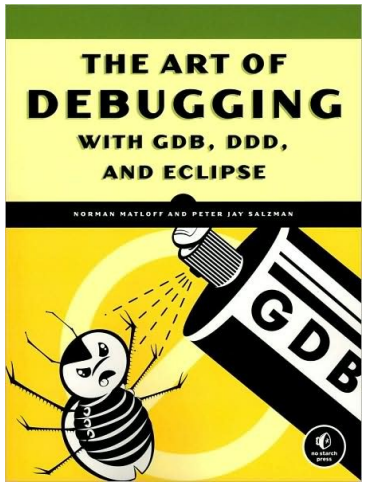
My Biases (cont'd.)

- Debugging is one of the most underrated software skills.
  I may not think IDEs are important, but debugging tools are crucial.
  That's why Pete Salzman and I wrote our book on debugging.



My Biases (cont'd.)

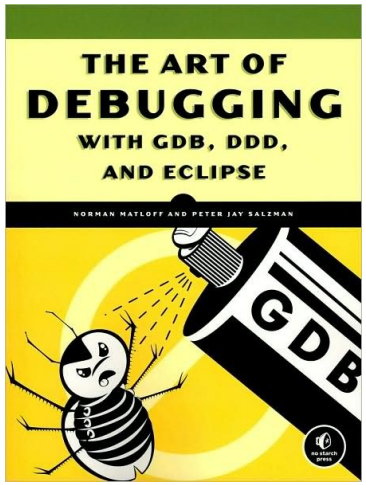
- Debugging is one of the most underrated software skills.
  I may not think IDEs are important, but debugging tools are crucial.
  That's why Pete Salzman and I wrote our book on debugging.



- R's debugging tools have been its weakest link.

My Biases (cont'd.)

- Debugging is one of the most underrated software skills.
  I may not think IDEs are important, but debugging tools are crucial.
  That's why Pete Salzman and I wrote our book on debugging.



- R's debugging tools have been its weakest link.
- I thus am delighted that REvolution Computing is stepping into the void. I hope they or others go to open source/cross platform.

What Has Been Available?

- R's built-in **debug()** function: non-GUI, limited capabilities but serviceable. Somewhat improved in R 2.10.0.

What Has Been Available?

- R's built-in **debug()** function: non-GUI, limited capabilities but serviceable. Somewhat improved in R 2.10.0.
- R's built-in **trace()**, **browser()**, **recovery()** etc. functions: These add finer control, e.g. conditional breakpoints, crash post mortems, etc.

What Has Been Available?

- R's built-in **debug()** function: non-GUI, limited capabilities but serviceable. Somewhat improved in R 2.10.0.
- R's built-in **trace()**, **browser()**, **recovery()** etc. functions: These add finer control, e.g. conditional breakpoints, crash post mortems, etc.
- Mark Bravington's **debug** package: GUI view of one's source code as one traverses it. But can't use mouse to click-and-set breakpoints, query values of variables, etc.

What Has Been Available?

- R's built-in **debug()** function: non-GUI, limited capabilities but serviceable. Somewhat improved in R 2.10.0.
- R's built-in **trace()**, **browser()**, **recovery()** etc. functions: These add finer control, e.g. conditional breakpoints, crash post mortems, etc.
- Mark Bravington's **debug** package: GUI view of one's source code as one traverses it. But can't use mouse to click-and-set breakpoints, query values of variables, etc. (Mark just informed me today he's preparing an update to the package.)

Desiderata for Debugging Tools

- Viewable breakpoints.

Desiderata for Debugging Tools

- Viewable breakpoints.
  Not in the above tools. (An example in my forthcoming R book has a kludge fix for this.)

Desiderata for Debugging Tools

- Viewable breakpoints.
  Not in the above tools. (An example in my forthcoming R book has a kludge fix for this.)
- Saveable debugging sessions. So can come back the next day for more torture without setup time. :-)

Desiderata for Debugging Tools

- Viewable breakpoints.
  Not in the above tools. (An example in my forthcoming R book has a kludge fix for this.)
- Saveable debugging sessions. So can come back the next day for more torture without setup time. :-)
  Not in the above tools.

Desiderata for Debugging Tools

- Viewable breakpoints.
  Not in the above tools. (An example in my forthcoming R book has a kludge fix for this.)
- Saveable debugging sessions. So can come back the next day for more torture without setup time. :-)
  Not in the above tools.
- User-customizable: Ability to program macros, etc.

Desiderata for Debugging Tools

- Viewable breakpoints.
  Not in the above tools. (An example in my forthcoming R book has a kludge fix for this.)
- Saveable debugging sessions. So can come back the next day for more torture without setup time. :-)
  Not in the above tools.
- User-customizable: Ability to program macros, etc.
  Doable in above tools via **trace()** and **browser().**

Desiderata for Debugging Tools

- Viewable breakpoints.
  Not in the above tools. (An example in my forthcoming R book has a kludge fix for this.)
- Saveable debugging sessions. So can come back the next day for more torture without setup time. :-)
  Not in the above tools.
- User-customizable: Ability to program macros, etc.
  Doable in above tools via **trace()** and **browser().**
- GUI. Most people other than me really want it (me too, to a large degree).

Desiderata for Debugging Tools

- Viewable breakpoints.
  Not in the above tools. (An example in my forthcoming R book has a kludge fix for this.)
- Saveable debugging sessions. So can come back the next day for more torture without setup time. :-)
  Not in the above tools.
- User-customizable: Ability to program macros, etc.
  Doable in above tools via **trace()** and **browser().**
- GUI. Most people other than me really want it (me too, to a large degree).
- Watchpoints. Run until specified variable changes value.
  Fairly easy to implement in an interpreted language like R.

Desiderata for Debugging Tools

- Viewable breakpoints.
  Not in the above tools. (An example in my forthcoming R book has a kludge fix for this.)
- Saveable debugging sessions. So can come back the next day for more torture without setup time. :-)
  Not in the above tools.
- User-customizable: Ability to program macros, etc.
  Doable in above tools via **trace()** and **browser().**
- GUI. Most people other than me really want it (me too, to a large degree).
- Watchpoints. Run until specified variable changes value.
  Fairly easy to implement in an interpreted language like R.
- Ability to debug parallel code (next slide).

Debugging Parallel Code

Debugging Parallel Code

- Debugging of parallel processes much harder than for single process.

Debugging Parallel Code

- Debugging of parallel processes much harder than for single process.
- Not many tools out there even for C/C++. TotalView (commercial), XMPI (open source, for MPI).

Debugging Parallel Code

- Debugging of parallel processes much harder than for single process.
- Not many tools out there even for C/C++. TotalView (commercial), XMPI (open source, for MPI).
- Screen footprint problem: If have n processes, that means n windows. Problem is compounded if use GUI.

Debugging Parallel Code

- Debugging of parallel processes much harder than for single process.
- Not many tools out there even for C/C++. TotalView (commercial), XMPI (open source, for MPI).
- Screen footprint problem: If have n processes, that means n windows. Problem is compounded if use GUI.
- Many existing parallel R platforms make parallel debugging very difficult, due to lack of terminals for the processes. (One of my Rdsm modes allows it.)

Tips on Debugging R

Tips on Debugging R

Sorry, no magic bullets.

Tips on Debugging R

Sorry, no magic bullets.

- Fundamental principles of debugging:

Tips on Debugging R

Sorry, no magic bullets.

- Fundamental principles of debugging:
  - Principle of Confirmation:

Tips on Debugging R

Sorry, no magic bullets.

- Fundamental principles of debugging:
  - Principle of Confirmation: Even though you are “sure” a certain variable has a certain value, or that a certain if-condition holds, confirm it.

Tips on Debugging R

Sorry, no magic bullets.

- Fundamental principles of debugging:
  - Principle of Confirmation: Even though you are “sure” a certain variable has a certain value, or that a certain if-condition holds, confirm it.
  - Start small: Try the program on a small vector, maybe in with a scaled-down version of the program itself.

Tips on Debugging R

Sorry, no magic bullets.

- Fundamental principles of debugging:
  - Principle of Confirmation: Even though you are “sure” a certain variable has a certain value, or that a certain if-condition holds, confirm it.
  - Start small: Try the program on a small vector, maybe in with a scaled-down version of the program itself.
  - Top-down approach: When debugging **f()** which calls **g()**, don’t follow calls to **g()** at first. Check first whether the return value of **g()** is correct.

Tips on Debugging R

Sorry, no magic bullets.

- Fundamental principles of debugging:
  - Principle of Confirmation: Even though you are "sure" a certain variable has a certain value, or that a certain if-condition holds, confirm it.
  - Start small: Try the program on a small vector, maybe in with a scaled-down version of the program itself.
  - Top-down approach: When debugging **f()** which calls **g()**, don't follow calls to **g()** at first. Check first whether the return value of **g()** is correct.
  - Use binary search: Say you have a syntax error that's baffling you. Comment-out half the code of the function, to see if the error disappears. Then comment-out half of the half that triggers the error, etc.

Tips (cont'd.)

- Have a boolean global variable, say **dbg**, that turns debugging on and off, and then insert breakpoints with something like

```
if (dbg) browser()
```

Tips (cont'd.)

- Have a boolean global variable, say **dbg**, that turns debugging on and off, and then insert breakpoints with something like

```
if (dbg) browser()
```

- My aforementioned kludge may help you organize better, e.g. keep track of your breakpoints. Download from `http://heather.cs.ucdavis.edu/DebugKludge.r`.

Tips (cont'd.)

- Have a boolean global variable, say **dbg**, that turns debugging on and off, and then insert breakpoints with something like

```
if (dbg) browser()
```

- My aforementioned kludge may help you organize better, e.g. keep track of your breakpoints. Download from `http://heather.cs.ucdavis.edu/DebugKludge.r`.
- If you are using a terminal-less parallel R package and are forced to use print statements in lieu of a debugging tool, use **message()** instead of **print()**. (The latter may not actually print.)

Tips (cont'd.)

- Have a boolean global variable, say **dbg**, that turns debugging on and off, and then insert breakpoints with something like

```
if (dbg) browser()
```

- My aforementioned kludge may help you organize better, e.g. keep track of your breakpoints. Download from `http://heather.cs.ucdavis.edu/DebugKludge.r`.
- If you are using a terminal-less parallel R package and are forced to use print statements in lieu of a debugging tool, use **message()** instead of **print()**. (The latter may not actually print.)
- Use a good text editor, with syntax highlighting, matching for braces etc., infinite undo, comment/uncomment, etc. This saves typing, so you are distracted less from the task at hand.