User Guide for "Two-D Optimization Examples.xlsm"

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Introduction

The file "Two-D Optimization Examples.xlsm" is an Excel file with VBA macros to use a variety of optimization techniques on a variety of two-dimensional functions with a variety of convergence criteria. You will need to enable macros to use the file. If you are not familiar with programming in Visual Basic for Applications (VBA), and wish to see the code read my Excel VBA primer (located under the Software menu link on this site).

A 2-D function can be represented as $z = f(x, y)$, and imagined as a land contour map in which elevation, z, is a function of E-W or N-S positions (x, y). However, in the nomenclature of the software, the two decision variables, the independent variables are not labeled x and y, but x1 and x2. And the function response is labeled OF, or J. The optimizers solve the statement:

$$\underset{\{x_1, x_2\}}{min} J = f(x_1, x_2)$$

Open the Excel file. You will see tabs for various worksheets along the bottom. Start with the tab labeled "Main".

Main

The upper center shows a contour plot of the function. It is an Excel 3-D chart. Overlaid on it, is a transparent x-y scatter plot that will reveal the optimizer trial solution path (red line with blue dots marking each iteration) or the players (large dots), and the prior converged spots (X marks). To make sense the two plot areas need to be aligned. You can shift either of the two plot areas. But, doing so will un-align them. The x_1, x_2 variables are both scaled on a 0 to 10 basis. The OF values are also scaled on a 0 to 10 basis, with contour line values representing 1, 2, 3, … 9, and 10.

The yellow highlighted cells are where you input options. The button labeled "Optimizer" starts the procedure, and "Contour" will display the contour of a new function choice. The list of functions is in the lower left. Choose a function that you wish to observe, and place its number in cell L11 (Row 11, Column 12). Then press the button "Contour" to update the contour plot.

The list of optimizers is in the upper left. Choose an optimizer that you wish to observe, and place its number in cell L12 (Row 12, Column 12). The list of convergence criteria is in the upper right. Not all are appropriate for every optimizer. For instance, a single trial solution optimizer cannot use the criteria in the light blue cells that are based on multiple players. Choose a convergence criterion appropriate to the optimizer, and place its number in cell L13 (Row 13, Column 12). Choose a threshold value for your convergence criterion and place that value in cell L14 (Row 14, Column 12). Choose whether to observe the optimizer progress (Y is recommended so that you can see how the procedure moves the trial solution, but it runs faster if N is entered), the number of trials from randomized initializations, and the stopping criterion for excessive iterations. Press the button labeled "Optimizer" to observe the procedure.

If you wish to stop the procedure, press and hold the escape (ESC) key, or the "BREAK" key (on my keyboard it is Function-Break).

If you wish to slow down the procedure enter a pause-between-iteration value in seconds in Cell L17 (Row 17, Column 12). A good value is 0.2 sec.

Optimizer progress can be observed in the graph titled "Approach to Convergence" and the green highlighted cells in Column 12. The graph reveals the best OF value w.r.t. iteration. It is semi-log plot to permit a wide range of OF values and discrimination when near the minimum, but you may need to convert the vertical axis to the primitive OF values if there are negative values. Different cells in the green field will be used for different optimizers. ANOFE (Row 23 Column 12) is the average number of function evaluations over the optimizer trials. I believe that this is a key quantifier of the amount of work that an optimizer does. Avg Iter (Row 26, Column 12) reveals the average number of iterations to stop, but depending on the optimizer there may be just 2 or up to 20 function evaluations per iteration. So, number of iterations is not a true indicator of computational work when comparing different optimizers. The best x_1, x_2 and OF-values are iteratively updated in the cells in Column 12, Rows 31 through 33.

Below the approach to convergence graph is a CDF of OF Solutions graph. This presents the cumulative distribution function of OF values from the multiple runs. If there are local optima that trap the optimizer, then the CDF graph will reveal a stair-step pattern, and the CDF value of the first horizontal step will be the probability that the optimizer finds the global solution on any one run, and each vertical step will indicate the OF value at the global and local optima. If there is a single optimum, then the "steps" in the graph will just indicate the OF value at convergence in the proximity of the single value, and the range on the OF axis will be very small. For statistically meaningful interpretation of the CDF of OF graph, you should run 100 or more trials.

3D_View

The tab "3D_View" opens a worksheet with a 3-D representation of the function. Net lines are constant x_1, x_2 values. The contour lines are also drawn on the surface net.

Converged_Data

The tab "Converged_Data" reveals the converged results in Columns 1 through 7 for all of the optimizer trials. These are sorted by OF value.

Path_Data

The tab "Path_Data" reveals various aspects of the trial solution path in Columns 1 through 10 for the last optimizer trial. It provides the data for plotting the path on the Main contour graph. Similarly, the tab

Player_Data

"Player_Data" reveals values of the players (trial solutions) as they change with iteration. It provides the data for plotting the player positions on the Main contour graph.

Contour

The tab "Contour" reveals values of the function at all x_1, x_2 values between 0 and 10 on a 0.2 increment. This provides the basis for the 3D and contour graphs. Of course this is not a continuum of values, and the 0.2 increment may miss a local feature on some particular application. In the lower left of the data field, Rows 57-59, Column 2 present the minimum, maximum and range of the data above. I find these values useful in scaling the functions to get a 0 to 10 OF range for display.

VBA Code

To access the VBA code, press the ALT-F11 function key (may need to use FN-ALT-F11). This will open the VBA editor. Four modules should be revealed in the upper left Project Window. It seems to open the most recent first, but "A_Main_and_Auxiliary_Routines" is a best place to start. Module "B" holds the 20-or-so optimizers. Module "C" holds the 80-or-so functions. Module "D" holds the 13-or-so convergence criteria.

Hopefully, the code is adequately commented for you to follow, and modify.

Contact me

I want to make this web site and its offerings helpful and easy to use. If you run into difficulty, it could be because my instruction misled your interpretation. Alternately, you may have found an error or omission. In any case, I want to fix it. Please send me a note about your experience so that I can continue to evolve the site and offerings. My email is russ@r3eda.com.