

This is an edited and updated version (Oct 2009) of a paper published in:

Geomatics Research Australasia

No. 66 June, 1997

pp. 47 -54

The game has been rewritten a number of times with different software but the educational basis remains much the same.

LEAST SQUARES TREASURE HUNT

—

AN EDUCATIONAL GAME

Bruce R. Harvey

School of Surveying and Spatial Information Systems

University of NSW

ABSTRACT

The Least Squares Treasure Hunt Game is an educational game. Its aim is to motivate students and assist them to understand some of the concepts of Least Squares. This paper describes the development of the game, primarily considering educational rather than technical aspects. Some screen images are included. The game was originally written as a Microsoft Excel V5 (hereinafter called Excel) workbook.

1. Introduction

This author had previously prepared an educational game as part of a group of computer educational aids for learning least squares analysis (Harvey, 1994). For many students learning about least squares analysis (LS) is a daunting task that involves many calculation steps. Before the widespread use of computers this turned many cadastral, land and engineering surveyors away from using least squares. The complexity of the theory and the amount of calculations is a barrier to learning. To ease this burden a computer game was written. It works like a treasure hunt that is quite easy at the beginning and grows in difficulty as the player makes progress (gets closer to the answer). It was designed to highlight, and to assist students to learn, some of the important concepts of least squares analysis as they play the game. Whilst the game was a standalone package it did not include graphics, updating of values was not as clear as on a spreadsheet, and all formulae used were hidden within the source code.

Holmes et al. (1996) reported on a low cost CAL (Computer Assisted Learning) package that triggered the idea to convert the game to an Excel workbook. Tidball (1995, and personal communications) gives details and examples on how to produce CAL with Excel, using colour graphics, macros, buttons, and user interaction. Tidball's book covers all the essential technical aspects, so this paper will not discuss the technical aspects but some screen captures of the game are included.

There are many articles on computers and education that list desirable features of computer based teaching often report on successes, but rarely report results that were not rewarding or effective. This paper reports both successes and unfavourable results so that other teachers may benefit from both experiences.

Preparing good computer based learning material is a very time consuming activity, and thus has high set-up costs. Anecdotal evidence suggests that it is not uncommon for expensively developed computer based learning material to be rarely used ("to sit on someone's shelf"). To prevent that happening to this game it was decided to implement some elements of a quality system. A quality control checklist (requiring written answers, not just ticks) was prepared and completed during development of this game. The document was prepared by the author based on educational requirements and objectives described in Harvey (1994).

2. Aims

The game aims to teach the concept that LS gives the smallest residuals, and the concepts of iteration, residuals & convergence. For many students learning about LS is a daunting task. It involves many calculations and steps. The complexity of the theory and the amount of calculations is a barrier to learning. This game aims to ease this burden. It works like a treasure hunt that is quite easy at the beginning and grows in difficulty as the player makes progress (gets closer to the answer). It has been designed to highlight and assist students to learn some but not all of the important concepts of LS as they play the game. It does not teach students how to write model equations, how to use commercial software packages for LS, or statistical analysis.

3. Design Features

The main design elements required were: motivation of students, students to do things not just reading, the game should give feedback, and encourage reflection by the students. The game challenges students to a competition; they estimate and enter coordinates, see changes in numbers and graphs and are asked questions that encourage reflection. Teachers sometimes have to motivate students who want to gain the skills, experience and understanding but don't want to do the work involved. By including enjoyment, enthusiasm and motivational aspects in this game students may choose to learn more about LS. Figure 1 is a screen image of one of the sheets in the game.



Figure 1. Screen image of Easiest level of game

The game does need to be computer based to do calculations and graphing of student's entries. Other authoring software could have been used but Excel is widely available to students studying LS and the spreadsheet software with matrix algebra capability allows students to concentrate on the problem and leave the computer to do the routine calculations. Excel programming changed considerably after version 5 (in which the game was written) so a new version written in Visual Basic was created. In the Excel version Tabs for all seven screens are present at all times so navigation through the CAL should not be a problem. However students who have never used Excel before may need a little help. In the newer Visual Basic version hypertext links were inserted instead of Tabs and Buttons so students could navigate similarly to the way they navigate web pages.

The game allows students to explore and experiment without constrained navigation paths, or they can follow sequentially through the sheets. It is designed with different levels of difficulty to suit a variety of students. Three game levels are included each is similar, but they are progressively more difficult (less graphical help, harder tasks and questions).

B.R. Harvey: Least Squares Treasure Hunt – an Educational Game

Figure 1 shows the easiest level of the game. It is a four distance resection. Most students (at least initially) use the graph to help them estimate the coordinates of T (the treasure). The graph in figure 1 changes in response to the coordinates entered. Students can also zoom into the 'semigraphic lines' when they get close to the treasure. The scanned map usually arouses interest and can activate the imagination and emotions.

The moderate level of the game is a resection by bearings. It does not include graphs so students must think about how to reduce the residuals. The hardest level of the game returns to distance observations. It has no graphical assistance, requires more digits to be determined and asks the student to also estimate the quality of the observations.

The game needs to be integrated into the students' course, not as a spare time activity (Cochrane et al (1993)). Some other CAL products ask questions and supply answers but university students may get more reward from producing a good product, such as small residuals, than from software responses praising them. Another reward for students is that it includes a full worked solution of LS calculations. There are questions in this game, but not with supplied answers. The questions require thinking about what they have done thus avoiding surface learning, and perhaps ask someone else for help or read a text book. Teachers could ask students to submit their answers to these questions for assessment.

The game is self paced so students can move from one display to the next when they wish. The computer is put to new uses not just to do things the same 'old way'. Students use problem solving skills or design skills minimally because most of the solution is prestructured. But they do have to think about how to improve their coordinates and there are questions on interpreting the results.

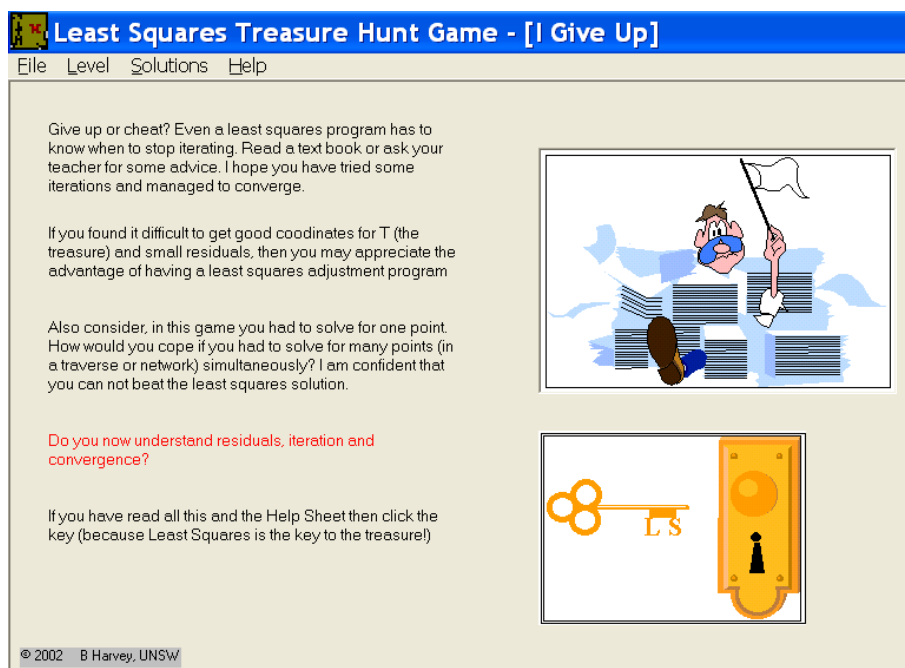


Figure 2. Screen image of Give up sheet of game

Stubkjaer (1996) says “...propriety software is not designed to be transparent. Aspects of pedagogical importance may be deliberately hidden for commercial reasons.” Teaching should encourage and support a “curiosity” to learn what is inside. This CAL game does. Students can see the equations used and can do calculations themselves to confirm them.

In this game students learn by doing, reading, and watching. They can click on cells and see the equations used, and results and graphs change when they enter values. Buttons are widely used and some ‘hot spots’.

The best feedback is that which happens as soon as an error is made. When students make mistakes it is better for them to see the effects of their work and to see that it is a mistake rather than just to be told that they are wrong. Poor coordinates give large residuals instantly. No message tells them their residuals are large or what to do about it, but there is a help page with suggestions.

Students are anonymous users, so they can explore and experiment without being embarrassed or ashamed of mistakes. Exploring and even making intentional errors deepens a student’s learning.

4. Computer details

The minimum hardware and software needed to run the game is common place. The game does not include sound because noises from other computers in a laboratory class are a distraction and learners may want some privacy (e.g. not showing other learners that they are slow). Will changes in technology limit access to the game in the future? The electronic material is archived and since the author did all the programming it should be possible to make new versions (and that has been done).

Is the game file corruptible? Only if someone is determined enough to find the passwords. If a teacher puts the file on a server with read only access and using the copy protection software dongle packaged with the game then users can be confident of using an unaltered version. Academics wishing to customise the game for their class should contact the author.

5. Evaluation

The common and easily administered evaluation method, student opinion questionnaires, was applied. Also staff and student users have been interviewed. The results have been very favourable. Students do feel in control when using the game and prefer to have a coach nearby when first using the game.

However the ultimate evaluation tool is whether the game continues to be used or remains shelf bound. Time will tell! *(and so it has, the game is still in use by me more than 10 years later)*

No tests have yet been made to determine how much better students who have used the game perform in examinations.

6. Conclusions

This paper has described the design features reviewed and given examples of CBL applied to least squares analysis of surveying data. The game was prepared in accordance with the guidelines of experienced educators and evaluated by its acceptance by the target students and their teachers. There are several other potential uses of spreadsheet based CAL with macros/buttons, graphics and text boxes that allow students to concentrate on the data and results and leave the computer to do the routine calculations. Those survey computations that involve tabulated or matrix data and graphical output are prime candidates.

This modest CAL cost nothing except the author's time while on sabbatical leave. It may not reach the quality to the sophisticated games packages available to students, but will it be used and will it be effective?

7. References

- Cochrane. T., H.D. Ellis, and S.L. Johnson (1993) Computer Based Education in Australian Higher Education, Dept of Employment, Education and Training, Australian Govt. Pub. Serv., Canberra. pp 140.
- Harvey, BR. (1994) Computer Based Learning and Least Squares Analysis, Aust.J.Geod.Photo.Surv., June 1994, pp. 21-32.
- Holmes, AJ. etal (1996) Low-Cost Computer Assisted Learning for Surveyors, in: Proceedings of Computer Assisted Learning and Achieving Quality in the Education of Surveyors, FIG Commission 2 Joint Workshop, Sept. 4-6 1996, Finland, pp 253-262. ISBN 951-22-3206-5
- Stubkjaer, E. (1996) WWW, Clickable maps, and Education in LIS/GIS, in: Proceedings of Computer Assisted Learning and Achieving Quality in the Education of Surveyors, FIG Commission 2 Joint Workshop, Sept. 4-6 1996, Finland, pp 263-273. ISBN 951-22-3206-5
- Tidball, J. (1995) An introduction to creating CAL courseware with Microsoft Excel 5. CLUES, University of Aberdeen, MERTaL Publications, ISBN 1-873154-30-5, pp108.

8. Acknowledgements

The original version was conducted while the author was on SSP leave at the Institute of Engineering Surveying and Space Geodesy, University of Nottingham, UK. To evaluate the product the author gave demonstrations and observed students' and academics' feedback at UNSW and IESSG. Useful discussions on technical implementation and educational aspects were had with Alan Dodson, Terry Moore, Chris Hill and Gethin Roberts (all at IESSG) and Joanna Tidball (at University of Aberdeen).