A MATLAB VISUAL TOOL FOR ANALYTIC HIERARCHY PROCESS

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ABSTRACT

Several software implements Analytic Hierarchy Process. In this paper, we proposed a MATLAB visual tool. MATLAB is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numerical computation. Many scientists use this environment to face daily challenge. One of the reasons why it is so in fashion is also because all this tools can be re-utilized, combined with other tools and integrated with more complex environments, also via web. Practically, it allows users to re-use any tool into more complex context to solve specific wide broad problems. For these reasons, we believe that a Matlab tool to apply Analytic Hierarchy Process (AHP), could be appreciate also by other scientists.
Basing on our previous experiences, we developed an AHP Matlab tool, to design a hierarchy, perform pair comparisons and generate final reports. The tool is designed both for expert users of MATLAB and AHP and for users not skilled in MATLAB (nor in AHP). The former could customize and integrate the functions in more complex environment. The latter, by using a Graphical User Interface, could solve complex decision problem through AHP. In this paper we present this tool and its preliminary application.

Keywords: Analytic Hierarchy Process tool, MATLAB

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1. Introduction

Several software implements Analytic Hierarchy Process (Saaty, 1980). They are usually stand-alone programs for supporting decision making and model complex decision. However, we found also some services by web which provided limited functions; for instance, they accept as input the Pair-wise Comparison Matrix and provide as output the weight and the consistency index.

In this paper, we proposed a visual tool with the following aims:

1) providing expert users of MATLAB and AHP with a set of functions (further referred as Package) to be customized and integrated in more complex environment;
2) providing users not skilled in MATLAB (nor in AHP) with a simple Graphical User Interface (further referred as GUI) to solve complex decision problem through AHP.

In section 2, we list the methods and materials adopted, providing also motivation for the choice. In section 3, we describe the functions of the Package and briefly report its application in another study (Melillo, 2011). In section 4, we describe the Graphical User Interface designed according to the criteria proposed by Ossadnik and Lange (Ossadinik, 1999) to for evaluation of AHP software.

2. Methods e materials

We developed the tool in MATLAB, a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numerical computation. Many scientists use this environment to face daily challenge. One of the reasons why it is so in fashion is also because all this tools can be re-utilized, combined with other tools and integrated with more complex environments, also via web. Practically, it allows users to re-use any tool into more complex context to solve specific wide broad problems.

The tool was tested on 32-bit and 64-bit Windows operating system on commercial personal computer, in particular Windows XP Service Pack 3 on a PC Pentium 4 2.80 MHz (RAM 512 MB), and Windows 7 on AMD-Athlon Dual Core QL-64 2.10 GHz (RAM 4.0 GB). The MATLAB version adopted is r2009a.

3. Description of the functions of the Package

The main functions of the package are:

1) to compute local weight and consistency index from pairwise comparison matrix;
2) to discard inconsistent matrixes choosing the threshold of the accepted level of inconsistency;
3) to compute global weight from the local weight of all the comparison matrixes;
4) to export the developed questionnaire in a MS Excel worksheet;
5) to import the results of the questionnaire from MS Excel worksheet.

The package was applied for the study described in (Melillo 2011). In that study, the authors applied the AHP to measure the quality of a single service. For the purpose of that study they need:

- all the local and global weight of the consistent matrixes in order to make other computation (satisfied by the functions 1-3).
- a questionnaire form, that could be printed (satisfied by the function 4);
- an easy way to import the answers of the questionnaire (satisfied by the function 5);

4. Description of the Graphical User Interface

The GUI is developed for users, who are not expert in MATLAB or are not interested in customizing the function or in research about the method itself. It is designed taking into account the criteria proposed by Ossadnik and Lange (Ossadinik, 1999) for evaluation of AHP software. We describe the GUI according to these criteria

4.1 Graphical presentation of results;

The results are presented in one bar graph to present the overall results. All the computed value (weights and inconsistency index) may be exported in a ..xls file.

4.2 Transformation of the specific AHP procedure

The GUI provides a support to build a Hierarchy though an Hierarchy tree browser which allows defining the hierarchy by adding and removing criteria or subcriteria. Figure 1 shows a screenshot of the Hierarchy tree browser: the user is defining a testing structure, in particular, adding a subcriteria.

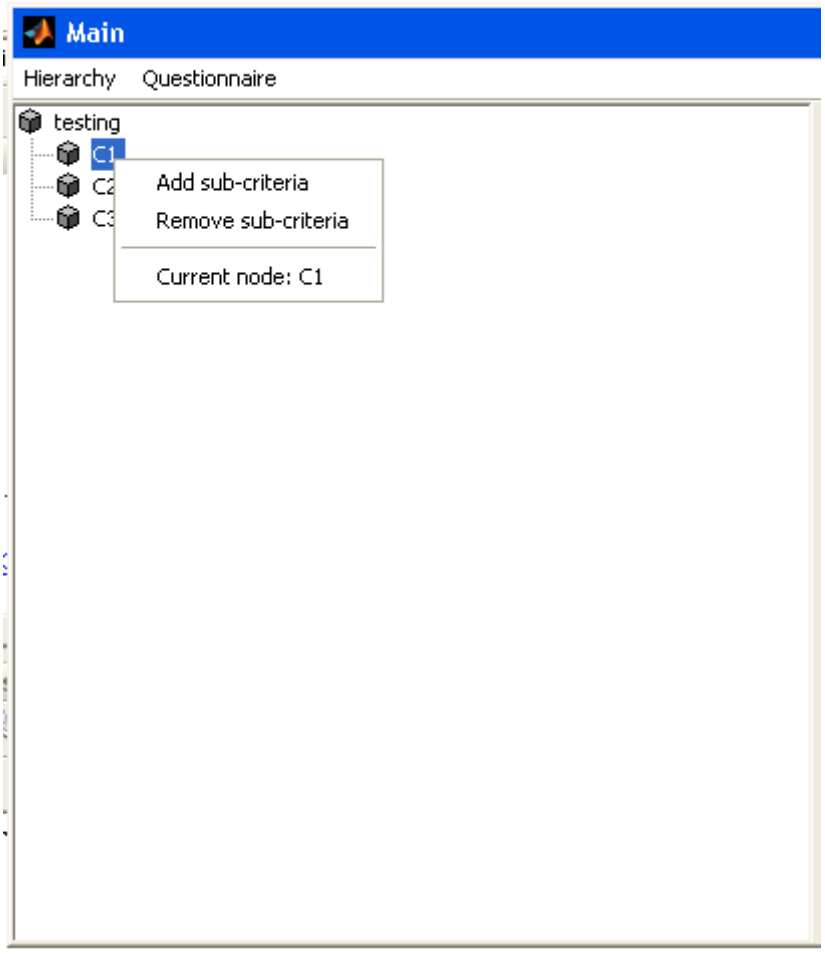

Figure 1. Screenshot of the Hierarchy tree browser: the user is defining a testing structure, in particular, adding a subcriteria.

4.3 Number of hierarchy elements

The number of hierarchy elements is obviously limited by problems related to memory requirement. So, it depends by the hardware and the version of MATLAB adopted. In order to avoid crash we enable hierarchy with a maximum of 20 levels, up to 9 subcriteria for each upper criterion and up to 9 alternatives. We took into consideration that some cognitive studies identified the intellectual capacity to be limited to comparison of 7 (±2) criteria (Sugden, 1985). The GUI provides a sufficient number of criteria for each level of hierarchy. Figure 2 shows a screenshot of the list of alternatives.

4.4 Provision of sensitivity analysis

Now, neither the package of functions neither the GUI provide a sensitivity analysis. It would be considered as further development of the tool. However, expert users could perform a sensitivity analysis by developing MATLAB script on the computed value of the weight or by using MS Excel worksheets.

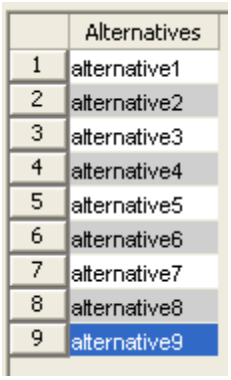

Figure 2. Screenshot of the List of Alternatives

4.5 Users' effort needed for modifications

The effort needed to modify paired comparisons is of special interest, because high inconsistencies lead to the need of reassessment and therefore modification of the former values. The GUI shows Inconsistency Index in real time as soon as the user answers all the questions: if the level of inconsistency is higher than 10% the user is invited to review the answers. Figure 3 shows the screenshot of a questionnaire: the user is not consistent and is invited to review the answers. Another important fact is the effort needed to modify a hierarchy, for instance, by adding a further alternative or criterion. The GUI enables users to load a previously saved hierarchy, to modify it by adding and removing criterion and save it. A change in the hierarchy requires re-submitting the questionnaire.

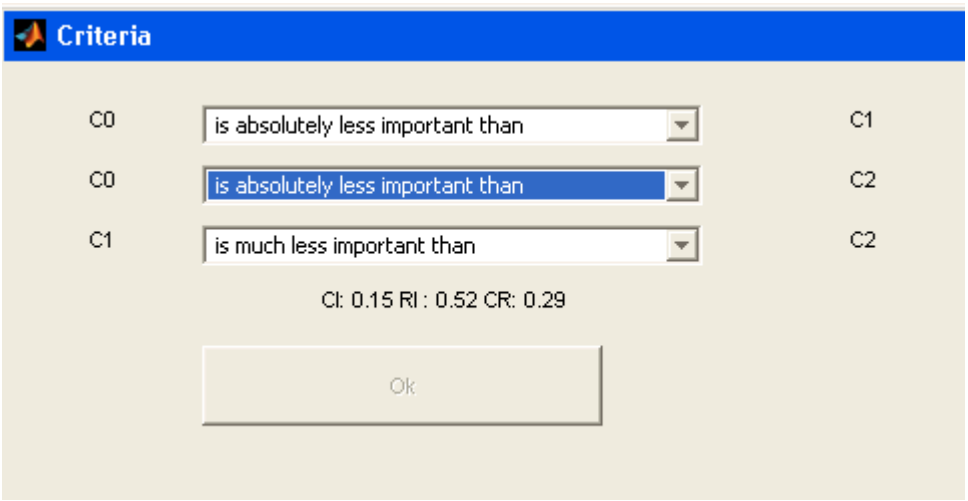

Figure 3. Screenshot the screenshot of a questionnaire: the user is not consistent and is invited to review the answers

4.6 Adaptation of problem structures

If a standardized usage of AHP is taken into consideration, the probability of getting new hierarchies, which are similar to former hierarchies, increases with the number of solved decision problems. Accordingly, the software alternative should provide an opportunity to adapt existing structures, in order to reduce the effort of data input. The GUI enables users to adapt a previously saved structure of a hierarchy by modifying it for another problem.

4.7 Comprehensibility/unambiguity of commands;

The GUI is menu-driven: the menu Hierarchy contains the submenu to create, load, save the structure of the hierarchy; the menu Questionnaire contains the submenu to submit a new questionnaire and to open a previously submitted questionnaire with its results.

4.8 Learnability, existence of relevant help and error messages

The authors are planning to write an user manual both for the package of function and for the GUI. Moreover, adding an online help permanently available (though F1 key) is under development.

4.9 Individual screen displays

The possibility to design the user interface individual is relevant from an ergonomic point of view. However, now the users could not change the interface, for instance, colors and backgrounds in the GUI.

5. Conclusion

We developed a MATLAB visual tool for implementation of AHP methods. It consisted in a Package of functions and Graphical User Interface. The Package of functions is designed for users expert in MATAB and in the methodology of AHP, who want to customize the parameters of the function, for instance, the level of accepted inconsistency, or to integrate them with other functionality or in other environments. The GUI is designed for users not skilled with MATLAB, who can use the main functions of the package by designing the hierarchy and answering to the questions, submitted by an electronic form.
The results of its preliminary application are presented in (Melilllo, 2011). However, the tool need further development to satisfy all the individuated need, such as manuals, help on line, provision of a sensitivity analysis.

REFERENCES

Melillo, P., Delle Donne, A., Improta, G., Cozzolino S. (2011). Assessment of Patient Satisfaction using an AHP model: an application to a service of pharmaceutical distribution. *Proceedings of the International Symposium on the Analytic Hierarchy Process 2011*

Ossadnik, W., Lange, O. (1999). AHP-based evaluation of AHP-Software. *European Journal of Operational Research, 3,* 578-588

Saaty, T.L. (1980). The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation. New York: McGraw-Hill.

Saaty, T.L. (1996). The Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process, Vol. IV of the Analytic Hierarchy Process Series. Pittsburgh, PA: RWS Publications.

Sugden, R., (1985). Why be consistent? A critical analysis in choice theory. *Economica* 52, 167–183