

MCDA Toolkit

User Guide

Last modified: 13. February 2015

Version: 5.0

Outline

MCDA (Multi Criteria Decision Analysis) is a methodology to support decision making with the benefit of, simply put, being capable to compare apples and oranges. Defining a goal to choose one alternative from a set several ones users can interactively weight the importance of influencing criteria. This process is often used when decision makers try to find a stable agreement that can be accepted by all members of the group.

This guide covers the usage of the MCDA Toolkit. The software was originally developed by the Institute for Nuclear and Energy Technologies (IKET) that is part of the Karlsruhe Institute of Technology [KIT].

Warning

At the time of writing this document the MCDA tool provides already a great amount of functionality and is used in many scientific projects as showcase for the potential of the MCDA methodology. It is considered to be stable in its core areas.



However it is not a commercial application. It is a scientific tool and continuously improved in its outer regions. Therefore it may contain bugs. It is sensible to make backups of your important analyses. You also may want to check for updates regularly. Finally if you encounter a bug feedback is appreciated to improve the stability of the application in the future.

Table of Contents

- 1. Introduction.....9
 - 1.1 License.....9
 - 1.2 Requirements.....9
 - 1.3 Installation and Start.....9
 - 1.4 Points of Interest.....9
- 2. Basics of MCDA.....11
- 3. Getting started.....13
 - 3.1 Creating a new MCDA.....13
 - 3.2 Loading an existing MCDA.....15
- 4. Working with the MCDA tool.....17
 - 4.1 Main window.....17
 - 4.2 Tools.....18
- Appendix A: Menu and Tool bar referenced.....27
- Appendix B: Localization.....29
- Appendix C: Customization.....31
- Appendix D: File Format.....33
- Bibliography.....35

Illustration Index

Illustration 1: The basic concept and data structure of MCDA.....	11
Illustration 2: The initial wizard window of the MCDA tool.....	13
Illustration 3: Entering alternatives in the wizard.....	13
Illustration 4: Entering criteria in the wizard.....	14
Illustration 5: Entering values and their ranking in the wizard.....	14
Illustration 6: The input summary of the wizard.....	15
Illustration 7: The main window of the MCDA tool.....	17
Illustration 8: The report tool verbalising the result.....	19
Illustration 9: The editor to handle the meta data.....	19
Illustration 10: The value editor and matrix view of the MCDA.....	20
Illustration 11: The tree view of the group view frame.....	21
Illustration 12: The importance respectively weight editor for criteria.....	21
Illustration 13: The editor to manipulate the normalisation of criteria.....	22
Illustration 14: The AHP frame defining the relations of alternatives for a criterion.....	23
Illustration 15: Visualisation of the MCDA result as stacked bars.....	23
Illustration 16: Cob web chart of the results of the MCDA.....	24
Illustration 17: Weights of criteria displayed as multi tier pie chart.....	24
Illustration 18: Analysis of the stability of the MCDA result.....	25
Illustration 19: Analysis of ranked correlation between criteria.....	25

1. Introduction

Up to writing of this document there is no official download page yet for the MCDA Toolkit. For the time being however there is an unofficial page providing basic information and access to the software. Special questions or requests for the software should be directed to KIT, namely Tim Müller (Tim.Mueller@kit.edu) to receive the most recent version. An official web presence is planned, probably in the form of a sourceforge collaboration project.

1.1 Requirements

The MCDA tool is completely written in Java and requires a Java Runtime Environment (JRE) when used. Therefore the tool is basically platform independent and can be used on any PC or operating system (Windows, Linux, Mac, ...) that supports Java 7 or up. The application itself neither requires high computation power nor a large amount of memory.

If for any reason no JRE is yet installed on the target PC several compatible implementations are available on the internet. The most common JRE is provided by Oracle and can be downloaded from their website [JRE]. The installation of the JRE is straightforward. Simply follow the instructions of the installation wizard.

1.2 Installation and Start

At this time of writing the installation of the MCDA Toolkit is very easy: download and unzip the MCDA.zip in a directory of your choice. Switch into the newly created directory named MCDA. On most systems a double click on MCDA.jar should start the application. In rare circumstances you may have to start it manually in a command line window with the following command: `java -jar MCDA.jar`

Starting the MCDA application presents the wizard window. It allows to load an existing analysis or to create a new one from scratch supported by a guided process. The Wizard is intended to provide an easy access for new users. Therefore it hides some details from the user in the creation process. Once the basic analysis input is complete the main application provides the full functionality when editing an the MCDA.

1.3 Points of Interest



In general the MCDA application consistently provides context sensitive help. When in doubt hover the mouse over a GUI element as most times a helpful tooltip will appear. Also in many locations clicking the second mouse button opens a context menu with additional functionality.

The application is prepared to be multi-lingual. Up to now English and German are provided. New languages, even special wording can be easily integrated. Proposals and help are welcome. For details check out Appendix B: Localization.

All subcomponents follow the same concept and style. Icons and colours usually have the same meaning. The icons and colours can easily be customized. For details check out Appendix C: Customization.

Many components of the user interface already provide a brief contextual help which is activated by hovering the mouse over it. More detailed help is available by clicking the help button which is available in several contexts. Most components also provide context menus. They are activated by right clicking onto a graphical component.

A global undo/redo is provided. Also changes made can often be discarded or confirmed in the corresponding windows. The analyses as well as parts of it like the weights can be stored as and restored from file. The format is XML thus allowing to edit it with text editors manually if necessary. For details check out Appendix D: File Format.

1.4 License

The MCDA Toolkit is “open source” and free to use for non-commercial usage. The general goal is to wide-spread the tool and improve it in a collaborative manner in a scientific community therefore distribution and usage is explicitly welcome. However “making money” with it is subject to negotiation.

The specific license is not yet fixed but is likely to be similar to the BSD [BSD] license for non-commercial usage.

2. Basics of MCDA

Performing a Multi Criteria Decision Analysis (MCDA) can be roughly separated in two parts: firstly in the definition of the MCDA data structure and the input of the corresponding data values and secondly in the actual analysis with the help of different visualisation means.

The most simple form of MCDA boils down to a value matrix and computing weighted sums [Illustration 1]. For a given problem to be solved i.e. to choose one solution of a set of solutions, the columns of the matrix represent the set of available solutions of the problem and the rows represent the attributes or measurements that are taken into account to choose the “best” solution. In the further context of this document the problem is referenced to as **goal**, the solutions are referenced to as **alternatives** and the attributes are referenced to as **criteria**. Furthermore not all criteria are equally important and therefore are fitted with an importance value referenced to as **weight**.

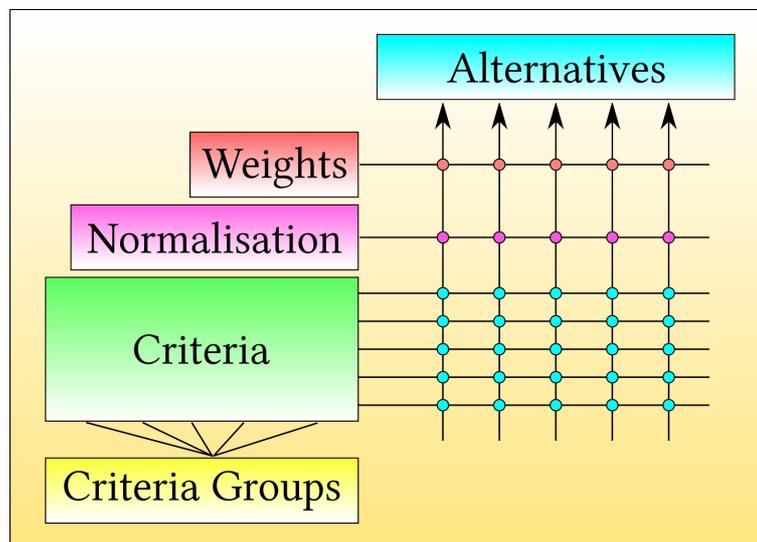


Illustration 1: The basic concept and data structure of MCDA.

The more criteria are used the more confusing it is to understand and organise the value matrix. Also in real life application many criteria are members of a set of criteria of a aggregating higher level criterion. Therefore the MCDA tool provides means to organise the criteria in a treelike view to help to better understand the overall structure. In the following this is referenced to as **grouping**. Grouping is by no means necessary for MCDA and just helps to simplify the handling. The final structure of a MCDA problem is always a plain matrix.

As many different criteria can be used e.g. money value, temperature, height but also vague measurements like public acceptance, social benefit, etc. they cannot be compared naturally. To make them comparable they all need to be normalised. Many normalisation methods are integrated in the MCDA tool already. Some of them need additional user interaction, but mostly common sense when selecting one method from the set. The final value for each alternative is the weighted sum of the normalised criteria values.

Therefore to use MCDA as a support tool to solve your specific problem, you need to identify your alternatives and criteria first and enter the according values into the MCDA tool.

3. Getting started

After starting the MCDA tool a window is presented [Illustration 2]. It provides a list of recently processed problems and three buttons with different functions: to create a new MCDA, to load an existing one from the file system, or to exit the application.

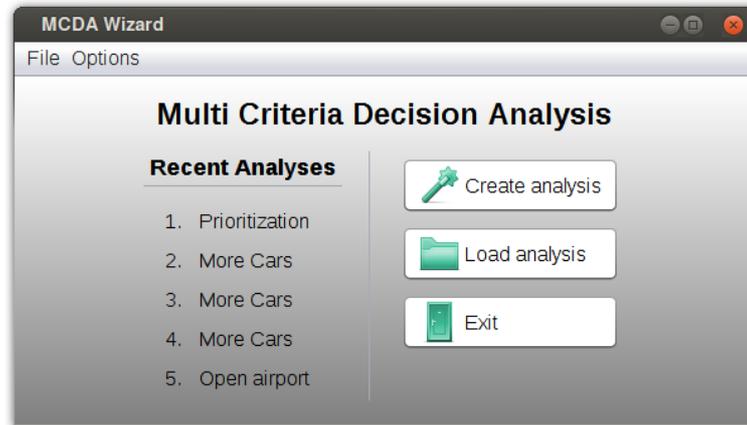


Illustration 2: The initial wizard window of the MCDA tool.

3.1 Creating a new MCDA

To create a new MCDA click on the create analysis button. As the the wizard creates a backup of its progress one has to initially choose if the previous content should be restored. Selecting “Yes” will restore the previous content, selecting “No” will start from scratch. Either way the wizard continues with presenting the set of alternatives [Illustration 3].

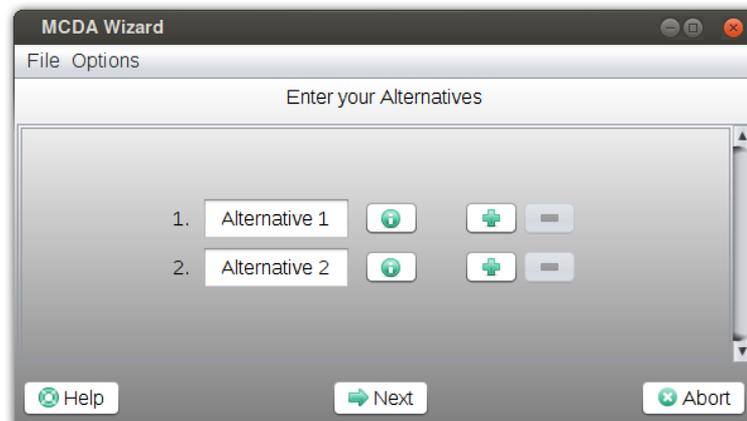


Illustration 3: Entering alternatives in the wizard.

Each alternative has a label (preferably distinctive) which can be typed into the text field and a textual description. The description can be entered by clicking on the information button. Initially two alternatives are defined by default. Additional alternatives can be added by clicking on any add button and removed accordingly by clicking on the corresponding remove button. At least two alternatives must be defined. Once the input is complete the next button has to be clicked to move to the definition of criteria.

The procedure to define criteria is almost identical to the process of defining alternatives [Illustration 4]. The only additional input to be defined is the weight respectively importance factor of a criterion. Values between 1.0 and 10.0 are allowed as input, 1.0 meaning least

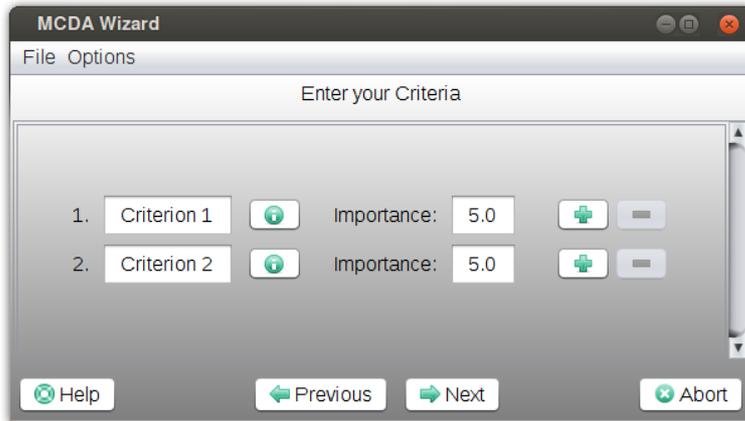


Illustration 4: Entering criteria in the wizard.

important and 10.0 meaning most important. Bear in mind that the importance factor is relative i.e. if two criteria are defined with importance factors 1.0 and 2.0 the second criterion will be twice as important as the first one. Importance factors of 5.0 and 10.0 would lead to the exactly same result.

The next button will lead to the first of a series of input forms to define the values of criteria. For each criterion an input form is presented where the values for each alternative has to be entered [Illustration 5]. As input any numerical values are allowed. As the values need to be (automatically) normalised internally it is mandatory to rank them by simply marking the “best” value. This usually is either the maximum or minimum of the criterion, but not necessarily. It can also be one of the values between maximum and minimum. If multiple alternatives share the same best value any of these can be marked.

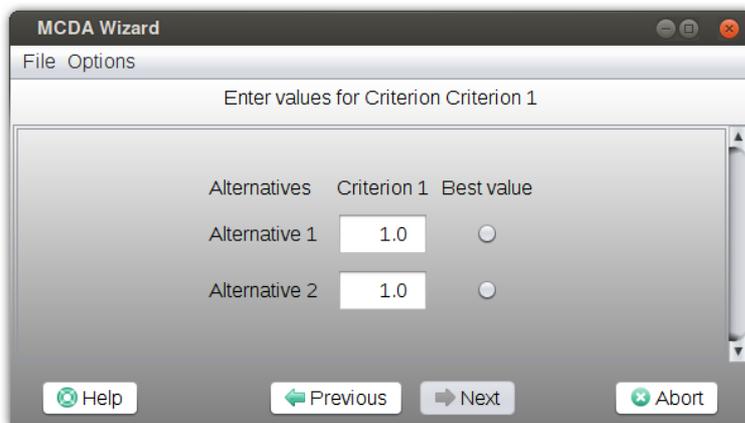


Illustration 5: Entering values and their ranking in the wizard.

The next button will lead to the next input form for the next criterion. From the last criterion the next button will lead to the summary.

After completing the input of the criteria values a summary is presented allowing to briefly check for obvious mistakes [Illustration 6]. Clicking on the finish button closes the wizard window and opens the main MCDA window.

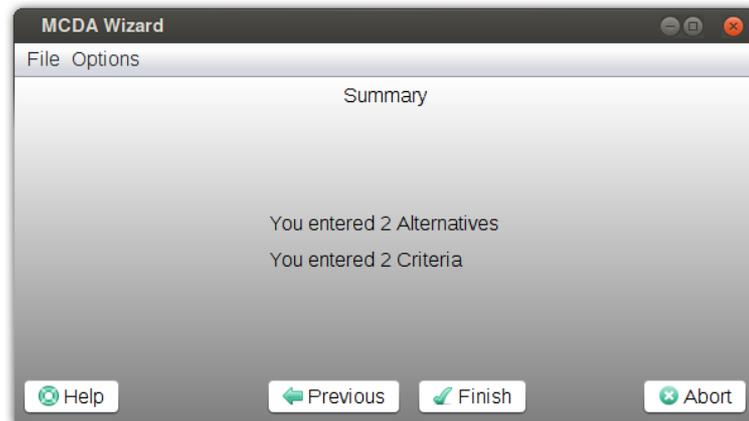


Illustration 6: The input summary of the wizard.

3.2 Loading an existing MCDA

To load an already existing MCDA click on a recent analysis or on the load button of the initial window [Illustration 2]. While clicking on a recent analysis will directly open the main window the load button will open a file chooser first and the main window after selecting an appropriate MCDA file. The “examples” directory in the MCDA installation contains some example files.

4. Working with the MCDA tool

The MCDA application provides a single main window from which all functionality and tools are available [Illustration 7].

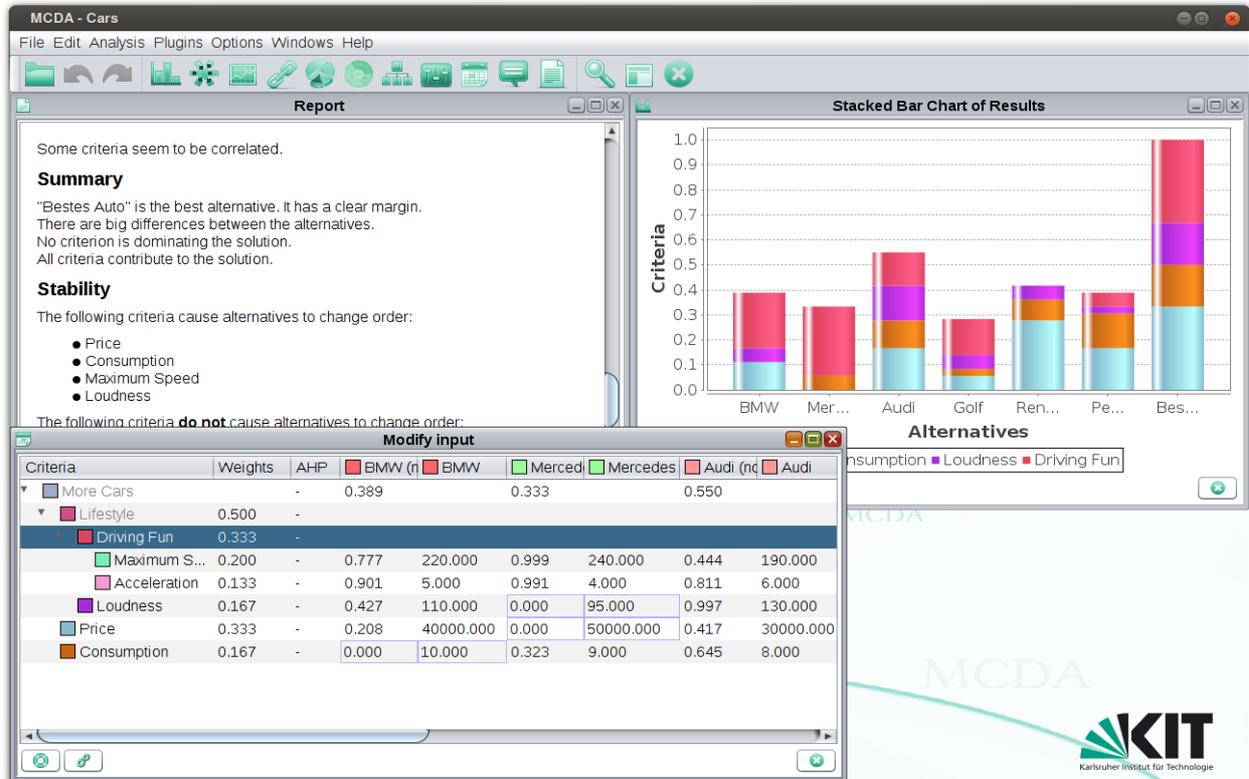


Illustration 7: The main window of the MCDA tool.

4.1 Main window

The main window contains the three important parts of the MCDA tool: the workspace, the menu bar and the tool bar.

Workspace

The largest part of the main window is covered by the workspace. It contains the windows respectively frames of the various tools. The workspace allows handling of the frames like a common desktop. Frames can be moved, minimised, maximised and closed. Some menu and tool bar entries allow manipulation of the frames like e.g. arranging them neatly.

Menu bar

The menu bar contains all available functions. In general the objective of each entry is obvious or can be estimated from its tooltip. In contrast to the tool bar not all of the available functions are considered to be stable. The menu bar is separated in the following groups:

- **File:** in this group all input and output functions are grouped. Besides creating, loading, and saving MCDA import and export is possible. It is mentionable that parts of a MCDA can be imported and exported e.g. the definition of the weights may be exported separately. For this reason it is easy to mix different setups with the same structure. Furthermore it is possible to export the report as HTML.

- **Edit:** this group for one contains undo and redo functionality and also means to edit the defining parameters of the MCDA e.g. the meta information, values, and weights of the MCDA.
Many actions of the editors can be undone and redone so far. However not all existing actions are covered yet. The tooltip of the menu entry verbalises the action to be undone respectively redone.
- **Analysis:** this menu provides functions for analysing the structure and the behaviour of the MCDA. This starts from the very important visualisation methods like charts or tree graphs up to the verbalised report and deep analyses regarding stability or correlations. Some pie charts are still experimental and may not work as intended yet.
- **Plugins:** this menu is reserved for the menu entries of extensions. A plugin framework is available. One example is provided for demonstration purposes of the framework.
- **Options:** personal preferences can be customised using this menu. So far display language and font size are available. Some other preferences like window location or recently used folder are set implicitly and are hidden from the user.
- **Windows:** the functions from this menu interact with the frames on the desktop e.g. arrange them neatly or allow to bring a frame from a list to the front.
- **Help:** until now the entries in this menu provide access to the user guide and information about the application.

Tool bar

The tool bar contains the most commonly used functions. Some icons may not be obvious but their tooltips help to identify their objectives. At the time of writing the functions of the toolbar are considered to be stable.

4.2 Tools

In general using a function respectively starting a tool opens a frame in the main window. All frames share the same basic structure: decorations with buttons for minimising, maximising, and closing the frame, a main panel displaying the content and a button toolbar containing buttons for help, options (if available), and closing.

Report

The report tool verbalises the mathematical results of the MCDA [Illustration 8].

The report contains several sections like e.g. basic information about the MCDA or the result of the stability analysis of the solution. The sections can be enabled or disabled in the options of the tool. Using the export result function from the main window will generate a HTML file with the same content as the report frame.

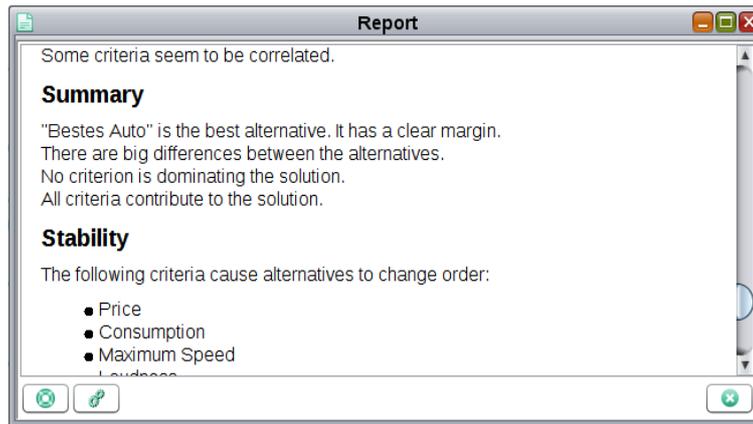


Illustration 8: The report tool verbalising the result

Meta Data

The MCDA contains additional information e.g. label or description of the goal that is not actually required for the actual analysis. This data can be changed with the meta data editor [Illustration 9].

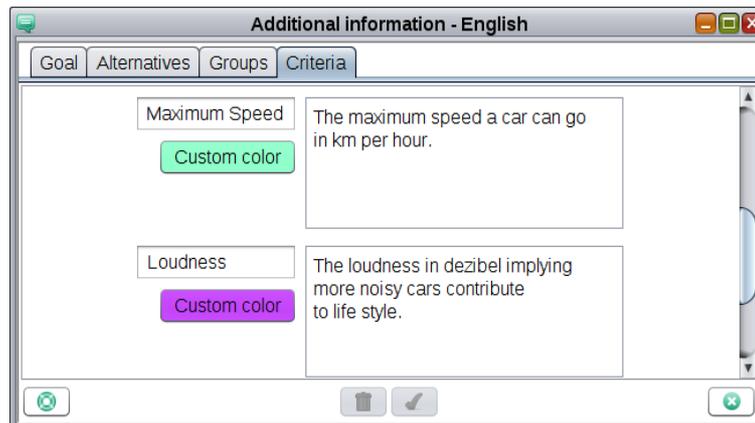


Illustration 9: The editor to handle the meta data.

The frame provides four tabs each following the same structure: for the goal, the alternatives, the groups, and the criteria. The smaller text field holds the label of the entity. The larger text field holds the description of the entity that in general is shown as tooltip in other contexts. The coloured rectangle shows the colour of the entity that is used e.g. in charts to draw the entity. The colour can be changed by clicking onto the rectangle.



The text entered is in general sensitive to the language that has been selected for the MCDA application. For example, if German language is selected changing the label of the goal will be marked as German label. Switching the language for the application to English afterwards will show the label marked as English. If no text is available for the selected language the default is taken, the default being the first text ever entered.

Matrix View

The matrix view displays the values and normalised values of the MCDA. The columns refer to the alternatives and the rows refer to the criteria. In the first column the criteria are displayed as a tree structure to reflect their arrangement in groups. Additionally in the second and third column

Criteria	Weights	AHP	BMW (n)	BMW	Merced	Me
More Cars	-	-	0.389		0.333	
Lifestyle	0.500	-				
Driving...	0.333	-				
Max...	0.200	-	0.777	220.000	0.999	240.000
Acc...	0.133	-	0.901	5.000	0.991	4.000
Loudn...	0.167	-	0.427	110.000	0.000	95.000
Price	0.333	-	0.208	40000.000	0.000	50000
Consump...	0.167	-	0.000	10.000	0.323	9.000

Illustration 10: The value editor and matrix view of the MCDA.

the weights and AHP indicators are shown. Optional the minimum and maximum of each criterion are marked in blue respectively in red [Illustration 10].

To edit a value double click into the corresponding cell. Normalised values as well as weights and AHP indicator cannot be edited. Clicking on the column header will cause the rows to be sorted in ascending respectively in descending order. A click with the second mouse button opens a context menu to hide respectively show columns.

The tree view also provides a context menu that can be accessed using the second mouse button. Depending on the underlying criterion or group the menu entries may differ. Amongst others the menu entries allow to add and remove criteria and groups as well as to open the normalisation editor for the underlying criterion. For usage of AHP see section Analytic hierarchy process (AHP) page 22. Last but not least the nodes in the tree can be dragged and dropped to rearrange the structure of criteria and groups.

Group View

The group view provides three different views on the MCDA data structure: a classical tree view, a vertical MCDA view and a horizontal MCDA view. To switch between the three modes the option button of the frame can be used [Illustration 11].

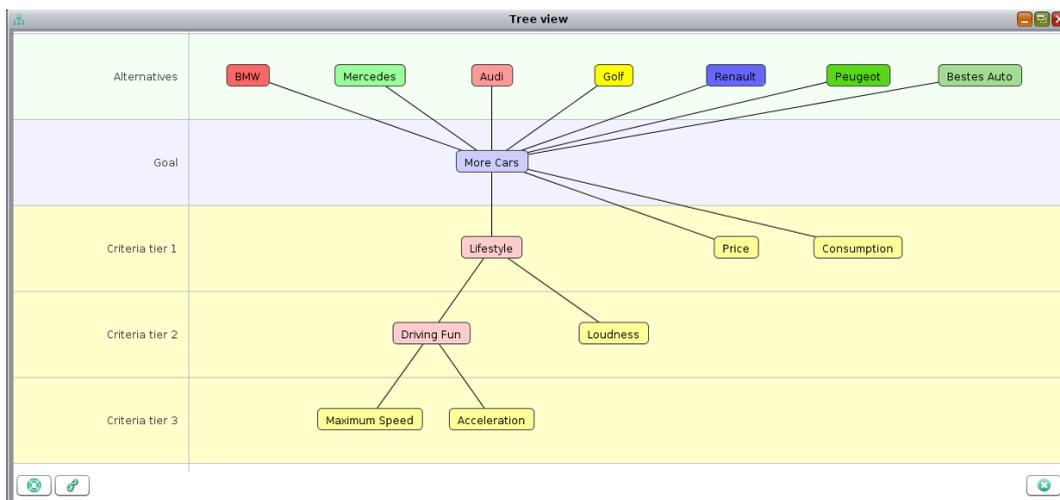


Illustration 11: The tree view of the group view frame.

The view displays goal, criteria, alternatives and groups at the same time. In general, the leaves represent the criteria while inner nodes represent groups. The view allows to zoom in and out using the mouse wheel and to pan the view by clicking and dragging on the background. Using the second mouse button anywhere on the background or nodes opens a context sensitive menu. The entries of the menu are similar to the ones used in the tree of the matrix view.



At the time of writing this document there are know issues with bringing up the correct context menu after zooming out and panning.

Weighting

The weighting frame is one of the most used tools. It focusses on interactively defining the importances respectively weights of criteria. For each criterion respectively group a slider is displayed that allows to easily change the weight of the criterion [Illustration 12].

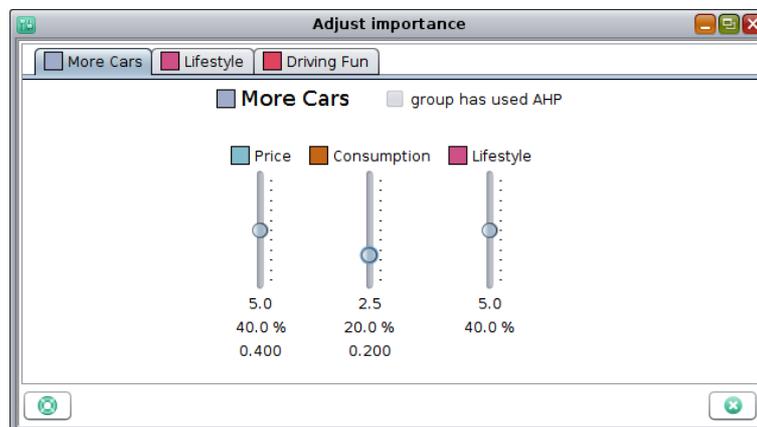


Illustration 12: The importance respectively weight editor for criteria and groups.

Each group is represented by its own panel and can be selected by clicking on the corresponding tab on the top of the frame. The number in brackets indicates the tier of the group. Within each group each criterion and sub group has its own slider that has a value range from 0.0 to 10.0 in a relative scale to the other members of the group, meaning a criterion with weight of 5.0 is considered twice as important as a criterion with weight 2.5. A value of 0.0 means the criterion is not considered at all. Below the sliders some values are displayed. Firstly the relative value, secondly the relative normalised weight within the group, and thirdly the absolute normalised weight in the MCDA are displayed. As an example an absolute normalised weight of 0.4 means that the corresponding criterion has 40% influence on the overall result of the MCDA. Note that groups actually have no absolute normalised weight as they do not contribute themselves to the result, but propagate their relative weight to their subcomponents.

Dragging the slider will change the value. Holding Control while doing so will force the value to an integer slot. Using the mouse wheel on a slider will increase respectively decrease the value in steps of 1.

If the weights of the mebers of a group are determined by AHP the sliders are locked and a button is displayed allowing to discard the AHP and enter weights manually. Also if no AHP is used each tab provides a button that allows equalising the weights of all members in the group.

Normalisation

The criteria values have to be normalised for further processing. A large set of normalisation methods is integrated and available from the normalisation frame [Illustration 13]. You have to select whatever normalisation method seems to fit your criterion best.

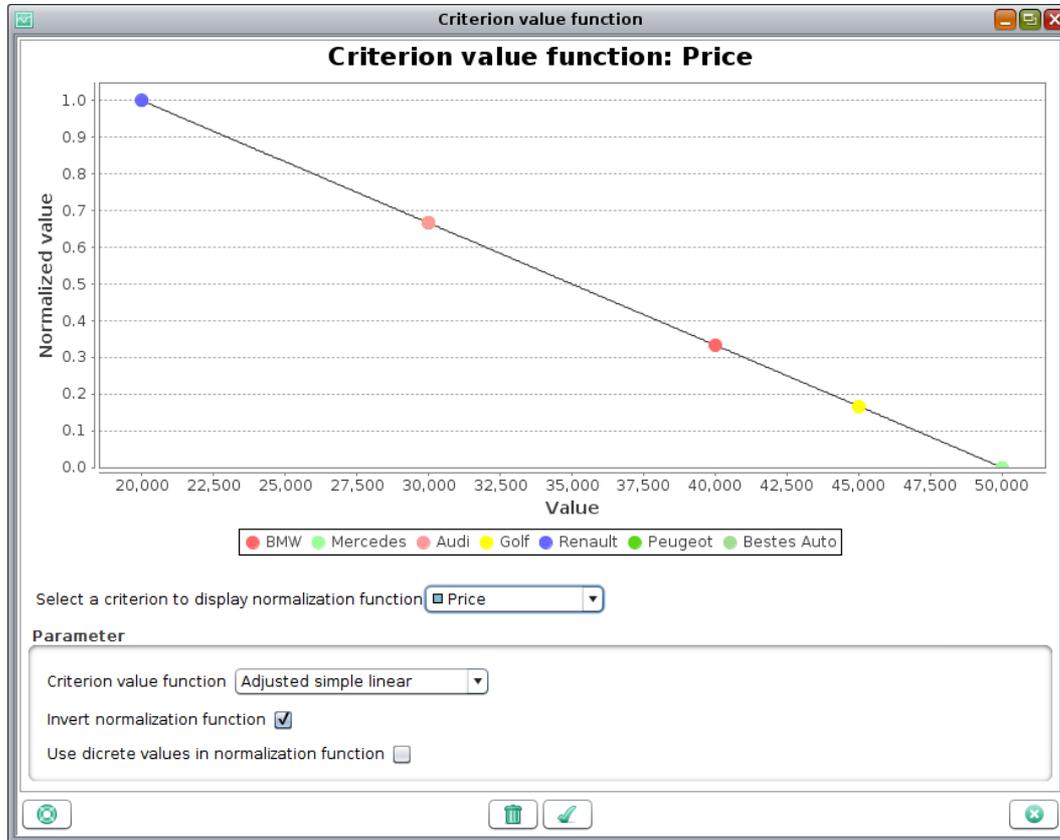


Illustration 13: The editor to manipulate the normalisation of criteria.

For a selected criterion, the chart displays the mapping of criterion values to the range between 0.0 and 1.0. The graph can be zoomed in by dragging a rectangle to the bottom left corner around an area of interest. Dragging in any other direction will cause to zoom out. The graph also provides a context menu.

The criterion in charge can be selected using the combo box beneath the chart. At the bottom of the frame the actual normalisation method can be selected using the according combo box. Some normalisation methods require specific parameters. If needed they are displayed at the bottom of the frame.

Analytic hierarchy process (AHP)

The AHP allows to define values or weights of the criteria by systematically and pairwise define the relations of the alternatives for said criterion. For simplification the relations are verbalised and mapped in a predefined range of values [Illustration 14].

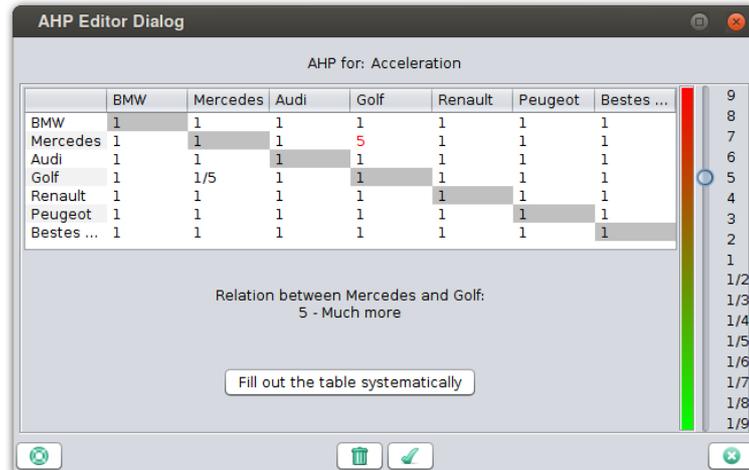


Illustration 14: The AHP frame defining the relations of alternatives for a criterion. The result leads to normalised values for this criterion.



The AHP is quite complex and difficult to handle and therefore it is recommended that it should be used by experienced users only.

Stacked Bar Chart

This frame visualises the results of the MCDA as stacked bar chart. For each alternative its resulting value is presented as bar. The contribution of each criterion is stacked to indicate its contribution to the final bar [Illustration 15].

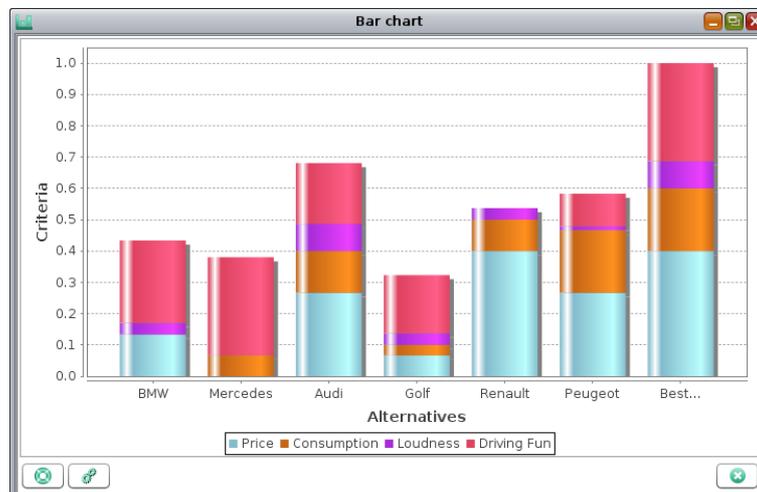


Illustration 15: Visualisation of the MCDA result as stacked bars.

The graph also provides a context menu. As option the bars can be sorted to better display the differences between stacks in a distinctive order. Also a group tier can be defined in the options resulting in groups and criteria above the selected tier to be aggregated to simplify the view.

Cobweb Chart

Two versions of cob web charts exist: firstly to display the weights of the criteria and secondly to display the results of the MCDA [Illustration 16].

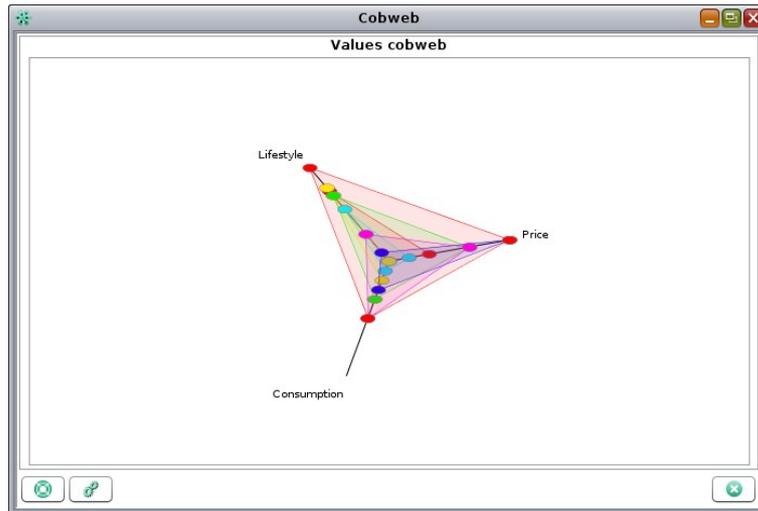


Illustration 16: Cob web chart of the results of the MCDA.

The example shows three criteria where Lifestyle and Price both contribute equally and most to the overall result. The alternative “Best car” (red triangle marked by red dots) has the highest values for each criterion and therefore covers the largest area.

Pie Chart

The pie chart frame displays the result of the MCDA, the weights and the values as a sections of a circle.

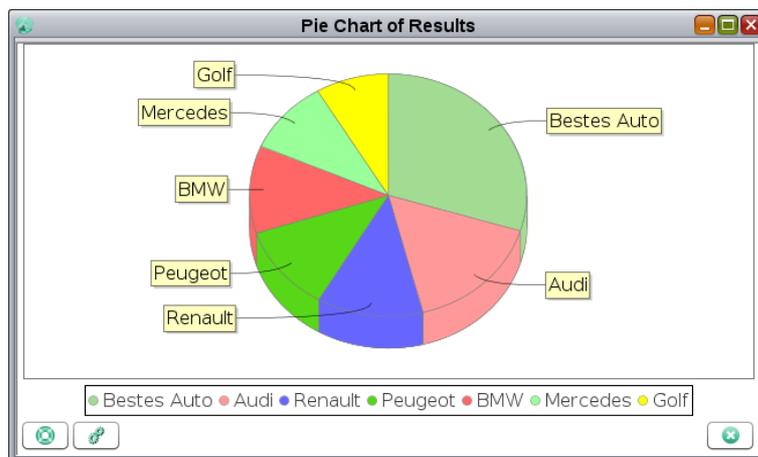


Illustration 17: Pie chart of the results of the MCDA.

If criteria data is displayed the criterion in charge can be selected by a combo box. The options button provides means for selecting custom colours or to sort the sections.

Multi Tier Pie Chart

The multi tier pie chart displays the absolute weight of criteria as area in a pie chart. Additionally the groups respectively tiers are included in the visualisation [Illustration 18].

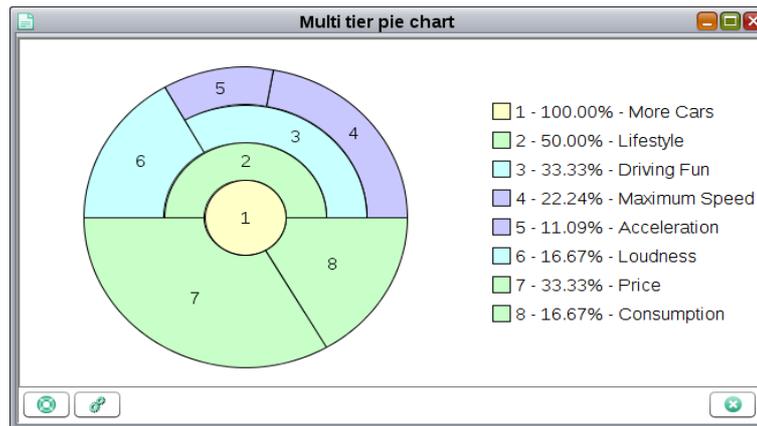


Illustration 18: Weights of criteria displayed as multi tier pie chart.

The criteria and groups are visualised as pie chart. The rings represent the different tiers the groups and criteria are located in. The weights are displayed in percent. As usually in charts zooming and panning with the mouse is possible. Using the options the display of labels, sizes, and colours can be customised.

Stability of the Analysis

This frame helps understanding about the stability of the results, i.e. what will happen if preferences respectively weights of the criteria are changed [Illustration 19].

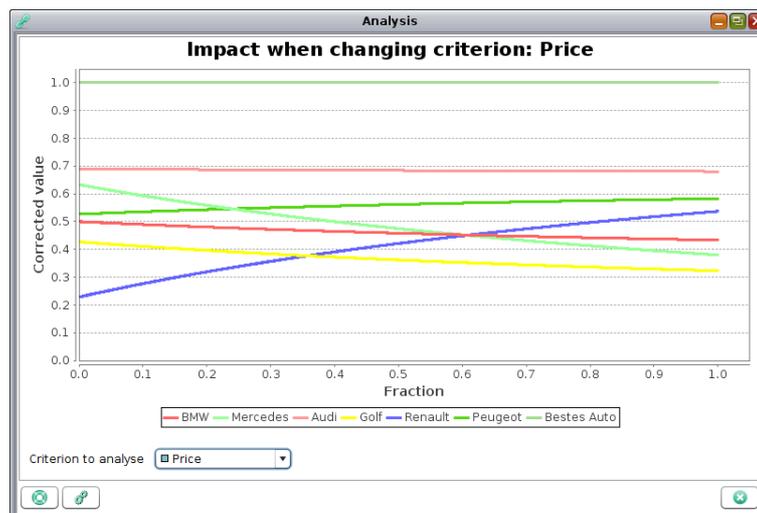
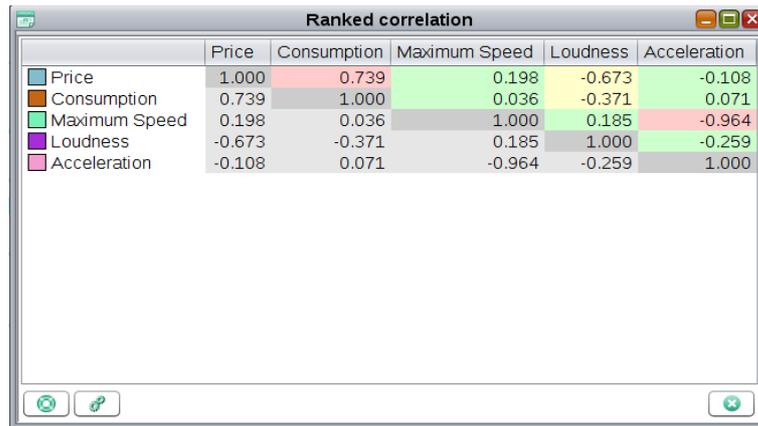


Illustration 19: Analysis of the stability of the MCDA result.

Changing the weight of a criterion influences the result of the MCDA and especially the ranking of the alternatives. The analysis provides two approaches that can be selected from the options: on one hand changing a relative weight of a criterion from 0.0 to 10.0 and on the other hand keep the relative weight but gradually include the contribution of the criterion in the MCDA from 0.0 to 1.0. The interesting points in the graph are the crossings of the curves indication a change in the ranking of the alternatives.

Ranked Correlation of Criteria

This frame provides means to analyse potential correlation of criteria [Illustration 20]. It displays a matrix containing the ranked correlation values. The cells of the matrix are coloured from green over yellow to red indicating low respectively high ranked correlation.



The screenshot shows a window titled "Ranked correlation" with a table of correlation coefficients. The table is a 5x5 matrix where the diagonal elements are all 1.000. The off-diagonal elements represent the correlation between different criteria. The values are: Price vs Consumption: 0.739; Price vs Maximum Speed: 0.198; Price vs Loudness: -0.673; Price vs Acceleration: -0.108; Consumption vs Maximum Speed: 0.036; Consumption vs Loudness: -0.371; Consumption vs Acceleration: 0.071; Maximum Speed vs Loudness: 0.185; Maximum Speed vs Acceleration: -0.964; Loudness vs Acceleration: -0.259.

	Price	Consumption	Maximum Speed	Loudness	Acceleration
Price	1.000	0.739	0.198	-0.673	-0.108
Consumption	0.739	1.000	0.036	-0.371	0.071
Maximum Speed	0.198	0.036	1.000	0.185	-0.964
Loudness	-0.673	-0.371	0.185	1.000	-0.259
Acceleration	-0.108	0.071	-0.964	-0.259	1.000

Illustration 20: Analysis of ranked correlation between criteria.



The ranked correlation is just one method of many to determine potential correlation and an intelligent interpretation is required.

Appendix A: Menu and Tool bar referenced

- Analysis→Charts→Cobweb charts→Values
Cobweb Chart, page 23
- Analysis→Charts→Cobweb charts→Weights
Cobweb Chart, page 23
- Analysis→Charts→Stacked bar chart
Stacked Bar Chart, page 23
- Analysis→Charts→Pie charts→Results
Pie Chart, page 24
- Analysis→Charts→Pie charts→Values
Pie Chart, page 24
- Analysis→Charts→Pie charts→Weights
Pie Chart, page 24
- Analysis→Charts→Pie charts→Multi tier pie chart
Multi Tier Pie Chart, page 24
- Analysis→Trees
Group View, page 20
- Edit→Meta data
Meta Data, page 19
- Edit→Values
Matrix View, page 19
- Edit→Normalisation
Normalisation, page 22
- Edit→Weights
Weighting, page 21
- Analysis→Ranked correlation
Ranked Correlation of Criteria, page 25
- Analysis→Stability
Stability of the Analysis, page 25
- Analysis→Report
Report, page 18

Appendix B: Localization

Creating translations for languages other than English or German is trivial. In general it is sufficient to fill a text file with the according translations. However at the moment no automatic mechanism is established to include local translations. If you are interested in having a specific localisation (Spanish, French, ?, ...) do not hesitate to contact us. If (quite) complete it can easily be integrated into the MCDA application.

Appendix C: Customization

The base directory containing icons, images and colour definitions is customization within the MCDA distribution folder.

Simply edit the files or replace them to customise the application to your needs.

Still more details need to be described here in later editions.



It is recommended to create backups before making any changes. The MCDA tool may not start anymore if the file contents are broken.

Appendix D: File Format

For persistent data storage the XML file format is used. Most of the tags are self explaining. Nevertheless a detailed description of the file format with the XML Schemes and examples are available in the directory docs/XML of the MCDA distribution folder.

Bibliography

[KIT] KIT, Karlsruhe Institute of Technology, <http://www.kit.edu/english/>
[BSD] Wikipedia, BSD licenses, http://en.wikipedia.org/wiki/BSD_licenses
[JRE] Oracle, Java Runtime Engine (JRE),
<http://www.oracle.com/technetwork/java/javase/downloads/index.html>