Optimization **w**ith **L**eisure

SOVA

1.0

User´s Guide

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Introduction

Software SOVA (Czech name for an owl) was made for optimal formulation of the composite materials, but it is useful for an optimization of any numerical factors, which have impact on some goal function. The only condition for its using is number of the control variables N, which has to be between 2 and 12.

The subject of the optimization can be not only the composition of the developed material (e.g. content of the components), but the technological factors as a temperature, setting time, pressing force or other parameters, necessary for the achievement of the best results.

At the start the number and the type of the control variables has to be determined. Two initial values have to be determined for each variable. From these values the software generates the initial simplex with N+ 1 trials. Each trial is composed as a unique combination of the initial values of all the control variables.

For each trial of the initial simplex the response values has to be find. All the response values are than entered into the program. Than the optimization process starts.

From inserted data the software calculates new (optimized) trial. After inserting of the new response value (obtained from this new trial) another new trial is calculated automatically and after inserting each other new response value the another trial is calculated again. The response values could be inserted repeatedly and software would generate other and other trials.

The optimization process is sequential, which often brings considerable economy of the experimental data with comparison of the factorial experiments, in which the optimization is in the large experimental sets.

The software was tested on the simulated and real data and obtained results were (particularly) compared with the results from other optimization software. Some problems, found during the beta testing, were repaired, but occurrence of other hidden problems couldn't be excluded.

We welcome your report of any other problems and we will be pleased, if you let us know, that the software works without problems. For the communication you can use these address:

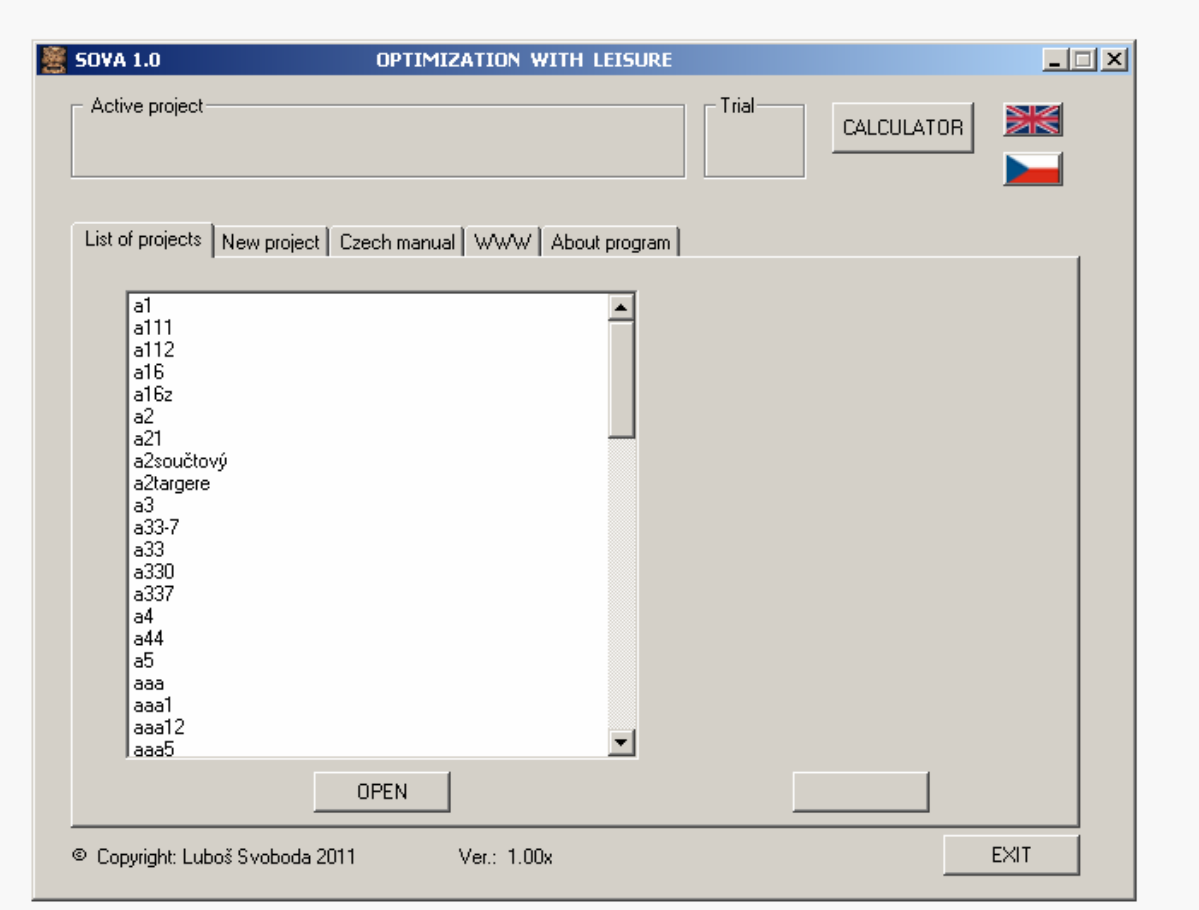
lubos.svoboda@fsv.cvut.cz

alena.vimmrova@fsv.cvut.cz

The software overview

The software is the implementation of the amoeba algorithm (sometimes called flexible simplex method).

Basic screen



On the first screen there is the horizontal menu with the five items:
List of projects , New project , Manual, WWW, About program.

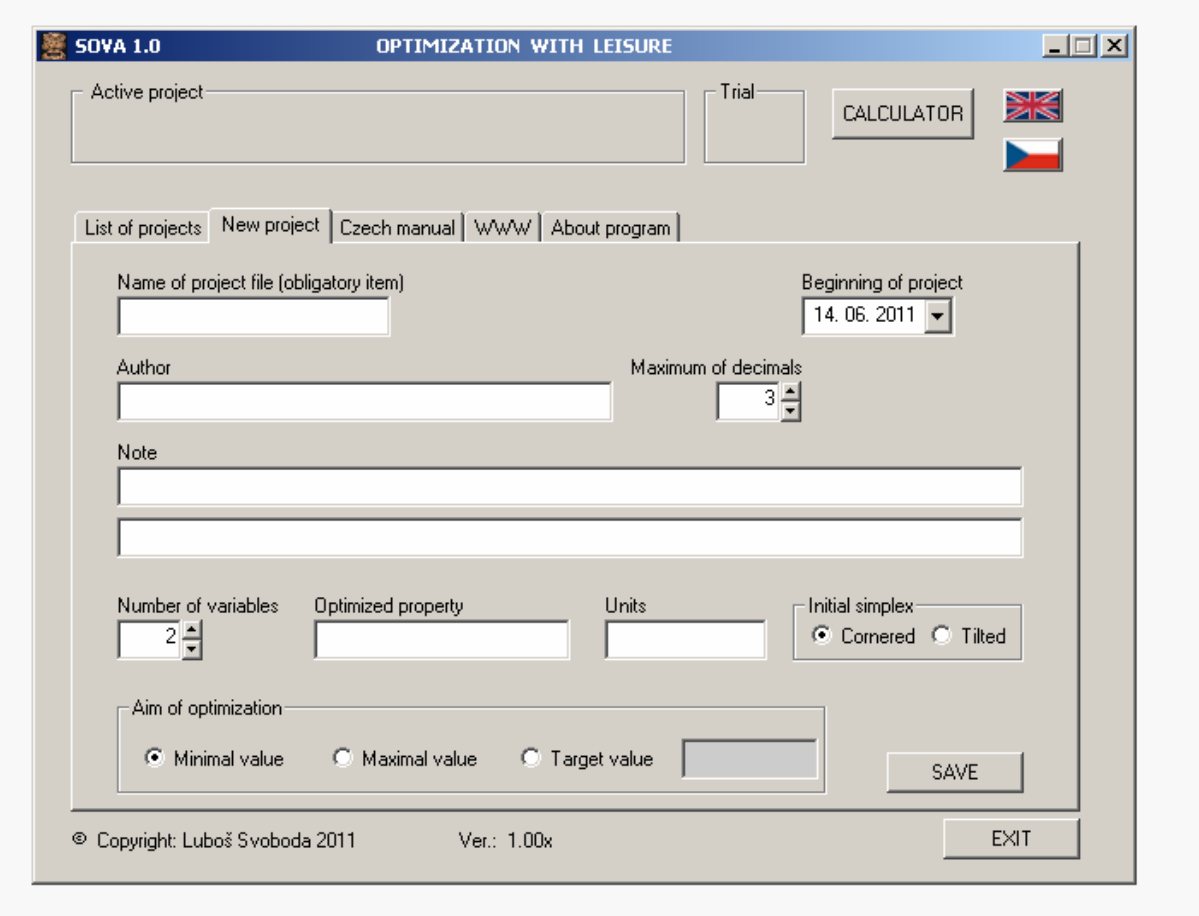
The application works with the screen size 640 x 480 px and 800 x 600 px. The bigger screen is compatible with the SVGA graphic card. By decreasing of the screen resolution to the SVGA value the bigger screen can be obtained without the loss of information. Most users will be probably satisfied with the initial size of the screen.

In the right upper corner there is the button CALCULATOR, which starts the independently working calculator, which can be used for the auxiliary calculations. The results from the calculator (red figures) can be moved to the application by the button RESULT (which is on the last screen of the application). Without using this button the work with the calculator has no effect in the next software function.

On the right side of the CALCULATOR button there are two flag buttons for Czech or English version

English version is the basic version of the software. The file with the English description of the control components has inner backup in the application and it is not recommended to edit it. Czech file can be removed by its equivalent in other language.

New project



Once program is started, select the *New project* button and make the specification of the first optimization task.

After opening of the *New project* screen the button *CALCULATOR* and both flag buttons are functional, but after using some of these buttons the application returns to the basic screen *List of projects* and the content of the *New project* screen will be lost.

For saving of the new project the box *Name of the project file* has to be completed. The name of the project has to be compatible with the Windows 32bit requirements. The name of the project will be saved in the subfolder SovaData as the file Name.owl

To completion of the other boxes in the *New project* screen is not obligatory for saving, but the right setting of the numerical and text boxes is necessary (or the default values will be

saved). It is recommended to fill in also the optional boxes to be prepared for the future protocol.

The beginning of the project can be set at the any date by the calendar utility Beginning of the project (default value is today). The name of the author (*Author* box) and each note (*Note* box) will be visible in the each protocol printed directly from the application.

The box *Maximum of decimals* (1 – 6) gives the number of decimals, which appeared if the value is smaller than one unit. When the value increases in order of magnitude, the number of the decimals decreases (the relative accuracy of the value stays the same). The default number of the decimals is 3 (relative accuracy 0.1 %) which is usually sufficient for technical calculations.

Box *Number of variables* gives the number of the control variables (2 – 12), which can be either components of the optimized product or any factors, which could influence the response value in some way. Default setting of control variables is 2.

To fill in the boxes with the characterization of the optimized value (*Optimized property*) and units of the optimized value is not obligatory, but it is important for the future understandability of the project. The type of the used units appears in the protocol.

In the box *Initial simplex* the cornered or the tilted simplex can be chosen as an initial experimental simplex. Both possibilities are the classical first simplex designs and generating of the initial simplex table is automatic in both cases.

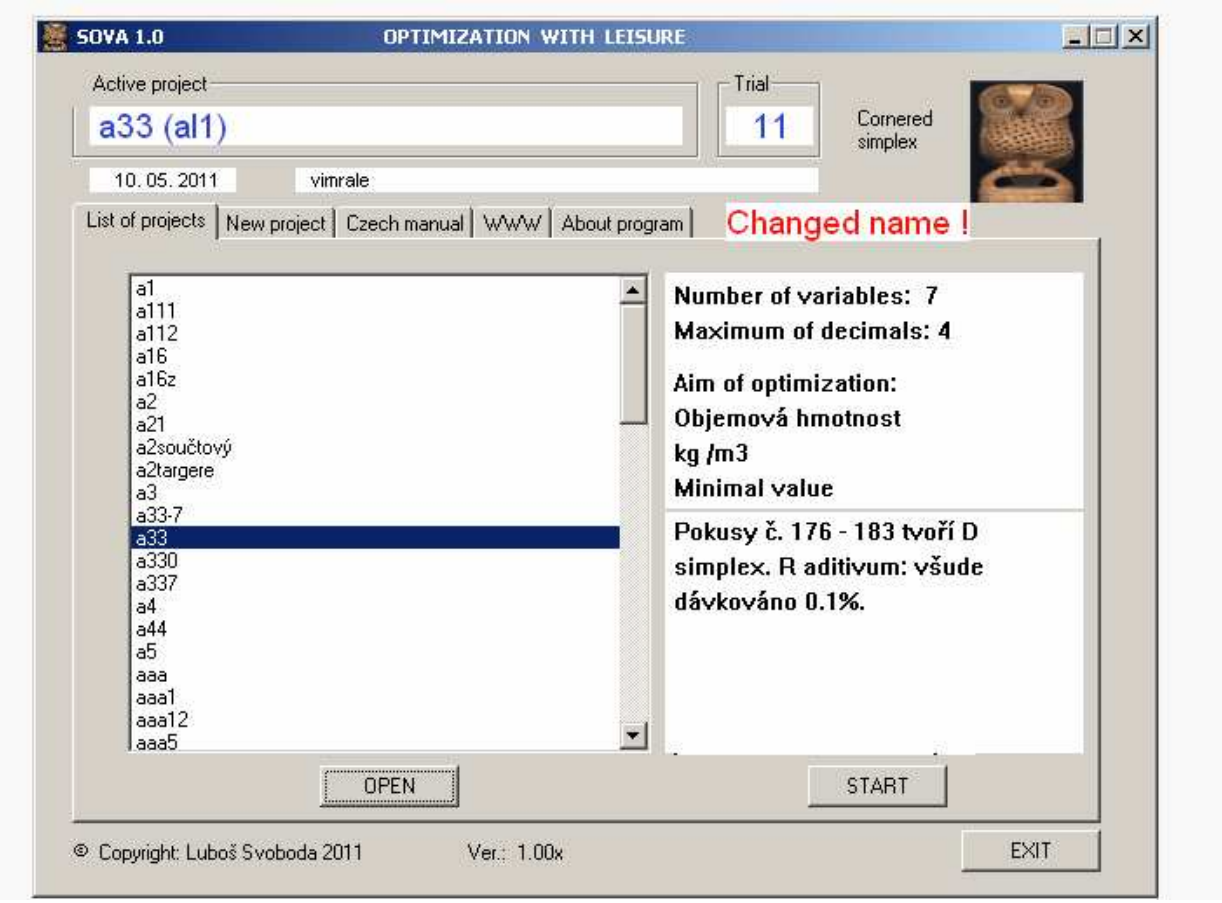
Choosing from these two variants is not so important. In both cases the result of optimization will be the same. The cornered simplex is probably better for the calculation of the design of the composites; tilted simplex is considered by some authors as more suitable for the optimization process with the high number of the optimization steps. The default setting is *Cornered* simplex.

There is choice menu *Aim of optimization* at the bottom side of the *New project* screen. The choices are: minimization, maximization or target value. If the target value is chosen, its value has to be filled in the next box. The default setting is *Minimal value.*

Button *SAVE* is used after filling of all the boxes. After using of this button the screen New project is closed and its content can be visible only after opening the project from the *List of projects* and cannot be changed. Do not save the new project prematurely

By using additional information at the end of this guide the saved information about project could be changed by the direct editing of the data file. This procedure is exceptional, but nevertheless possible with the great care.

List of projects



On the screen *List of project* any item can be chosen by the left mouse button and can be open by the button *OPEN*.

After opening of the project all the initial information about the project (completed in the *New project* screen) appear in the right window. It is possible to switch between the projects and inspects their initial information repeatedly.

If the item was renamed (e.g. as a result of the disc reorganization) the warning message appears and original name of the project appears in the brackets beside the new name. Original name has no influence on the application and is given only for user's information.

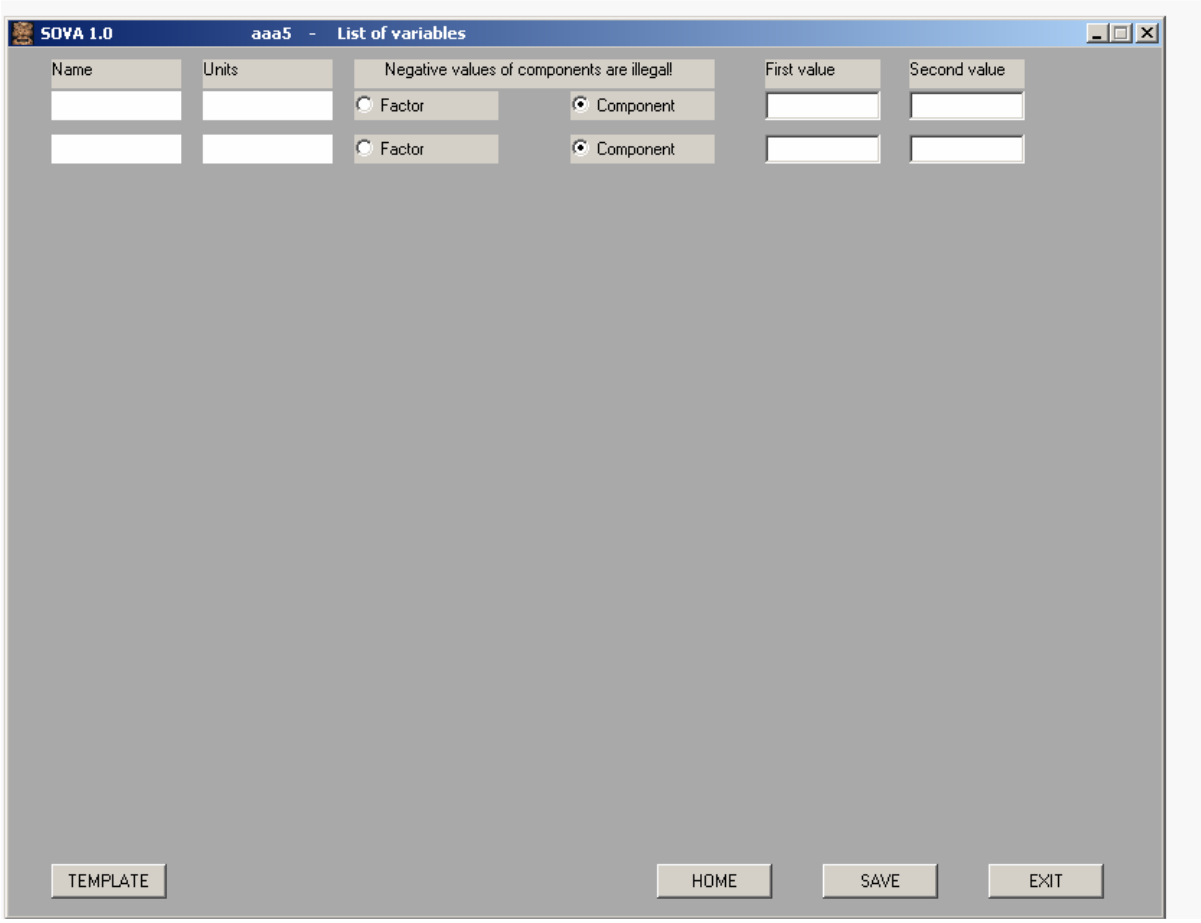
In the *Trial* box the number of the completed experiment steps is displayed. If the number -1 appears, it means that the project has only initial information and any experiment was not yet performed.

List of variables

For the work with the chosen project press the button START. If the project has only initial information (*Trial* = -1), the table *List of variables* appears. The table has four text boxes and two choice buttons in each row.
The number of the rows corresponds with the number of variables, given in the initial information .

The name (or code) of the variable is typed into the first text box. Into the second box the units of the variable can be typed. The filling of this box is voluntary, but its content appears in the final protocol and it is recommended to fill in this box also.

By the choice buttons the possibility *Factor* or *Component* can be chosen for each variable. Chose *Component* if the variable is substance and *Factor* if the variable is property. The default setting is *Component*



Into the third and fourth text boxes two values (in the further text marked D and H) for any variable have to be written. These values are obligatory.

The variables, marked as components couldn't obtain negative value. The software does not allow inserting the negative value in this case. The value of the factor variables is not limited in this sense.

The table *List of variables* cannot be saved until all the variable names and two initial values for each variable are not filled in. If the table is not saved, its content disappeared and at the next opening of the application the table is empty again.

The completed table can be saved by the button SAVE. After successful saving the plan of the initial experiments appears.

The plan of the initial experiments is made from two given values (**D** < **H**) of all variables and their mean value **P**. The plan appears as a table, which is in fact the matrix form of the initial simplex.

Next table shows the sample of the two types of the initial simplex for the optimization of the four variables (**w,x,y,z**).

Variables:	**w**	**x**	**y**	**z**		**w**	**x**	**y**	**z**
1st experiment	D_1	D_2	D_3	D_4		P_1	P_2	P_3	P_4
2nd experiment	H_1	D_2	D_3	D_4		H_1-	P_2+	P_3+	P_4+
3rd experiment	D_1	H_2	D_3	D_4		P_1+	H_2-	P_3+	P_4+
4th experiment	D_1	D_2	H_3	D_4		P_1+	P_2+	H_3-	P_4+
5th experiment	D_1	D_2	D_3	H_4		P_1+	P_2+	P_3+	H_4-

In the algorithm for the corner simplex (pink color) the given values are used directly and the initial corner simplex is made from their combinations.

Thereby the recommended given values should be about 1/3 and 2/3 of the expected range.

There is no range limit for the input values in the application. If the value proposed by the application is not acceptable it could be excluded from the optimization by the button *PENALTY*.

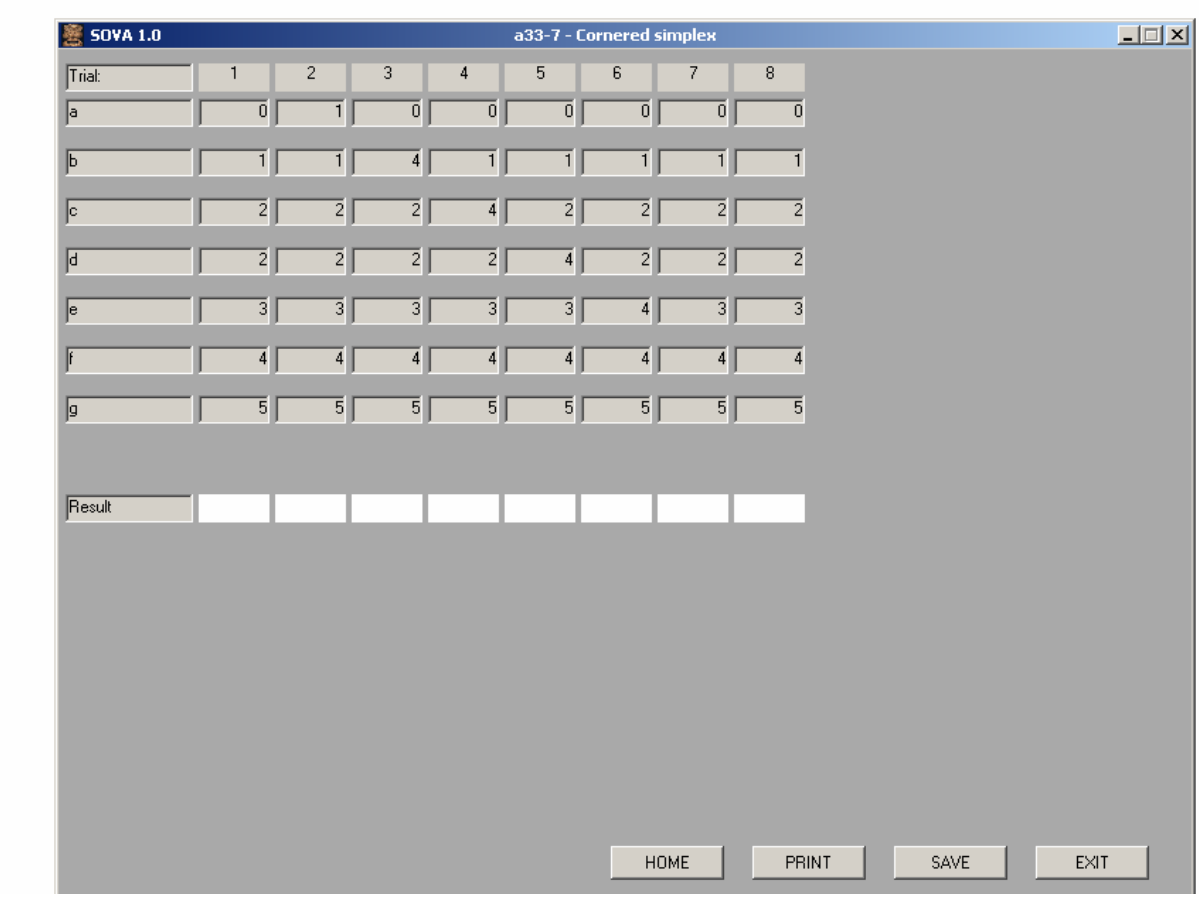
In the algorithm for the tilted simplex (blue color) the proposed values of the variables for the initial experiments are modified by adding (marked +) of the certain part of difference between **D** and **H** to the mean value **P** and subtracting (marked -) of analogous value from the **H** value.
If the tilted simplex is chosen, the values **D** and **H** could be chosen in the same interval from the middle of expected range (e.g. **D** can be 1/4 of the expected range and **H** 3/4 of the expected range). This recommendation is not obligatory.

By the optimization of the mixtures the important fact is that the change of the percentage amount of one component influenced the percentage amount of the other components. This fact does not restrain using of the simplex for optimization of the composition in the percents.

Simplex algorithm does not take into consideration the relationship (constraint) between components and therefore it is not able to obey condition, that the sum of all components has to be 100 %.
The possible solution of this problem can be making simplex-matrix from only N-1 components and the amount of the N^{th} component calculate as a complement to 100 %. If the application proposed the simplex, in which even the amount of N-1 components exceeds 100 %, this proposal can be excluded by the button *PENALTY*.

The meaning of the *TEMPLATE* button is explained in the additional information. During normal work this button is not used.

Initial data



The table of the initial experimental set (*Cornered simplex* or *Tilted simplex*) is matrix, which has for **N** components N rows and **N**+ 1 columns. Number of the columns is equal to number of the experiments, made during the initial simplex. Maximum size of the matrix in the application is 12 x 13 (e.g. 12 components, 13 experiments).

Project, which has the table of the initial experiments not yet filled in, shows zero as a number of trials (*Trial = 0*) in the initial information. This table appears after pressing *START* button.

Into the last row (*Results*) the results of the experiments, performed according the formulas in the columns have to be filled in. If the row *Results* is empty, the table can not be saved. Nevertheless the empty table (only with formulas) can be printed by the button *PRINT* and can be used at the work.

If the table of the initial experimental set is not saved yet, after each opening of the project the table appears in the initial form (e.g. with the formulas and empty Results row).

After filling in all the obtained results the table can be saved by the pressing SAVE button. From this moment saved initial data can be seen after pressing *PREVIEW* button in the final window of the application only.

Optimization

Immediately after successful saving of the results of initial simplex the final window *Optimization* appears. This window contained controls and information in thirteen frames.

In the frame *Trial + number* the number of the trial (optimization step) can be seen. The values of the variables for the trial are shown and at the each variable there is *x* sign, if the variable is factor or component.
If some of the component variables achieved negative value during the optimization, the application changes this value to zero automatically. At the factor variable the negative value remains.

The frame *Prepare data* contains two buttons. By the button *CALCULATOR* the calculator, described in the chapter Basic screen, is started. After closing calculator window (*x* button in the right upper corner) the results can be transferred to the *INPUT* box of the application by the *RESULT* button.

Adjacent frame called *INPUT* is for inserting of the result for given trial. The content of the box is editable. The value in the box can be filled in by hand without the help of the calculator. This possibility will be probably the most frequent. Result value can be inserted into the application by the *RESULT* button.

In the frame *Reject* there is button *PENALTY*. By pressing it the slightly worse value than the most unfavorable result yet appears in the *INPUT* frame. It causes that (after pressing *INPUT* button) the experiment will be excluded from the next optimization as unsuccessful.

In the frame *Last steps* there is the button *UNDO*. To explain its function, there is to be said, that repeated closing and starting of the single projects is presumed during working with the OWL application. Each opening of the project is considered as a one session. At the beginning of each session the backup of the momentary state of the project is made. By the pressing the *UNDO* button this momentary state (e.g. at the beginning of the recent session) is restored.

In the frame *Notes* there are buttons *ADD* and *READ* for making and reading of the notes.
In the protocol only firs note, saved from the screen *New project*. The notes, made by the button *ADD* are only for experimenter's use only and can be printed as a separate document only, not as a part of protocol. To print the notes press the button *PRINT* in the frame *Notes*.

The frame *Protocol* contains button *PREVIEW* and *PRINT*. By pressing of the button *PREVIEW* all the information about all performed experiments so far, which could be useful sometimes.

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The last frame in the left column is *Return home* with the button *HOME*. By this button the actual project is aborted, but the application still works. Actual project is saved by using the button *HOME* and the basic screen appears. By choosing any item from the *List of projects* another session can be started by the *START* button.

In the right column in the frame *Course of optimization* there is a button *GRAPH*, which displayed bar chart with the last 37 results. Usually all the achieved results appeared, because to extend optimization beyond this value is not likely.
The graph serves for the quick orientation in the optimization course and size of the bars changes with the maximum achieved value of the optimized property. The maximum value is displayed always as 100 %.

Next frame *Aim of optimization* contains only information boxes. The optimized property is displayed and the information, what should be achieved by the optimization.

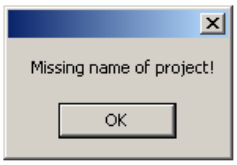
In the frame *Results* there are only information boxes too. The so far best achieved value of the optimized property is displayed as *best* and the worst obtained value as *poor*.

After definite finishing of the project the project can be removed from the *List of the project* on the basic screen by pressing the button *ARCHIVE*. The backup of the project will be deleted and actual data file is moved to the directory SovaArch under the name *NameOf TheProject.owl.*

For closing of the application the button *EXIT* can be used. The current project is saved and the application is closed.

Other propeties

Error messages appear as small windows and to continue the OK button has to be pressed.



Mostly it is only warning message and not a critical error. After the correction of the announced problem the program can continue.

Special attention has to be given to the message *Unknown type of simplex!*, which warns that the simplex type label is not from the allowed set of labels (CS, TS, GP) and message *Unknown type of optimization!*, which appears when the type of optimization is not encoded by the admissible number (19, 20, 21). The message is usually caused by the corruption of the data file during careless editing.

Messages *Couldn't open the file!*, *Data file problem* ! or *Archive operation failed!* mean more serious type of errors.

They are caused mostly by the problems at the reading, copying or creating of the data files. This could be caused by the lack of disk space, the corruption of the file name or missing authorization for writing into the chosen directory.

In the directory *Sova* are the data subdirectories too and the directory has to be located on that part of the disk, to which the future user has access rights. Otherwise the quite usual location in the directory *Progam Files* could be the source of the problems.

The software SOVA can be run several times even in the same directory. This could be used e.g. for comparing two projects and it does not causes any problem. There is no reason to run the same project twice in the same time and it is necessary to avoid it.

To display bar chart correctly there is assumed that optimized value is a positive number. When the value is negative, it can be seen on the chart, but its dimension is not displayed properly. However the input of the negative number is not forbidden, the algorithm works with negative values too.

Using of a comma to separating of thousands is not possible. The commas are always converted to decimal points (for comfort of Czech users).

Optimization procedure is not provided by any terminating condition intentionally. It is only the user decision to terminate the project.

Additional information

This part of the guide is intended for the skilled users, which want to use all of the software possibilities, even if it means the intervention in the program files.

These users appreciate the fact that the main data file of the each project *Project.owl* is in a pure text form and therefore can be edited (with due care) in the each plain text editor (Notepad, Crimson Editor) and in the Word too (using the choice Save as a text).

Particular groups of the items are divided by the lines in the data file and moreover the each test is numbered. Consequently the data are clearly organized and their editing is not difficult.

The button *TEMPLATE* makes the template of the data file. Template head (data from the New *project*) is filled in, but the items of the initial file are empty. Any information from the table *List of variables* is not saved in the template and therefore it is pointless to fill the table before pressing the *TEMPLATE* button.

By filling in the template any type of the initial polyhedron can be created instead of the cornered or tilted simplex.

To make completely random polyhedron probably would not be effective. However there is possible to use design of some factor analysis (e.g. D optimal design) or to input the results of the earlier made tests instead of one or more the simplex steps and thus decrease the number of necessary trials.

The next example is to explain the template structure (and data file at all). Explaining comment is added straight into the template by the bold font.

The template is saved as a file Name.owl (into the subdirectory Sova.Data).

Structure of the template

1: Name **name of the project**
2: 04. 06. 2011 **date of the project start**
3: L. Svoboda **author or contact person (item is given in the protocol))**
4: Model template . **note**
5: **empty item**
6: 2 CS **the line is corrected later, because template does not make cornered simplex**
Valid codes in this line are three (CS=cornered simplex, TS=tilted simplex, GP=general polyhedron), for empty template the only reasonable choice is GP.
7: 195 **First two digits are code: 19 = minimization 20 = maximization 21=target value. Third digit indicates the maximum number of decimal position in the results**
8: **the number of target value (if required)**
9: Optimized property **specification (name) of the optimized property**
0: Property unit **units of the optimized value**
==========

6: 2 GP **revision of the 6th line – number in front of alphabetic code gives the number of variables**
(The revision is necessary, because incorrect code was saved during the template head creation before the command to make template. The revision is made automatically)
_____
A: Name 1 **has to be overwritten by the real name of first variable**
A: 0 **leave without changes**
A: 0 **leave without changes**
A: 1 **1= component 0 = factor**
A: Units 1 **units of variable Name 1**
_____
B: Name 2 **has to be overwritten by the real name**
B: 0 **leave without changes**
B: 0 **leave without changes**
B: 1 **1= component 0 = factor**
B: Units 2 **units of variable Name 2**
_____
==========
---------- 1 ---------- **number of experiment**
A**: the value of the relevant variable in the experiment**
B: **the value of the relevant variable in the experiment**
C: **the value of the relevant variable in the experiment**
D: **the value of the relevant variable in the experiment**
Y: **found value of optimized quantity**
---------- 2 ----------
A:
B: **analogous with first experiment**
C:
D:
Y:
---------- 3 ---------- **Total number of initial experiments = number of variables +1**
A:
B:
C: **analogous with first experiment**
D:
Y:
==========

FIRST THREE SYMBOLS IN EACH DATA LINE (LETTER OR DIGIT, COLON AND SPACE) HAS TO BE LEFT IN THE ORIGINAL FORM!

Attention has to be given especially to the leaving of the space. Data line is identified by the first three symbols and when the space is missing, the program skips the line!

File *Name. owl* saves all the information about solved project. It serves to the repeated work with the project and to the print of the protocol.

Translated by A. Vimmrová