— Computer Aided Design Optimizer —

USER GUIDE

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ABOUT

This document provides general information about using the CADO software. CADO is a fully CAD-integrated topology optimization tool under the open source BSD license. It resulted from a project as part of the Bavarian Graduate School of Engineering at TU München and was developed by Saumitra Joshi, Juan Carlos Medina, Friedrich Menhorn, Severin Reiz, Benjamin Rüth, Erik Wannerberg and Anna Yurova in 2015-2016.

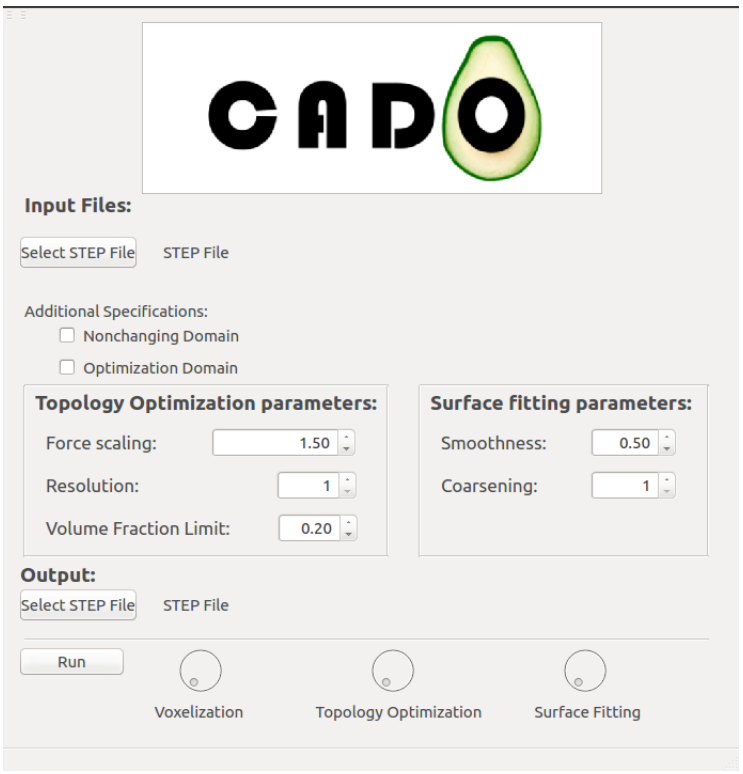

Figure 1: CADO main window

1 PREPARING YOUR COMPUTER

1.1 Technical requirements & Installation

Please make sure that the following software is installed on your computer in order to fulfil CADO's dependencies:

- ToPy
- OpenCascade
- FreeCAD
- Qt (version > 5.4.2)
- QtCreator (version > 3.4)

For the detailed installation instructions, please refer to:

CADO_InstallationGuide.pdf

Once all necessary software is installed CADO can be run from the terminal by issuing:

```
> ./cado
```

Once CADO is running, the main window appears on the screen (see fig. 1).

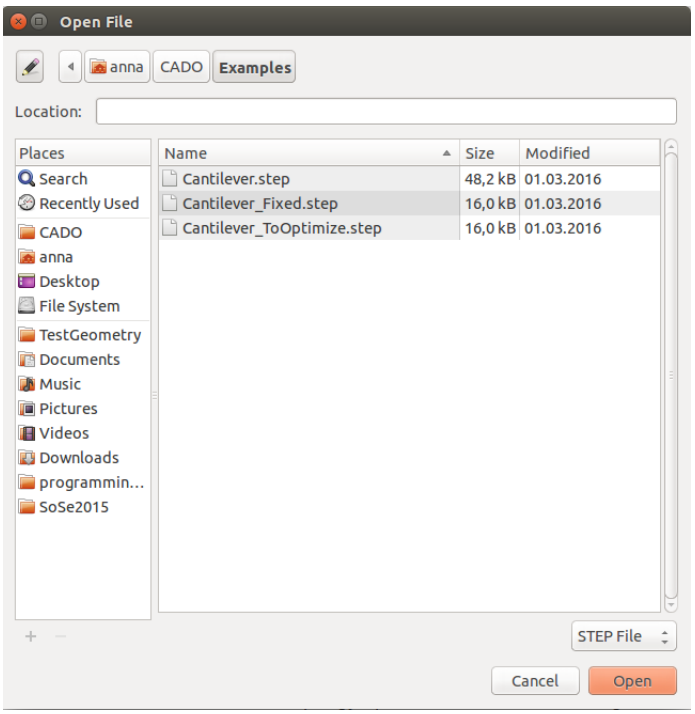

Figure 2: CADO input files. Please make sure that files follow the naming convention stated in the document.

2 STRUCTURE

Now let us take a closer look at the parameters required by CADO.

2.1 Input files

To select your input *.step* file:

- Press the **Select STEP File** button in the top left corner of CADO;
- Choose the appropriate file by navigating through the file system in the opened dialog (see fig. 2);
- Press the **Open** button.

After that, the path to the chosen file should appear near the **Select STEP file** button (see fig. 3).

Note that the same directory must also contain an *.iges* file with the information about colors (see fig. 2) with an identical name:

<StepFileName>.iges

2.1.1 *Nonchanging domain*

In case some domains need to be kept unchanged during the optimization (for example, screw threads), select the **Nonchanging domain** checkbox in the *Additional Specifications* section. Make sure that your *.step* file that specifies the nonchanging domains is located in the same directory as the original *.step* file (see fig. 2) and named as:

<StepFileName>_Fixed.step

2.1.2 *Optimization domain*

You can constrain the solution to be limited to a certain domain of optimization. In order to specify this, select the **Optimization Domain** checkbox in the *Additional Specifications* section. Make sure that your *.step* file with the optimization domain is located in the same directory as the original *.step* file (see fig. 2) and named as:

<StepFileName>_ToOptimize.step

2.2 Topology Optimization Parameters

In order to tune the topology optimization for your specific problem, please enter the following parameters:

- **Force Scaling** - scaling factor for the force from the input file. Scaling is performed from the range $-0.5 - 0.5$ (corresponding to the color in the original input file) to the desired one.
- **Resolution** - the resolution of the optimized geometry. Increase the number to increase the resolution and get a more accurate solution.
- **Volume Fraction Limit** - the fraction of the volume to be kept in the voxel after the topology optimization

To fine-tune the parameters, use the raise/lower arrows. You can also enter the numbers directly into the fields.

2.3 Surface Fitting Parameters

In order to specify the desired quality of the output surface, please enter the following parameters in the *Surface Fitting Parameters* section:

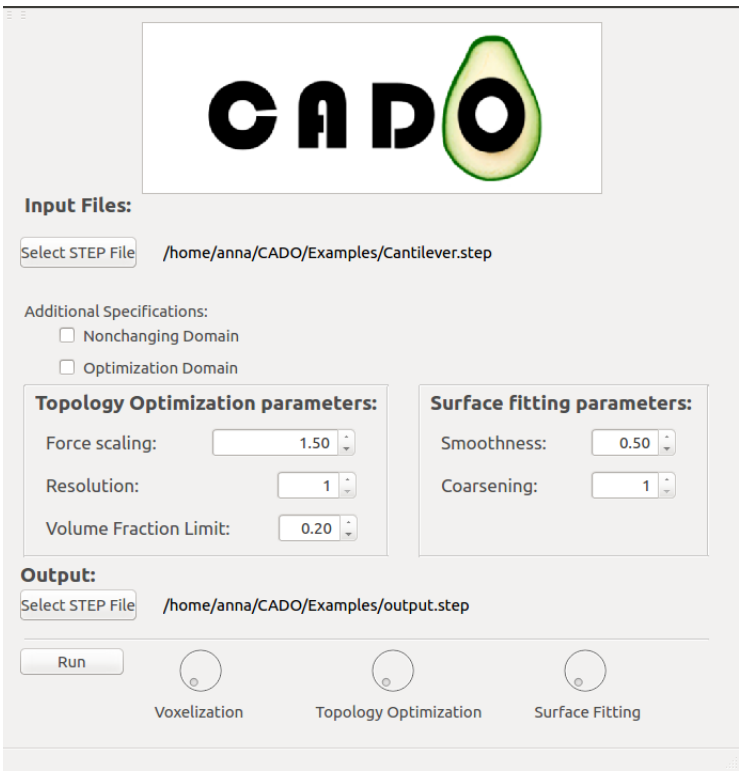

Figure 3: CADO main window with specified parameters

- **Smoothness** - increase the number to increase the smoothness. Note that some features might be lost if your desired smoothness varies from the physical result.
- **Coarsening** - the resolution of the output surface. Increase the coarsening to reduce the number of patches in the output surface. Note that increasing the coarsening factor can lead to loss of the features of the surface (such as holes, etc.).

2.4 Output

To specify the output file:

- Press the **Output** button;
- Choose the output destination by navigating through the appeared file dialog (see fig. 2);
- Enter the name of the output file;
- Press **Open**.

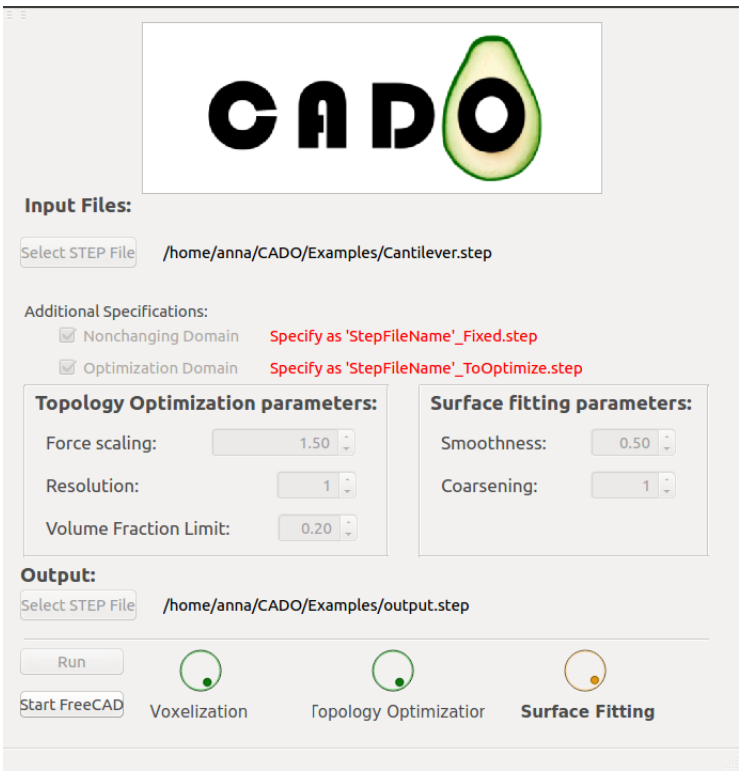

Figure 4: CADO in progress

Once the optimization process is completed (all progress bars are colored green), view your results in FreeCAD by clicking **Start FreeCAD** button.

3 EXAMPLE

To run a sample optimization, run CADO from the command line as described in 1. In the appeared window (see fig. 1) you can see the default parameters for the **Cantilever** test case, provided together with the source code distribution. To complete the necessary input for running the program, enter the following information:

- Choose the input file as described in sec. 2 from the following folder:

  Examples/Cantilever/

- Check the checkboxes **Nonchanging Domain** and **Optimization Domain**. The files with appropriate names are already placed in the folder.

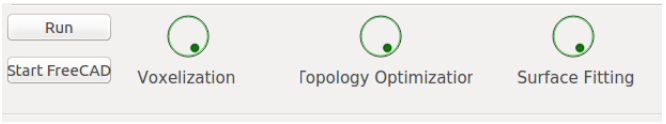

Figure 5: CADO. Optimization is finished

- Specify the output file following the instructions from the sec. 2.

To run the optimization press the **Run** button in the bottom of the window.

The progress of the Topology Optimization pipeline can be observed on the progress bars near the **Run** button (see fig. 4). Each round-shaped progress bar corresponds to one of the three main steps of the pipeline. While one of the steps is running, the corresponding progress bar is indicated yellow and moving. Once the step is finished, the progress bar is colored green (see fig. 5).

Once all progress bars are marked green the optimization process has finished. To see the optimized result in FreeCAD click on the **Start FreeCAD** button (see fig. 5).

Enjoy your topology optimized result in FreeCAD!