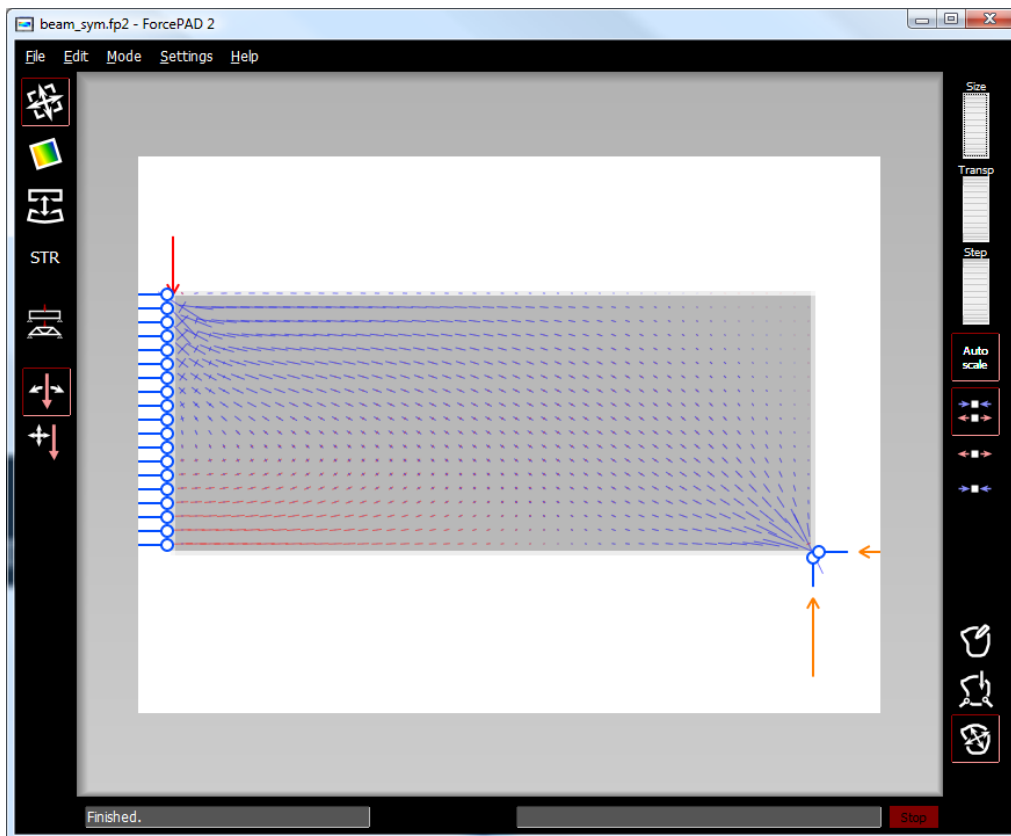


11/3/2009



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FORCEPAD MANUAL

ForcePAD 2.4.1 | JonasLindemann

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Introduction

ForcePAD is a sketch program for material shape and form. Using the program structures can be easily drawn and analysed with regards to applied forces and constraints. The design of the program is based on the same conceptual model as image editing applications such as Microsoft Paint, Adobe Photoshop, Paint.NET or The GIMP. Structures are drawn using pens and other drawing tools. Forces can be placed by simple clicks with the mouse. Constraints are placed in the same way as forces. Stresses and displacements are also calculated and visualized quickly without any delays.

Installation

System requirements

	Windows	Mac OS X
Operating system	Windows XP Windows Vista Windows 7	Mac OS X 10.4, 10.5 eller 10.6 with an Intel based processor
CPU	Intel Pentium 4 or higher.	Intel Pentium 4 or higher.
Memory	At least 512 Mb	At least 512 Mb
Harddrive	4 Mb installed, 1 Gb or more to run larger models.	4 Mb installed, 1 Gb or more to run larger models.
Graphics	Hardware accelerated OpenGL graphics.	Hardware accelerated OpenGL graphics.

Windows

Download the installation package from <http://forcepad.sourceforge.net>.

Downloading ForcePAD

ForcePAD is available in three versions, an old version 1.0.5 version, a stable version 2.3 and the next generation version 2.4. Hardware accelerated OpenGL capable graphics card is required. 512 Mb or more memory to use finer grid spacings.

Current stable version: 2.3.0

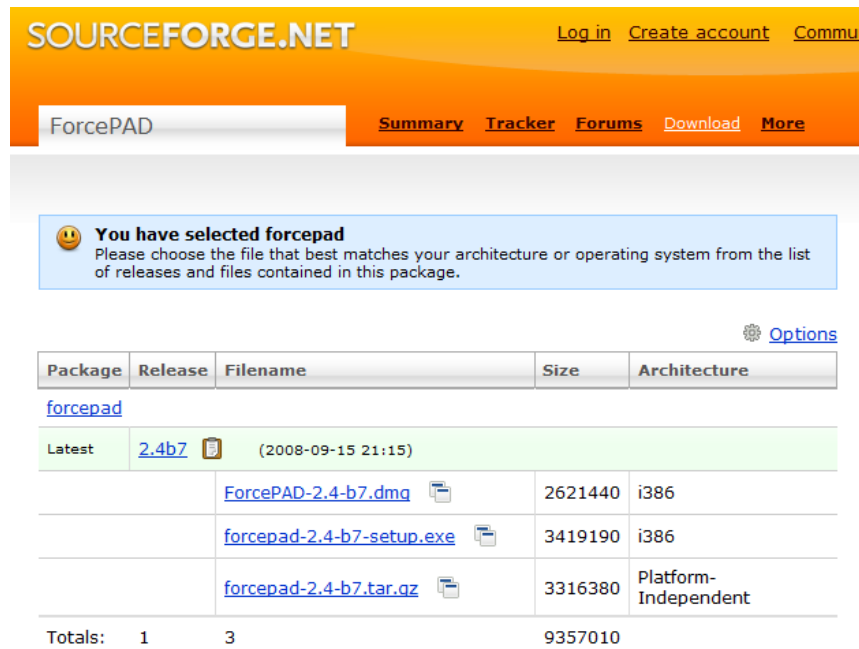
Current development version: 2.4.0 BETA7

Binary installs for Windows/MacOSX

- ForcePAD 2.4.0 (BETA7) (Windows/MacOSX)
- ForcePAD 2.3.0 - Latest stable version (Windows)
- ForcePAD 1.0.5 - Unsupported version (Windows)

Figure 1 – Download page on forcepad.sourceforge.net

Click on ForcePAD 2.4.x to get the latest version. A new page is shown in the web browser.



Package	Release	Filename	Size	Architecture
forcepad				
Latest	2.4b7	(2008-09-15 21:15)		
		ForcePAD-2.4-b7.dmg	2621440	i386
		forcepad-2.4-b7-setup.exe	3419190	i386
		forcepad-2.4-b7.tar.gz	3316380	Platform-Independent
Totals:	1	3		9357010

Figure 2 – Sourceforge installation package selection

The installation package for Windows is the file with the extension .exe. Click on the link to download the package. After a couple of seconds a dialog box is shown with a request to save the installation package file.

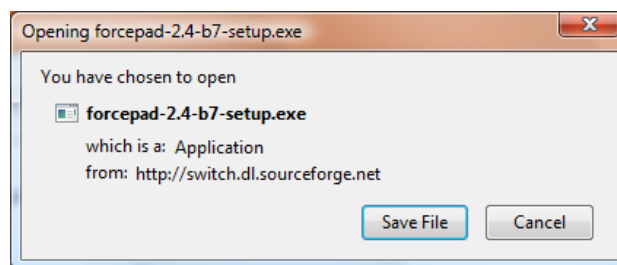


Figure 3 – Dialogbox for saving installation package

Click on **Save File** to save the file on the local hard drive. The installation package can then be started by double clicking on the downloaded file.

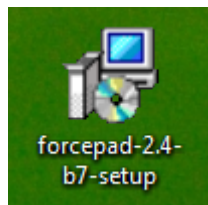


Figure 4 – Icon for the ForcePAD installation package

Follow the instructions to finish the installation. After a successful installation ForcePAD can be started from the start menu by selecting it from the start menu group “Structural Mechanics” and selecting “ForcePAD 2”.

Mac OS X

The Mac OS X installation is similar to the Windows installation, but instead of downloading the setup program directly, the installation package including the manual is provided in disk image format (.dmg).

The downloaded dmg-file is opened by double-clicking on it. The image contains a standard Mac OS X installation package and the ForcePAD manual. Installation is started by double-clicking on the installation package. Follow the instructions and if all has worked there should be a ForcePAD icon in the Application Folder.

ForcePAD main window

ForcePAD uses a task oriented user interface, which means that the user interface adapts to the task at hand. The left toolbar in the main window contains the main task categories. The right toolbar shows the main tasks and their related properties.

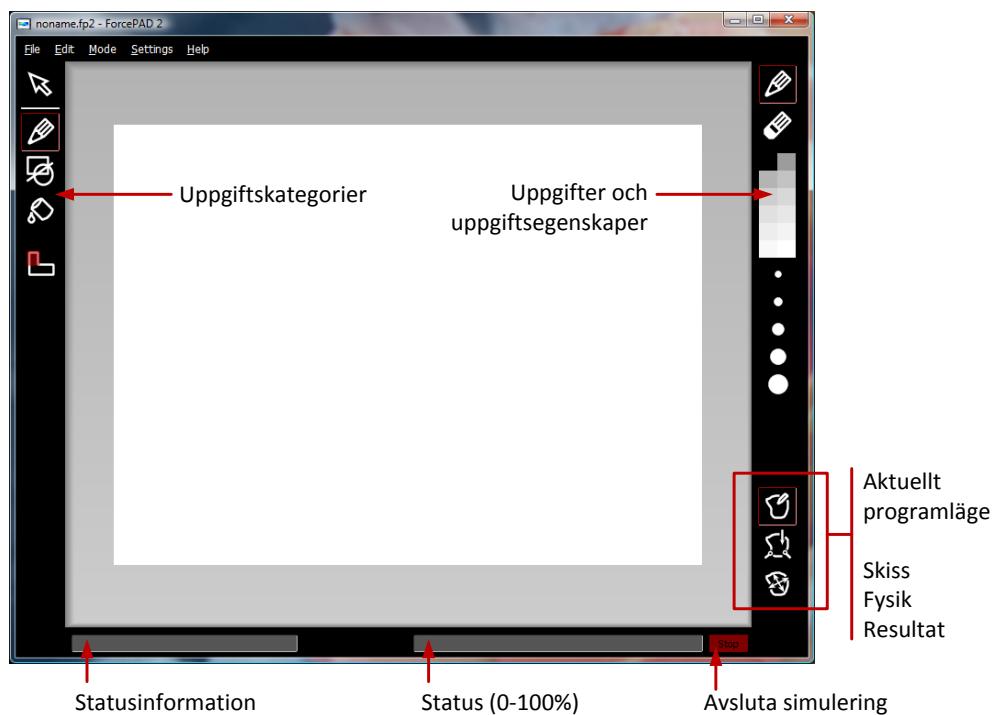


Figure 5 - ForcePADs programfönster

To reduce user interface clutter, ForcePAD operates in three main modes:

- **Sketch mode** - In this mode the analysed structure is defined by sketching using the available drawing tools.
- **Physics mode** - In this mode the physical boundary conditions, such as loads and constraints, for the analysed structure are defined.
- **Result mode** - In this mode the forces and structure deflections can be visualized and analysed.

Switching between the modes is accomplished by using the mode switch buttons located in the lower right corner of the window.

Sketch mode

In sketch mode the analysed structure is created by drawing with stiffness. Black color denotes full stiffness and white color no stiffness. To create structures, paint tools used in normal image editing applications can be used, such as pens with different sizes, lines, rectangles, circles and flood fills. In this section these tools are described detail with examples how they are used.

Drawing with stiffness

The easiest way to create structures is to use the pen tools. To use this tool, select the pen task in the left toolbar (1). When this task category is chosen the available tasks are shown in the right toolbar (2).



Figure 6 – Choice of drawing tools

When the pen task category is chosen for the first time the a pen with 100 % stiffness is preselected in the task toolbar. Drawing is done by moving the cursor over the drawing area holding the left mouse button down. As long as the left mouse button is down the pen will leave a trace with the selected stiffness and pen thickness. Figure 7 illustrates the process of drawing using the pen tool.

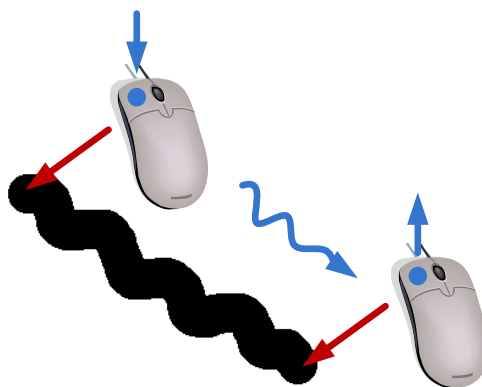


Figure 7 – Using the pen tool

The eraser tool is used in the same way as the pen tool with the difference that it will use 0 % stiffness.

Stiffness can be chosen by clicking on the grayscale buttons in the property toolbar. Black is 100% stiffness white is no stiffness.

Pen thickness is chosen by clicking on the 5 circles in the property toolbar on the right. The size of the circles corresponds roughly to pen size when drawing. Figure 8 – shows the property menu for the drawing tools.



Figure 8 - Drawing tools property toolbar

Filling surfaces and holes

A common operation in image editing application is to fill closed surfaces with colors. In ForcePAD this is done using the floodfill tool. The tool is found in the left toolbar. Figure 9 shows where the flood fill tool is located in ForcePAD.

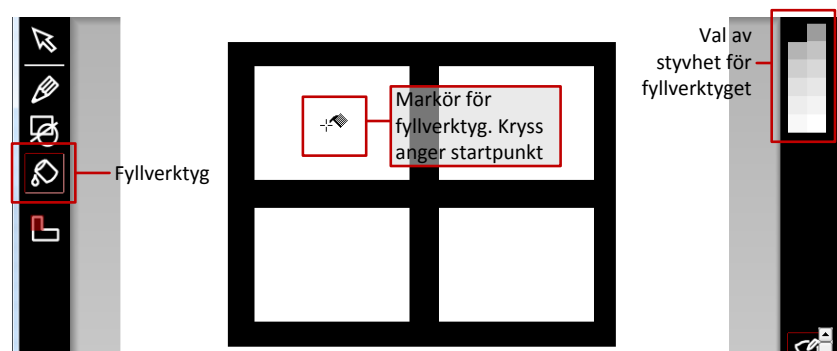


Figure 9 – Flood fill tool

A surface is filled by selecting the stiffness in the property toolbar and then clicking with the left mouse button in the middle of the surface. The cross in the cursor denotes where the flood fill tool will start the fill process. Figure 10 illustrates the use of the fill tool.

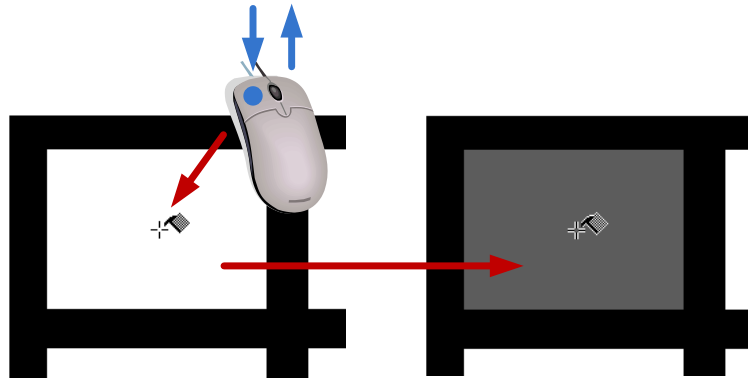


Figure 10 – Using the fill tool

Geometric tools

To draw geometric shapes there is a special task category for this purpose in ForcePAD. Figure 11 shows the tools in this category.

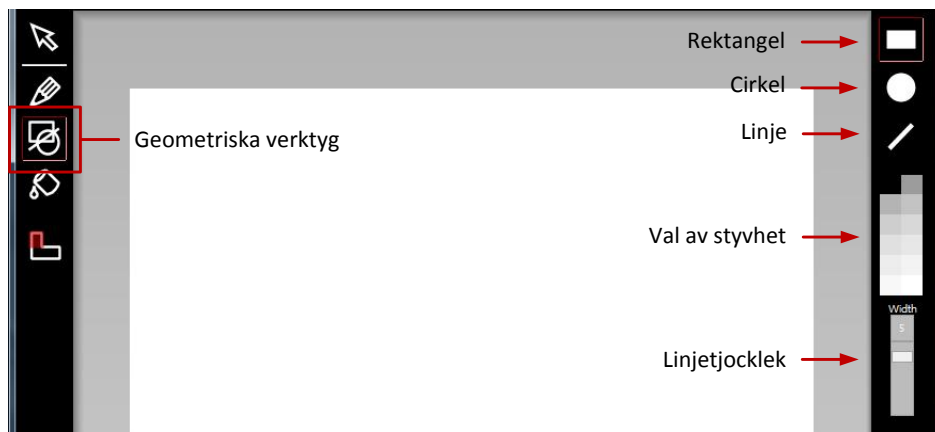


Figure 11 – Geometric tools

Rectangle tool

Rectangles with different stiffness can be created using the rectangle tool. A rectangle is created by selecting the starting point with the left mouse button, moving the mouse with the mouse button down, releasing it at the endpoint of the rectangle. Figure 12 illustrates this process.

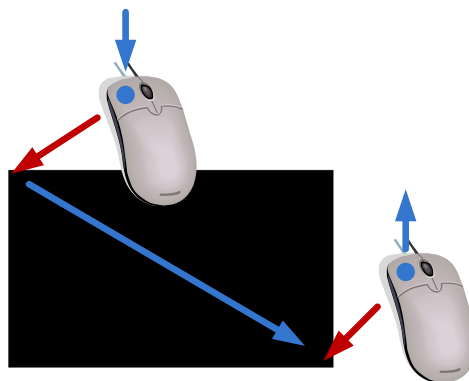


Figure 12 – Creating rectangles with the rectangle tool

Circle tool

Using the circle tool, circles and ellipses can be quickly created. A circle is created by selecting the starting point with the left mouse button, moving the mouse with the mouse button down, releasing it at the endpoint of the circle. Figure 13 illustrates this process.

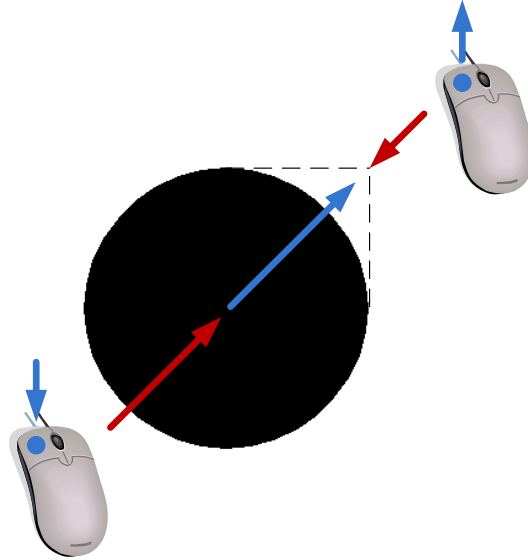


Figure 13 – Creating circles with the circle tool

Line tool

Using the line tool lines with varying thickness can be created. A line is created by selecting the starting point with the left mouse button, moving the mouse with the mouse button down, releasing it at the endpoint of the line. Figure 14 illustrates this concept.

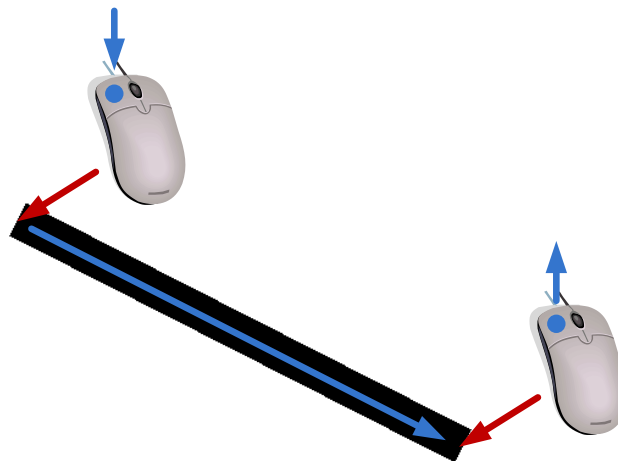


Figure 14 – Creating lines with the line tool

Using the grid

To create more exact drawings, ForcePAD can activate a drawing grid. The grid is activated by selecting **Settings/Snap to Grid** in the menu. The grid can also be activated temporarily by us-

ing the [\uparrow /Shift] key. The grid has the same spacing as the calculation grid. Changing the grid spacing can be done in the calculation settings dialog found in the **Settings/Calculation...** menu.

Cut, Copy and Paste

When editing an image it is often needed to copy or move data in the image. ForcePAD supports a basic clipboard that can be used to accomplish this. To use the clipboard the selection task category must be selected from the right toolbar as shown in Figure 15.

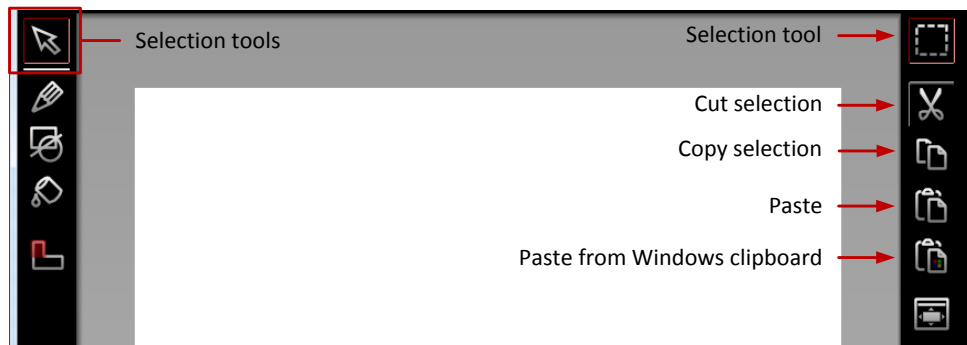


Figure 15 - Selection tools in ForcePAD

To copy or move objects in the image, the selection tool is used to select the object. A selection is placed by clicking on the start point, holding the left mouse button down and moving the mouse to the end point of the selection, finally releasing the button. Figure 16 illustrates this process.

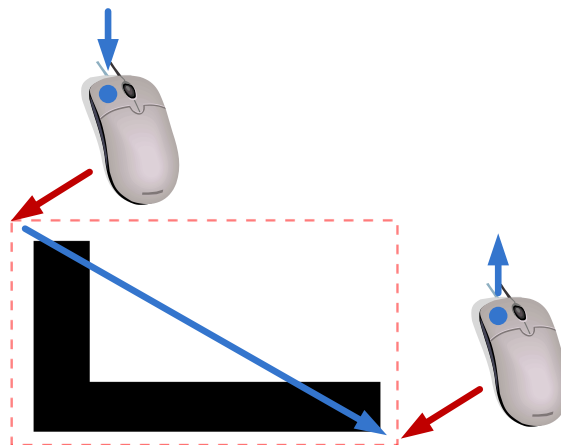


Figure 16 - Creating a selection with the selection tool

When the selection is placed the other tools in this task category can be used.

Copy

The copy tool will copy the pixels in the selection box to the ForcePAD clipboard as shown in Figure 17.

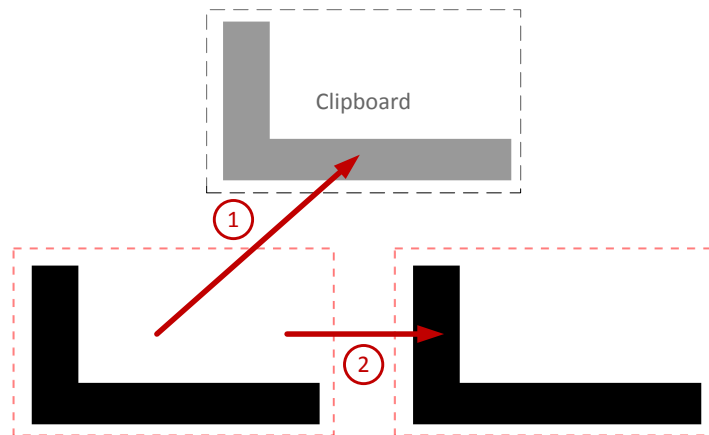


Figure 17 - Copying pixels from selection box to the clipboard

Cut

The cut tool copies the pixels in the selection box to the clipboard while replacing the pixels on the drawing area with white (no stiffness). The process is shown in

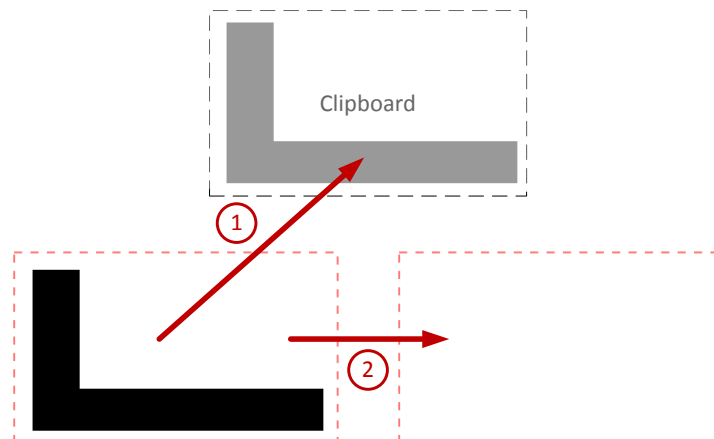


Figure 18 - Using the cut tool to move pixels from the selection box to the clipboard

Paste

Using the paste tool the pixels copied to the clipboard can be pasted back into the image. When the paste tool is selected the copied image in the clipboard appears under the cursor and can be moved over the image. The image is copied to the drawing by clicking on the left mouse button. Multiple copies to the image can be done by repeated clicking on the mouse button.

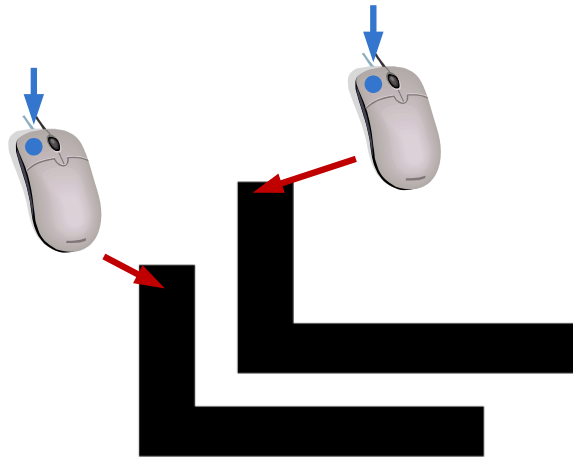


Figure 19 - ForcePAD Paste tool operation

Expanding the drawing surface fit the window

When resizing the ForcePAD window the drawing surface is not automatically resized. To do this, first click on the selection tools button then click on the expand workspace button in the right toolbar, see figure 20



Figure 20 - Expand workspace button

The existing image will be copied to the expanded workspace placed in the lower left corner, as shown in figure 21.

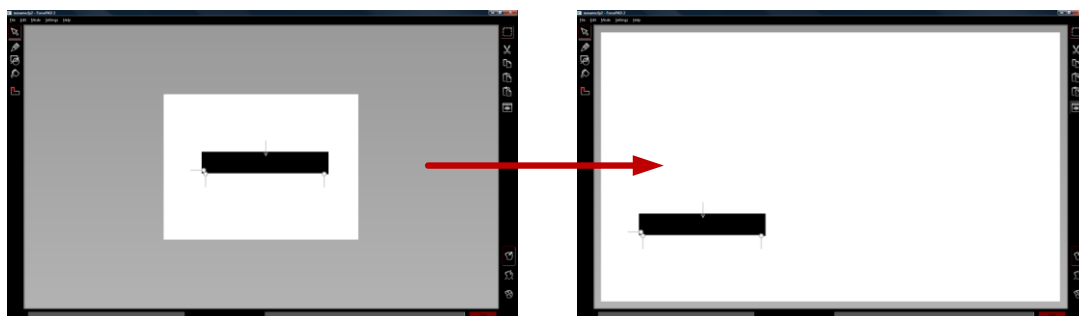


Figure 21 - Expanding the workspace

Physics mode

In physics mode the forces and constraints can be placed on the model. Placement of forces and constraints are a two click process. In principle set the position and rotation.

Creating forces

A force is created by clicking on the position in the structure where it is acting ①. While holding the mouse button down the direction of the force can be changed by moving the mouse around the force application position ②-③. Figure 22 illustrates the process of creating a force.

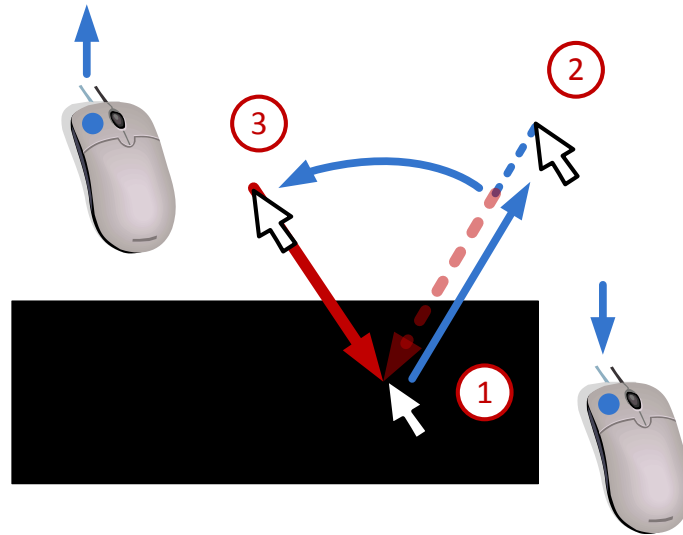


Figure 22 - Creating forces

Creating constraints

A constraint is created by clicking on the position in the structure where it is acting ①. While holding the mouse button down the direction of the constraint can be changed by moving the mouse around the constraint application position ②-③. Figure 23 illustrates the process of creating a constraint.

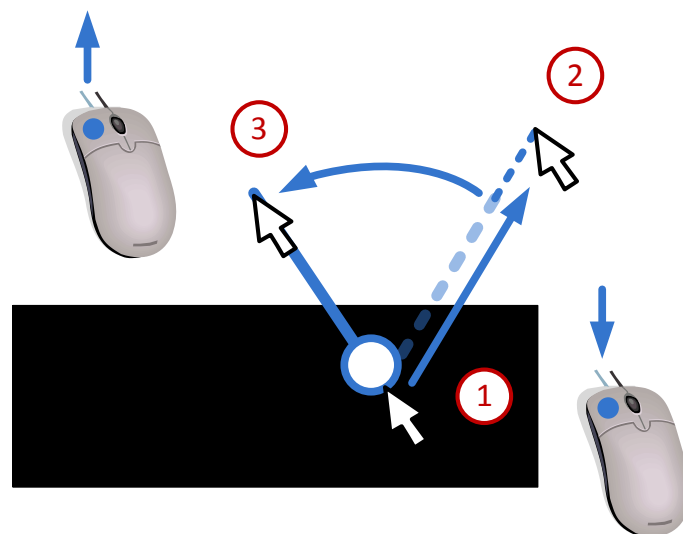


Figure 23 - Creating constraints

Action mode

In action mode the stresses and displacements on the structure can be visualized in various ways. The effect of changing the directions of forces can also be visualized in real-time.

Show principal stresses

Principal stress visualisation is the default visualization when action mode is activated. To access this mode click on the principal task category button on the top left toolbar as shown in figure 24.

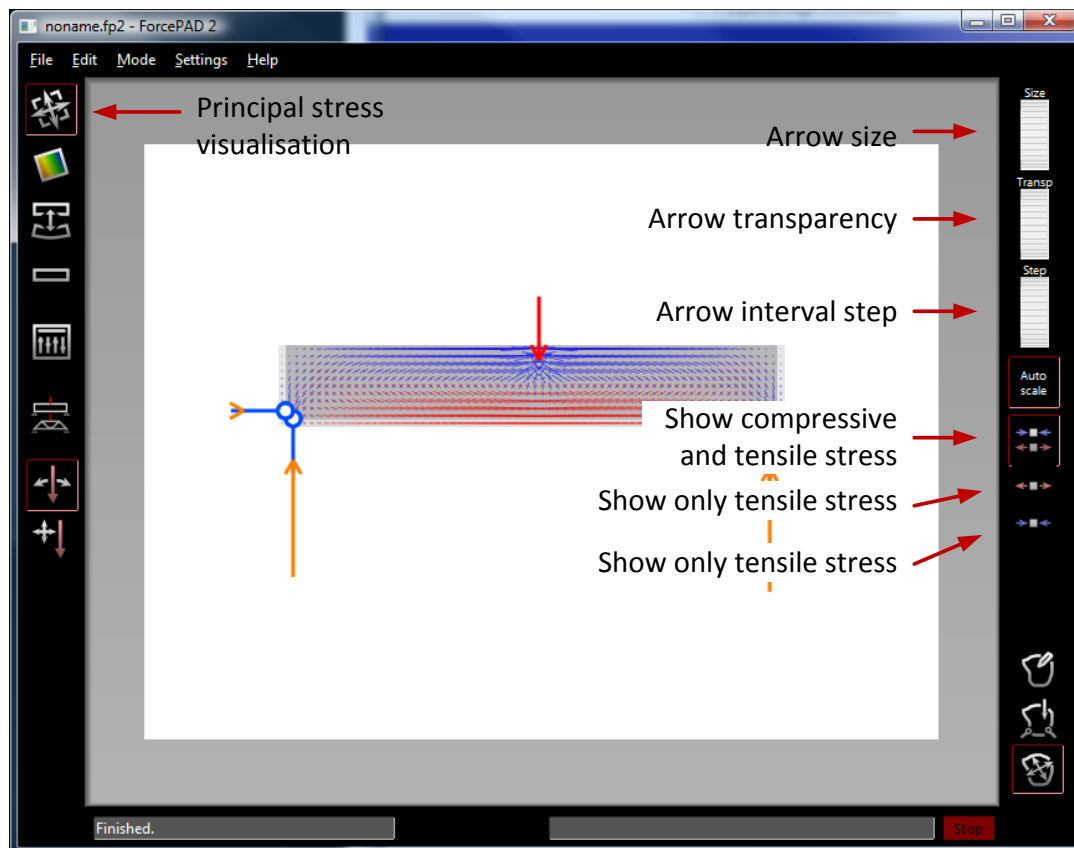


Figure 24 - Principal stress visualisation

Using the tools in the right toolbar the properties of the visualization can be changed in various ways. The **Size** roller controls the size of the stress arrows. The **Transp** roller controls the transparency of the stress arrows. This can be used to reduce the visual effect of the arrows, so that the underlying structure is better shown. The **Step** roller controls how many steps there are between the stress arrows. The default value is 1 step between the arrows. Increasing this value will reduce the number of stress arrows shown in the visualization as shown in figure 25.

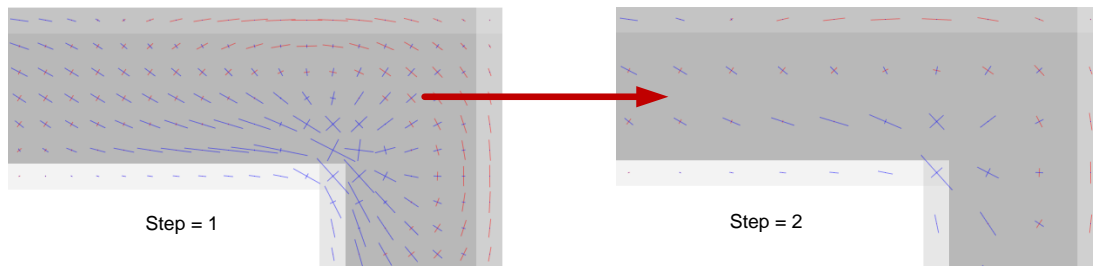






Figure 25 - The effect of different step values

The **AutoScale** button controls how the arrow sizes are calculated. If enabled the size is automatically calculated each time action mode is entered.

The last three buttons in the toolbar controls which stress arrows should be drawn the default is to draw both compressive (blue) and tensile (red) stress arrows .

 Draws only tensile stresses.  Draws only compressive stresses.

Von Mises stress visualisation

To show the von Mises stresses the second button, , in the left toolbar is selected in the left toolbar. This brings up the properties toolbar for this visualization mode in the right toolbar. This toolbar contains 4 controls. The first 2 controls selects which colormap to use when visualising the stress field. The first one, , selects rainbow colormap (default), showing low stresses as blue and high stresses as red. The, , uses “hot” colormap showing low stresses as dark red and high stresses as yellow.

The slider in the toolbar controls which stress level represents the maximum color in the colormap, as described in figure 26.

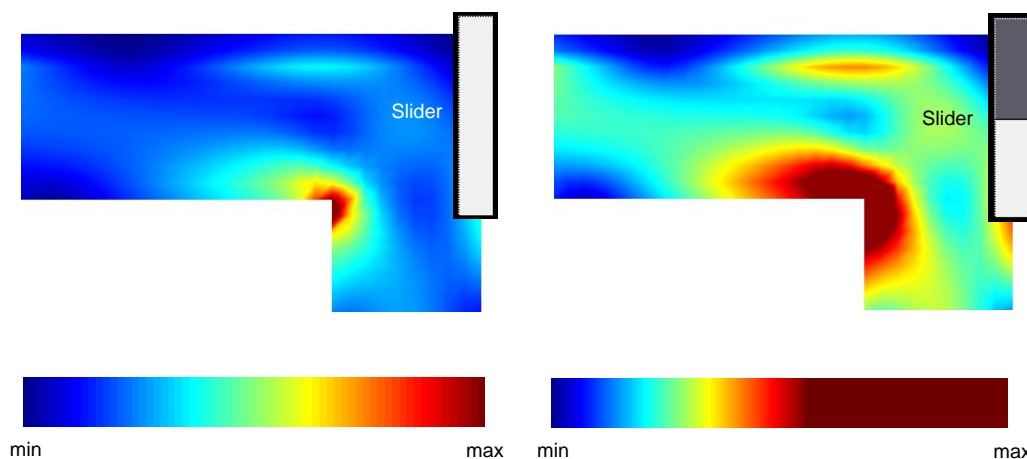



Figure 26 - Comparing the stress colormap


The last control in the toolbar is a checkbox that can be used to invert the selected colormap.

Displacement visualization

Structure displacements can be visualized by selecting, , in the left toolbar. This also updates the right toolbar showing a slider for scaling the displacements.

Updating force direction and position

Forces shown in action mode can be rotated and moved in action mode. This will automatically update any visualization mode in real-time. When action mode is entered for the first time the

ForcePAD is set to update force directions, . In this mode Forces can be rotated by clicking on the force tip and moving the mouse while holding the left mouse button pressed. The effect is shown in figure 27.

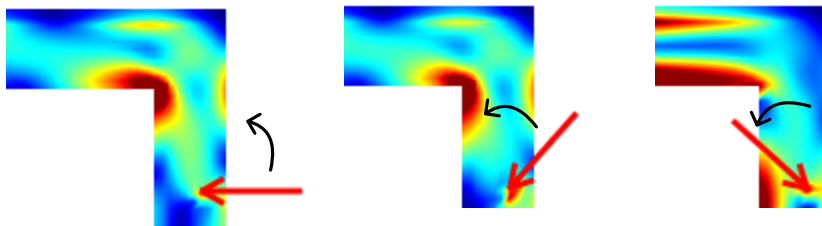



Figure 27 - Rotating forces

To move the force position select the force movement mode, , in the left toolbar. The force can now be moved by clicking on the force tip and moving the mouse while holding the left mouse button pressed. The effect is shown in figure 28.

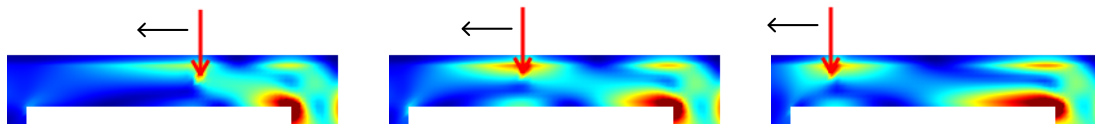



Figure 28 - Moving forces

Magnifying results

To be able to examine the visualizations in more detail ForcePAD provides a special zoom mode

to magnify the view. The mode is activated by pressing the magnifying button, , in the left toolbar. The immediate effect of pressing the button is that the current view is magnified. The magnifying factor can be changed by using the scroll wheel or using the **[Page Up]** or **[Page Down]** buttons.

The view can be moved by dragging the mouse in the view as shown in figure 29.

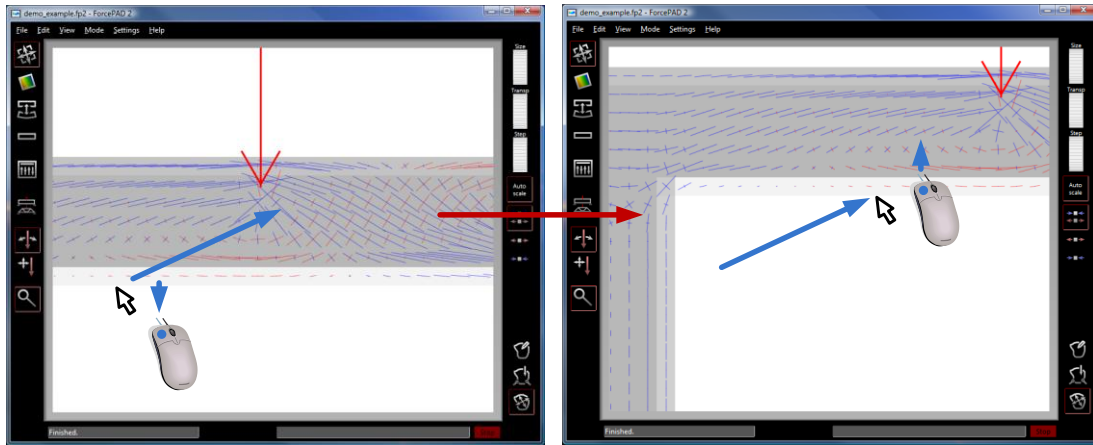


Figure 29 - Dragging the view in magnifying mode

Calculation settings


Calculation settings can be changed using the **Calculation Settings** dialog. This dialog can be opened by selecting the **Settings/Calculation...** in the menu. There are three tabs in this dialog. The first, **Mesh**, controls the resolution of the calculation grid used. The second, **General**, controls general constants used by the finite element solver. The last tab, **Constraints**, controls options governing the constraints used in the model.

The grid step setting in the **Mesh** tab is the most important calculation setting in ForcePAD. The grid step defines the size of the grid elements used in the calculations. A value of 4 will average a 4x4 pixel square for each calculation element. A low grid step value will increase the calculation times, but will produce much nicer visualizations in Action Mode. A high grid step value will reduce the calculation time, but will produce more coarse visualizations.

Most of the settings in the last two tabs requires knowledge of finite element modeling and the default values should suffice for the most models used in ForcePAD.

Structural Optimisation

As of version 2.4 ForcePAD contains a topology optimizer. The optimizer can be invoked from

action mode by clicking on the optimize button, . This will show a special dialog which controls the initial parameters for the optimization algorithm. Please see relevant literature for a more thorough description of these. When the parameters are set the optimization algorithm is started by clicking on the **Ok** button in the dialog. The algorithm will run until the optimisation criteria is fulfilled or the **Stop** button in the lower right of the window is pressed. Figure 30 shows the optimization algorithm at work.

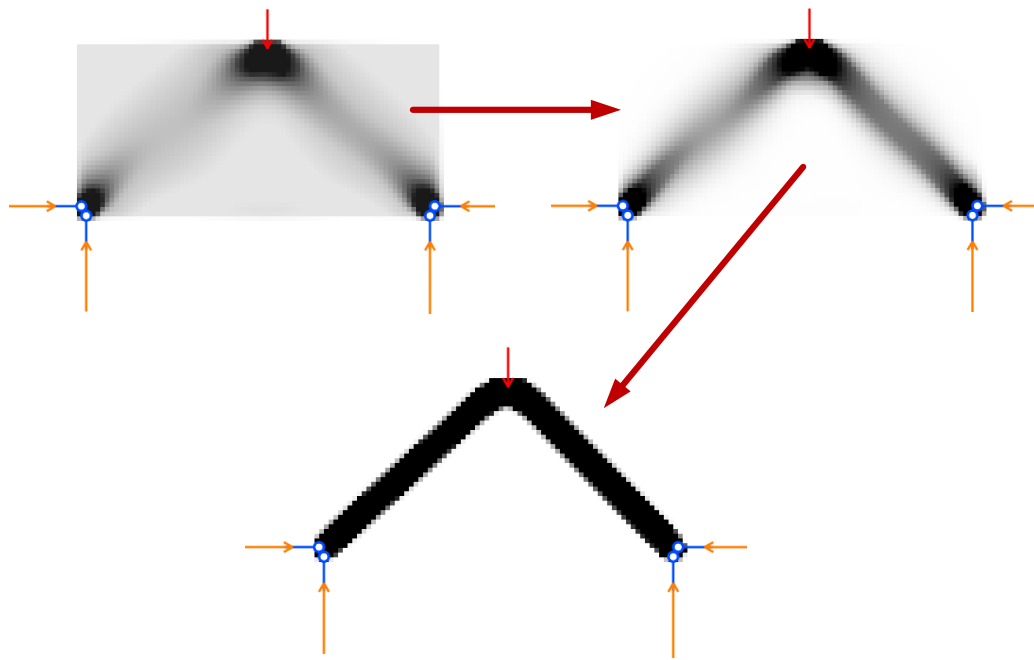




Figure 30 - Optimisation in ForcePAD

Using the optimization result in sketch mode

When the optimized shape has been found from the initial sketch the result can be transferred back to sketch mode. This is accomplished in action mode by first selecting the structure button, . This will show the optimized structure without any constraints or results. To transfer the structure to sketch mode click the transfer structure button, , in the top right toolbar. Please note that any existing structure in sketch mode will be replaced by the optimized structure.

Creating a new model

To create a new model in ForcePAD select **File/New** from the menu. This will bring up a new model dialog.

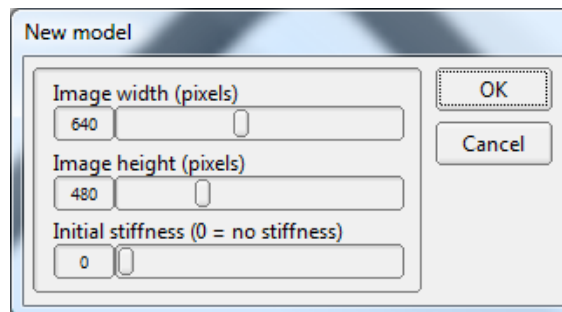


Figure 31 - New model dialog

From this dialog the image size of the new model can be set by using the sliders. An initial stiffness can also be provided. The new model is created by clicking on the **OK** button. The creation of a new model can be cancelled by clicking on the **Cancel** button.

Saving and loading models

Created models in ForcePAD can be loaded and saved using the **File/Open**, **File/Save** and **File/Save as...** menus. These menu options will show standard file dialogs for opening and saving ForcePAD models.

The default extension of a ForcePAD model is *.fp2.