uFlow v0.1 Documentation

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ABOUT

uFlow is a graphical tool for the rational design of inertial microfluidic

devices that utilize pillar geometries to deform the laminar flow field.

uFlow assembles pre-computed advection maps to enable fast, real-time feedback

of flow deformation without requiring an online Navier-Stokes solver. Find

out more about the inner workings of the program in an upcoming publication.

uFlow is provided as-is without guarantee of stable operation or accuracy

of results. Please bear in mind that uFlow is beta software; as such,

it is expected to contain show-stopping bugs. We have, to the best of our

ability, tested the program on a range of hardware and determined it to be

usably stable and accurate for a limited set of use-cases. If you have

questions about the accuracy of the program output, or find an error in

the program's operation, or wish to speak with us for any other reason,

please feel free to contact us as detailed in the CONTACT section of this

document.

Simulation results provided by the Yu Xie and Baskar Ganapathysubramanian

of Iowa State University.

DOWNLOAD

The latest release version of uFlow can be downloaded from:

http://biomicrofluidics.com/software.php

If you obtained this software from a different source, we cannot guarantee

the safety of the program's execution. Please be sure that you have

downloaded the software from a trustworthy source.

INSTALLATION

Presently, the software is shipped in a self-contained ZIP or TAR.GZ archive

depending on your platform. Once this archive is extracted, no further

installation steps are required. However, some platforms require further

dependencies to be installed to ensure full range of software functionality.

Please find your platform in the list below.

WINDOWS

The Windows binary includes all required and optional dependencies. To

run the program, simply double-click the uFlow.exe executable in the

extracted folder.

LINUX/UNIX

Most linux distributions will include the necessary python interpreter.

You will need to use your distribution-specific method of installing the

relevant python libraries; beyond the standard ones, you'll need pyglet,

Tkinter (optional) and PIL (optional). On Ubuntu and its derivatives,

these may be installed from the command line as follows:

sudo apt-get install python-pyglet python-imaging python-tk

You may also consider using python's library installation if you do not

have administrator priveleges:

pip install PIL

pip install pyglet

You will need to make sure that libjpeg, libz, and libfreetype are

available on your system.

Once the relevant dependencies have been installed, you can run the

software by executing the uflow.py script from the unzipped directory.

Please ensure that the working directory matches the location of the

uflow.py script; this is required to allow the software to locate the

data used to compute the transformations.

cd uFlow/

python uflow.py

USAGE NOTES

Upon first run of the software, you will be greeted with a device consisting

of a single empty channel and three parallel inlet flows, represented with

three colored dyes. The screen is divided into three parts. From left to

right, they are: (1) the tool pane, (2) the device pane, and (3) the output

visualization pane.

THE TOOL PANE

At the top of the tool pane, the user may adjust the inlet flow conditions.

This is done by sliding the triangular handles marking the boundaries

between fluid streams. To add a new handle, double-click somewhere within

the fluid stream. To remove a handle, drag a handle all the way to the

left or right edge of the fluid stream. To change the color of a fluid

stream, right-click that stream to bring up the color palette, and select

a color from the options presented. Note that adjustments to the inlet

flow conditions are reflected instantaneously at the output and at all

points in the flow. Click on any stream to highlight it in the device

schematic.

In the middle of the tool pane are controls for adjusting the parameters of

the currently-selected pillar in the schematic. To use these controls,

click on an already-placed pillar in the schematic and drag the handles.

Note that the controls snap to a number of discrete points rather than

having continuous operation; this is because the results have been pre-

computed and cached for a finite number of pillar geometries and

locations. In some cases, some tick marks will be inaccessible; this is

because there is no data store for that particular geometry configuration.

At the bottom of the tool pane are buttons for standard operation of the

software. uFlow supports unlimited UNDO and REDO. These commands may also

be accessed using the Ctrl+Z and Ctrl+Y hotkeys, respectively. The NEW,

SAVE, and LOAD buttons can be used to store devices in the software's

native format. This allows the devices to be reloaded at a later date for

further work. This functionality is also bound to the Ctrl+N, Ctrl+S, and

Ctrl+O hotkeys, respectively. The EXPORT DXF option exports a version of

the device suitable for interoperability with other computer-aided design

programs, such as AutoCAD, as well as vector graphics programs such as

Illustrator.

For certain low-resolution environments, it may be useful to hide the tool

pane to devote more screen space to the device pane. To do this, press the

V key on your keyboard. This will toggle the tool pane to the side. To

restore the tool pane, press the V key again.

THE DEVICE PANE

In the center pane, the user can interact with a schematic representation

of the device. Note that the spacing between pillars in this pane is not

accurate; it has been reduced to enable easier user interaction. To view

an accurate physical description of the device, it is recommended to export

a DXF and view the device in your tool of choice.

In this pane, green cubes represent candidate pillar positions for pillars

of the currently-selected diameter. To place a pillar, position the mouse

cursor over a candidate pillar position, and press the left mouse button.

Once a pillar has been placed, the software automatically shifts the view

downstream of the placed pillar, to facilitate placement of additional

pillars. The user may adjust an already-placed pillar by positioning the

mouse cursor over that pillar, and clicking on it. This selects the pillar

for adjustment. That pillar may now be adjusted using the sliders in the

tool pane, or by left click-dragging the pillar into a new position. The

user may also change the current selection using the LEFT and RIGHT arrow

keys on his or her keyboard. The UP and DOWN arrows can be used to change

the current pillar diameter.

To remove a pillar, select the pillar and press the DELETE button on your

keyboard.

To zoom in on the device, use the mouse scroll wheel. Right-click drag to

orbit the current view about the device. Left-click drag to pan around the

device. Use the C hotkey to toggle between the standard view and a top-

down orthographic view of the device.

At each boundary between pillars, a representation of the fluid cross-

section appears. This representation indicates the deformed flow field

that would be observed if a cross-section were taken following the

previous pillar.

THE OUTPUT PREVIEW PANE

At the top of the rightmost pane of the screen is the realtime output

preview. This is a low-resolution preview of the transformation at the

location beneath the mouse cursor. Note that this is simply an

interpolation of the transformation occuring at each boundary, and does

NOT represent the actual fluid cross-section at the mouse position.

Instead, it is intended as a visual tool for understanding the steps in

the fluid transformation. The actual fluid dynamics are more complex and

are not captured in this preview.

Second, in the output preview pane is a high-resolution view of the fluid

cross-section at end of the device, after all pillars have contributed

their transformation. The user may click this preview to compute a very

high-resolution version of the result. If PIL is present on the system,

a SAVE button will appear below the high-resolution result, allowing the

user to save a PNG of this image. Note that a number of numerical issues

at the boundaries of the simulations result in visual artifacts in the

computed flow field. These are non-physical and unfortunately unavoidable

at present. We are investigating methods for mitigating these artifacts.

In the preview versions of the software, a debug window appears at the

bottom of the output preview pane. This window contains information on the

state of the program, and can be useful for spotting bugs. For more

information, please see the TROUBLESHOOTING portion of this document.

TROUBLESHOOTING

VISUAL ARTIFACTS, NO OUTPUT, AND/OR OPENGL 1286 ERROR

uFlow requires a modern OpenGL implementation with floating-point

framebuffer support, in order to perform fast computation with the GPU.

This feature is supported by the majority of graphics cards manufactured

since 2004. However, some Windows installations do not ship with the

drivers necessary to expose this functionality. Please ensure that you have

complete, up-to-date drivers installed for the graphics hardware in your

computer, available from the manufacturer's website.

In certain integrated graphics hardware found in laptops, this

functionality is (unfortunately) not available. If your graphics drivers

are up-to-date and you still receive this error, it is possible that you

have one of these chipsets. In our experience, some hardware drivers will

support the relevant functionality in one OS but not another (in

particular, OpenGL support on Intel chipsets appears to be better on

linux than on Windows). Unfortunately, there is nothing we can do to fix

this issue, and we recommend switching to another computer or installing a

new graphics card.

If you find any bugs, or if your question is not answered here, please do

not hesitate to contact us using the information described in the CONTACT

section of this document.

CONTACT

For general information about the software, please see:

http://biomicrofluidics.com/software.php

If you wish to contact the author with questions, comments, bug reports, or

for any other purpose, please do so at the following address:

stoeckd AT ucla DOT edu

This software is being developed as part of an ongoing research effort by

the Di Carlo lab at UCLA. For more information about the lab and our other

work, please see our website, at:

http://biomicrofluidics.com