



HELP SESSION

IMPRESSIONIST

OUTLINE

- ▶ OpenGL
- ▶ Qt
 - ▶ Debugging Hints
- ▶ Skeleton Code
- ▶ Project requirements
 - ▶ Brushes
 - ▶ Alpha Blending
 - ▶ Filter Kernel
 - ▶ Mean Bilateral Filter
- ▶ Git Tutorial



OPENGL

- ▶ Good(ish) environment for PC 2d/3d graphics applications
- ▶ Extremely well documented... well not really!
 - ▶ Lots of beginner tutorials online (like learnopengl.com)
 - ▶ www.khronos.org/opengl/wiki/
 - ▶ Keys to understanding how OpenGL works
 - ▶ But sometimes has unfinished pages
- ▶ We will be using it throughout the quarter
- ▶ This project uses the basics of OpenGL
 - ▶ Although you're welcome to learn more on your own (and we encourage this), the focus of this project is on 2d image manipulation

HOW OPENGL WORKS

- ▶ OpenGL draws primitives - lines, vertices, or polygons - subject to many selectable modes
- ▶ It can be modeled as a state machine
 - ▶ Once a mode is set, it stays there until turned off
- ▶ It is procedural - commands are executed in the order they are specified

DRAWING A POLYGON

```
// Let's draw a filled triangle!  
// first, set your color  
glm::vec4 color;  
color.r = red;  
color.g = green;  
color.b = blue;  
// set the vertices  
std::vector<GLfloat> vertex = {  
    Ax, Ay,  
    Bx, By,  
    Cx, Cy  
};  
// send the vertex data to the GPU buffer  
glBufferData(GL_ARRAY_BUFFER, sizeof(float)*vertex.size(),  
    vertex.data(), GL_STREAM_DRAW);  
// Draw polygon  
glDrawArrays(GL_TRIANGLES, 0, 3);
```

DRAWING A POLYGON

- ▶ A lot going on behind the scenes
- ▶ There is a lot of prep code needed to draw
 - ▶ We need to create a vertex array object that records all the state needed to draw a brush, bound every time we draw
 - ▶ We need to create a vertex buffer object to hold the vertex positions and specify the format of the vertex data(`GL_LINES`, `GL_TRIANGLES`, `GL_QUADS`, ... and many more!)
 - ▶ We need to create a shader program (we did this for you)

GETTING STARTED

- ▶ Clone the Impressionist skeleton code
 - ▶ `git clone git@gitlab.cs.washington.edu:cse457-20sp-impressionist/YOUR_REPO.git impressionist`
- ▶ Install Qt Creator
 - ▶ www.qt.io/download > Downloads for open source users
 - ▶ On Windows, first install the MSVC C++ compiler
 - ▶ Installing Visual Studio (not Visual Studio Code) with C++ support enabled will do this
- ▶ In Qt Creator, “Open Existing Project” and open Impressionist.pro

QT

- ▶ Enables developers to develop applications with intuitive user interfaces for multiple targets, faster than from scratch
 - ▶ It's a cross-platform GUI toolkit
 - ▶ We needed a windowing toolkit to handle window/rendering context creation for OpenGL since we don't want to do that ourselves
 - ▶ FLTK (what we used to use) is lightweight, but has sparse features that don't play as well with nicer, newer hardware
- ▶ Event-Driven (via callbacks as slot and signal pairings)
- ▶ QtCreator IDE - installed with Qt
- ▶ mainwindow.cpp has several widget examples

The image shows the Qt IDE interface with several key components and annotations:

- Projects Panel:** Shows the project structure for 'Impressionist [master]'. The 'src' folder is expanded, showing subfolders like 'brushes', 'filters', and 'forms'. The 'main.cpp' file is highlighted.
- Editor:** Displays the source code of 'main.cpp'. The 'Currently open files dropdown' is visible at the top of the editor window.
- Debugger:** Located at the bottom, it includes a toolbar with icons for 'Continue', 'Step Over', 'Step Into', and 'Step Out'. The main area shows a table for the call stack.
- Variable Inspector:** Located on the right side, it shows a table with columns for 'Name', 'Value', and 'Type'.

Annotations in red text point to specific features:

- Open Edit view:** Points to the 'Edit' icon in the left sidebar.
- Open Debug view:** Points to the 'Debug' icon in the left sidebar.
- Switch between Debug and Release build:** Points to the 'Debug' icon in the bottom toolbar.
- Build and Run:** Points to the 'Run' icon in the bottom toolbar.
- Build and Run with Debugger:** Points to the 'Run with Debugger' icon in the bottom toolbar.
- Add breakpoints in gutter:** Points to the gutter area in the editor.
- Step Over, Step Into, Step Out, Stop, Continue:** Points to the corresponding icons in the debugger toolbar.

```
1 1 //*****  
10  
11 #include "mainwindow.h"  
12 #include <QApplication>  
13  
14 int main(int argc, char *argv[]) {  
15     // Represents the format of a renderable surface  
16     // NOTE: If not set as default, Mac renders as black screen  
17     QSurfaceFormat glFormat;  
18     glFormat.setRenderableType( QSurfaceFormat::OpenGL );  
19     glFormat.setMajorVersion( 4 );  
20     glFormat.setMinorVersion( 1 );  
21     glFormat.setProfile( QSurfaceFormat::CoreProfile ); // Functionality deprecated in OpenGL 3.0 is not available.  
22     glFormat.setSwapBehavior( QSurfaceFormat::DoubleBuffer );  
23     // glFormat.setStencilBufferSize( 8 );  
24     // glFormat.setSamples(4);  
25     QSurfaceFormat::setDefaultFormat(glFormat);  
26     QCoreApplication::setAttribute(Qt::AA_ShareOpenGLContexts);  
27  
28     // High DPI Support  
29     // qputenv("QT_AUTO_SCREEN_SCALE_FACTOR", "1");  
30     QCoreApplication::setAttribute(Qt::AA_EnableHighDpiScaling);  
31  
32     QApplication a(argc, argv);  
33     MainWindow w;  
34     w.show();  
35  
36     return a.exec();  
37 }  
38
```
































Name	Value	Type
------	-------	------

Level	Function	File	Line	Number	Function	File	Line	Address	Condition	Ign
-------	----------	------	------	--------	----------	------	------	---------	-----------	-----

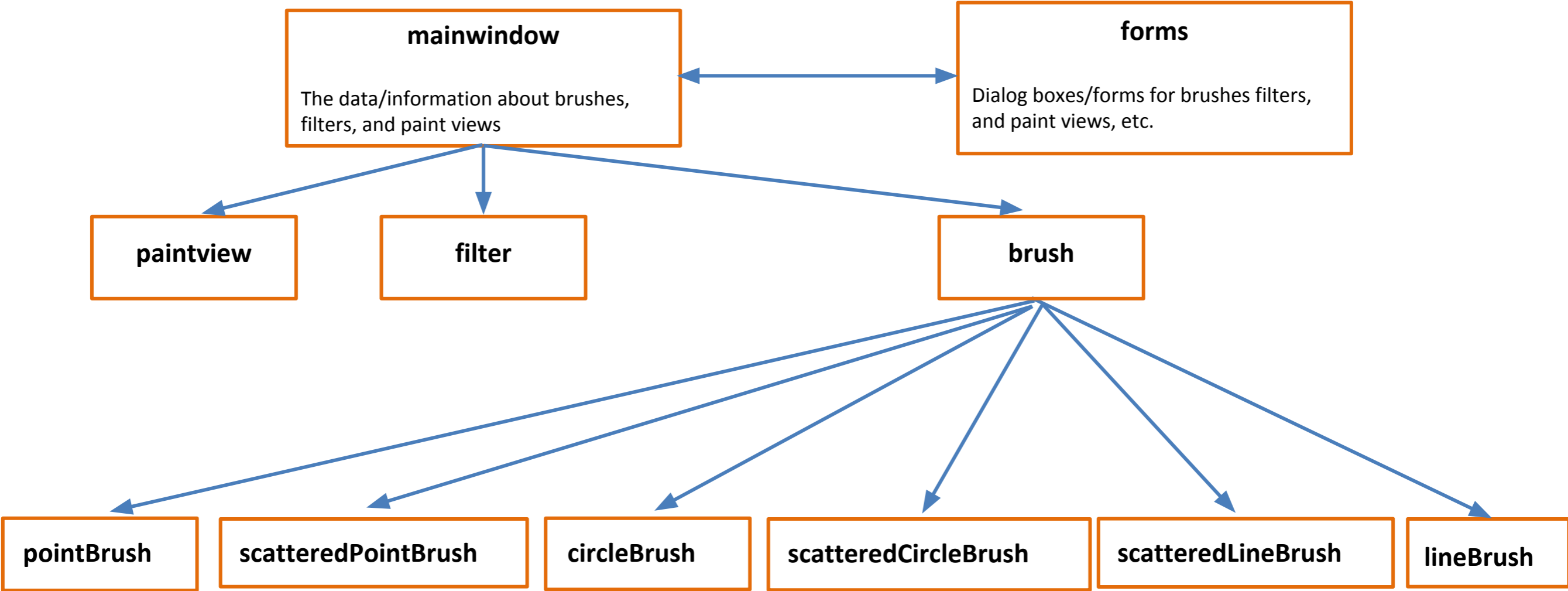
DEBUGGING

- ▶ Debugging in Qt
 - ▶ Use Qt's built-in debugger (works just like VS, Eclipse, or just about any IDE you've used).
 - ▶ Print out debugging info
 - ▶ `#include <QDebug>`
 - ▶ Use `QDebug()` when you want to display information
 - ▶ `QDebug() << "debugging info: " << debugInfo;`
 - ▶ Rebuild the project
 - ▶ Clean → Make → Build the Project
- ▶ Debugging OpenGL
 - ▶ It might help to check for errors after each call. When it seems like nothing is happening, OpenGL is often returning an error message somewhere along the line.
 - ▶ `#include <glinclude.h>`
 - ▶ Use `GLCheckError()`;

SKELETON CODE

- ▼  **Impressionist [master]**
 -  Impressionist.pro
 - ▶  glew-2.0.0
 - ▼  Impressionist
 -  Impressionist.pro
 - ▶  color_widgets
 - ▶  Headers
 - ▼  Sources
 - ▼  src
 - ▼  brushes
 -  brush.cpp
 -  circlebrush.cpp
 -  linebrush.cpp
 -  linesegmentbrush.cpp
 -  pointbrush.cpp
 -  scatterbrush.cpp
 - ▼  filters
 -  filter.cpp
 - ▼  forms
 -  bilateralgaussdialog.cpp
 -  bilateralmeandialog.cpp
 -  brushdialog.cpp
 -  filterkerneldialog.cpp
 -  glerror.cpp
 -  layer.cpp
 -  main.cpp
 -  mainwindow.cpp
 -  mousetracker.cpp
 -  paintview.cpp
 -  qlabeledslider.cpp
 - ▶  Forms

SKELETON CODE



FILES

- ▶ **mainwindow. [h | cpp]**
 - ▶ Handles all of the document related items like loading and saving, selecting brushes, and applying filters
- ▶ **forms/**
 - ▶ Various UI components (the main window, brush & kernel dialog boxes, etc...)
- ▶ **paintview. [h | cpp]**
 - ▶ Handles the original image side of the window (left side) and the drawing side of the window the user paints on (right side)
- ▶ **brush. [h | cpp]**
 - ▶ The virtual class all brushes are derived from
- ▶ **pointbrush. [h | cpp]**
 - ▶ An example brush that draws points



REQUIREMENTS

BRUSHES

- ▶ Let's make a triangle brush! (this will of course NOT count towards extra credit)
- ▶ Make a copy of `pointbrush.[h|cpp]` and rename to `trianglebrush.[h|cpp]`
 - ▶ Right-click `pointbrush.h/cpp` -> Duplicate File...
 - ▶ Right-click `pointbrush_copy.[h|cpp]` -> Rename...
 - ▶ Rename to "`trianglebrush.[h|cpp]`"
 - ▶ They should show up as part of the impressionist project
- ▶ Go through the `trianglebrush.[h|cpp]` code and change all `pointbrush` labels to `trianglebrush` labels

BRUSHES, CONT'D

- ▶ Go to `brush.h` and add `Triangle` to the `Brushes` enum class
- ▶ Open `forms/brushdialog.cpp`, add `"brushes/trianglebrush.h"` to the includes. Scroll down a bit, and add the triangle brush to the selectable brushes.

BRUSHES, CONT'D

- ▶ Modify the `BrushMove` method to draw a triangle instead of a point in `trianglebrush.cpp`

```
int size = GetSize();
std::vector<GLfloat> vertex = {
    pos.x - (size * 0.5f), pos.y + (size * 0.5f),
    pos.x + (size * 0.5f), pos.y + (size * 0.5f),
    pos.x, pos.y - (size * 0.5f)
};

glBufferData(GL_ARRAY_BUFFER, sizeof(float)*vertex.size(),
             vertex.data(), GL_STREAM_DRAW);

glDrawArrays(GL_TRIANGLES, 0, 3);
```

EDGE DETECTION & GRADIENTS

- ▶ The gradient is a vector that points in the direction of maximum increase of f

$$\nabla f = \frac{\partial f}{\partial x} \hat{x} + \frac{\partial f}{\partial y} \hat{y}$$

$$\theta = \text{atan2} \left(\frac{\partial f}{\partial y}, \frac{\partial f}{\partial x} \right)$$

- ▶ Use the sobel operator

ALPHA BLENDING

▶ A weighted average of two colors: $F_{new} = \alpha C + (1 - \alpha)F_{old}$

▶ Suppose $\alpha = 0.5$ $C = \begin{bmatrix} 255 \\ 255 \\ 255 \end{bmatrix}$ $F_{old} = \begin{bmatrix} 255 \\ 0 \\ 0 \\ 128 \end{bmatrix}$

▶ Then

$$F_{new} = ?$$

ALPHA BLENDING

- ▶ A weighted average of two colors: $F_{new} = \alpha C + (1 - \alpha)F_{old}$

- ▶ Suppose $\alpha = 0.5$ $C = \begin{bmatrix} 255 \\ 255 \\ 255 \\ 255 \end{bmatrix}$ $F_{old} = \begin{bmatrix} 255 \\ 0 \\ 0 \\ 128 \end{bmatrix}$
- ▶ Then

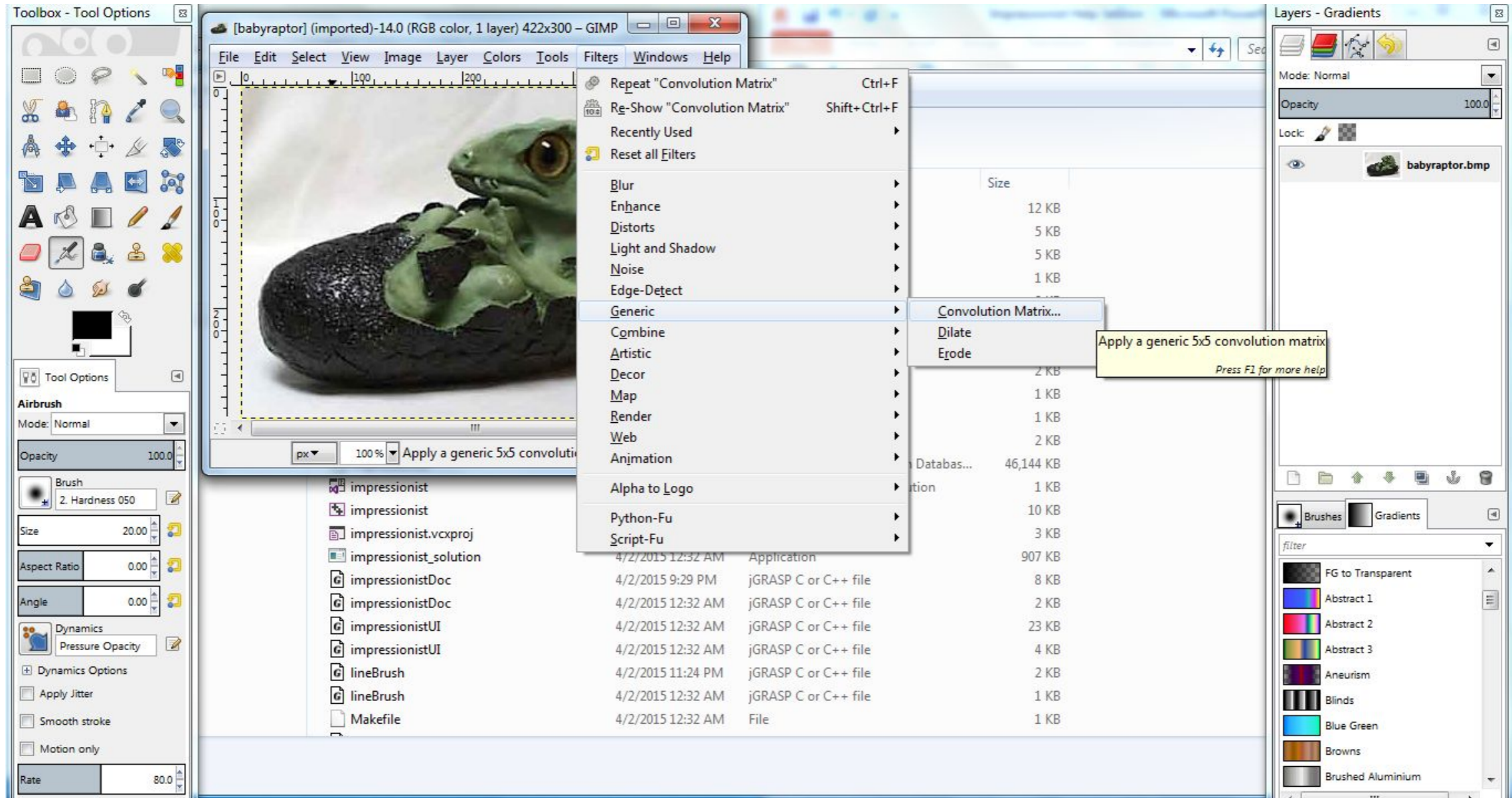
$$F_{new} = 0.5 \begin{bmatrix} 255 \\ 255 \\ 255 \\ 255 \end{bmatrix} + (1 - 0.5) \begin{bmatrix} 255 \\ 0 \\ 0 \\ 128 \end{bmatrix} = \begin{bmatrix} 128 \\ 128 \\ 128 \\ 128 \end{bmatrix} + \begin{bmatrix} 128 \\ 0 \\ 0 \\ 64 \end{bmatrix} = \begin{bmatrix} 255 \\ 128 \\ 128 \\ 192 \end{bmatrix}$$

FILTERS

- ▶ Remember how filter kernels are applied to an image
 - ▶ Look at the sample solution. How does it apply a filter?
 - ▶ What could go wrong?
 - ▶ What cases do you need to handle?
- ▶ We will be looking closely at your filter kernel

REQUIREMENTS

USE GIMP/PHOTOSHOP TO SEE FILTERS IN ACTION



REQUIREMENTS

3X3 MEAN BOX FILTER

The screenshot displays the GIMP interface with the following components:

- Toolbox - Tool Options:** Shows the Airbrush tool selected. The mode is set to Normal, and the brush is '2. Hardness 050' with a size of 20.00.
- Image Windows:** Two windows are open, both showing the same image of a baby raptor. The top window is titled '[babyraptor] (imported)-2.0 (RGB color, 1 layer) 422x3...' and the bottom window is '[babyraptor] (imported)-3.0 (RGB color, 1 layer) 422x...'. Both are at 100% zoom.
- Convolution Matrix:** A dialog box is open showing a 3x3 matrix of ones, indicating a mean filter. The matrix is:

0	0	0	0	0
0	1	1	1	0
0	1	1	1	0
0	1	1	1	0
0	0	0	0	0

The divisor is set to 9, and the offset is 0. The 'Preview' checkbox is checked, and the 'Normalise' checkbox is also checked.
- Layers - Brushes:** Shows the current brush settings for '2. Hardness 050 (51 x 51)'.



ARTIFACTS

EVERY PROJECT HAS AN ARTIFACT

- ▶ Individual (except for final project)
- ▶ Due after the project
- ▶ Showcase the tool you built
 - ▶ A good place to demonstrate any bells and whistles you implemented
- ▶ In-class voting to determine the best
 - ▶ Winner gets extra credit!





GIT TUTORIAL

RESOURCES

- ▶ Basics for this course:
 - ▶ <https://courses.cs.washington.edu/courses/cse457/17au/src/help.php>
- ▶ Official documentation:
 - ▶ <https://git-scm.com/book/en/v2>
 - ▶ `git -help <command>`

WORKFLOW

▶ Starting

- ▶ Navigate to the directory you want to work in and run

```
$ git clone
```

```
git@gitlab.cs.washington.edu:cse457-17au-impressionist/YOUR_REPO.git impressionist
```

- ▶ This clones your repository into a working directory named "impressionist"

▶ Working

- ▶ You will want to periodically check your code in, either to avoid disaster or to rollback broken code to an earlier working version. Run:

```
$ git add -all
```

```
$ git commit -m "added a triangle brush"
```

```
$ git push
```

- ▶ If you made any changes remotely, run

```
$ git pull
```


SUBMITTING

- ▶ Build your executable in Release Mode and test it
- ▶ Be sure to have everything properly committed and pushed to your Gitlab repository first
 - `$ git status`
On branch master?
Your branch is up-to-date with "origin/master"?
Nothing to commit, working directory clean?
- ▶ Tag it
 - ▶ `$ git tag SUBMIT`
`$ git push -tags`
- ▶ Clone your tagged repo into a SEPARATE directory and test running the program

THE END

GOOD LUCK

