HELP SESSION

IMPRESSIONIST

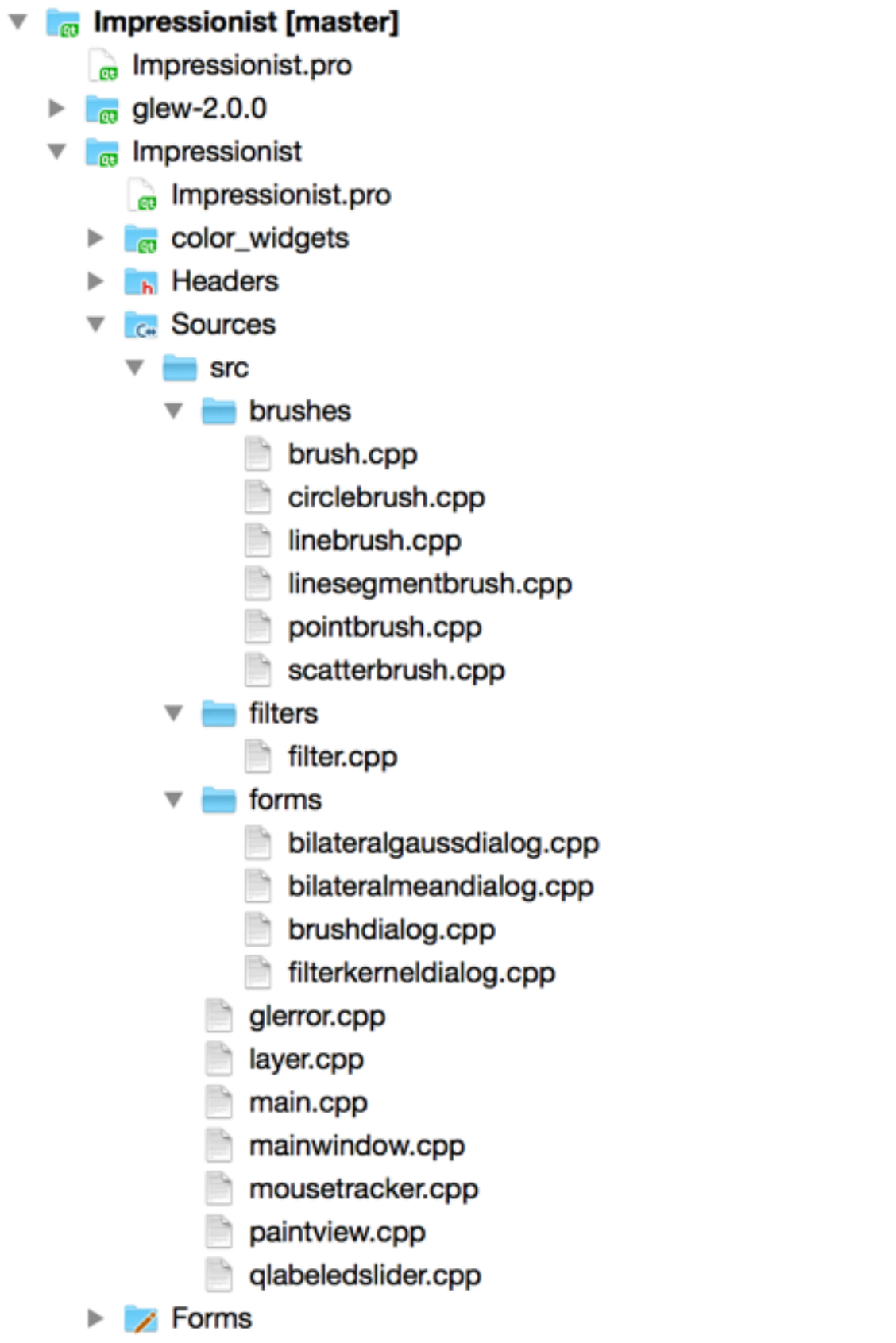
OUTLINE

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

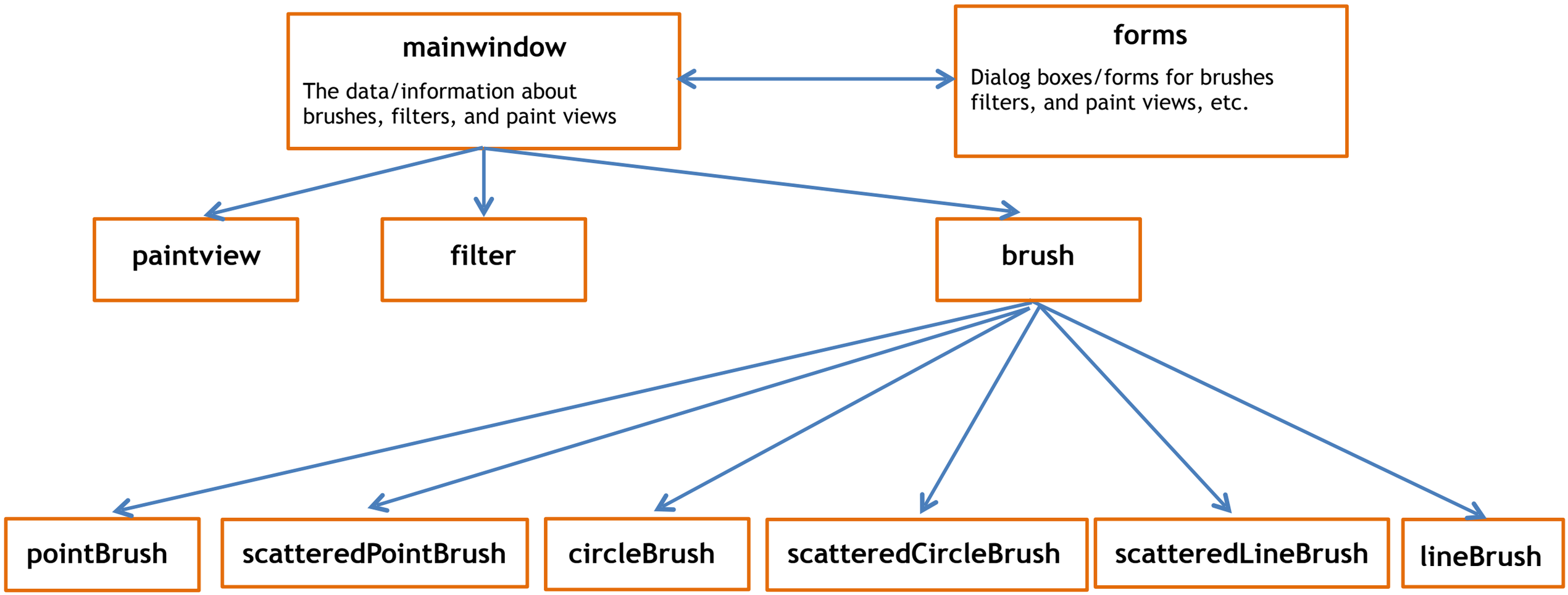
GETTING STARTED

- Clone the Impressionist skeleton code
  - `git clone git@gitlab.cs.washington.edu:cse457-17au-impressionist/YOUR_REPO.git impressionist`
- Install Qt Creator (if working on your own machine)
  - www.qt.io/download > “Desktop & Mobile Applications” > Open Source
  - 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

SKELETON CODE



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

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);
```

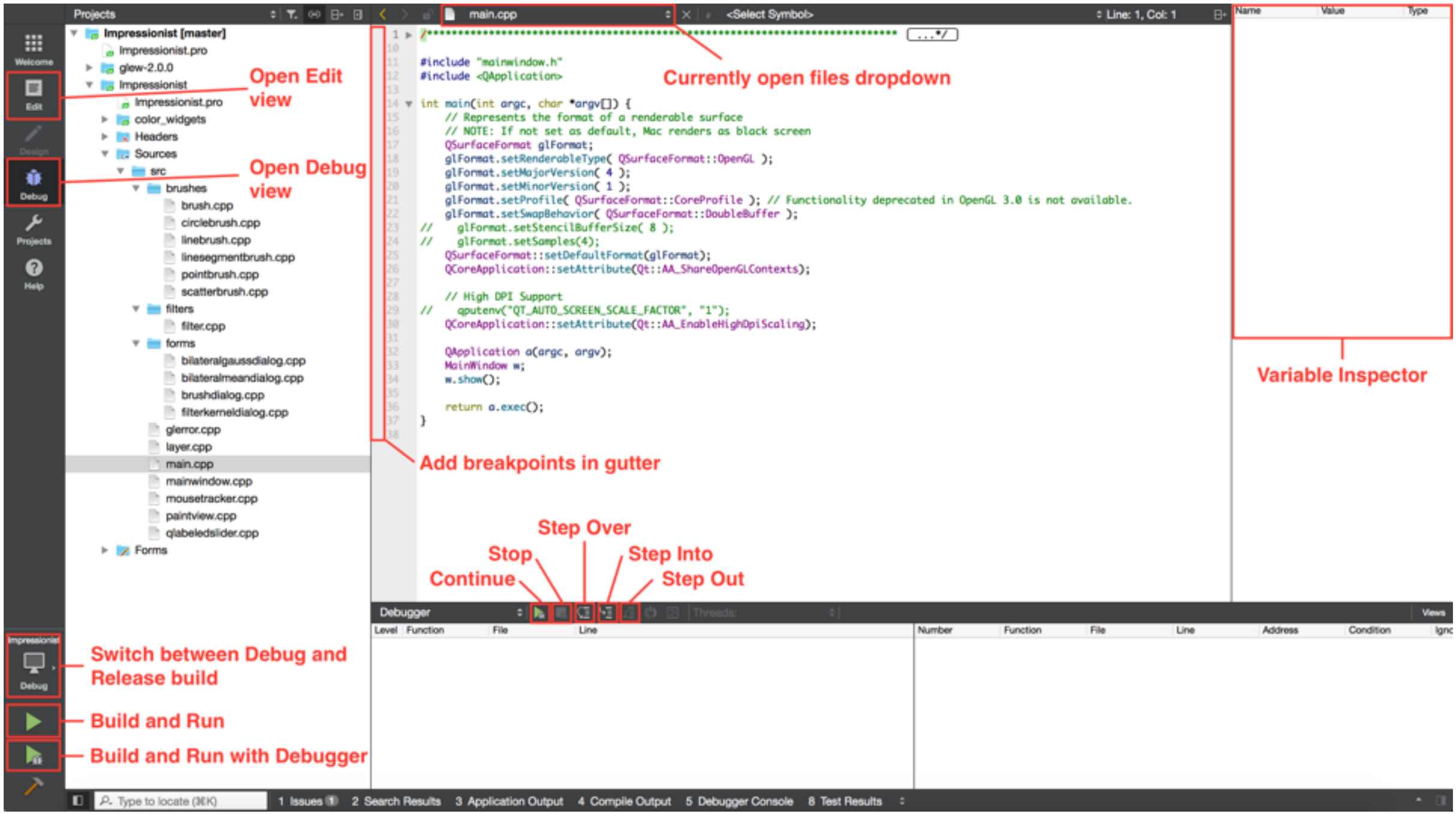
DRAWING A POLYGON

- 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)

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

QT


Open Edit view
Open Debug view
Currently open files dropdown
Variable Inspector
Add breakpoints in gutter
Step Over
Stop
Step Into
Continue
Step Out
Switch between Debug and Release build
Build and Run
Build and Run with Debugger

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();`

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*

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

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

- Use the sobel operator

ALPHA BLENDING

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

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

- Then

$F_{new} = \ ?$

ALPHA BLENDING

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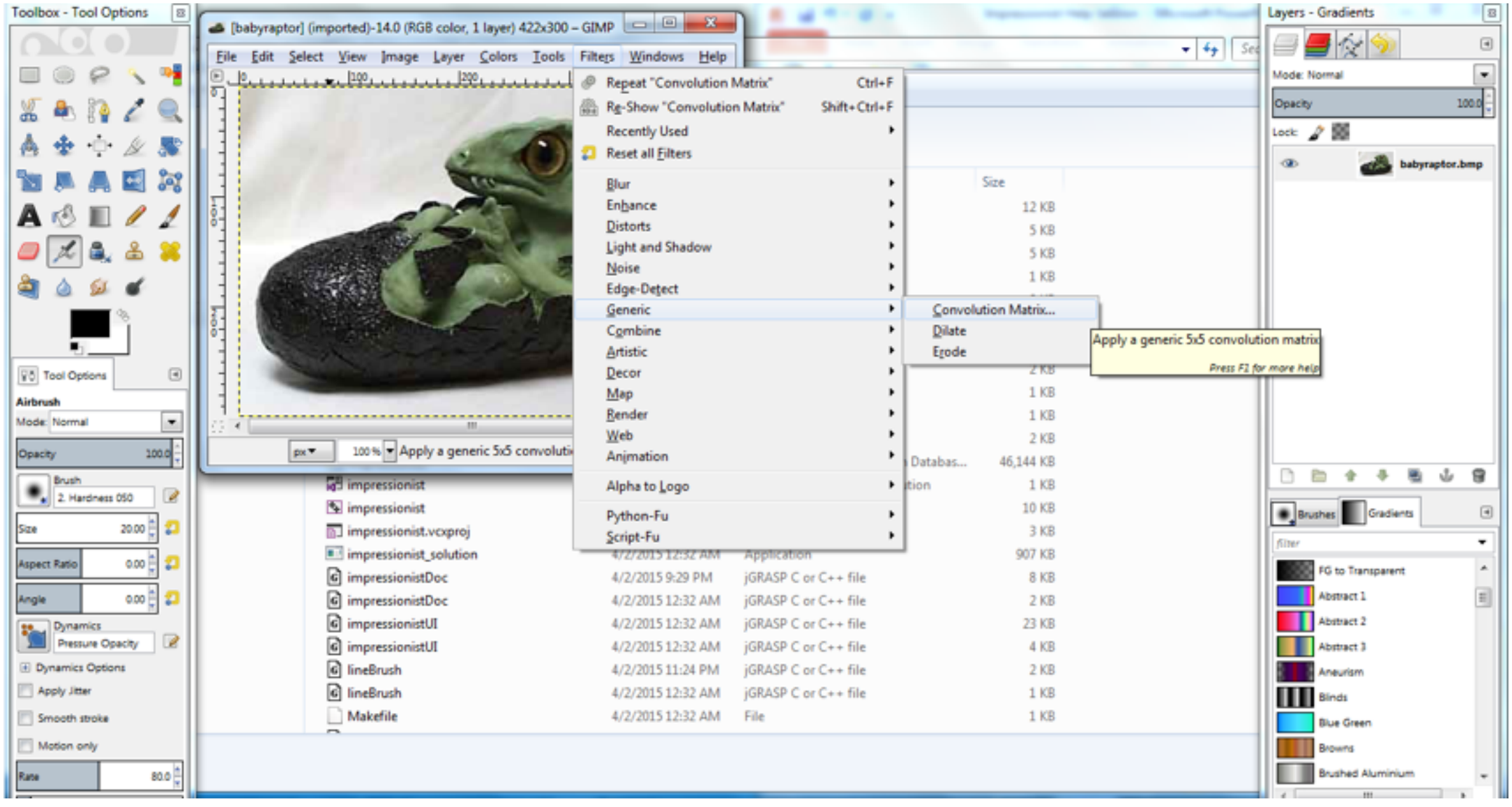
- Suppose $\alpha = 0.5$ $C = \begin{bmatrix} 255 \\ 255 \\ 255 \end{bmatrix}$ $F_{old} = \begin{bmatrix} 0 \\ 0 \\ 128 \end{bmatrix}$
- Then

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

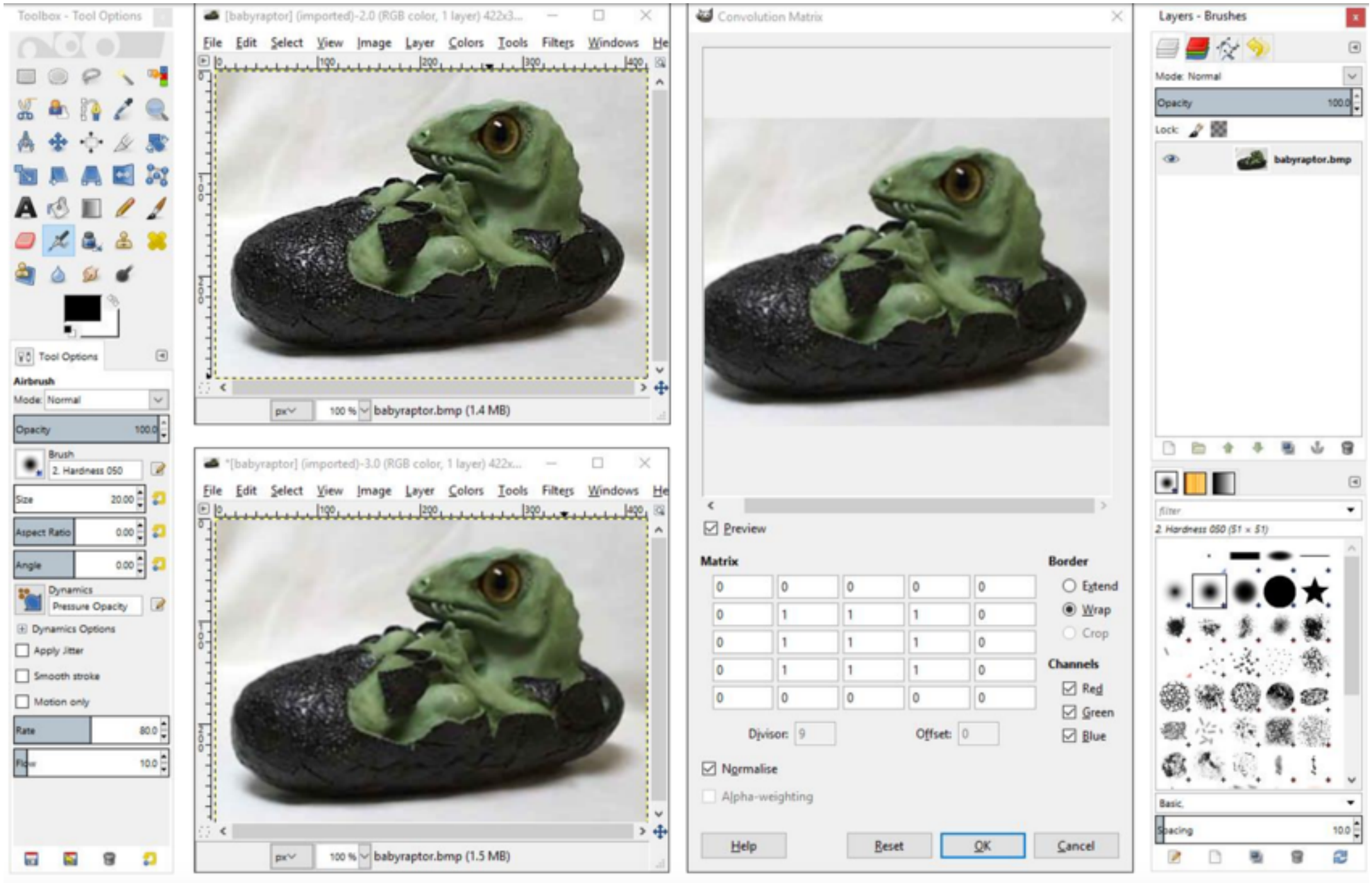
FILTERS

- 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

USE GIMP/PHOTOSHOP TO SEE FILTERS IN ACTION



3X3 MEAN BOX FILTER



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 int a SEPARATE** directory and test running the program
    ```

THE END

GOOD LUCK