Instructor: Andy Mina
Grade Level and Subject: 12th Grade - Introduction to Computer Vision
Topic: Introduction to Convolutions
Lesson: 01_2d_convolution

NYS Computer Science and Digital Fluency Learning Standards	9-12.CT.2 - Collect and evaluate data from multiple sources for use in a computational artifact 9-12.CT.5 - Modify a function or procedure in a program to perform its computation in a different way over the same inputs, while preserving the result of the overall program.
Content Objective	Students will be able to: ● Perform 2D convolution ● Understand different solutions for convolution near borders
Scaffolding Needed	Students should be able to: ● Perform 1D convolution at a comfortable/familiar level
Key Vocabulary	**Zero padding:** missing values when convolving near the border are set to 0 **Circular padding**: missing values when convolving near the border are copied from the opposite end of the list **Replicate/duplicate padding:** missing values are duplicates of the nearest row/col **Symmetric padding:** missing values are filled as the reflection of the nearest rows/cols
Assessments	Roll for Confidence (Formative) Students will be asked to “roll for confidence” and respond by showing the instructor a number from 1 to 5 on one of their hands. Their confidence is representative of how comfortable they feel in continuing to explore and compare other sorting algorithms on their own. Scores represent the following: 1. **Not confident.** Needs a re-explanation or summary of the lesson with emphasis on key points. 2. **Pretty shaky.** Needs a brief recap and some teacher-guided practice to solidify concepts and understanding. 3. **Okay.** Needs some peer-guided practice and some more time to let things sink in. Ideal rating after

	the lesson. 4. **Pretty confident.** Needs some peer-guided practice for more challenging algorithms, but is self-sufficient for what's covered in class. Ideal rating before a unit test. 5. **Extremely confident.** Needs little to no guidance and can tackle problems of exceptional difficulty with relative ease. Indicative of an under-challenged student. These checks shouldn't take any longer than one minute.
Materials	01_slides

Lesson Component	**Description or Execution of Lesson Component (w/ scripting when appropriate)**
Essential Question	How do we perform 2D convolution?
Do Now	**S1, 3m** Read the Do Now for students. Note that partner work will be important for this unit so they should get to know their partner. Emphasize that students only have to answer 2/4 questions. **S2, 4m** Review the answers to the Do Now questions. Then roll for confidence on 00_homework. This will inform the pace of today's lesson.
Presentation of Content	**S3, 3m** Stress to students that 2D convolution follows the same steps and rules as 1D convolution; the only difference is the number of steps. Emphasize that students should flip the kernel across both axes! It's a common mistake to only flip across one axis when dealing with 2D convolution. For simplicity, we will only work with 2D square kernels of an odd size. Other kernels exist, but we are only focusing on a few for the context of this unit. Since we're working with 2D square odd kernels, there will **always**

	be a center square. We compute the convolution by overlaying the kernel's center pixel with the target pixel in the first array. We'll go through an example together. **S4-9, 6m** Note to students the colors of each array here: the input is red and the kernel is blue. This means when we overlap them in future slides, the overlap region will be purple. Take this very slowly, but don't stop for questions until complete. It's important that students get a sense of this process from beginning to end, uninterrupted. "Each pixel in the input array has its coordinates and the pixels in the kernel are labeled with letters. When we start convolving, pay special attention to these values." Answer questions and roll for confidence after convolving Pixel (1, 1). **S10-13, 8m** Walk through this problem with mainly student contribution. Direct them to refer back to the previous slides, but don't offer any answers. Have them work this out slowly as a class. Answer questions. **S14-16, 8m** Introduce the problems on this slide to the students. Work together in pairs. Note to students that we're using actual numbers in this example and pay special attention to the note at the top. Review solution step-by-step for RESULT #3 when done. Roll for confidence. **S17-18, 5m** Emphasize to students that for this example we were only convolving inner pixels. However, as mentioned in the previous lesson, sometimes we **want** to convolve at the border. How do we handle missing values since the kernel is bigger than the input data? Read the slide off to students and answer questions along the way. "There are many different ways to convolve near the border. However, the most common solution is usually symmetric padding since it keeps the general "shape" of the image the same. Most of the time, symmetric padding fills the border with relevant information or, at the very least, information that isn't jarring."

Homework	n/a