Instructor: Andy Mina
Grade Level and Subject: 12th Grade - Introduction to Computer Vision
Topic: Introduction to Convolutions
Lesson: 00_intro

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.
Content Objective	Students will be able to: ● Perform 1D convolution ● Understnad why convolution is useful ● Like convolution to another math operation
Scaffolding Needed	Students should be able to: ● Take the average of elements in an array
Key Vocabulary	**convolution:** a mathematical operation with multiple, different steps that takes two arrays (input and kernel/filter) and produces an output array; used to extract data, derive information, or modify images **kernel**: the second operand in convolution
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	00_intro 00_homework

Lesson Component	**Description or Execution of Lesson Component (w/ scripting when appropriate)**
Essential Question	What is convolution and how can it be used?
Do Now	**S1 (slide 1), 3m** Read the Do Now for students and give them time to work on the two problems. After reviewing questions, prompt students to consider: "How might the process change if we calculated the average for every 3/4/5 adjacent numbers? What if we had to do a weighted average?" 1. [78, 15, 50, 16, 72] → **ANSWER: [47, 33, 33, 44]** 2. [33, 52, 22, 80, 71] → **ANSWER: [43, 37, 51, 76]**

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<td>Presentation of Content</td>
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“The work you did in the Do Now is a math operation called convolution. You’ve already learned about other math operations, like PEMDAS, and modulo, to find the remainder in code. Today we’re talking about convolution since it’s an operation commonly used in Computer Vision.”

S2-3, 5m
Walk students through the difference in other mathematical operations and the steps required as compared to convolution:
- Addition and subtraction are simple operations: they require two numbers and only take one step.
- Multiplication, division, and exponentiation are complicated operations: they require two numbers and may take multiple, repetitive steps. For example, breaking down multiplication: 2*3 means add 2, three times.
- Convolution is a complex operation: it requires two lists of numbers and multiple, different steps.

Emphasize that a convolution kernel must be flipped. Usually we can skip this when the kernel is symmetric, but this is a very important first step.

S4, 2m
Read through slide and then roll for confidence.

S7-13, 8m
“Let’s reframe the Do Now as a convolution problem. Our first list would be a list of regular numbers: [78, 15, 50, 16, 72]. Two important notes about our second list:
1. The size/shape of the second list is determined by how many or which elements we want to look at.
2. The elements in the second each item in the second list would be it’s weight toward the final value.

In the Do Now, the second list would be [½, ½]: we look at two elements (the length) and each elements contributes ½ to the total average. If we wanted to look at three evenly weighted elements the second list would be [⅓, ⅓, ⅓].”
Emphasize to students that during convolution we “apply ther kernel” onto all possible locations. For now, we’re only doing contained/complete intersection where the kernel has all matching values, but there are cases where we may want to start the convolution earlier or later.

Stop for questions and roll for confidence about reframing the Do Now as a convolution problem.
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	S14, 10m Assign student to work on problems in pairs. Reminder that all of the second arrays/operands are called “kernels.” **S15, 10m** Review problems 2 and 4 with students step-by-step on the board. Heavily emphasize to students that the kernel in problem 4 must be flipped! Roll for confidence.
Homework	00_homework, two convolution problems