



On Teaching Image Recognition to Children at a Summer Camp

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Background

- K-12 AI literacy is increasingly significant
- Image Recognition education
 - Fundamental
 - Wide-ranging applications
 - Aligns with AI4K12 Big Ideas 1-3
- Significance
 - Module combining software and unplugged activities
 - AI-See uncovers matrix math



Research Questions

(RQ1) What evidence is there of student learning of aspects of image recognition?

(RQ2) How can software-based and unplugged activities complement each other?

(RQ3) Can we design an engaging and fun session for teaching image recognition?



Study Design

- 4-day AI-focused summer camp
 - 2 days of instruction – included 2-hour Image Recognition module
 - 2 days of creative projects
- Participants – middle school age children
- Data Collection
 - Pre- and post-surveys
 - Make-A-Matrix Worksheets
 - Audio recordings
 - AI-See user interaction data

Module Design

1. Interactive Presentation
2. Make-A-Matrix Unplugged Activity
3. AI-See Web Application
4. DoodleIt Web Application
5. Group Interviews

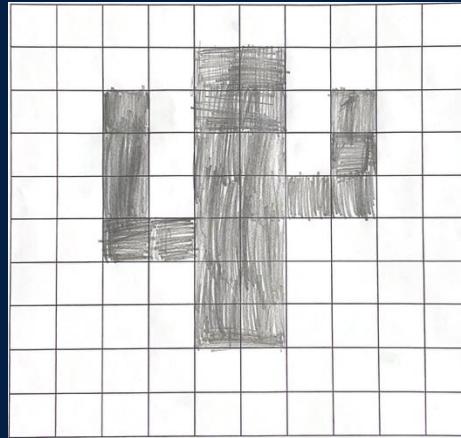
Module Design – (1) Interactive Presentation

Computers break pictures into small squares called **pixels**. Each pixel is a number. In grayscale (black and white images), it's a number between 0 (black) and 255 (white).

255	0	255	0	255
255	0	255	0	255
255	0	0	0	255
255	0	255	0	255
255	0	255	0	255

This grid is
called a
matrix

Module Design – (2) Make-A-Matrix Unplugged Activity



255	255	255	255	255	255	255	255	255	255	255
255	0	255	255	255	255	255	255	0	255	255
0	0	0	255	0	255	0	0	0	255	0
0	0	0	0	0	0	0	0	0	0	255
255	0	0	0	0	0	0	0	0	255	255
255	255	255	0	0	0	255	255	255	255	255
255	255	0	0	0	0	0	255	255	255	255
255	255	0	0	0	0	0	255	255	255	255
255	255	255	255	0	255	255	255	255	255	255
255	255	255	255	255	255	255	255	255	255	255

Module Design – (3) AI-See

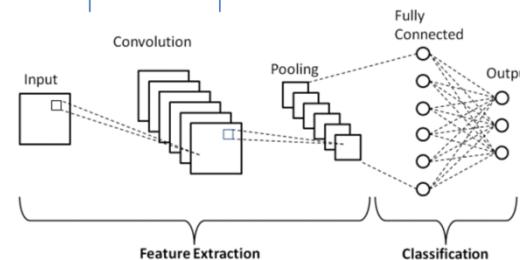
AI-See --- Introduction to CNNs

CNNs, or Convolutional Neural Networks, are a type of computer vision algorithm that allow computers to process and recognize patterns in images.

CNNs use a lot of different processes, like convolution and pooling, to find patterns in images and make decisions about them.

In AI-See, you will learn about how CNNs use kernels to detect patterns in images!

We're going to be focusing on this part of the process!



Next

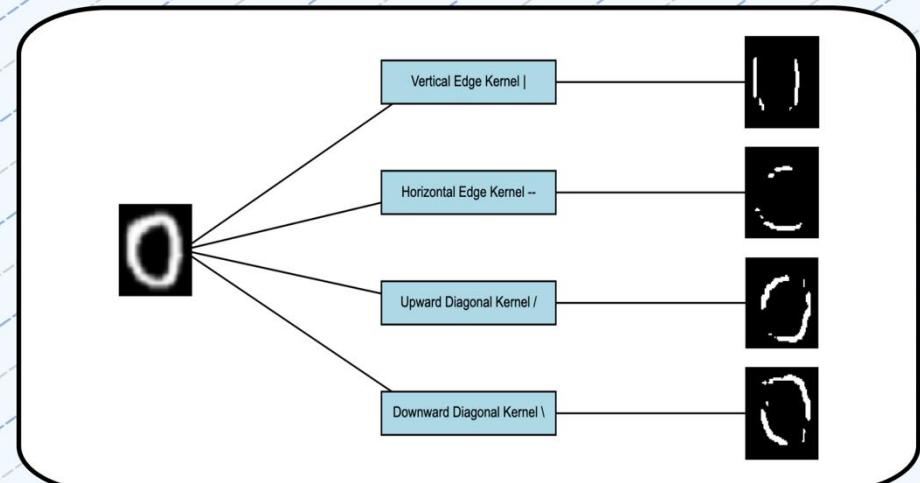
Module Design – (3) AI-See

AI-See --- Kernels and Feature Maps Introduction

CNNs use kernels to detect different patterns in an image, and those patterns appear in feature maps.

A vertical edge detection kernel can recognize vertical lines, and a horizontal edge detection kernel can find horizontal lines in an image.

On the right, you can see the feature maps that were generated based off of the different kernels that were used with the image shown. Feature maps show patterns that the CNN found in the input image.



Next

Module Design – (3) AI-See

AI-See --- Feature Map Make-A-Match

Match each feature map with the kernel it was created by! If you need to change your answers, use the 'Reset' button!



Vertical Edge Kernel |

Horizontal Edge Kernel --

Upward Diagonal Kernel /

Downward Diagonal Kernel \



Reset

Test Accuracy

Module Design – (3) AI-See



AI-See --- Kernel Math Introduction

The computer will represent the input image using numbers. Here, the black and white 1 is shown using 0s and 1s. The kernel is something the computer will use to find patterns in the input image.

Input

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

Kernel

1	0	1
1	0	1
1	0	1

Previous Step

Next Step

Module Design – (3) AI-See

AI-See --- Kernel Math Practice

Calculate the feature map the computer would get when applying this kernel on this input image:

Input Image:
0 1 1 1 0
0 1 0 0 0
0 1 1 1 0
0 1 0 1 0
0 1 1 1 0

$$\begin{matrix} 0 & 1 & 0 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \end{matrix} * \quad =$$

Kernel:
?
?

Fill out the resulting feature map here:

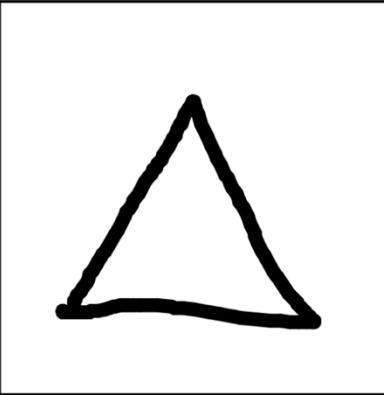
You can slide this semi-transparent block over the input image to help out if you'd like to :)

Submit

Module Design – (4) DoodleIt Web Application

You can draw images of cat, sheep, apple, door, cake and triangle!!

Code-Name :



Choose a Challenge

CLEAR

Filters Feature Maps Output Neurons

Filters	Feature Maps	Output Neurons
1		CAT = 0.00%
2		SHEEP = 0.00%
3		APPLE = 0.00%
4		DOOR = 0.00%
5		CAKE = 0.00%
6		Triangle = 100.00%
7		
8		

Vaishali Mahipal, et al.
2023. DoodleIt: A Novel
Tool and Approach for
Teaching How CNNs
Perform Image
Recognition. 25th
Australasian Computing
Education Conference
(ACE '23).
<https://doi.org/10.1145/3576123.3576127>

Module Design – (5) Group Interviews



Results – (RQ1) What evidence is there of student learning of aspects of image recognition? (1 of 2)

COMPUTER REPRESENTATION OF IMAGES

- 15 / 17 student pairs understood a pixel is indivisible
- Many students wrote numerical values for colors
- Many discussed how the number of pixels determine image quality

FEATURE MAPS

Item	p ₁	p ₂	p-value
Feature Map Definition	0.48	0.75	0.021
Feature Map Match	0.42	0.69	0.024

Two-proportion z-test results for pre- and post-survey multiple choice items

- 11 / 15 pairs achieved average accuracy scores $\geq 90\%$ on feature map match level of AI-See

Results – (RQ1) What evidence is there of student learning of aspects of image recognition? (2 of 2)

KERNELS

- 12 / 15 pairs achieved average accuracy scores $\geq 90\%$ on kernel math practice levels of AI-See

Item	p ₁	p ₂	p-value
Kernel Definition	0.29	0.69	0.0011
Kernel Math	0.10	0.50	0.00038

Two-proportion z-test results for pre- and post-survey multiple choice items

Response Category	# Responses
No Response	1
I don't know or confusing	2
Funny or off-topic	6
Computer seeing	12
Finding patterns	11

Categorized responses to open-ended post-survey item asking students to explain kernels, listed from least to most insightful.

(RQ2) How can software-based and unplugged activities complement each other?

- Make-A-Matrix (unplugged activity) was enjoyed
- Connections between unplugged and software activities
- Thoughtful discussions about lessons learned

(RQ3) Can we design an engaging and fun session for teaching image recognition?

	μ	σ	1	2	3	4	5
Make-A-Matrix	3.75	0.8	2	9	16	0	5
AI-See	3.59	1.27	2	5	7	8	10
Doodlelt	3.61	1.09	2	2	8	13	6

Students ratings of how fun each activity was on a scale from 1 (least fun) to 5 (most fun) on post-survey item

Limitations and Future Work

- Limited sample size
- Further practice and instruction on kernel math
- Integrating code activities
- Adding more image recognition concepts



Discussion & Conclusion

- Open source image recognition module
- Successful aspects
 - Variety between unplugged and software activities
 - AI-See's timed challenge levels
 - Interactive discussions
- Effective introduction to image recognition fundamentals

Questions?



*Access a repository
containing our module and
this presentation here*

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