Neural Networks and Computer Vision in AP Computer Science

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Project Focus

How do neural networks work and how do they compare to traditional computer algorithms?

What are some example applications of neural networks in computer vision research?

What current programming skills can students apply related to the research topics presented?

Motivation/Educational Goals

1. Generate excitement about the multitude of opportunities for students of computer science.
2. Expose students to some cutting edge real-world applications of computer science that are exciting and relevant.
3. De-mystify the terms "neural networks", "machine learning", and "artificial intelligence" so the students can talk more intelligently about these topics.
4. Provide practice in one and two-dimensional array algorithms.

Project Overview

- This project introduces the students to the concepts of neural networks and shows them two applications currently being researched: self-driving cars and lung cancer detection.

- One of the goals is for the students to get a basic understanding of what neural networks are, how they learn, and how this approach to computational problems is similar to and different from standard algorithms.

- The students will evaluate the self-driving car's results by writing an algorithm to detect potential errors in its output.

- They will also implement a standard edge-detection algorithm and learn how it differs from the approach used in the lung cancer detection neural network.
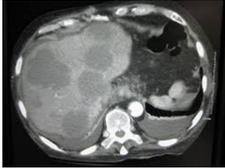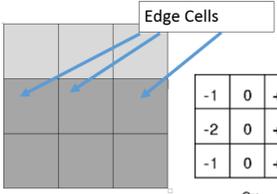
Self-driving Car
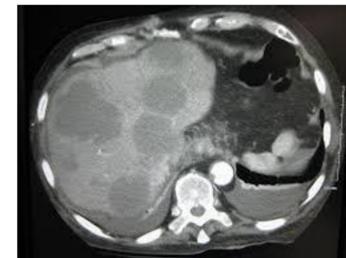
Cancer Detection
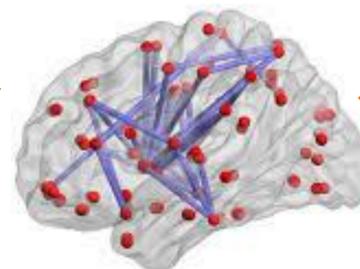
Self Driving Car

Windshield View	Neural Network Output	Actual Steering Wheel	Algorithm to Check For Output Errors
This is the image data captured by a camera attached to the front of the car.	This is a visualization of how the car would steer using the neural network output.	This is a visualization of how the car was actually steering at the moment shown.	The students will create an algorithm to determine if the output of the network is reasonable.

Lung Cancer Detection

Edge Detection Used in Cancer Detection	Simple Edge Detection Algorithm	Sobel Mask Edge Detection Algorithm	Algorithm Comparison

Edge Cells

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Students introduced to an application using edge detection.

Students will implement the simple edge detection algorithm.

Simple

Sobel

Activities

After students have had practice using 2-dimensional arrays:

- Web Quest on Self-Driving Cars
- Presentation on Neural Networks
- Demo of UCF Self-Driving Car Computer Vision Research/simulation
- Students implement error detection algorithm for self-driving car neural network (Python)
- Presentation on UCF Cancer Computer Vision Research Project and Edge Detection algorithms used in neural networks
- Students implement simple edge detection algorithm (Java)

Related Computer Science Standards

- SC.912.CS-CS.1.1 Analyze data and identify real-world patterns through modeling and simulation.

- SC.912.CS-CS.6.6 Describe a few of the major branches of artificial intelligence (e.g., expert systems, natural language processing, machine perception, machine learning).

- SC.912.CS-CS.6.7 Describe major applications of artificial intelligence and robotics, including, but not limited to, the medical, space, and automotive fields.

- SC.912.CS-CS.2.11 Evaluate algorithms by their efficiency, correctness, and clarity (e.g., by analyzing and comparing execution times, testing with multiple inputs or data sets, and by debugging).