

UCF RET: Research Experiences in Calculus, Neural Networks and Artificial Intelligence

1202310: AP Calculus AB

2018

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Calculus, Neural Network and Artificial Intelligence

Lesson Plan

Course: AP Calculus AB
Grade Level: 11th – 12th
Suggested Length of Lesson: 4 School Days (90' sessions)

Technology Needed:
- Projector
- PowerPoint and Python
- Laptops and Tablets
- Internet

Where this Fits
- As an extension lesson after all basics have been covered on differential calculus and chain rule to expose students to exciting and relevant applications of computer science including calculus concepts like partial derivatives.

Learning Goals
- Students will be able to…
  - Find the partial derivative of a function with two variables.
  - Compute a neural network's output, calculate the loss function, find the partial derivatives due to weights in the backpropagation, and compute new weights with the gradient descent algorithm.
  - Discuss the relevance of the CRCV research projects and run the crowd counting demo.
  - Analyze and discuss current applications of neural networks in computer vision and artificial intelligence and their social impact.

Enduring Understandings in AP Calculus
- *EU 2.2: A function's derivative, which is itself a function, can be used to understand the behavior of the function.*
- *EU 2.3: The derivative has multiple interpretations and application including those that involve instantaneous rate of change.*

Standards for Mathematical Practice
- Make sense of problems and persevere in solving them.
- Use appropriate tools strategically.
- Attend to precision.
- Look for and make use of structure.
- Look for and express regularity in repeated reasoning.

Evidence of Learning (Assessment Plan)
- Worksheet (partial derivatives).
- Handout (neural network).
- Presentation (artificial intelligence).

Instructional Strategies
- Summarizing and note-taking
  - *Allowing students to analyze what is important in a video.*
- Cooperative learning
  - *Allowing students to focus on positive interdependence and group accountability.*
- Setting objectives and providing feedback
  - *Allowing students to have a sense of direction and personalize the goal by identifying areas of interest.*
- Reinforcing effort and providing recognition
  - *Allowing students to experience the connection between effort and achievement.*

Description of Lesson Experiences

Lesson 1 – Partial Derivatives

Students will be introduced to functions with multiple variables and partial derivatives.

1. Video: students will watch the video and the teacher will address their questions. The students will watch the video as a group using the projector.
   - *Khan Academy: Multivariable Functions (6:02 min)*
2. Video: students will watch the video and make notes on partial derivatives. The students will watch the video individually using laptops and tables.
   - *Khan Academy: Partial Derivatives, introduction (10:55 min)*
3. Practice: students will complete a list of exercises and compare answers.
   - *Worksheet: Partial Derivatives*

Lesson 2 – Neural Networks

Students will be introduced to neural networks, the forward pass, the loss function, the backpropagation, and the gradient descent algorithm. This activity will be done first by hand, using calculators, and then their solution will be tested using a Python code.

4. Tutorial: students will follow steps and instructions to compute hidden and output neurons, calculate errors, find partial derivatives due to weights, and compute new weights in a neural network.
   - *Tutorial: Neural Networks*
5. Handout: students will fill tables and figures with the computed values of hidden and output neurons, s and errors in a neural network including the backpropagation.
   a. *Name of the handout****
6. Python Code: students will compare their answers with the ones provided by the Python code.
   a. *Name of the code****

Lesson 3 – CRCV and Crowd Counting

Students will be introduced to CRCV, its mission, their current projects and, in particular, their research in crowd counting.

Lesson 4 – Applications

Students will be introduced to the applications of neural networks in deep learning, machine learning and artificial intelligence. This will include cancer detection, self-driven cars, among others. The class should end with a discussion on the importance of Calculus and its applications in Computer Science.

7. *PowerPoint: teacher will introduce a list of applications of deep learning.*
8. *Videos: students will choose from a list of videos about the applications of deep learning based on their own interests. They can also do their own research.*
   a. *YouTube videos (list)*
9. Handout: students will discuss deep learning applications and the importance of calculus.
   a. *Name of handout*

Recommended Assessment(s) and Steps

Updating the list of videos by January 2019 to include the newest applications

If possible, UCF people will be invited to attend Lesson 3

Lesson 2 may take more than 1 session. If that happens, session 3 might be used to complete lesson 2 and start lesson 3

Use Desmos as a Homework assignment:
https://google-developers.appspot.com/machine-learning/crash-course/backprop-scroll/

List of Materials and Resources Used

- PowerPoint Presentations
- Videos
- Student handouts
- Calculators

Important Vocabulary

Term	Definition
Partial Derivative	Is
Neural Network	Is
Backpropagation	Is
Gradient Descent	Is
X	Is
X	Is
X	Is
X	Is

Troubleshooting Tips

1. If students…

Other Helpful Information

Attachments

References

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