UNT
UNIVERSITY OF NORTH TEXAS

CSCE 5218 & 4930
Deep Learning

Introduction

Prof. Heng Fan

University of North Texas

Many slides adapted from Adriana Kovashka

Plan for Today

- Review of Course
  - Organization
  - Content

- What is deep learning?

About the Instructor

- Self-introduction

Instructor: **Prof. Heng Fan**,

Ph.D. in Computer Science from Stony Brook University

Email: heng.fan@unt.edu (best way to reach out to me)

Office: Discover Park F284

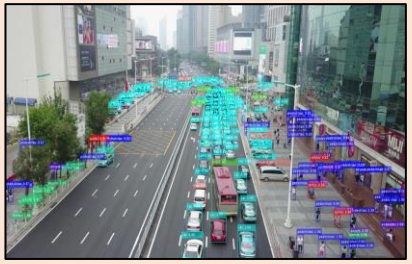
Phone: 940-565-3209

Website: https://hengfan2010.github.io/

Instructor Information

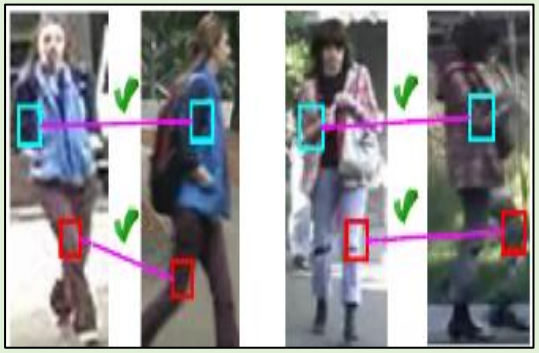
- Research interests
  - **Computer Vision, Artificial Intelligence**


Visual object tracking



Object detection

application

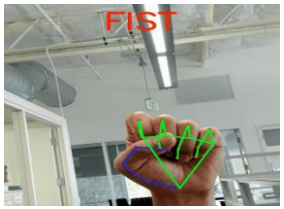


Person re-identification

Semantic segmentation

Intelligent vehicles

Robotics



Human-machine interaction

Video surveillance

more …

Some pictures are form Internet.

Resource

- Useful resources online
  - Convolutional Neural Networks by DeepLearningAI
    - Instructor: Prof. Andrew Ng at Stanford University, well known for deep learning
    - YouTube: https://www.youtube.com/playlist?list=PLkDaE6sCZn6Gl29AoE31iwdVwSG-KnDzF (free)
    - Course topics includes
      - Basic concepts in computer vision
      - Deep convolutional neural networks (CNNs)
      - State-of-the-art CNN models
      - Fundamental computer vision tasks, including but not limited to image classification, object detection, semantic segmentation, etc.
      - …

Focusing more on deep learning in computer vision!

Resource

- Useful resources online
  - Neural Networks and Deep Learning by DeepLearningAI
    - Instructor: Prof. Andrew Ng at Stanford University, well known for deep learning
    - YouTube: https://www.youtube.com/playlist?list=PLkDaE6sCZn6Ec-XTbcX1uRg2_u4xOEky0 (free)
    - Course topics includes
      - Basic concepts in deep networks
      - Mathematical computation in deep network, including gradient descent, various regression tasks, forward-pass, back-propagation, activation functions, etc.
      - …

Focusing more on mathematics in deep learning!

Resource

- Useful resources online
  - Implement your ideas using deep learning platforms
    - PyTorch (Facebook), using Python
      - Download: https://pytorch.org/
      - Tutorial: https://pytorch.org/tutorials/
    - TensorFlow (Google), using Python
      - Download: https://www.tensorflow.org/
      - Tutorial: https://www.tensorflow.org/tutorials
    - GPU resource
      - Google Colab
  - Research papers from conferences
    - Machine Learning: ICLR/ICML/NeurIPS …
    - Computer Vision: CVPR/ICCV/ECCV …
    - Robotics: RSS/ICRA/IROS …

Basic Course Information

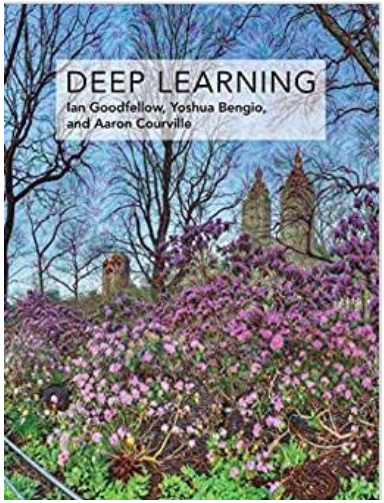
- Course webpage
  - **Canvas or https://hengfan2010.github.io/teaching/22S-5218_4930/**
  - Course materials, including slides, homework, project, etc.
- Schedule
  - **Tu & Th: 1:00 pm – 2:20 pm, NTDP B142**
- Office hours
  - **Th 3:30 – 5:30 pm, online (preferred, zoom link on Canvas) or in office, or by appointment**
- TA: Simon Tandi
  - SimonPeterTandi@my.unt.edu, office: F232, office hours: Tu 3:00-5:00 pm

Course Goals

- Expectations
  - Learn the basic concepts and tools that underlie all modern deep neural networks
  - Be able to select a suitable model architecture to process different types of data
  - Grow hands-on experience implementing deep neural network models for computer vision, natural language processing, robotic applications, etc.
  - To develop practical solutions for one real problem (course project)

Textbooks

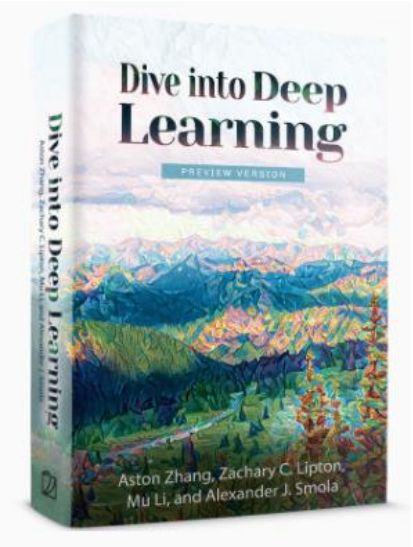
- Required textbooks
  - Deep Learning, by I. Goodfellow, Y. Bengio, A. Courville, MIT Press, 2016. online version



- Recommended textbooks
  - Dive into Deep Learning, by A Zhang, Z. Lipton, M. Li, A. Smola, 2019. online version

    Many examples to practice deep learning

    (highly recommended)
  - Additional readings from papers



Prerequisites

- The students are required to master basic knowledge about:
  - Calculus
  - Linear algebra
  - Programming in Python
  - Algorithm implementation.
- Machine learning background is beneficial for this course.

Programming

- Languages/frameworks: Python, NumPy, PyTorch
- NumPy tutorial (go through at home): http://cs231n.github.io/python-numpy-tutorial/
- NumPy for Matlab users: https://docs.scipy.org/doc/numpy/user/numpy-for-matlab-users.html
- PyTorch will be used for the course project
- Computing resource: Google Colab (free)

Course Structure

- Lectures
- Programming assignments
- Paper reviews
- Course project (teams of at most 3 students)
  - Proposal, final report, presentation
  - Check course website for detailed description
- Final exam

Lecture

- Topics include:
  - Review of machine learning
  - Basic concepts in neural networks
  - Loss, optimization, and training of deep neural networks
  - Convolutional neural networks (CNNs)
  - Recurrent neural networks (RNNs)
  - Transformer
  - Applications of deep neural networks
  - Advanced topics
    - Graph neural networks (GNNs)
    - Unsupervised representation learning
    - Deep reinforcement learning
    - Generative adversarial networks (GANs)

Tentative Schedule

Week	Lecture topic
1-2	Machine overview
3-4	Neural network basics
5-6	PyTorch tutorial and network training
7-11	Convolutional neural networks
	Recurrent neural network
	Transformer
12-13	Advanced topics, including
	Graph neural networks, Unsupervised representation learning,
	Deep reinforcement learning, Generative adversarial networks
14-15	Project presentation
16	Final Exam

This schedule may be updated in the future. Check Canvas or course webpage!

Assignment

- Three or four homework assignments
- Most are programming exercises
- Use Python for implementation on Google Colab
  - A useful tutorial to use Colab is here: https://colab.research.google.com/github/cs231n/cs231n.github.io/blob/master/python-colab.ipynb

- Important notes
  - Individual work. Discuss is allowed, but you should turn in your own. Do NOT share your code!
  - Turn in the .ipynb file and a file sharing the link to your assignment
  - A late penalty of 10% will be applied to all late assignments for up to 3 calendar days. **NO** credit will be given after 3 days.

Paper Review

- Select 15 papers for review from a list during the semester
- Only papers from the list qualified to be reviewed
- Review should contain:
  - summary (using your own word)
  - positive points (contributions)
  - critiques
- Use Python for implementation on Google Colab
- Individual work, don't copy
- More details (paper list, review sample, format, etc.) will be updated on the course website and Canvas

Course Project

- Teamwork with at most 3 members
- Topics
  - Selected among a number of projects
  - Suggested by the teams, especially topics related to your current research
- A complete project consists of:
  - Proposal:
  - Final report
  - Project presentation
- More details will be announced after few weeks
- The project MUST be related to deep learning

Tips for A Successful Project

- From your perspective
  - Learn something
  - Try something out for a real problem

Tips for A Successful Project

- From your classmates' perspective:
  - Hear about a niche of DL we haven't covered, or learn about a niche of DL in more depth
  - Hear about challenges and how you handled them, that they can use in their own work
  - Listen to an engaging presentation on a topic they care about

Tips for A Successful Project

- From my perspective:
  - Hear about the creative solutions you came up with to handle challenges
  - Hear your perspective on a topic that I care about

Tips for A Successful Project

- Summary
  - Don't reinvent the wheel – your audience will be bored
  - But it's ok to adapt an existing method to a new domain/problem…
  - Show interesting experimental results…
  - You analyze them and present them in a clear and engaging fashion

Final Exam

- There will be a final exam
- Focus on basic concepts and theories in deep learning
- Exam will be open book, open note.
- No search from Internet for the answers.
- Date is TBD

Grading

- **Class participation and homework assignment** 25%
- **Paper review** 20%
- **Course project** 40%
- **Final exam (open book, open note):** 15%

Grading Scale

- Tentative grading scale (based on 100 points)

  A 90-100

  B 80-89

  C 70-79

  D 60-69

  F below 60

- No absolute grading scale; appropriate letter grade cutoffs set by instructor at the end of semester.

Academic Integrity

- Academic Integrity

  Academic Integrity is defined in the UNT Policy on Student Standards for Academic Integrity. Any suspected case of Academic Dishonesty will be handled in accordance with the University Policy and procedures. Possible academic penalties range from a verbal or written admonition to a grade of F in the course. Further sanctions may apply to incidents involving major violations. You will find the policy and procedures at: https://vpaa.unt.edu/ss/integrity.

  - Each topic discussed in class will have associated assignment
  - Students may discuss assignment problems and approaches with each other but must write their solutions individually
  - Students may not copy assignment from any source (e.g., other students, the Internet)
  - No collaboration is allowed in paper review and exams

Do NOT Cheat!

Notes

- Attendance
  - Attendance may be checked on randomly selected days. You are responsible for any missed material and completing all work by the assigned due dates. You should notify the instructor of your absence as soon as possible. Special cases caused by COVID can be found below in "COVID Information".
- Important notes regarding COVID
  - UNT encourages everyone to wear a face covering when indoors, regardless of vaccination status, to protect yourself and others from COVID infection, as recommended by current CDC guidelines.
  - Students are expected to attend class meetings regularly. It is important that you communicate with the professor and the instructional team prior to being absent, so you, the professor, and the instructional team can discuss and mitigate the impact of the absence on your attainment of course learning goals. Please inform the professor and instructional team if you are unable to attend class meetings because you are ill, in mindfulness of the health and safety of everyone in our community (no penalty for this special case).

Should I Take This Class?

- A lot of work
  - I expect you'll spend around 6 hours on homework or the project each week
  - But you will learn a lot
- Some parts will be difficult and require that you pay close attention!
  - Read additional papers for related topics
  - Use instructor's and TA's office hours
  - Practice, practice, and practice

Questions?

What Is Deep Learning?

- One approach to finding patterns and relationships in data
- Finding the right representations of the data, that enables correct automatic performance of a given task
- Examples: Learn to predict the category (label) of an image, learn to translate between languages

Example Deep Learning Tasks

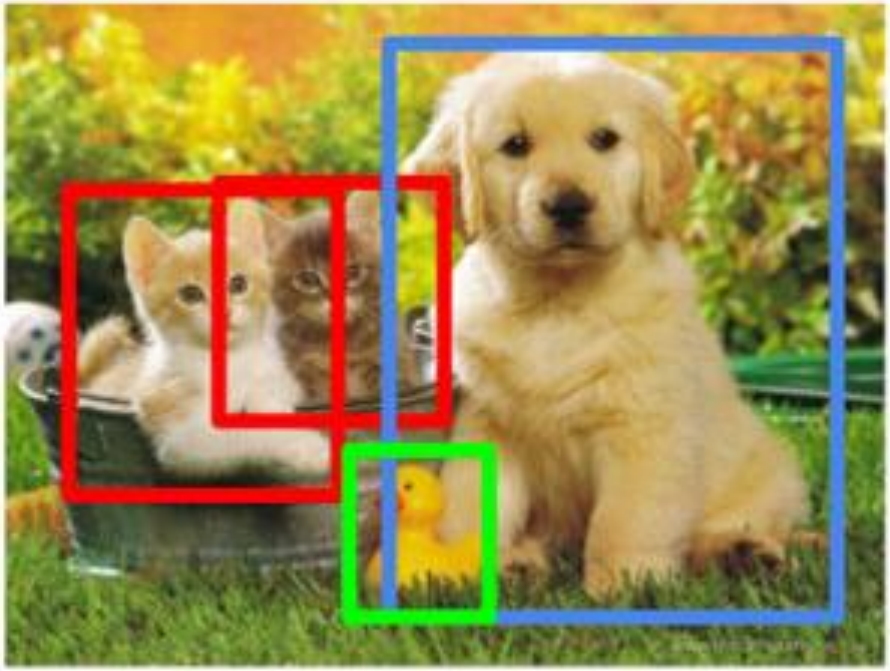
- Image classification

CAT

https://www.datacamp.com/community/tutorials/object-detection-guide

Example Deep Learning Tasks

- Object detection



CAT, DOG, DUCK

https://www.datacamp.com/community/tutorials/object-detection-guide

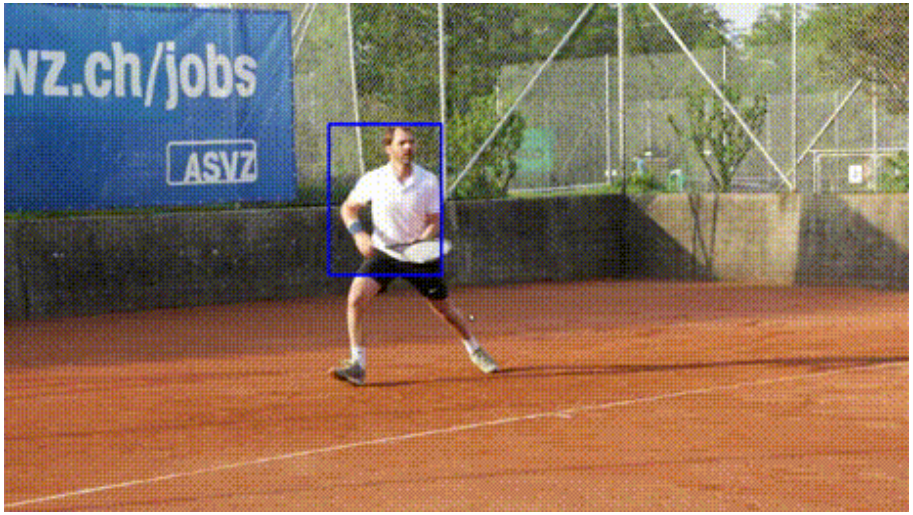
Example Deep Learning Tasks

- Semantic segmentation

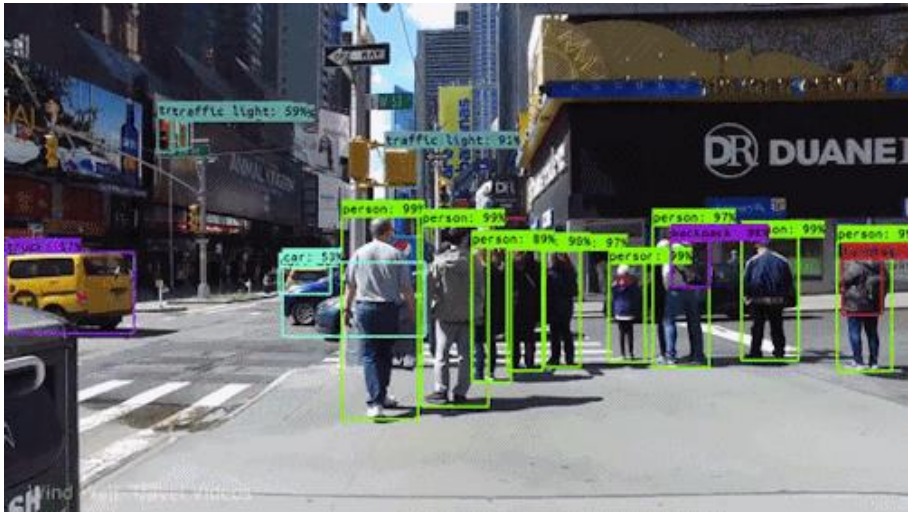
https://towardsdatascience.com/semantic-segmentation-with-deep-learning-a-guide-and-code-e52fc8958823

Example Deep Learning Tasks

- Visual tracking



single object



multiple object

https://blog.netcetera.com/object-detection-and-tracking-in-2020-f10fb6ff9af3

https://zhuanlan.zhihu.com/p/141444439

Example Deep Learning Tasks

- Image translation

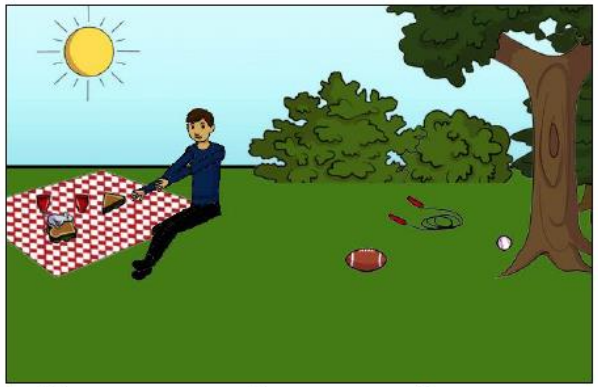
https://github.com/junyanz/pytorch-CycleGAN-and-pix2pix

Example Deep Learning Tasks

- Question answering

What color are her eyes?
What is the mustache made of?

How many slices of pizza are there?
Is this a vegetarian pizza?



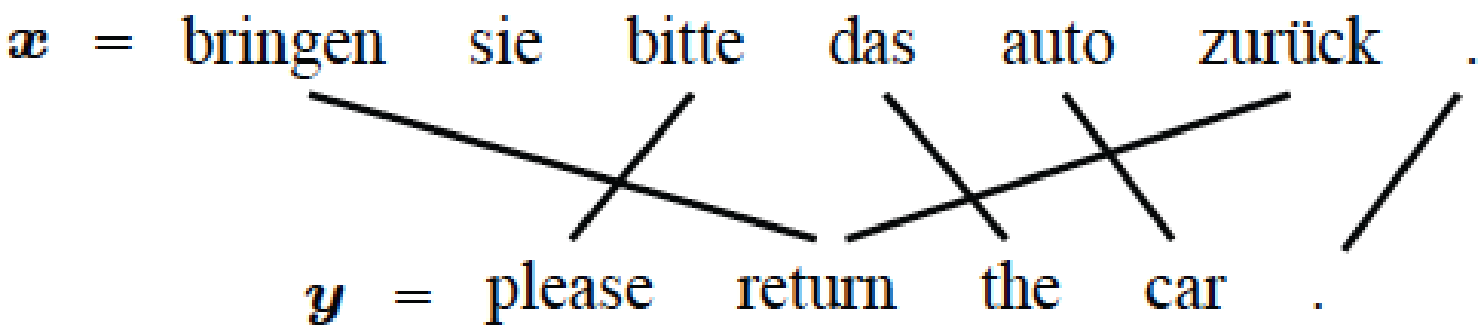
Is this person expecting company?
What is just under the tree?

Does it appear to be rainy?
Does this person have 20/20 vision?

Agrawal et al., "VQA: Visual Question Answering", ICCV 2015

Example Deep Learning Tasks

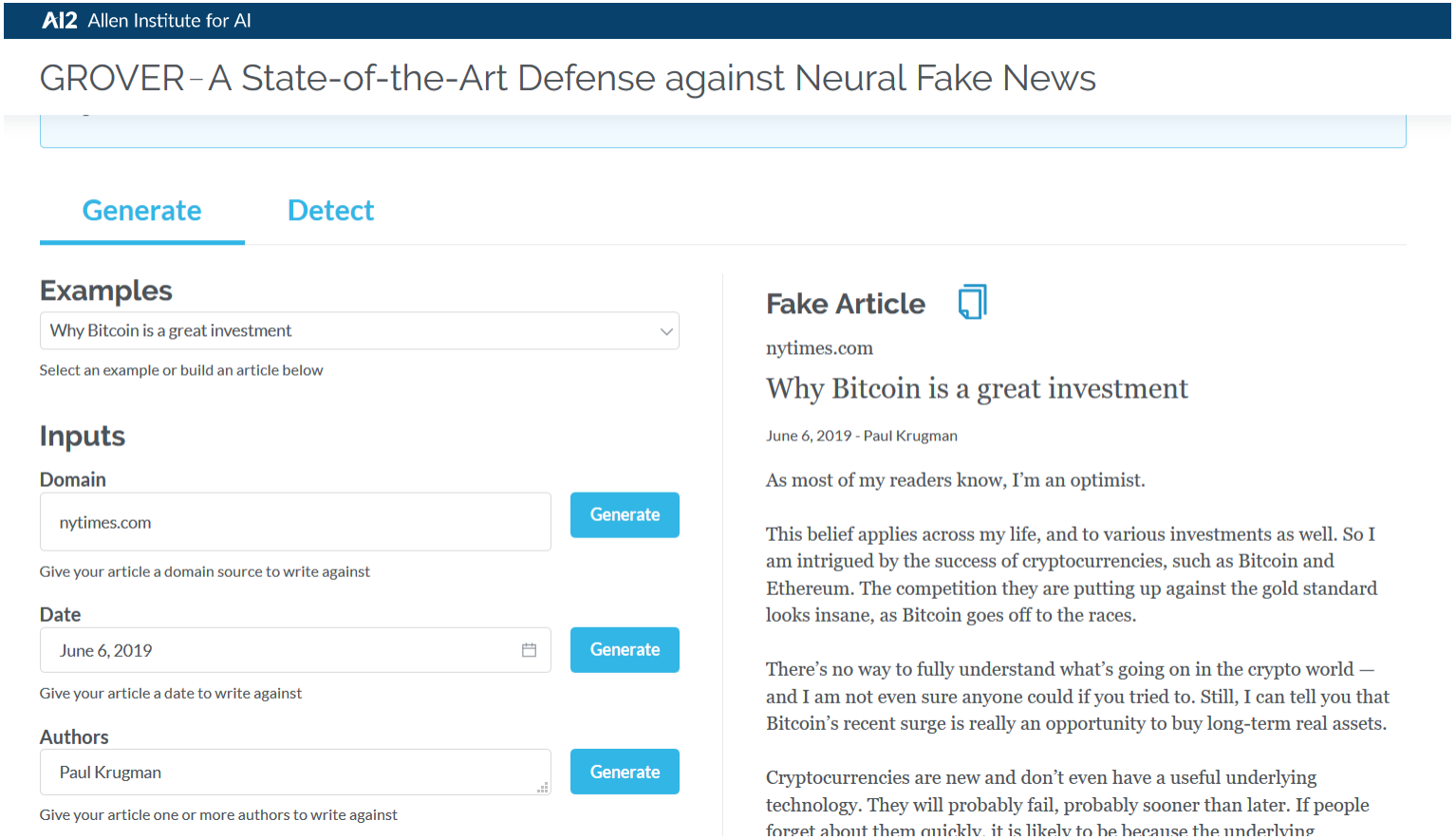
- Machine translation



Slide credit: Carlos Guestrin

Example Deep Learning Tasks

- Fake news generation and detection



https://grover.allenai.org/detect

Example Deep Learning Tasks

- Speech recognition

Slide credit: Carlos Guestrin

Example Deep Learning Tasks

- Robotic application

https://www.bostondynamics.com/

Challenges in Deep Learning

- DL requires a large amount of data for training
- DL is shallow
- DL is opaque
- DL algorithms are vulnerable to spoofing
- DL models may have bias (related to training data)
- Ethics in DL