ROB 498/599: Deep Learning for Robot Perception (DeepRob)

Welcome!

https://deeprob.org/w25/

ROBOTICS

Today

- Introductions (15min)
- Deep Learning x Robot Perception (25min)
- Course Resources (20min)
- P0 starter (10min)

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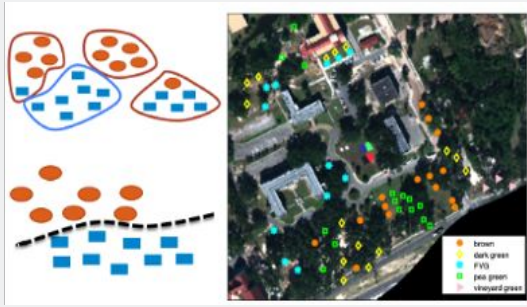
Xiaoxiao Du

[Sounds like “she-OW she-OW doo”]

Assistant Research Scientist
& Lecturer in Robotics

Email: xiaodu@umich.edu
Office: 3257 FRB or virtually

Research Interest: sensor data integration, pedestrian prediction, autonomous driving



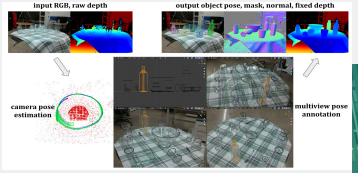
Anthony Opipari

Ph.D. student in Robotics

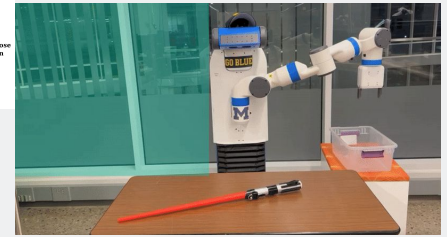
Email: topipari@umich.edu
Office: 2150 FRB (PROGRESS Lab) or virtually

Research Interest: Robot perception, computer vision, image and video segmentation, object pose estimation, goal-directed manipulation

Opipari et al.



Xen et al.



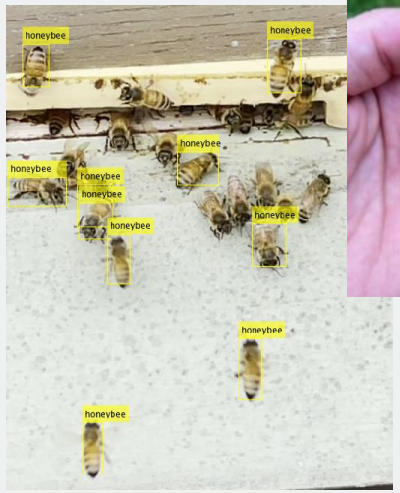
Cale Colony (GSI)

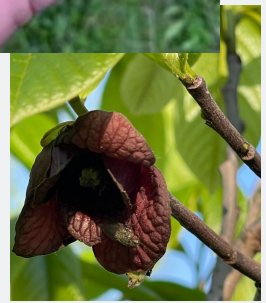
M.S. student in Robotics (Engineering), M.S. student in Sustainable Systems (SEAS)

Dow Sustainability Fellow (2025)
Bosch Sustainability Fellow (2024)
Michigan Climate Venture - Food/Agriculture Lead

Email: ccolony@umich.edu

Research Interest: Agricultural Robotics, Persistent Robotics, Edge ML, Weather/Renewable Energy Forecasting, Sustainable AI





Advaith Balaji (IA)

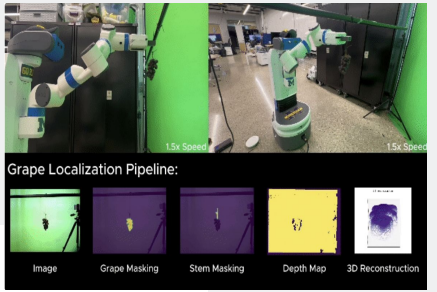
Undergraduate student in Robotics

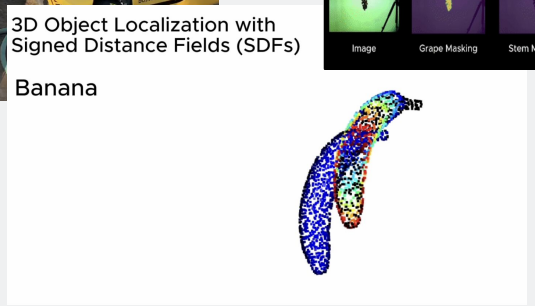
Researcher at ARMLAB

Email: advaithb@umich.edu

Research Interests:

- AI and Robotics for sustainability
- Perception and Planning for Manipulation





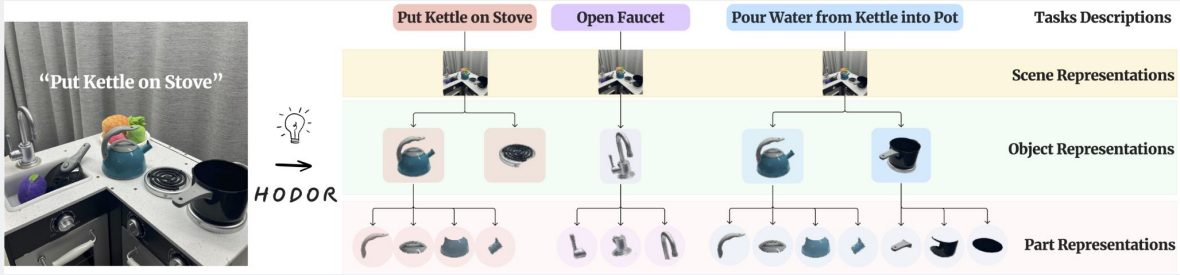
Sydney Belt (IA)

- Undergraduate student in Robotics
- President of UMARV team
- Mapping and Motion Lab Researcher

Email: sydbelt@umich.edu

Research Interests:

- Autonomous Vehicles
- Robot Manipulation
- ML for Embedded Systems



Qian, Jianing, et al. Task-Oriented Hierarchical Object Decomposition for Visuomotor Control. 2 Nov. 2024, https://doi.org/10.48550/arxiv.2411.01284.

Jason Brown (IA)

Undergraduate student in Robotics and Aerospace Engineering

Email: jaybrow@umich.edu

Research Interest: Aerospace and Robotics, exploration, navigation, and sensing

Meha Goyal (IA)

"I took DeepRob in W24, and since then, I've been able to use what I learned to research and build various exciting projects outside of class!"

- Senior studying CS and Business
- 1st semester teaching DeepRob, 4th semester teaching Web Systemd
- From Cupertino, CA

Email: mehag@umich.edu

Research Interest: AI and healthcare applications, entrepreneurial leadership

Nitin Jotwani (Grader)

M.S. student in Robotics

Email: njotwani@umich.edu

Research Interest: Multi-modal fusion, object detection

RGB

Thermal

Distributed Teaching Collaborative

Prof.
Chad Jenkins

Prof.
Karthik Desingh

Prof.
Iris Bahar

Prof.
Tom Williams

Prof.
Kaveh Fathian

UNIVERSITY OF MICHIGAN

UNIVERSITY OF MINNESOTA

COLORADO SCHOOL OF MINES

Special acknowledgment and Thanks to Stanford CS231N

Prof. Justin Johnson
EECS 498/598: Deep Learning for Computer Vision

THE LABORATORY FOR PROGRESS

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Aha Slides
(In-class participation tool)

Try it out!

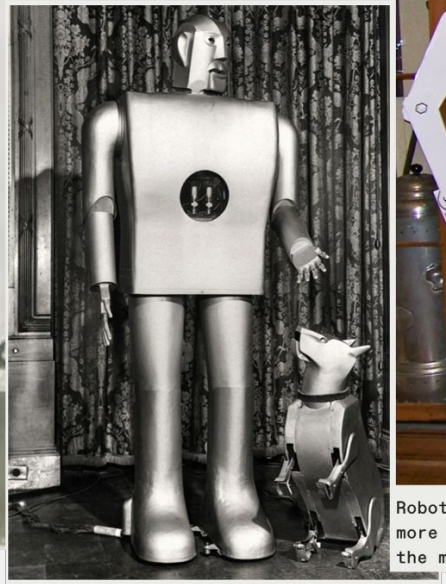
https://ahaslides.com/77GME


FIGURE 01 + OPENAI
SPEECH-TO-SPEECH REASONING

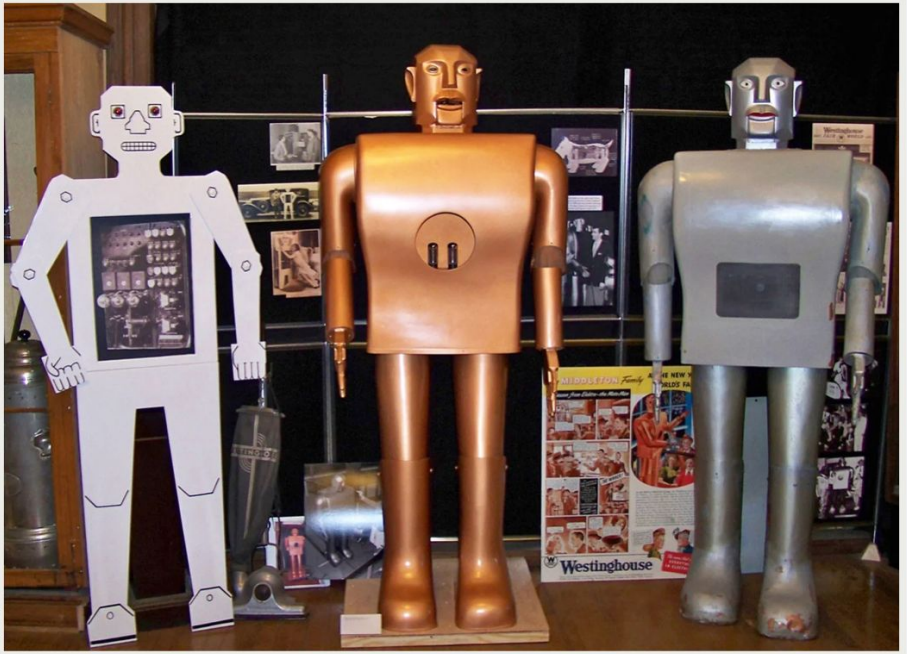

1X END-TO-END AUTONOMY
UPDATE, JAN 2024

How did we get started?

Elektro, 1939



Robot's Best Friend: Westinghouse introduced Sparko the dog as a companion for Elektro. PHOTO: BETTMANN/GETTY IMAGES



Robot Family: Herbert Televox (left) was Westinghouse's first human-form robot. The more famous member of the Westinghouse robot family was Elektro; a copy is shown in the middle, while the original is on the right. PHOTO: MANSFIELD MEMORIAL MUSEUM

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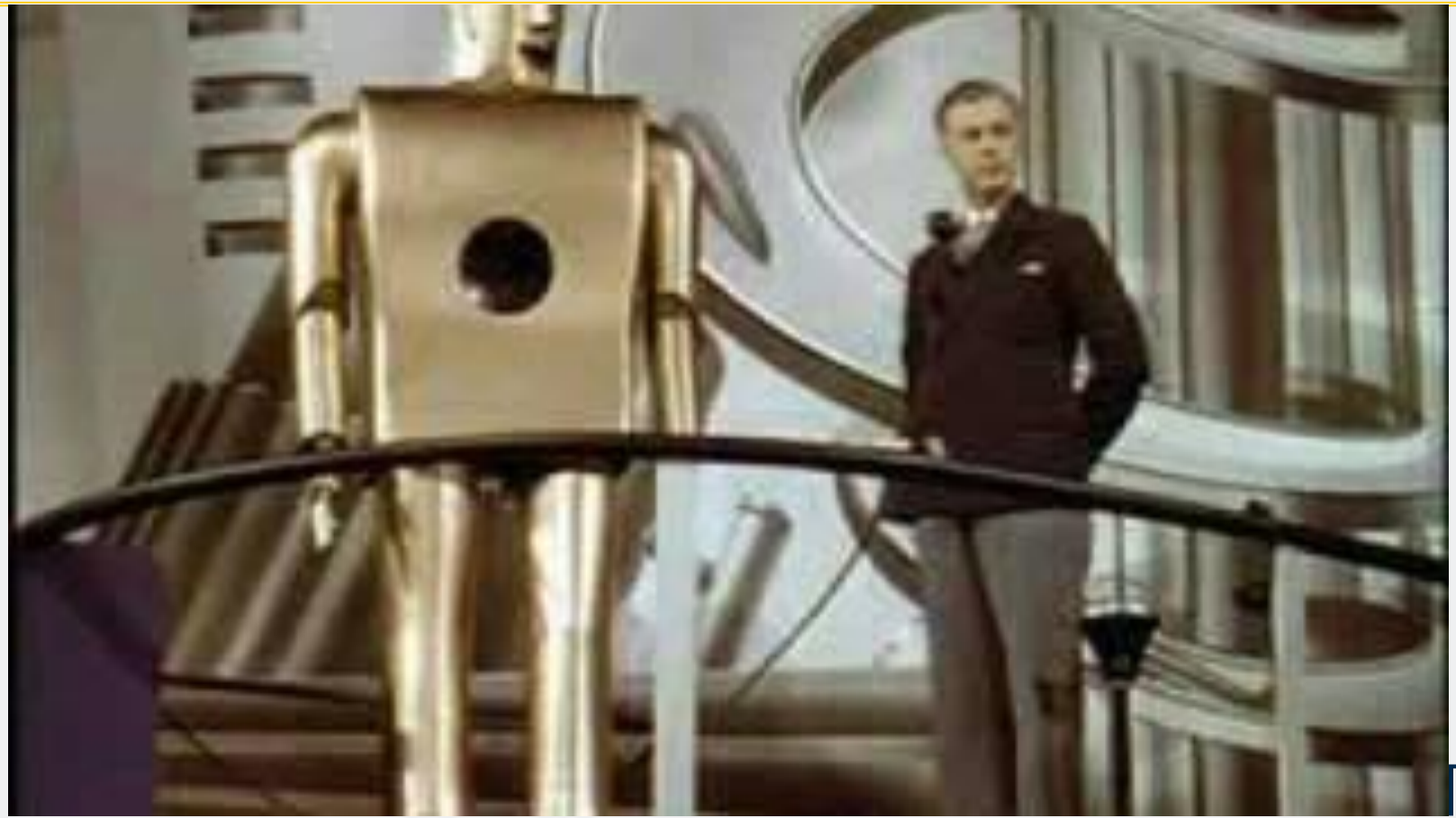
1939 World Fair – First Humanoid Robot



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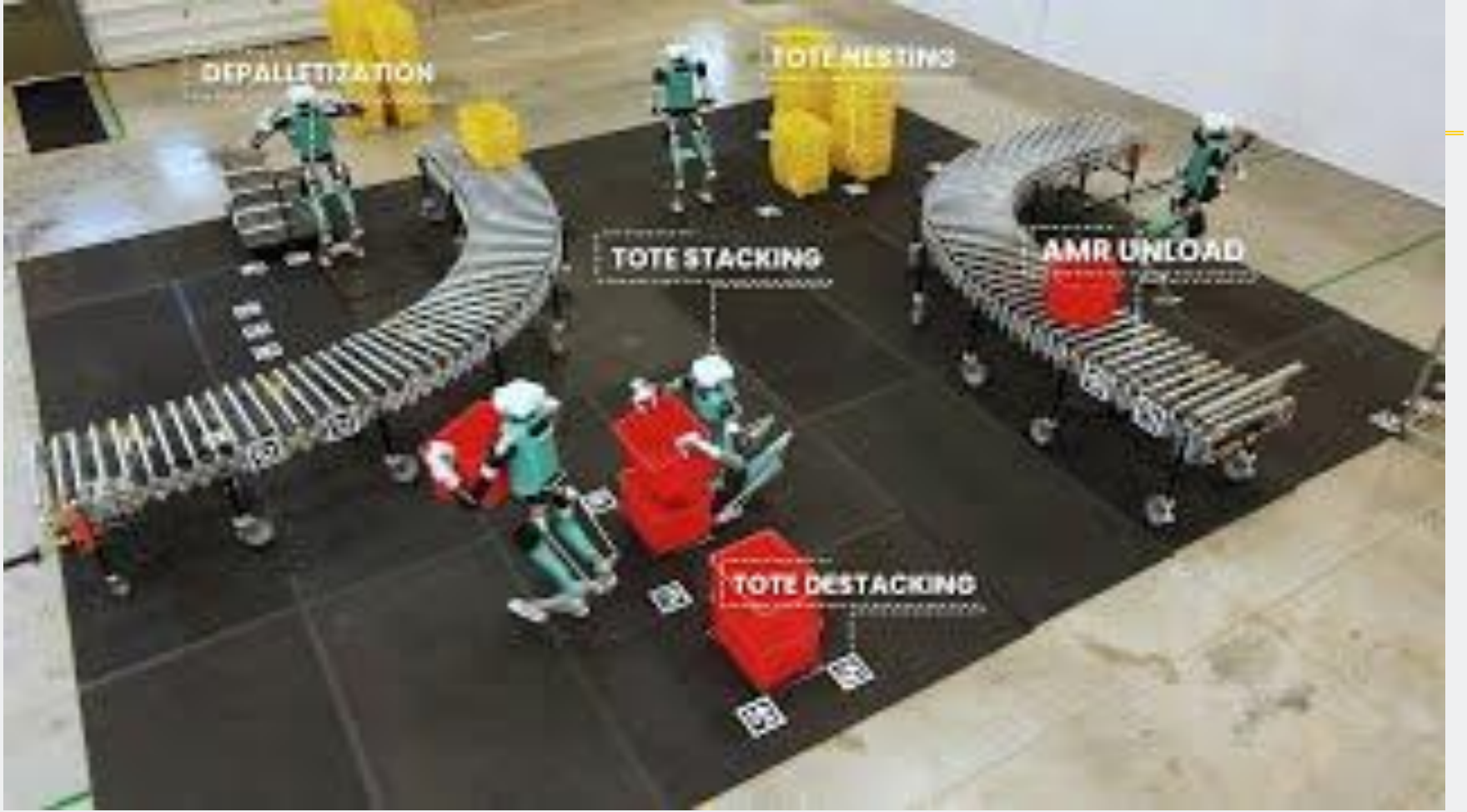
Elektro the Robot and his Dog Sparko (1940s)

(Oct. 2024)


DEPALLETIZATION
TOTE MESTING
TOTE STACKING
AMR UNLOAD
TOTE DESTACKING

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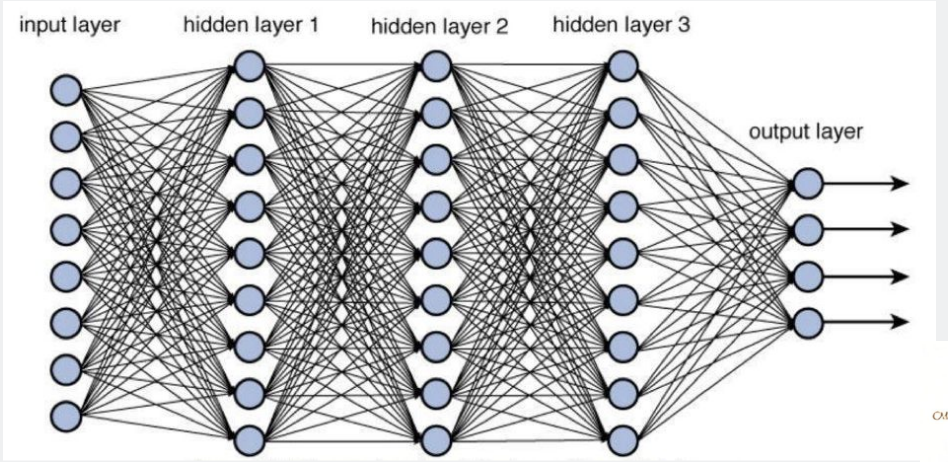
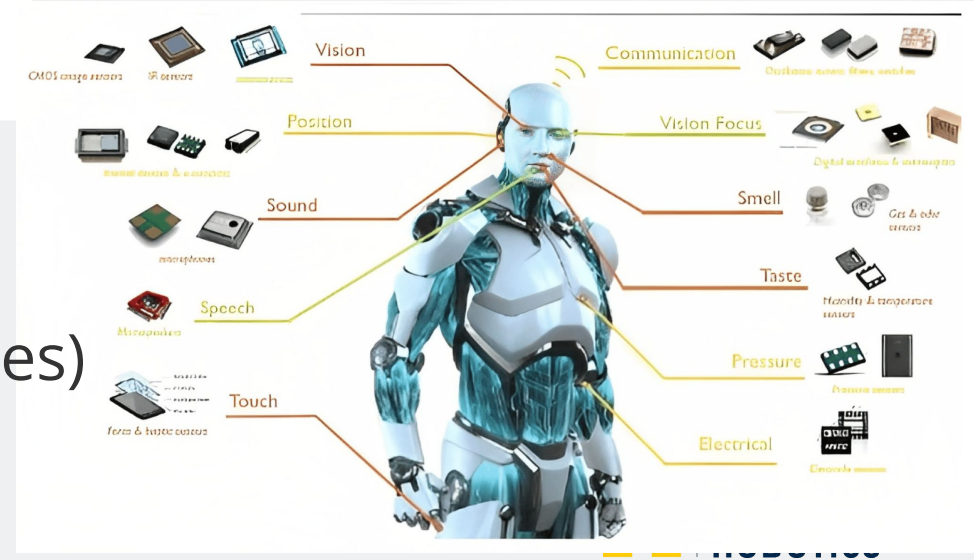
In-hand manipulation

Deep Learning x Robot Perception



Deep Neural Networks



Robot Sensory Data
Commonly, visual data (images)
(but not limited to)

PROGRESS Lab Fetch Robot (2017)

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Final Project (DeepRob 2024 GrapeBot)

More at:
https://deeprob.org/w24/reports/

Advaith Balaji, Isaac Madhavaram

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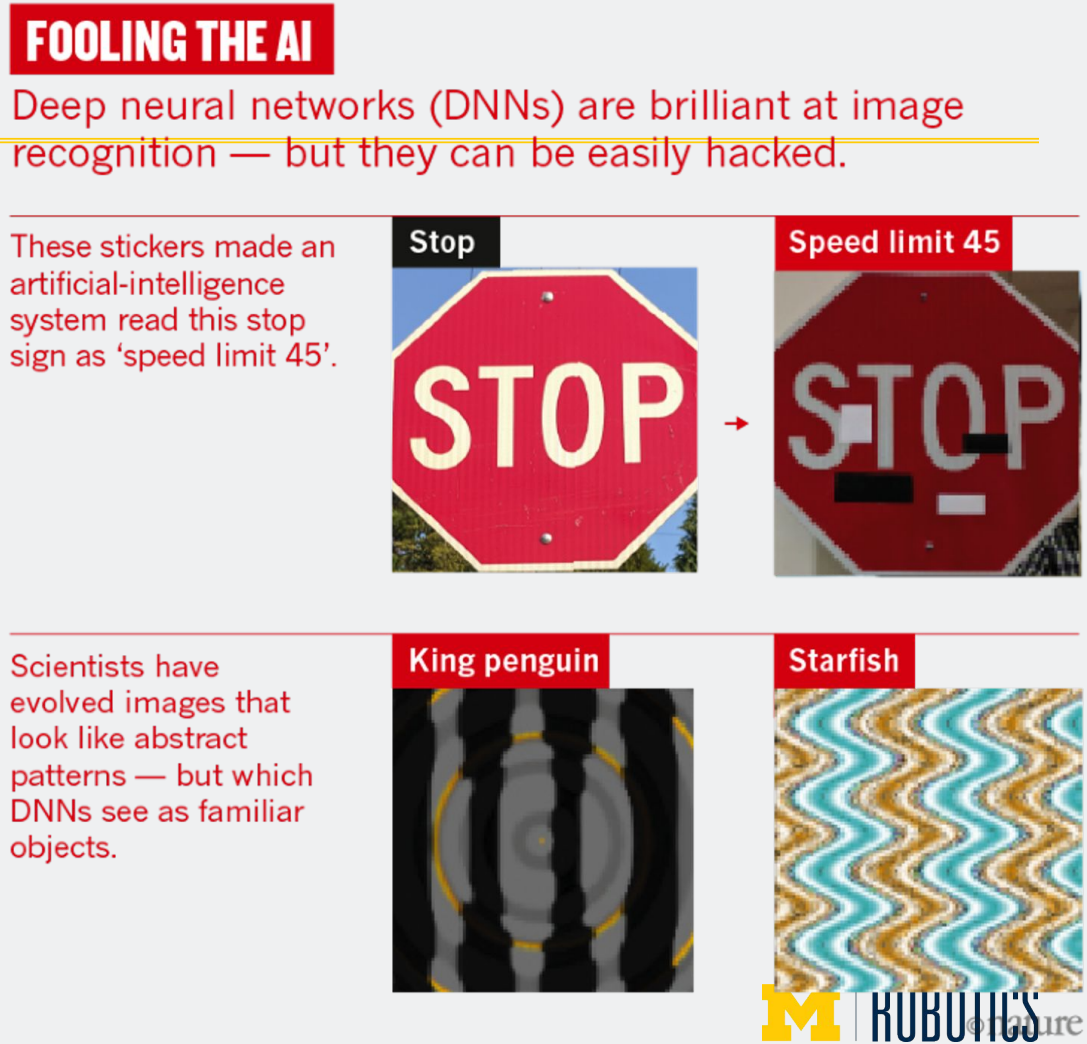
Challenges in DL

- "Easy to fool"
- Large volume of data
- Limited annotation/labels
- Ethics
- …



Challenges in DL

- "Easy to fool"
- Large volume of data
- Limited annotation/labels
- Ethics
- …

Baseball—or stripes?
mixed4a, Unit 6

Animal faces—or snouts?
mixed4a, Unit 240

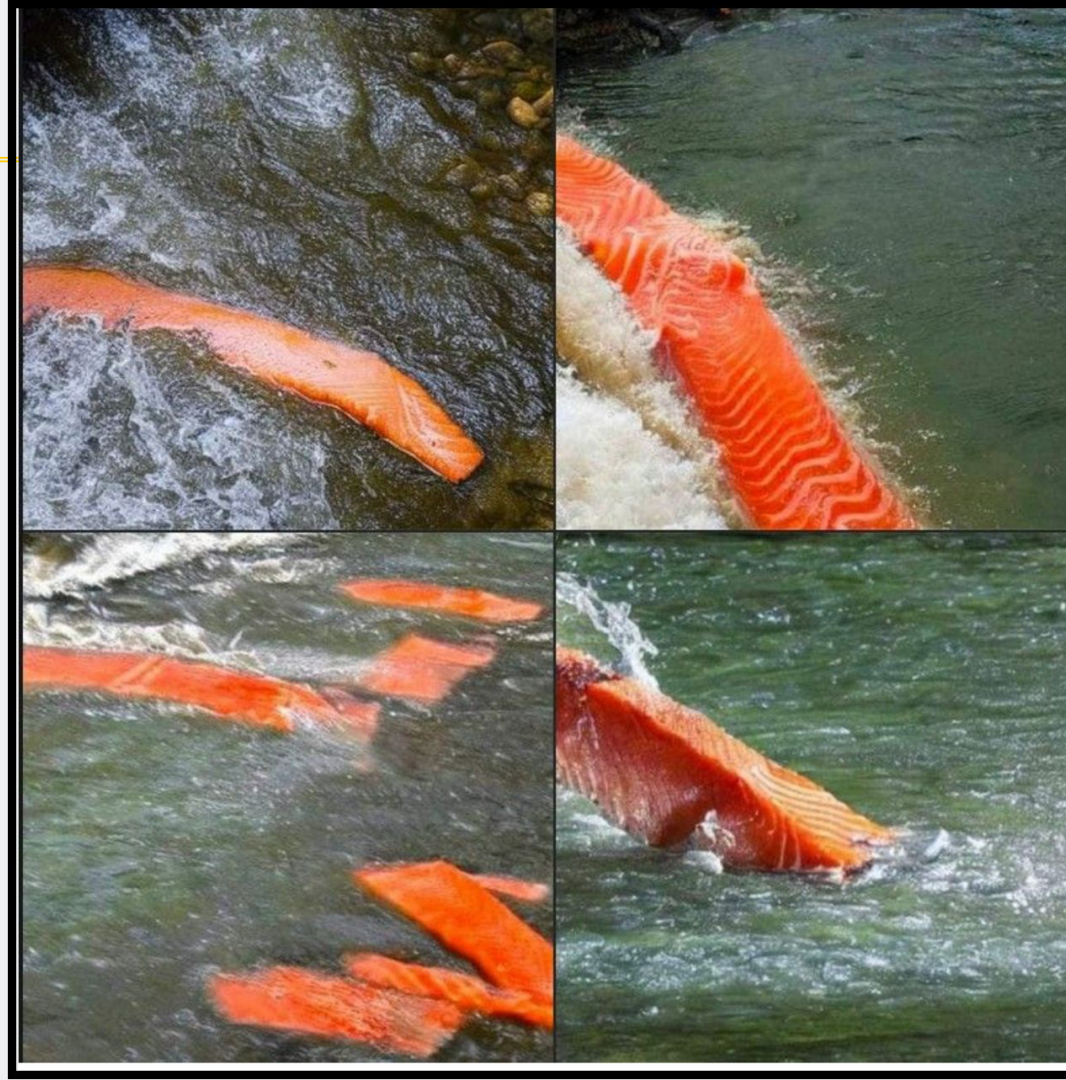
Clouds—or fluffiness?
mixed4a, Unit 453

Buildings—or sky?
mixed4a, Unit 492

Challenges in DL

- “Easy to fool”
- Large volume of data
- Limited annotation/labels
- Ethics
- …

“a salmon swimming down a river”



Other Robotics and AI courses

First wave AI: Model-based

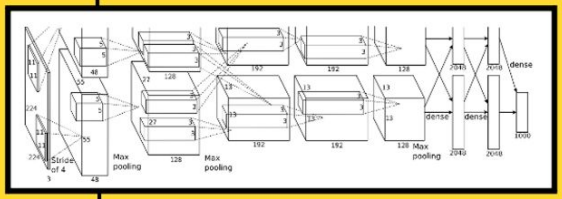
"Think through the entire problem"

1956

DeepRob is a step into modern robot learning

Second wave AI: Data-driven

"Learn from lots of data"



2011

Research for future AI

Third wave AI: Explainable

"Combine first and second wave AI to generate explanations"

??

20??

Time

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Course Resources

Google Drive (lectures slides, jupyter notebooks, etc.) https://drive.google.com/drive/folders/1vOz1SA_fb1ebIe0JIaFMHA3AdwKkh7sG?usp=sharing

Course website https://deeprob.org/w25/

Canvas https://canvas.it.umich.edu/

Piazza (Q&A, project help, etc.): https://piazza.com/umich/winter2025/rob498011598012

Autograder (project submissions): https://autograder.io/

Office Hour Queue https://oh.eecs.umich.edu/courses/rob498-599

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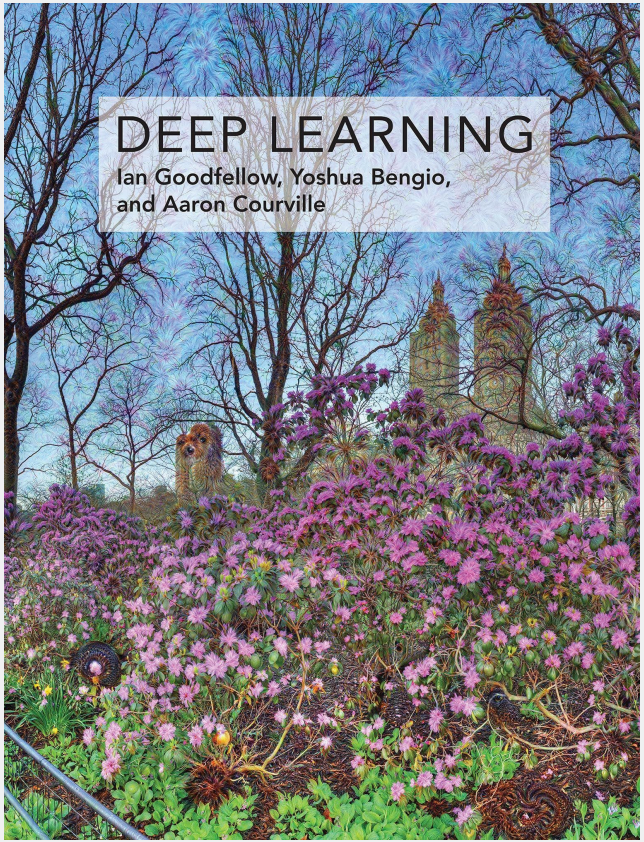
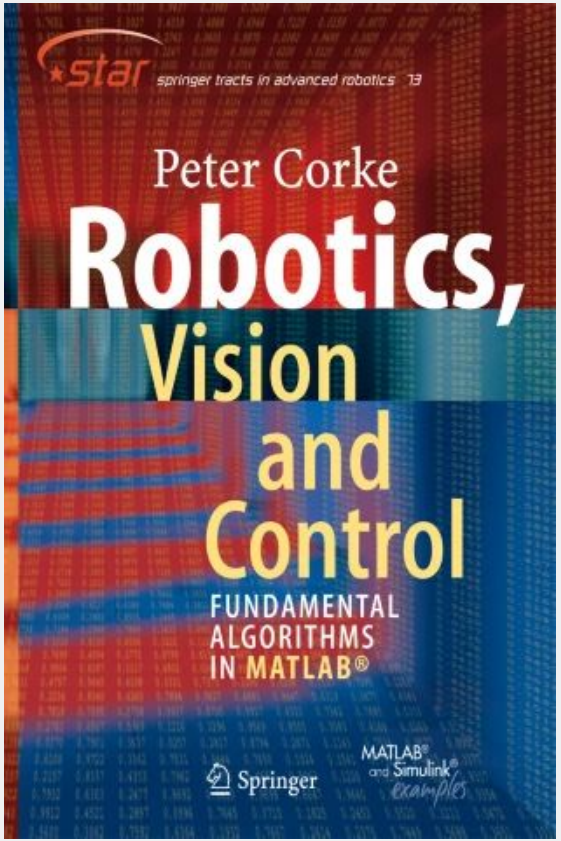
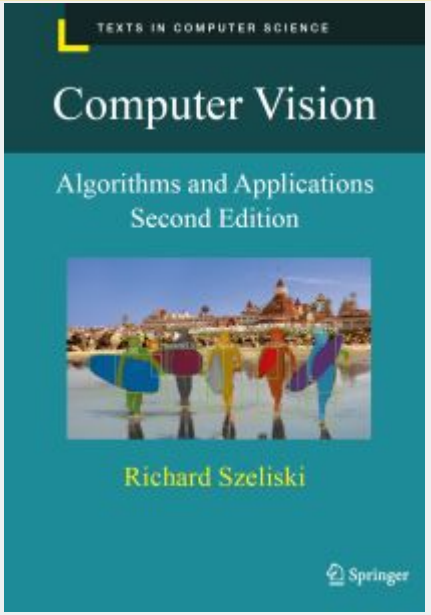
Reference Textbooks

(not limited to)







Robotics {book}

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Grading

- Programming Projects (individual) **(52%)**
  - Project 0 5%
  - Project 1 10%
  - Project 2 17%
  - Project 3 10%
  - Project 4 10%
- Midterm (individual) **(10%)**
- Final Project (Group) **(23%)**
  - Proposal Presentation 5%
  - Final Report and code (paper reproduction, algorithmic extension) 15%
  - Showcase (Video, Website, etc.) 3%
- In-class activities (individual) [quiz, notebooks, etc.] **(10%)**
- Participation (individual) [in class participation, office hours, Piazza, etc.] **(5%)**

Total: 100%

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Assignments

- P0: Intro to Python and PyTorch
- P1: KNN and Linear models
- P2: Classification and Detection using CNNs
- P3: Pose Estimation
- P4: Transformers
- Occasional in-class activities (Aha Slides, Codes, etc.)
- Mid-term (in-class)
- Final Project

Lecture content

- Image Classification (linear/non-linear)
- Training and Optimizing Neural networks
- Backpropagation
- Convolutional Neural Networks
- Pose Estimation
- Transformers
- Generative Methods

- Frontiers in DL
  - Neural Rendering (Nerf, Gaussian Splatting)
  - Diffusion
  - Language models
  - Reinforcement learning
  - Applications
  - …

If you have ideas, please feel free to reach out!

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GenAI Activity

U-M GenAI website: https://genai.umich.edu/

Activity: Use DALL-E to generate images based on prompts such as “deep learning for robot perception” “deep learning for robot perception and manipulation” and submit the generated images under Piazza thread.

Piazza: https://piazza.com/umich/winter2025/rob498004599005/home

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GenAI Course Policy

For individual projects (P0-P4) and mid-term, NOT ALLOWED - must complete code yourself

For final project, permitted to brainstorm with disclosure

See Course Information Document for more details

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Collaboration Policy

✅ Encouraged Collaboration	❌ Unacceptable Collaboration
✔ Discussing high-level design strategies, e.g., helper function organization or data structure choices	✘ Walking through an important piece of code step-by-step, sharing pseudocode, sharing comments
✔ Helping others understand the spec or project nuances	✘ Give someone your code as a reference
✔ Explaining a compiler or runtime error to someone	✘ Fixing/Debugging a compiler or runtime error for someone
✔ Brainstorming edge cases for testing	✘ Discussing specifics about what test cases are on the autograder, especially if one person has submitted already and the other is still working on the code
✔ Sharing template code/code updates (if any) provided by the course staff	✘ Copying code in whole or in part, or writing original code for someone else, or having someone else write your project
✔ Looking at small snippets of someone else's code to understand concepts	✘ Copy code, or sharing your code in a way that could be copied, e.g., sending code over email or taking a picture of code

Collaboration Policy

- **Group assignment (final project) will contain a signed statement of contribution with your submission**

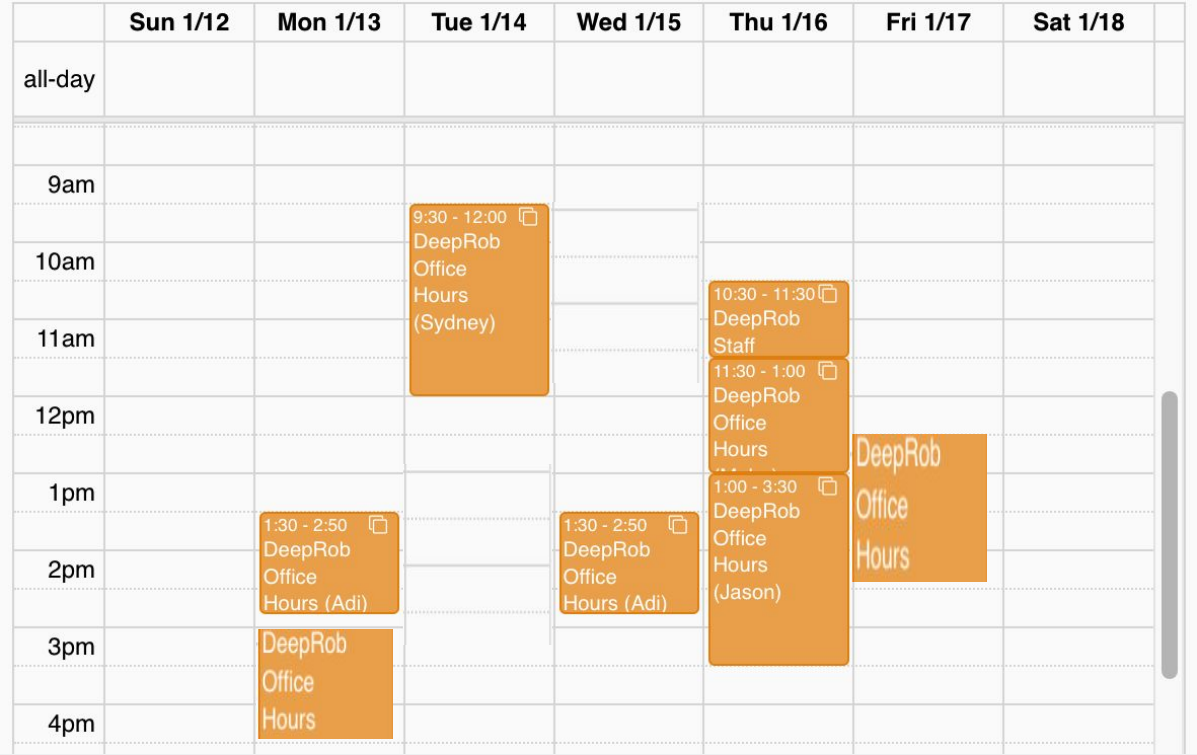
  "I participated and contributed to team discussions on each problem, and I attest to the integrity of each solution. Our team met as a group on [DATE(S)]. "

  “Contribution of Authors: [Team member A] did [Task XXX]; [Team members B and C] did [Task YYY]; [Team members A, B and C] did [ZZZ]. [All authors] [gave feedback on the software development, contributed to writing the report/making the demo presentation, and approved the final version for submission.]”

- **All members are expected to contribute to the project implementation (codes) as well as write-up and final presentation**

Office Hours

- See Course Info doc



*May have small changes - stay tuned

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P0 Starter

P0 folder:
https://drive.google.com/drive/folders/1gJKZlMKRuLmA4EsICxrREa3dujlyY9XC?usp=drive_link

Please create a “DeepRob” folder in your own Google Drive, and put P0 folder under there. This will be your individual private copy of the code - do NOT change the starter code in shared folder!

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