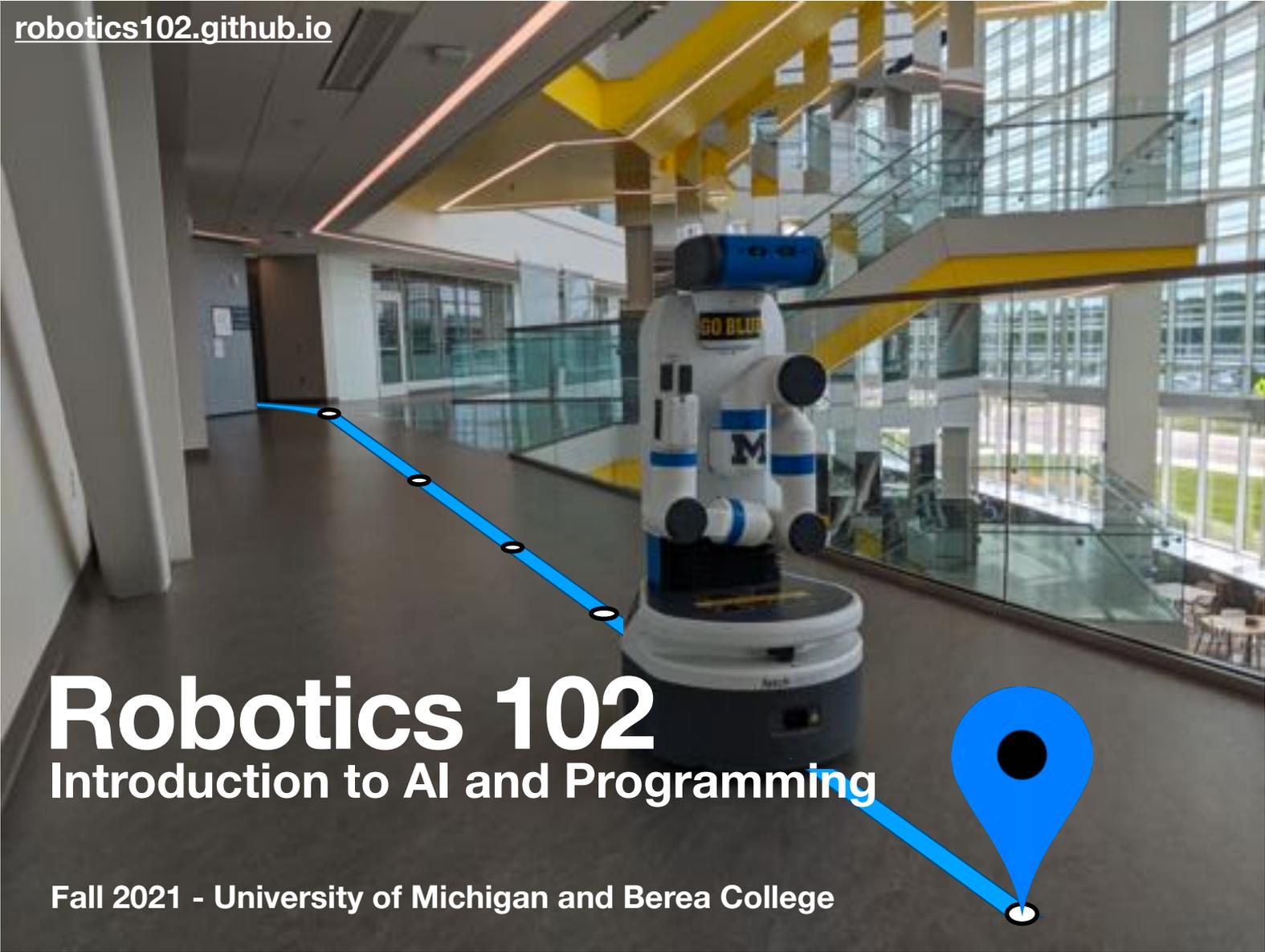


[robotics102.github.io](https://robotics102.github.io)

# Robotics 102

## Introduction to AI and Programming

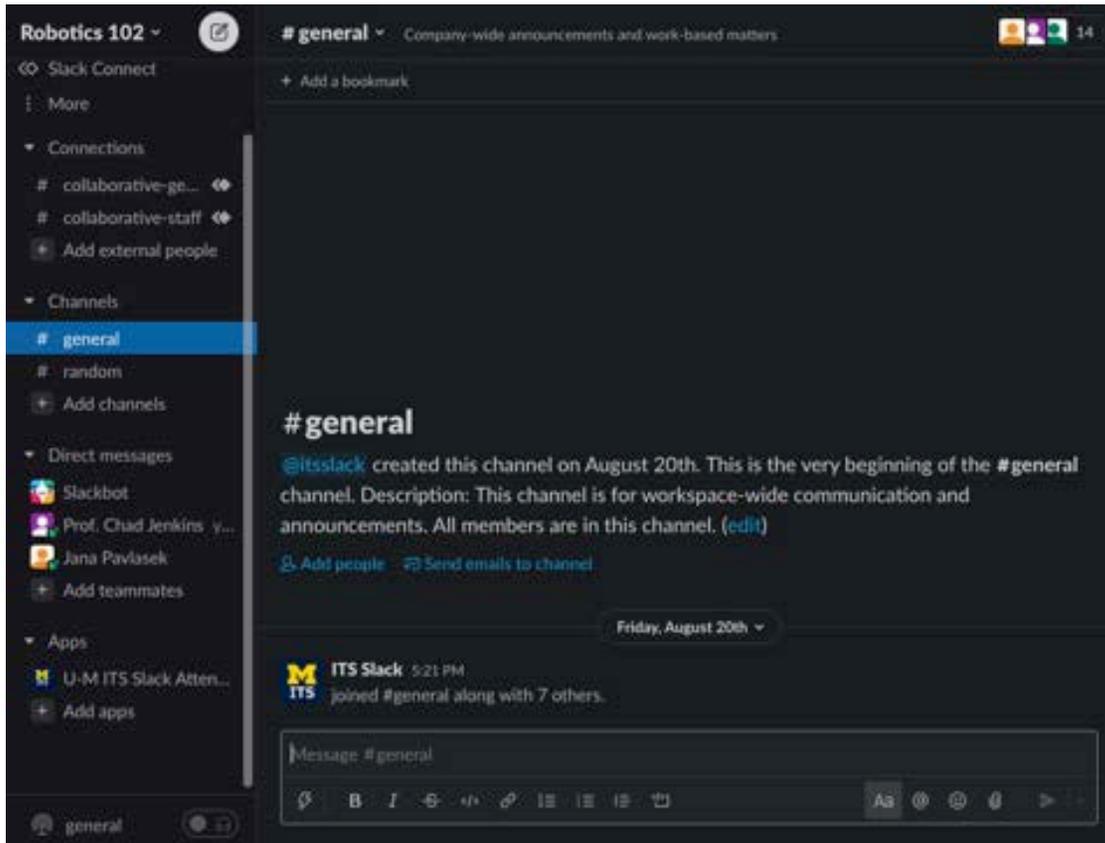
Fall 2021 - University of Michigan and Berea College



**Two Action Items for Today**

# Two Action Items for Today

Join Robotics 102 Slack Workspace



Complete Student Workflow Survey  
<https://forms.gle/HH6nPQNiNDZMR61z9>

**Student Workflow Survey - Robotics 102 Fall 2021**

This survey is being conducted for students of the Robotics 102 course (<http://robotics102.org>) at Michigan for the Fall 2021 semester. The purpose of this survey is to better understand student perspectives and their working environment of students coming into the course. Such insights are especially useful given the constraints of the COVID-19 pandemic. The results of this survey will be used to improve this pilot offering of Robotics 102, determine necessary accommodations for individual students, and adapt the administration of the course to best serve all students.

**Last Name or Family Name**

Short answer text

**First Name**

Short answer text

**Unique Name (e.g., ocj.pavlsek)**

Short answer text

**What is your anticipated major?**

Short answer text

# First Class

Action items: Join *robotics102* slack team, Complete workflow survey

Introductions

Safety and Masking Policies

*Autonomous navigation is all around!*

The engine of AI: Graphs and graph algorithms

*We are pioneers for robotics!*

Course objectives and administrative overview

Flipped classroom: “Hello world!” Lecture will be posted soon

Upcoming projects: Project 0 (Calculator) assigned Aug 30, due Sep 20

# **Introductions**

**Let's get to know each other**

# **Prof. Chad Jenkins**

**Office Hours: MW 1-3pm Eastern, Robotics 2236**

Michigan Robotics 102 Course Instructor



Faculty in Michigan EECS, PhD 2003 (Univ. Southern California)

Favorite song: Friday Morning by Khruangbin

Best use of robotics: Help care for our aging and disabled populations

# Jana Pavlasek

**Office Hours:**

Michigan Robotics 102 Co-Instructor

4th year doctoral student in Michigan Robotics

Favorite musical artist: Busty and the Bass

Best use of robotics: remote monitoring of our environment and planet



**Your health and wellness is  
our top priority**

**Your health and wellness is  
our top priority**

**Proper safety is mandatory**

<https://campusblueprint.umich.edu/faqs/>

U-M COVID-19 Vaccination Requirement: [SUBMIT YOUR INFO BY AUG 30](#)

STUDENTS + FAMILIES FACULTY + STAFF COMMUNITY VISITORS [REPORT COVID-19 VACCINATION](#)

 [VACCINE](#) [PREVENTION, TESTING & CARE](#) [FAQS](#) [MESSAGES](#) [U-M COVID-19 DATA](#) [SEARCH](#)

# FAQS

## FAQ Topics

- [COVID-19 Basics](#)
- [Quarantine & Isolation](#)
- [Testing](#)
- [CSTP Testing FAQ](#)
- [Vaccination & Self-reporting](#)
- [Case Investigation & Contact Tracing](#)
- [Policy & Compliance](#)
- [Events & Gatherings](#)
- [ResponsiBLUE](#)

## COVID-19 Basics

- + [COVID-19 symptoms and spread](#)
- + [How do I prevent COVID-19?](#)
- + [I think I've been exposed to/have COVID-19, what should I do?](#)

## Quarantine & Isolation

- + [Quarantine and isolation](#)
- + [I've been vaccinated: do I still need to quarantine after a COVID-19](#)



August 2020



August 2021

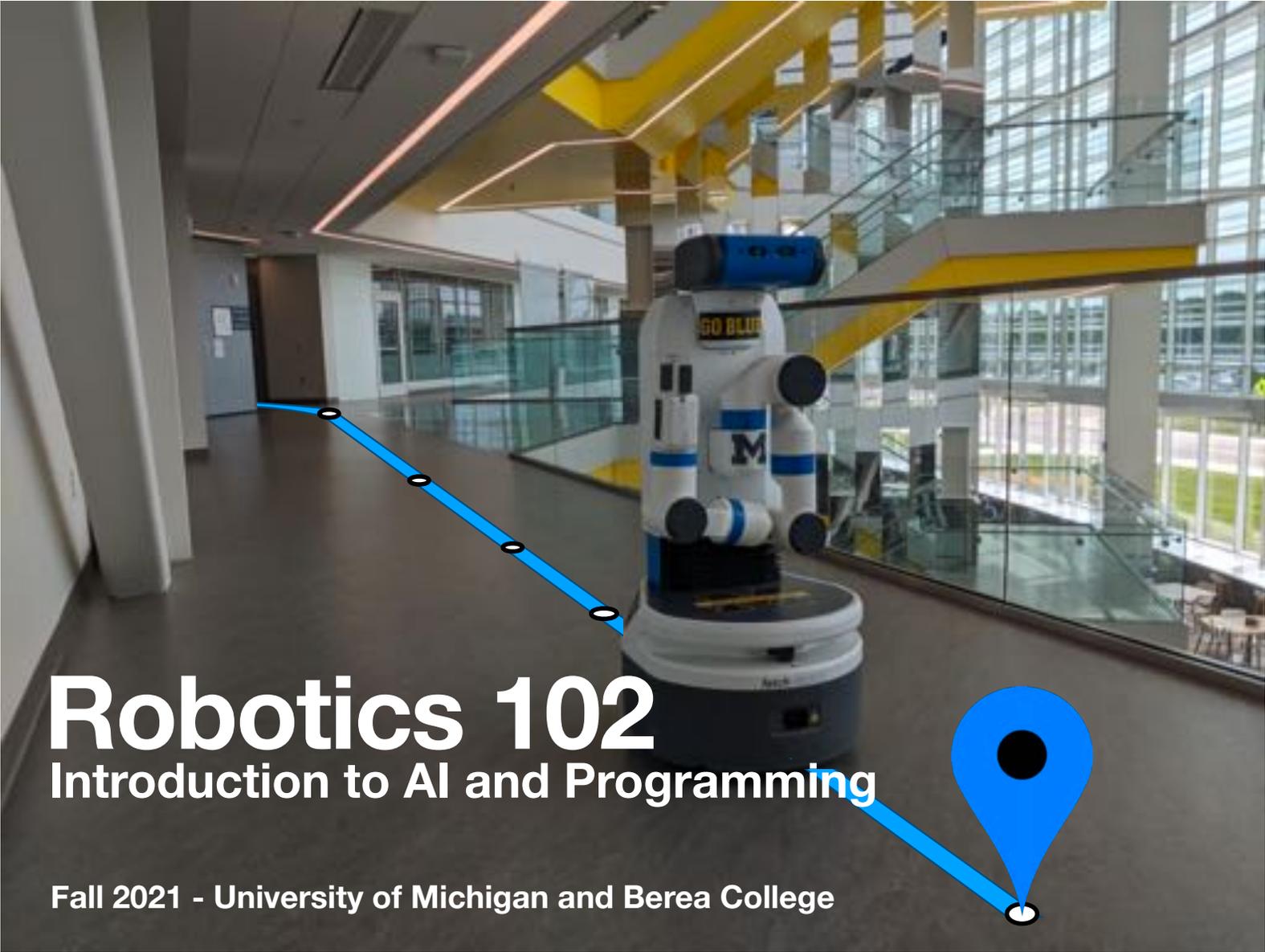


April 2021



July 2021

Academic Year 2021-22 ?



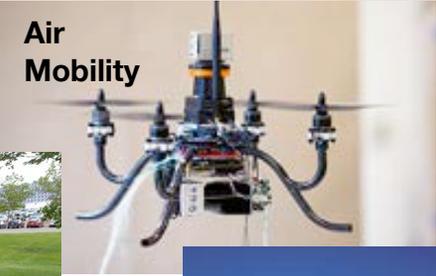
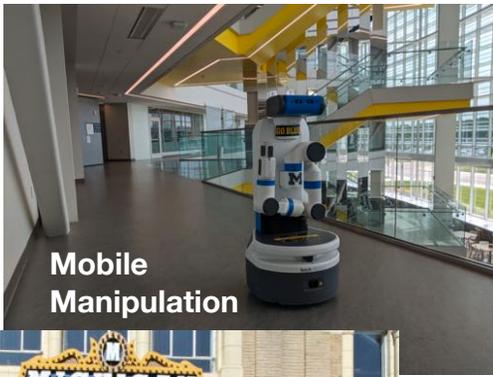
# Robotics 102

## Introduction to AI and Programming

Fall 2021 - University of Michigan and Berea College



**Autonomous Navigation  
is all around you**

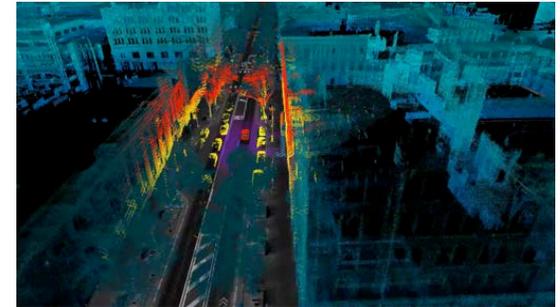


First wave AI: Model-based

“Think through the entire problem”



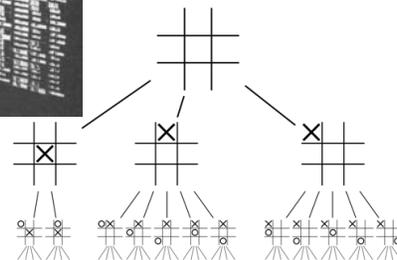
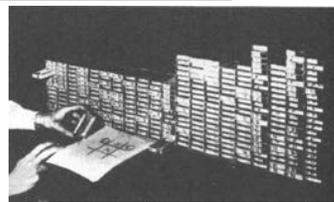
City-scale 3D mapping



Self-driving cars



Online route navigation



1956

1960

1970

1980

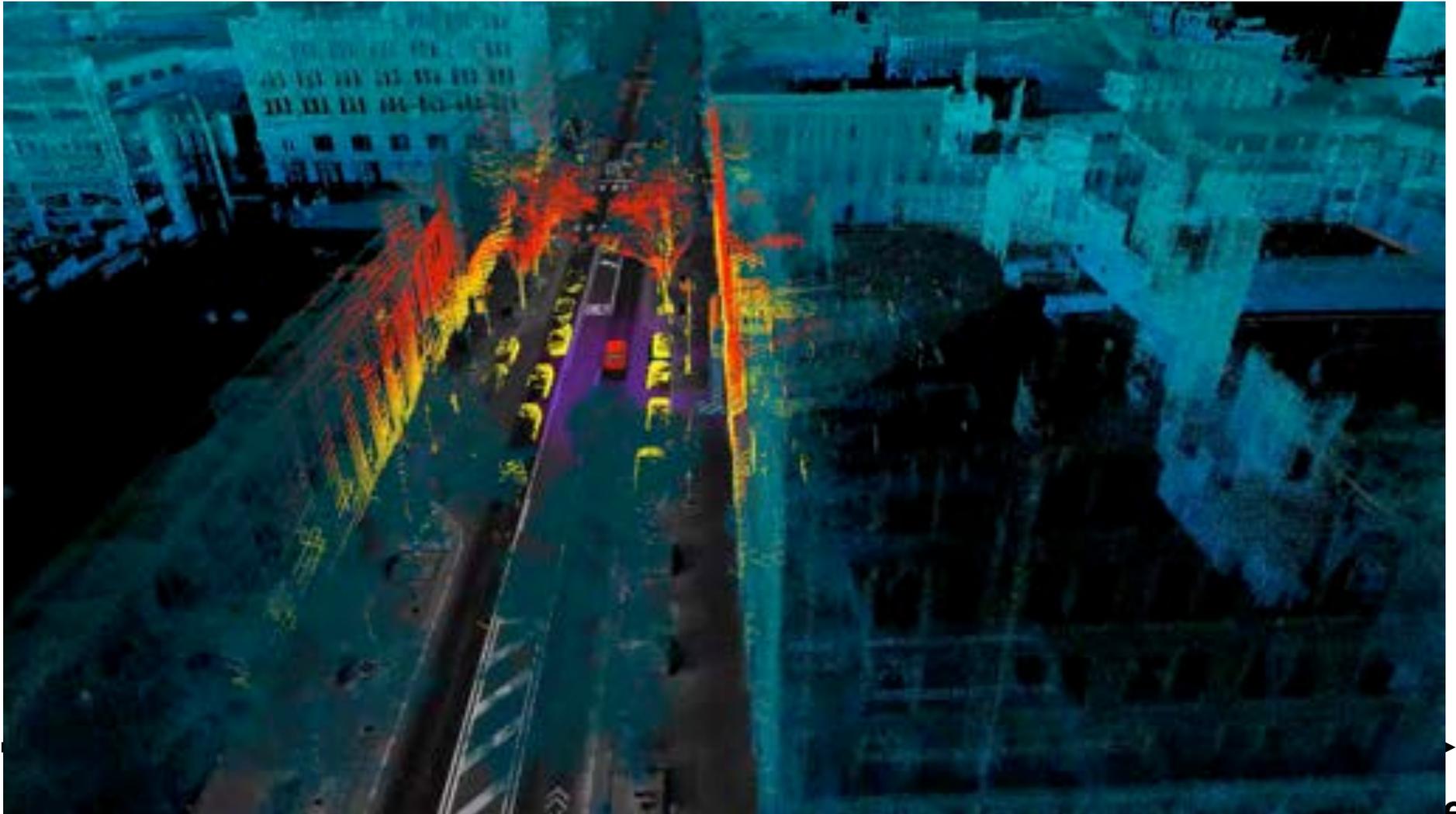
1990

2000

2010

Time

City-scale 3D mapping

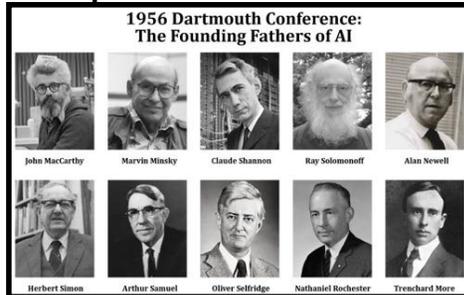


Let's watch this video closely

time

First wave AI: Model-based

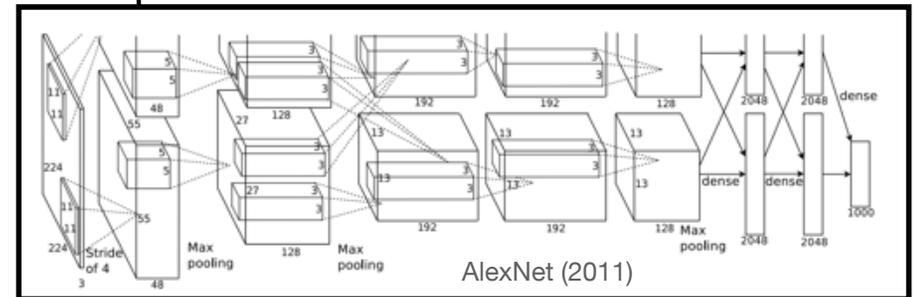
“Think through the entire problem”



Second wave AI: Data-driven

“Learn from lots of data”

Rise of “deep learning”

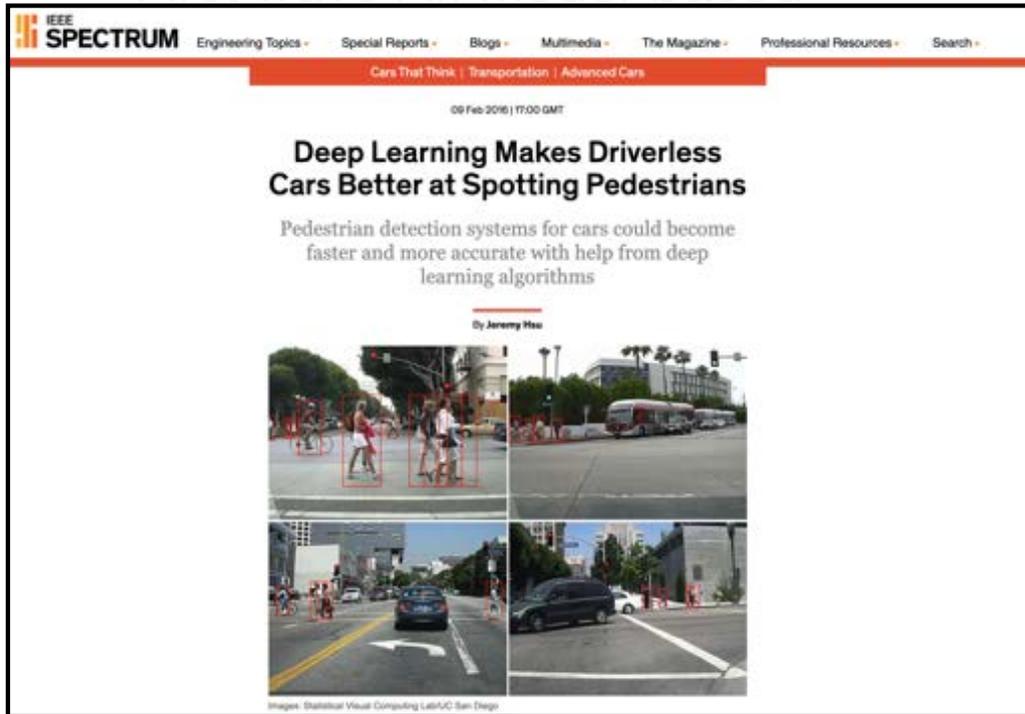


1956

2011

Time

First wave AI: Model-based



Second wave AI: Data-driven

“Learn from lots of data”



“deep learning”

1956

2011

Time

The AI of today needed decades of investment and research

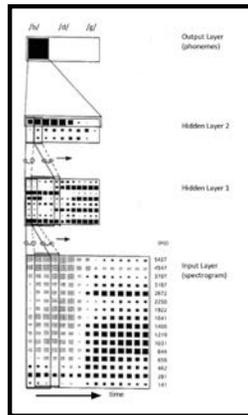


Rosenblatt's Perceptron

1958



Speech recognition by neural networks



Waibel et al.

1989

Second wave AI: Data-driven

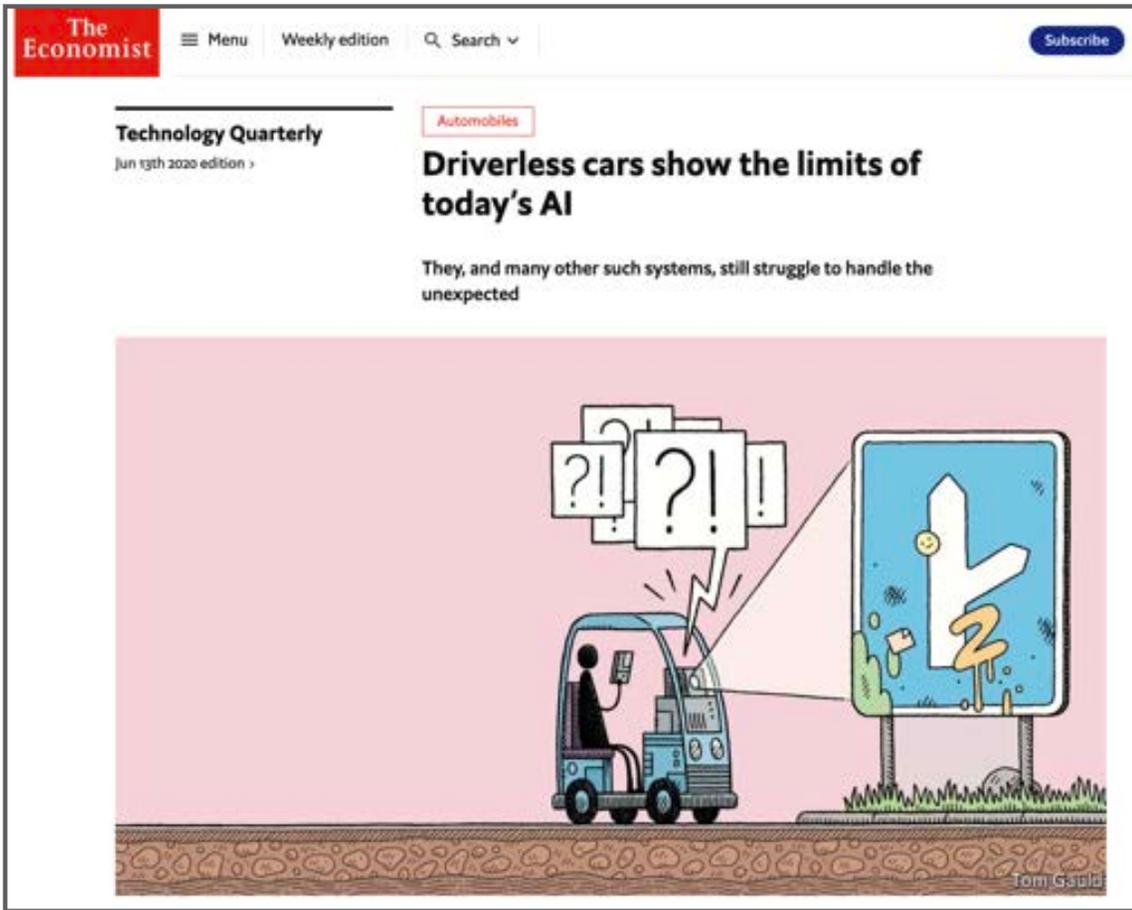
“Learn from lots of data”



“deep learning”

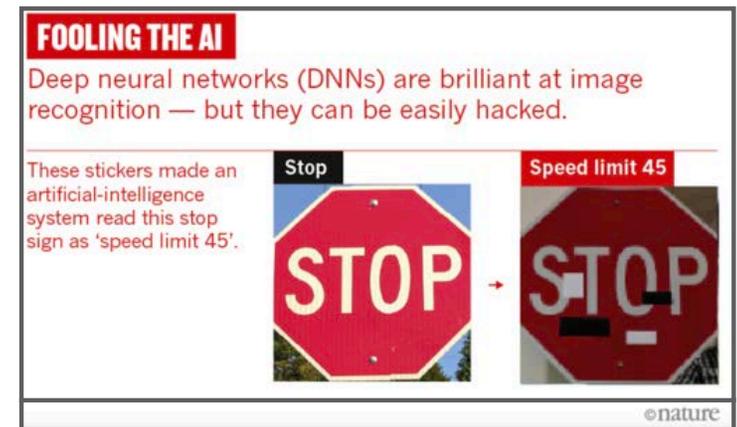
2011

Time



Second wave AI: Data-driven

“Learn from lots of data”



1956

2011

Time

First wave AI: Model-based

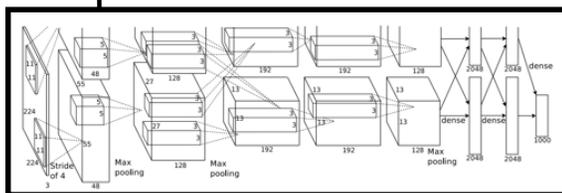
“Think through the entire problem”



1956

Second wave AI: Data-driven

“Learn from lots of data”



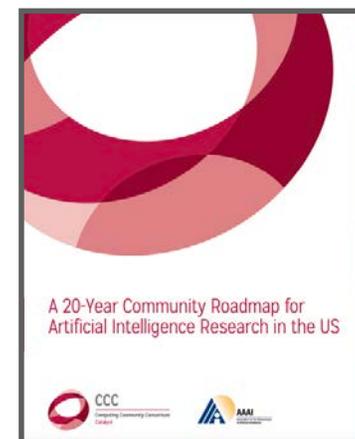
2011

Third wave AI: Explainable

“Combine first and second wave AI to generate explanations”



20??



Time

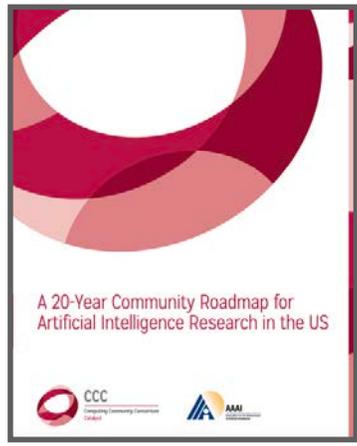
First wave AI: Model-based

Second wave AI: Data-driven

Third wave AI: Explainable

**Is this handwritten character a '9' or a '4'?**

“Combine first and second wave AI to generate explanations”



AlexNet

1956

2011

20??

**Time**

YouTube Search

# Models to drive decisions

Probable number of strokes: 1 - 4  
 Each stroke: probable trajectory  
 Each trajectory: probable shift in shape and location

**Seed model**

**Generative model**  
 Generates explanations of how a test character might have been created

**Training data**

DARPA

14:54 / 16:11

A DARPA Perspective on Artificial Intelligence

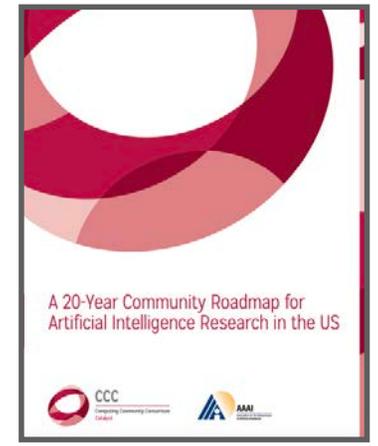
241,472 views · Feb 15, 2017

5.5K 130 SHARE SAVE ...

DARPA DARPAtv 143K subscribers SUBSCRIBE

Third wave AI: Explainable  
 "Combine first and second wave AI to generate explanations"

icate



1956

2011

20??

Time

First wave AI: Model-based

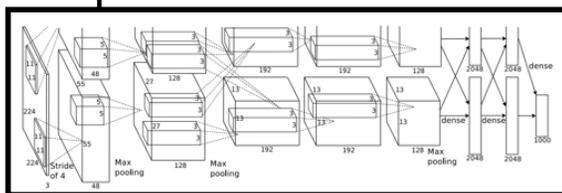
“Think through the entire problem”



1956

Second wave AI: Data-driven

“Learn from lots of data”



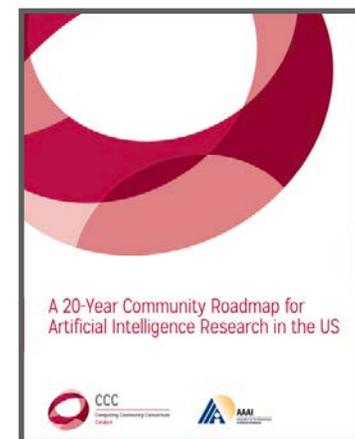
2011

Third wave AI: Explainable

“Combine first and second wave AI to generate explanations”



20??



Time

# Robotics 102 is a first step into modern AI

First wave AI: Model-based

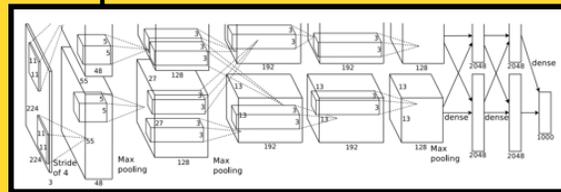
“Think through the entire problem”



1956

Second wave AI: Data-driven

“Learn from lots of data”



2011

Third wave AI: Explainable

“Combine first and second wave AI to generate explanations”



20??



Time

## Robotics 102 is a first step into modern AI

First wave AI: Model-based

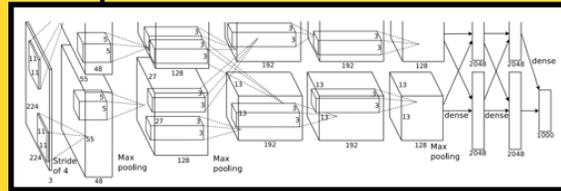
“Think through the entire problem”



1956

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

**Our goal**

# Our goal

Give you the power of autonomous navigation



# Our goal

Give you the power of autonomous navigation



# Our goal

Give you the power of autonomous navigation



# **Our goal**

**Give you the power of autonomous navigation**

# **Your task**

**Understand foundational AI algorithms  
and implement them in code**

# Our goal

Give you the power of autonomous navigation



**“KiMBot”**  
Kiwi Drive MBot

# Our goal

Give you the power of autonomous navigation



**“MBot Omni”  
Kiwi Drive MBot**

Robotics 102 Trailer (by Brody!)  
In the Michigan Robotics Building  
<https://youtu.be/XN5VHmK1mTM>



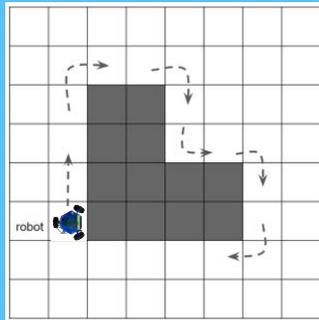
# Understand foundational AI algorithms and implement them in code



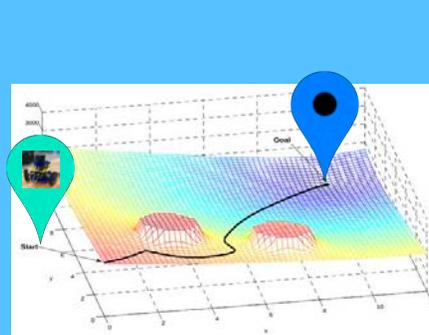
## C++ Programming



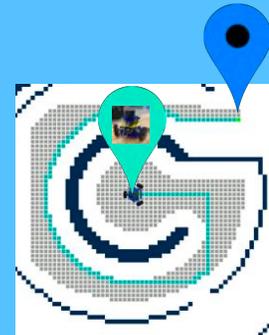
**Project 0:**  
Pocket  
Calculator



**Project 1:**  
Wall  
following



**Project 2:**  
Potential  
Fields



**Project 3:**  
A\*  
Pathfinding

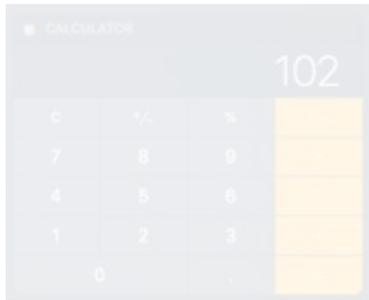


**Project 4:**  
Neural  
Networks

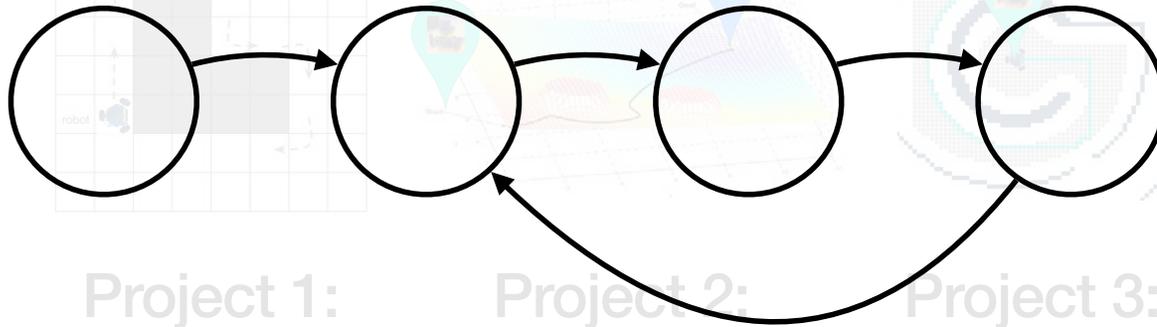


# Understand foundational AI algorithms and implement them in code as Graphs and Graph algorithms

A graph is a collection of nodes (noted by circles)  
that are connected by edges (noted by arrows)



Project 0:  
Pocket  
Calculator

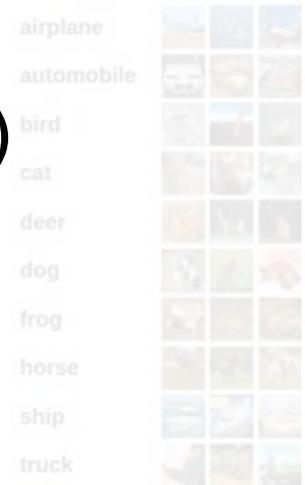


Project 1:  
Wall  
following

Project 2:  
Potential  
Fields

Project 3:  
A\*  
Pathfinding

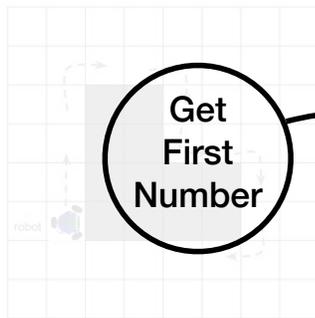
Project 4:  
Neural  
Networks



# Understand foundational AI algorithms and implement them in code as Graphs and Graph algorithms

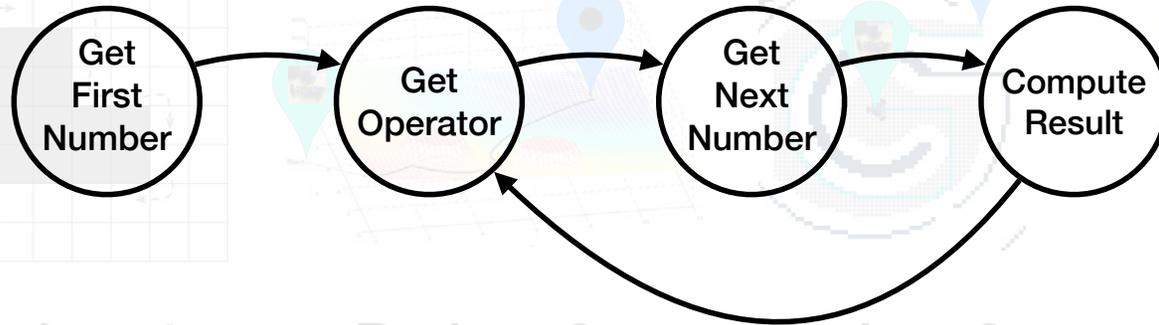


**Project 0:**  
Pocket  
Calculator



**Project 1:**  
Wall  
following

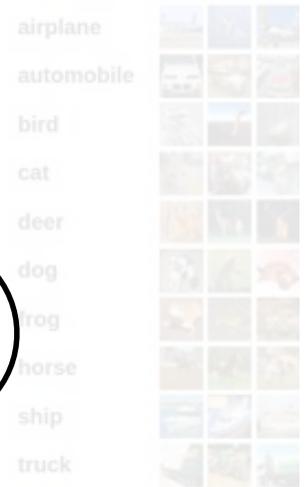
## Finite State Automata



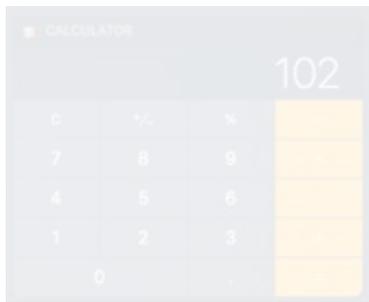
**Project 2:**  
Potential  
Fields

**Project 3:**  
A\*  
Pathfinding

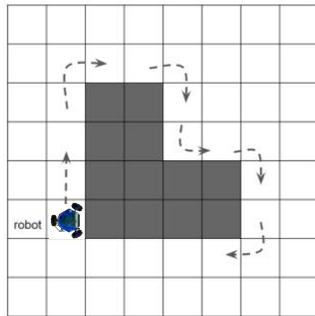
**Project 4:**  
Neural  
Networks



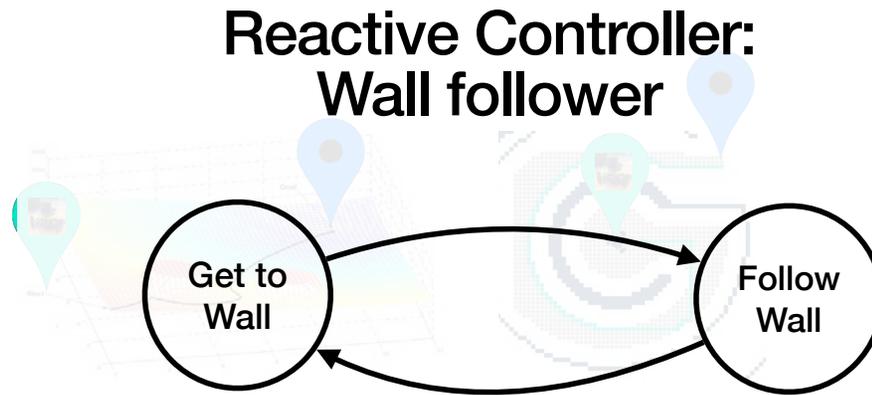
# Understand foundational AI algorithms and implement them in code as Graphs and Graph algorithms



Project 0:  
Pocket  
Calculator

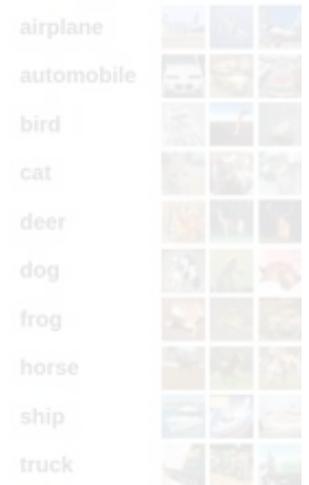


Project 1:  
**Wall  
following**



Project 2:  
Potential  
Fields

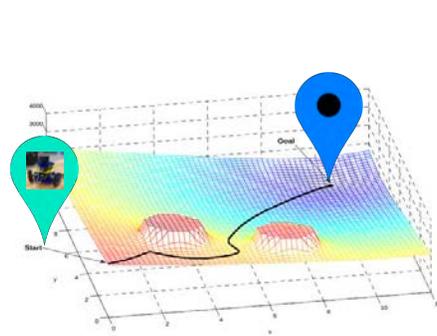
Project 3:  
A\*  
Pathfinding



Project 4:  
Neural  
Networks



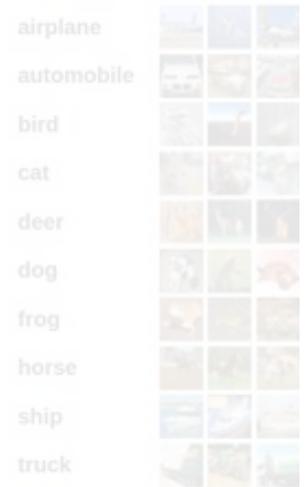
# foundational AI algorithms implement them in code Trees and Graph algorithms



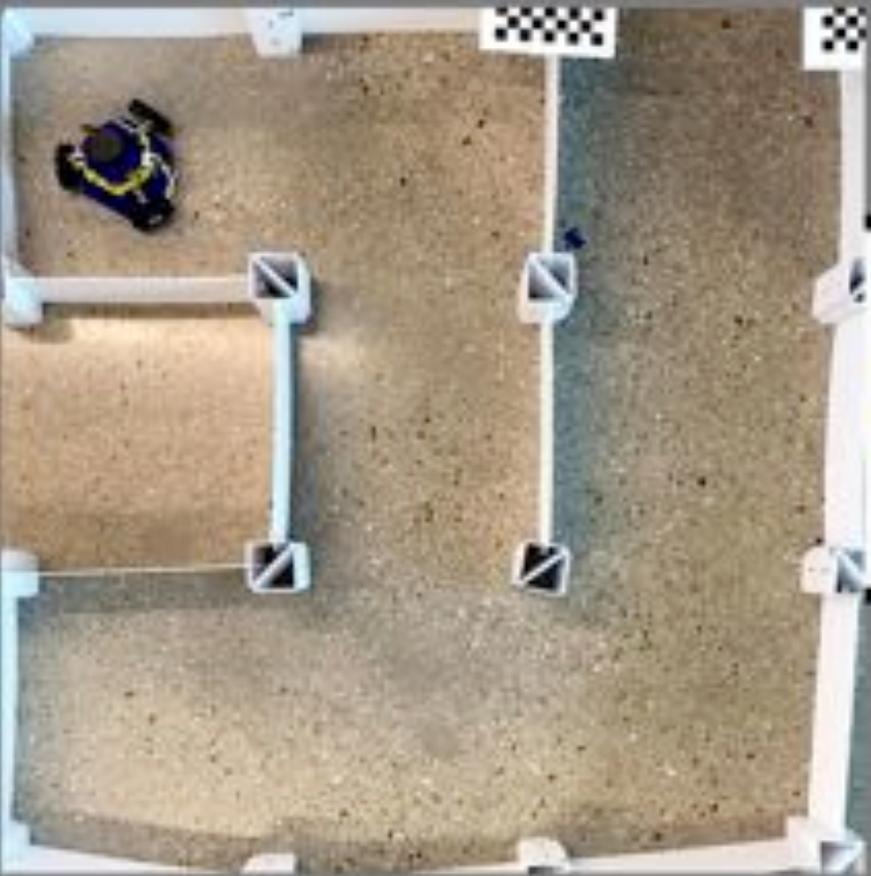
**Project 2:  
Potential  
Fields**



**Project 3:  
A\*  
Pathfinding**

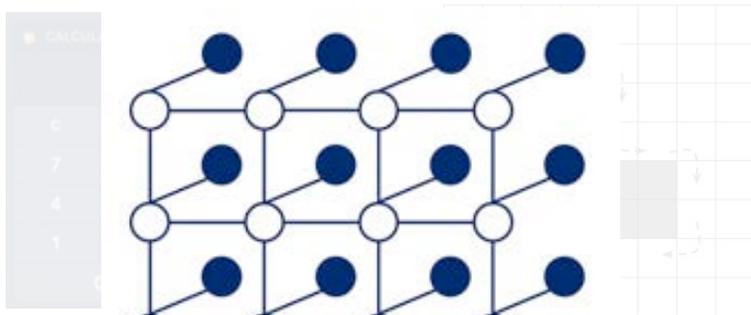


**Project 4:  
Neural  
Networks**

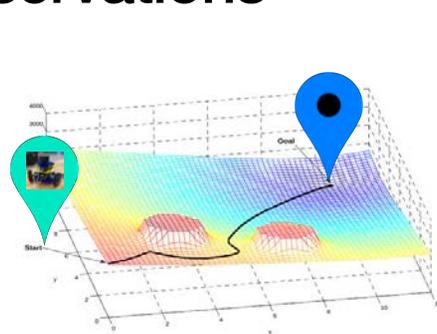


# Understand foundational AI algorithms and implement them in code as Graphs and Graph algorithms

Robot models its environment as graph  
of “hidden” nodes with observations



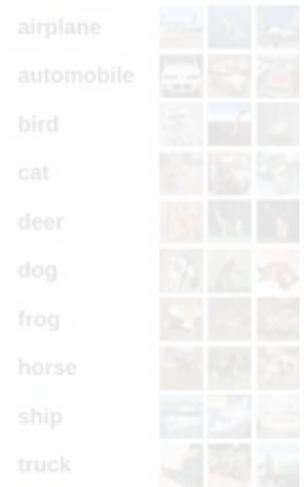
Project 1:  
Calculator  
following



Project 2:  
Potential  
Fields



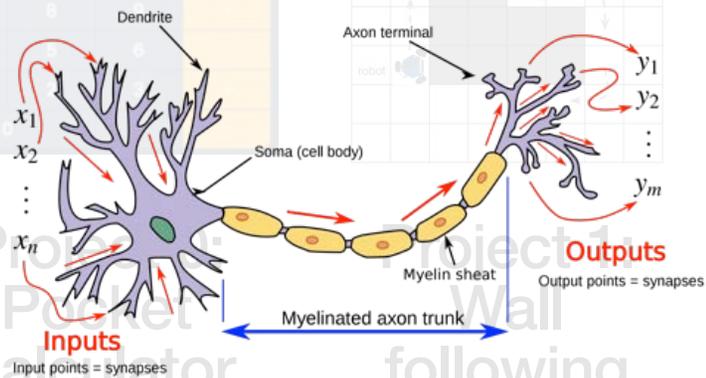
Project 3:  
A\*  
Pathfinding



Project 4:  
Neural  
Networks

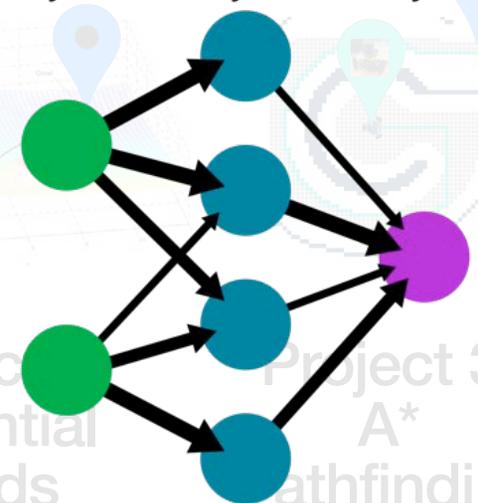
# Understand foundational AI algorithms and implement them in code as Graphs and Graph algorithms

Neural network is a graph of  
artificial neuron nodes that send  
activations



A simple neural network

input layer    hidden layer    output layer



airplane  
automobile  
bird  
cat  
deer  
dog  
frog  
horse  
ship  
truck



Project 4:  
Neural  
Networks

# ROB 102 Grading

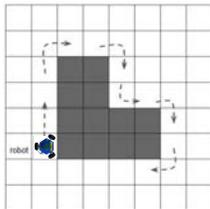
- Final grade determined by total of points earned
  - An A grade of some form is earned with 93 points or above
  - A B grade of some form is earned with 83 points or above
  - A C grade of some form is earned with 73 points or above

**In Class  
Activities:  
20 points**

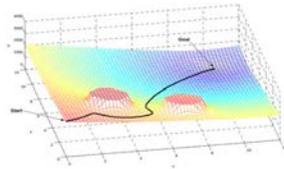
**Participation:  
5 points**



**Project 0:  
15 points**



**Project 1:  
15 points**



**Project 2:  
15 points**



**Project 3:  
15 points**



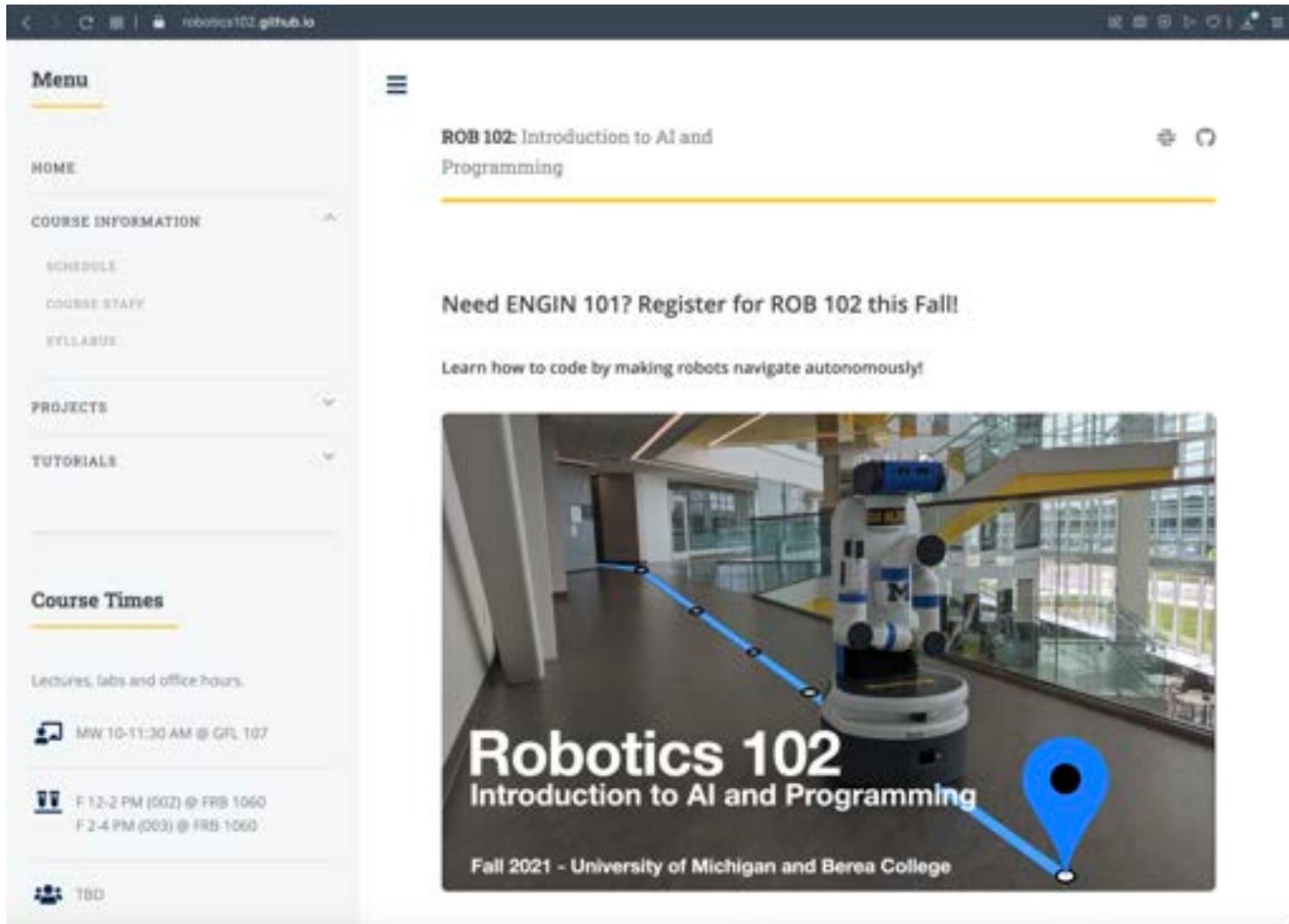
**Project 4:  
15 points**

**Advanced  
Extensions:  
4 points**

# ROB 102 Flipped Classroom

- Course website: [robotics102.github.io](https://robotics102.github.io) (or [robotics102.org](https://robotics102.org))
- All course material posted on course website, slack workspace, or your git repository
  - Robotics 102 does not use Canvas
- Lectures will be posted on course website
- Class lecture meetings (MW 10-11:20am) are dedicated to in-class activities and interactive help on projects
- Class lab sessions (F 12-2pm or F 2-4pm) are dedicated to tutorials for coding and working with robots, as well as interactive help

# Robotics 102 Course Website



The screenshot shows a web browser displaying the Robotics 102 course website. The browser's address bar shows "robotics102.github.io". The website has a clean, modern design with a light gray background and a dark blue header. On the left side, there is a navigation menu with the following items: HOME, COURSE INFORMATION (with a dropdown arrow), PROJECTS (with a dropdown arrow), and TUTORIALS (with a dropdown arrow). Below the menu, there is a section titled "Course Times" with a yellow underline. This section lists the following information: "Lectures, labs and office hours.", "MW 10-11:30 AM @ GFL 107", "F 12-2 PM (002) @ FRB 1060", "F 2-4 PM (003) @ FRB 1060", and "TBD". The main content area on the right features a large blue header with the text "ROB 102: Introduction to AI and Programming". Below this, there is a yellow horizontal line, followed by the text "Need ENGIN 101? Register for ROB 102 this Fall!" and "Learn how to code by making robots navigate autonomously!". The central focus is a large image of a white and blue mobile robot in a modern, brightly lit hallway. The robot is positioned on a dark floor, and a blue line with circular markers indicates its path. The text "Robotics 102 Introduction to AI and Programming" is overlaid on the bottom left of the image, and "Fall 2021 - University of Michigan and Berea College" is at the bottom. A blue location pin icon is also visible on the right side of the image.

robotics102.github.io

## Menu

- HOME
- COURSE INFORMATION
  - SCHEDULE
  - COURSE STAFF
  - SYLLABUS
- PROJECTS
- TUTORIALS

### Course Times

Lectures, labs and office hours.

- MW 10-11:30 AM @ GFL 107
- F 12-2 PM (002) @ FRB 1060  
F 2-4 PM (003) @ FRB 1060
- TBD

## ROB 102: Introduction to AI and Programming

### Need ENGIN 101? Register for ROB 102 this Fall!

Learn how to code by making robots navigate autonomously!

# Robotics 102

## Introduction to AI and Programming

Fall 2021 - University of Michigan and Berea College

# Robotics 102 Course Schedule

**Menu**

HOME

COURSE INFORMATION

- SCHEDULE
- COURSE STAFF
- SYLLABUS

PROJECTS

TUTORIALS

**Course Times**

Lectures, labs and office hours.

MW 10-11:30 AM @ GFL 107

F 12-2 PM (002) @ FRB 1060  
F 2-4 PM (003) @ FRB 1060

TBD

## Schedule

### Course Schedule (Michigan)

Date	Topic	Readings	Project
<b>Week 1</b>			
Aug 30	Introduction and Course Overview Lecture: Hello World!		Out: <a href="#">Project 0</a>
Sept 1	Pair Navigation Activity Lecture: Variables and Operators		
Sept 3	Lab: Coding Workflow		
<b>Week 2</b>			
Sept 6	<b>Labor Day</b> - No class		
Sept 8	Lecture: Functions		
Sept 10	Lab: Robot Workflow		
<b>Week 3</b>			
Sept 13	Lecture: Branching and Iterators		Out: <a href="#">Project 1</a>
Sept 15	Lecture: Vectors		

# Robotics 102 Project 0: Pocket Calculator

The screenshot shows a web browser window with the address bar displaying "robotics102.github.io/projects/00.html". The page has a sidebar on the left with navigation links: HOME, COURSE INFORMATION, PROJECTS, and TUTORIALS. Under PROJECTS, there are links for PROJECT 0: INTRO TO C++, PROJECT 1: WALL FOLLOWING, PROJECT 2: POTENTIAL FIELD CONTROL, PROJECT 3: PATH PLANNING, and PROJECT 4: MACHINE LEARNING. Under TUTORIALS, there is a section for "Course Times" with a yellow underline. Below this, it says "Lectures, labs and office hours." and lists two time slots: "MW 10-11:30 AM @ GFL 107" and "F 12-2 PM (002) @ FRB 1060" and "F 2-4 PM (003) @ FRB 1060". At the bottom of the sidebar, there is a "TBO" link with a person icon.

## Project 0: Introduction to Programming in C++

Before you start, make sure you have followed the [Setup Instructions](#). You will need to have VSCode, Docker and Git installed in order to complete this project. The following topics are covered on this page:

- [Getting the code](#)
- [Running a Docker container](#)
- [Project description](#)
  - [Hello World!](#)
  - [Pocket Calculator](#)
- [Task Summary](#)

## Getting the code

We will use GitHub Classroom to manage assignments. Use the following invite link to accept the assignment on the Github Classroom:

[Accept the assignment: https://classroom.github.com/a/KXN5N8Bh](https://classroom.github.com/a/KXN5N8Bh)

You will see a page that looks like this (make sure you are signed in to your account on [github.com](https://github.com)):

**GitHub Classroom** GitHub Classroom

robotics102-classroom

Accept the assignment —

Project 0: Intro to C++

Us

ROB 102





The background features a light blue gradient with several diagonal strips of yellow tape. Each strip has the word "WARNING" printed in black, bold, sans-serif capital letters. A faint, semi-transparent image of a blue robot is visible in the center, partially obscured by the tape.

# **We are on the cutting edge**

**Robotics 102 is for pioneers!**



# **We are on the cutting edge**

**Robotics 102 is for pioneers!**

**This is first offering of an innovative approach to education**

# Robotics with Respect



The image shows the top portion of the Michigan Robotics website. At the top left is the logo, a yellow 'M' followed by the word 'ROBOTICS' in blue. To the right is a navigation menu with links for 'Academics', 'Research', 'People', 'Events', 'News', and 'About', each followed by a small downward arrow, and a search icon. Below the navigation is a large banner image of a red car on a road at night, with yellow sensor beams and a yellow wireframe car ahead. The text 'Work together. Create smart machines. Serve society.' is overlaid in yellow. Below the banner is a dark blue section with a grey box containing the text: 'Michigan Robotics aims to create a collaborative community of roboticists, where through mutual respect, integrity in action, and transparency in thought, we accelerate socially beneficial advances in robotics.' Below this is a link 'More about our vision >'. At the bottom are three dark blue buttons with white text: 'Graduate programs in Robotics', 'Collaborative robotics research', and 'Cross-disciplinary roboticists'.

**M** | ROBOTICS

Academics - Research - People - Events - News - About - 

*Work together. Create smart machines. Serve society.*

Michigan Robotics aims to create a collaborative community of roboticists, where through mutual respect, integrity in action, and transparency in thought, we accelerate socially beneficial advances in robotics.

[More about our vision >](#)

Graduate programs in Robotics

Collaborative robotics research

Cross-disciplinary roboticists

# Robotics with Respect

The image shows a screenshot of the Michigan Robotics website homepage. At the top left is the logo 'M | ROBOTICS'. To the right is a navigation menu with links for 'Academics', 'Research', 'People', 'Events', 'News', and 'About', followed by a search icon. The main banner features a stylized, glowing blue and yellow scene of a car and a robot on a road, with the text 'Work together. Create smart machines. Serve society.' overlaid. Below the banner is a text box containing the organization's mission statement: 'Michigan Robotics aims to create a collaborative community of roboticists, where through mutual respect, integrity in action, and transparency in thought, we accelerate socially beneficial advances in robotics.' Below this text box are three buttons: 'Graduate programs in Robotics', 'Collaborative robotics research', and 'Cross-disciplinary roboticists'. The text 'Inspire from Day 1' is overlaid on the left side of the banner, and 'Provide opportunity' is overlaid on the left side of the text box.

**Inspire from Day 1**

*Work together. Create smart machines. Serve society.*

Michigan Robotics aims to create a collaborative community of roboticists, where through mutual respect, integrity in action, and transparency in thought, we accelerate socially beneficial advances in robotics.

[More about our vision >](#)

Graduate programs in Robotics

Collaborative robotics research

Cross-disciplinary roboticists

# Robotics with Respect

The image shows a screenshot of the Michigan Robotics website. At the top left is the logo "M | ROBOTICS". To the right is a navigation menu with links for "Academics", "Research", "People", "Events", "News", and "About", followed by a search icon. Below the navigation are two images: a small blue and yellow robot on a wooden surface, and a white Fetch robot holding an orange football with a black "M" and "MICHIGAN" text. Below these images is a section titled "PRISM Solving for Equity" with a date of "JANUARY 2021". The PRISM section features an illustration of five diverse people (two women and three men) standing between two stylized blue robots. Below the illustration is a short paragraph of text. The text "Work together to make machines" is faintly visible in the background of the top section. The text "Michigan Robotics aims to create a... where through mutual respect, inte... we accelerate social, beneficial ad... More..." is also faintly visible in the background of the bottom section. The text "Graduate programs in Robotics" and "Collaborative roboti..." are also faintly visible in the background of the bottom section.

**Inspire from Day 1**

**Provide opportunity**

**PRISM Solving for Equity**  
JANUARY 2021

A curriculum redesign breaks calculus's stranglehold on engineering education, inspiring students who may be underrepresented in math with



**Roboticists show and prove!**  
**Time for a demo...**  
**In the new Robotics Building**

# Robotics with Respect

The image is a screenshot of the Michigan Robotics website. At the top left is the logo "M | ROBOTICS". To the right is a navigation menu with links for "Academics", "Research", "People", "Events", "News", and "About", followed by a search icon. Below the navigation are two images: a small blue and yellow robot on a wooden surface, and a white Fetch robot holding an orange football with a black "M" and "MICHIGAN" written on it. Below these images is a section titled "PRISM Solving for Equity" with a date of "JANUARY 2021". The PRISM section features an illustration of five diverse people (two women and three men) standing next to two friendly-looking robots. Below the illustration is a short paragraph of text. On the left side of the screenshot, there are two text overlays: "Inspire from Day 1" and "Provide opportunity".

**M | ROBOTICS**

Academics - Research - People - Events - News - About - Q

**Inspire from Day 1**

**Provide opportunity**

**PRISM**  
**Solving for Equity**  
JANUARY 2021

A curriculum redesign breaks calculus's stranglehold on engineering education, inspiring students who may be underrepresented in math with