

# **Introduction to Computer Vision**

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**Kaveh Fathian**

Assistant Professor

Computer Science Department

Colorado School of Mines

**Lecture 1**

# Instructor



## Kaveh Fathian:

- Computer Science Assistant Professor
- Director of Autonomy, Robotics, & Intelligent Algorithms (ARIA) Lab
- MS/PhD @ UT Dallas; Postdoc @ MIT

## Teaching:

- Fall semester: “**Computer Vision**”
- Spring semester: “Robotic Mapping & Localization”

## Class schedule:

- **Class:** Mon/Wed/Fri, 3:00-4:15pm MT, CoorsTek 130
- **Office hours (after class):** Mon/Wed 4:15 – 5:00pm, Brown Building 280-N

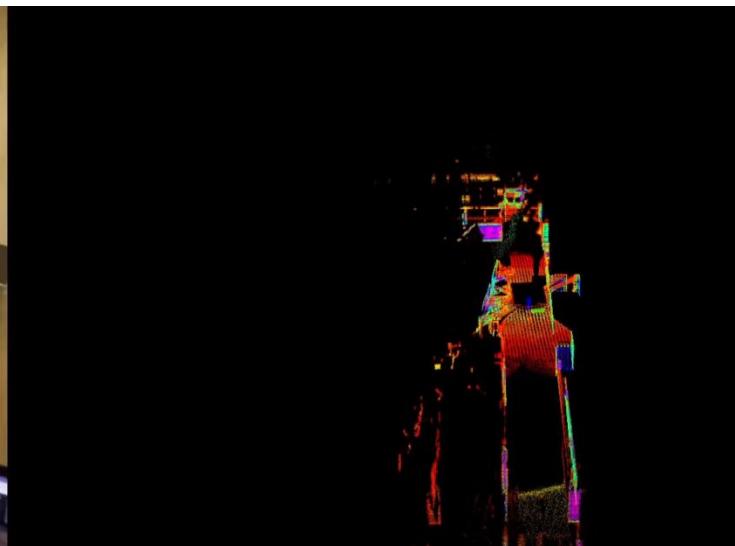
**Course repo:** <https://github.com/ariarobotics/cv>

**Email:** [fathian@ariarobotics.com](mailto:fathian@ariarobotics.com) or [kaveh.fathian@mines.edu](mailto:kaveh.fathian@mines.edu)

# ARIA Lab

**ARIA Lab's Mission:** We pioneer algorithms  
for robotic perception & autonomy

**Want to join?** Projects related to CS/EE/ME  
Visit <https://www.ariarobotics.com/join-us>



# Course Objectives

- Understand fundamental & modern concepts, problems, and solutions in CV
- Apply CV techniques to solve problems in research & industrial applications, such as image filtering, 3D reconstruction, and recognition
- Use image processing & image understanding software tools



# CV Applications

**Smartphones:** QR codes, computational photography (Android Lens Blur, iPhone Portrait Mode), panorama construction (Google Photo Spheres), face detection, expression detection (smile), face filters/tracking, FaceID (iPhone), Night Sight (Pixel), iPhone 12 Pro (LiDAR), body workout form detection

**Smartwatches:** Heart rate detection, proximity detection

**Security:** Fingerprint/iris/face scanning (offices, airports), CCTV monitoring

**Laptops/Desktops:** Biometrics auto-login (face recognition, 3D)

**Web:** Image search, Google photos (face recognition, object recognition, scene recognition, geolocalization from vision), Facebook (image captioning), Google maps aerial imaging (image stitching), YouTube (content categorization), Photoshop, PowerPoint (captioning, design suggestions)

**Virtual Worlds:** VR/AR head tracking (Oculus, HTC Vive), simultaneous localization and mapping, person tracking (Kinect), gesture recognition, virtual try-on, digital humans

**Telepresence:** Virtual backgrounds (Zoom, Google Meet), webcam person/face following

**Media:** Visual effects for film/TV, virtual sports replay, semantics-based auto edits

**Transportation:** Assisted driving (cruise control, self-driving), face tracking/iris dilation for safety

**Supermarkets:** Cashier-less checkout, theft detection (Walmart), fruits/vegetables sorting, packaging, manufacture

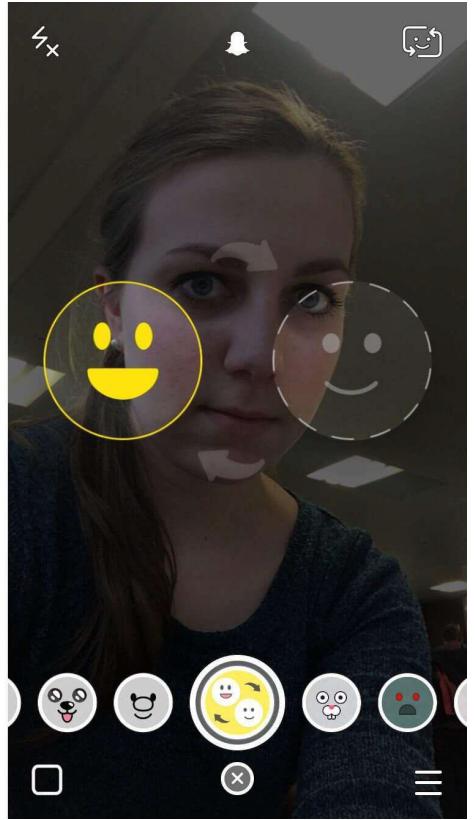
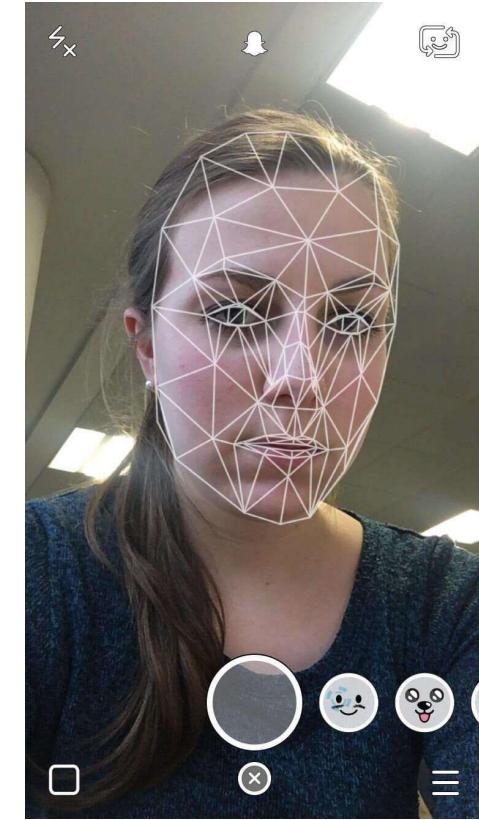
**Medical imaging:** CAT / MRI reconstruction, assisted diagnosis, automatic pathology, connectomics, endoscopy

**Space Exploration:** Mar rovers, space telescopes (Hubble, James Webb)

**Industry:** Vision-based robotics, online shopping (Amazon,Walmart), machine-assisted router (jig), OCR (USPS), ANPR (number plates for tolls), drones

**Creative:** Photoshop, vision-language models for image generation (Dall-E), video editors, GenAI editors

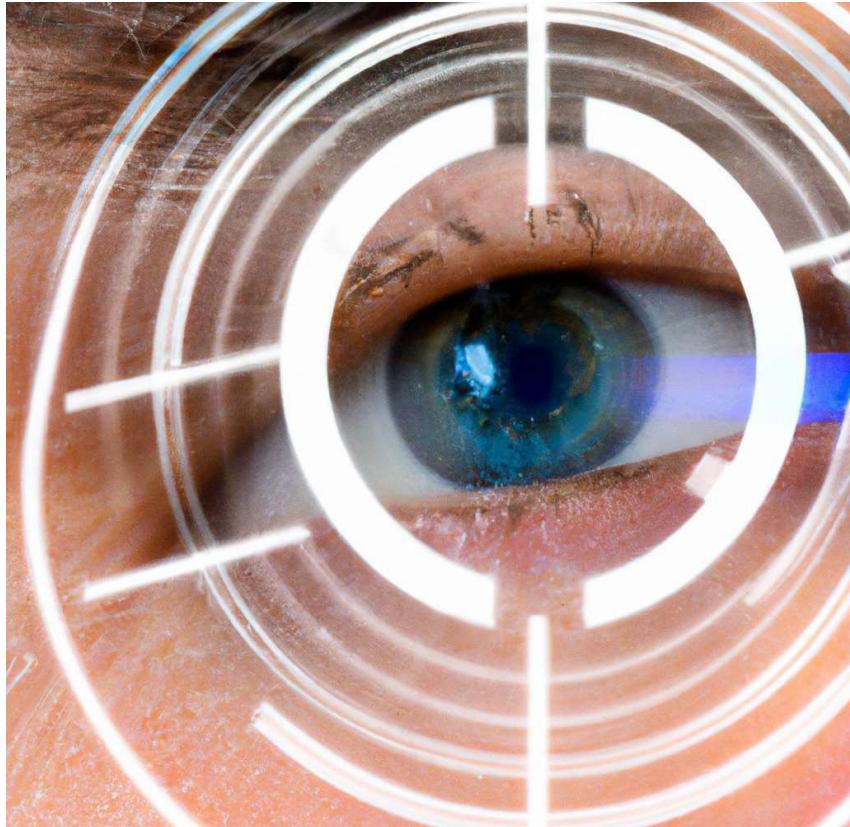
# Smartphones: QR Codes, Panorama, Emotion



# Smartphones: Face Filters

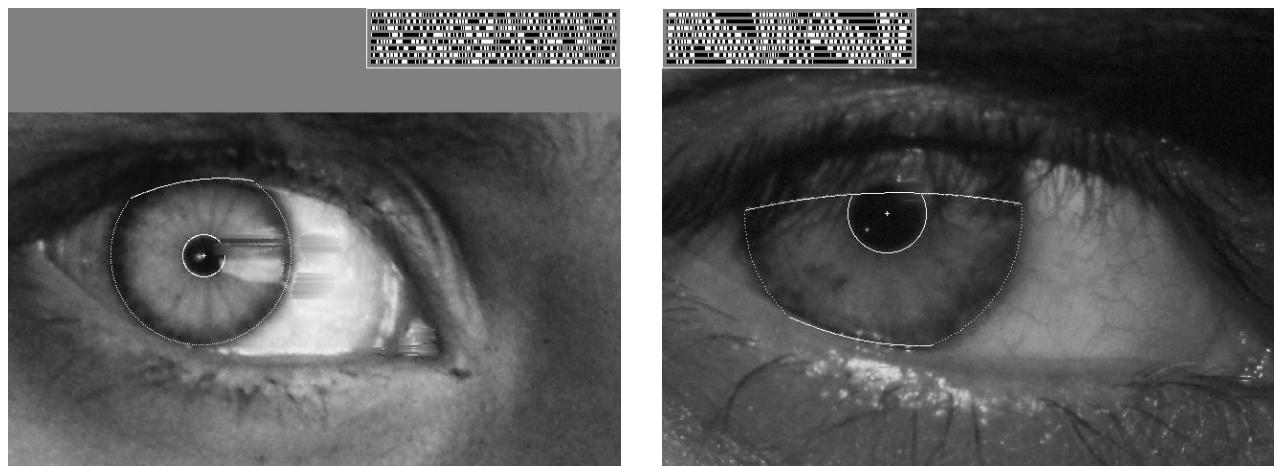


# Security | Biometrics

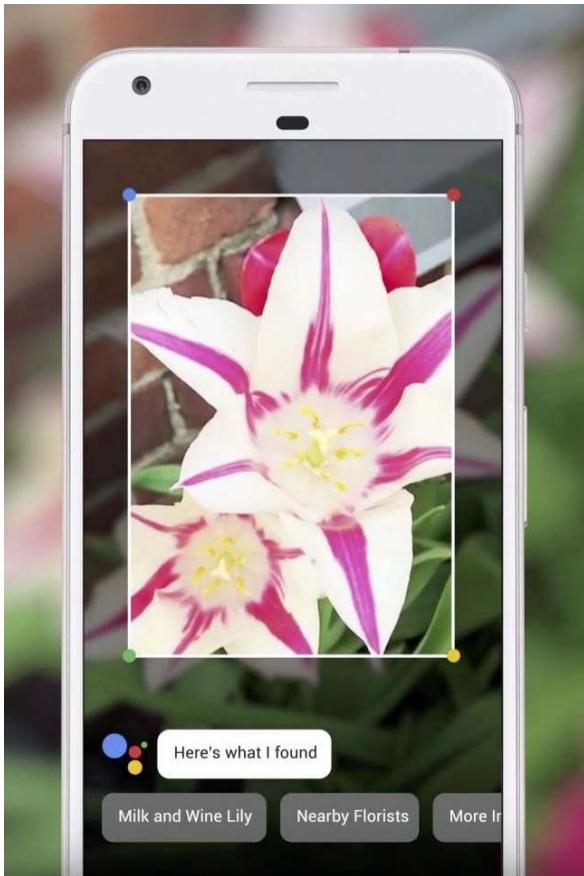
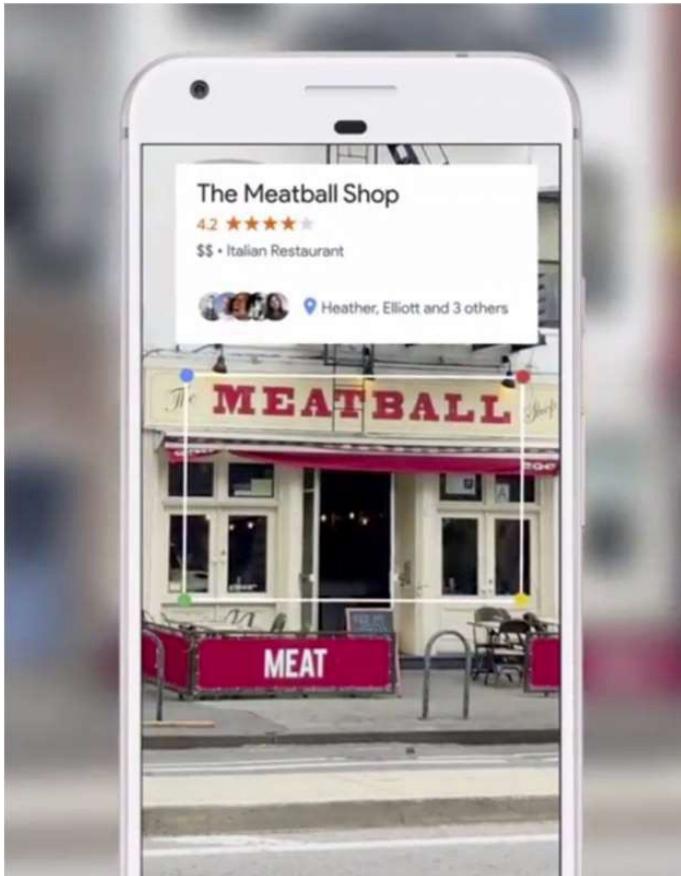


*“How the Afghan Girl was Identified by Her Iris Patterns”*

Read the [story \(Wikipedia\)](#)



# Web: Place | Thing Recognition



Google Lens

# Virtual Worlds

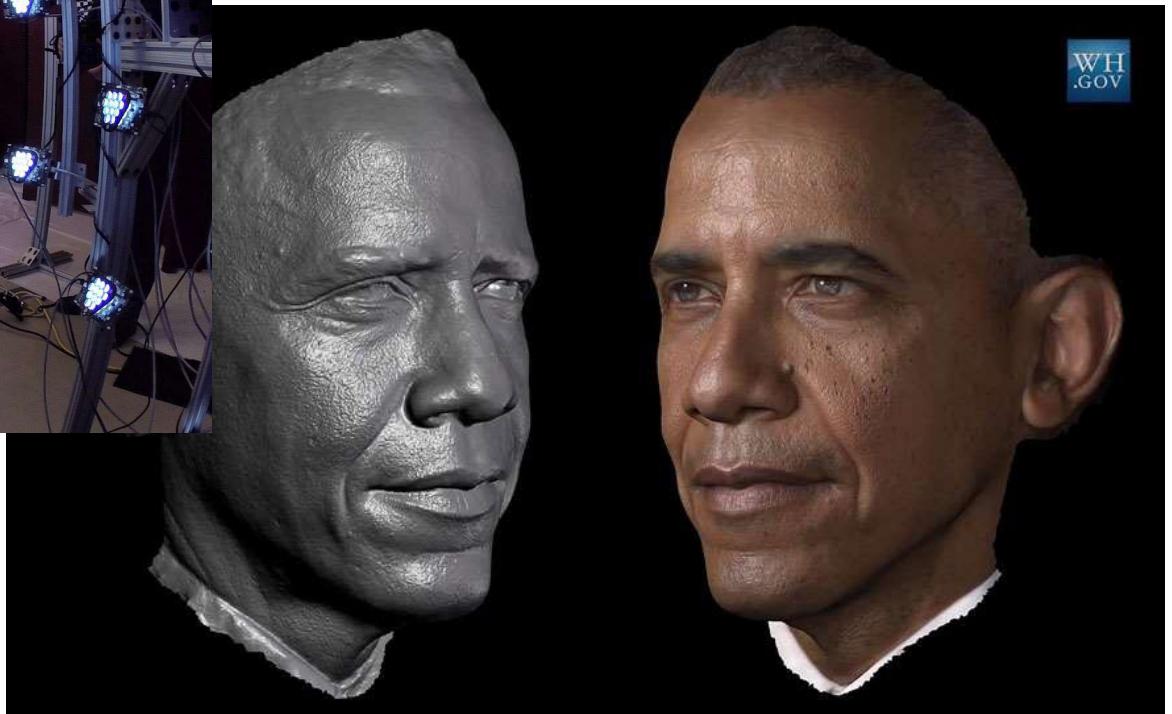


Metaverse

# Virtual Worlds: Digital Humans



Paul Debevec. <http://gl.ict.usc.edu/Research/presidentialportrait/>



# Visual Effects



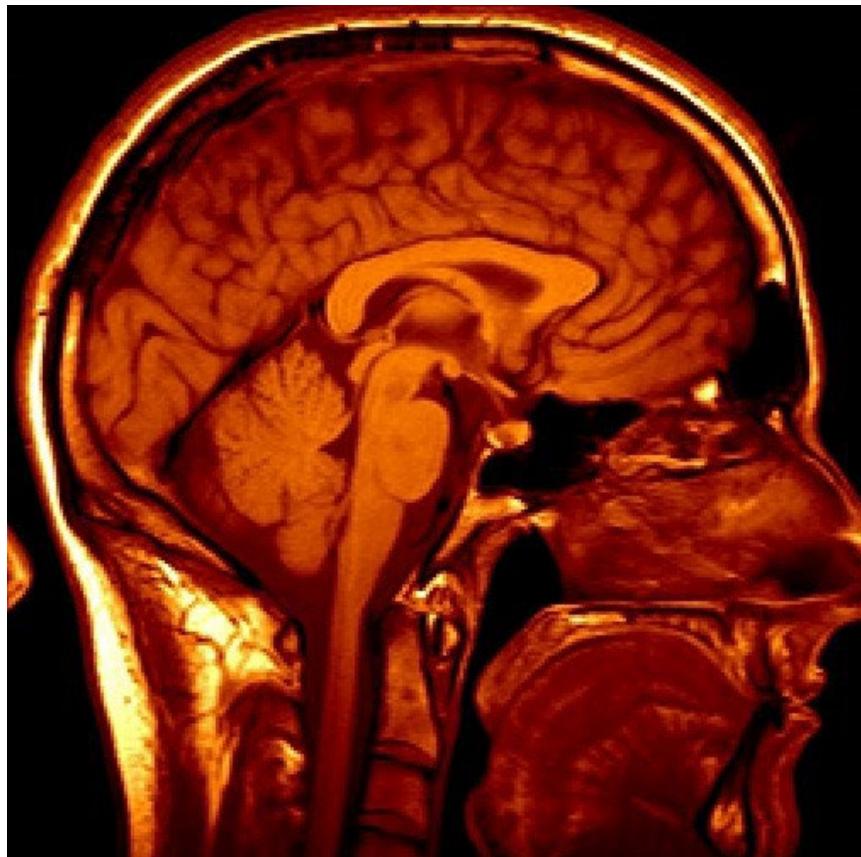
Dawn of the Planet of the Apes

# Transportation: Self-Driving Cars



Waymo. <https://www.youtube.com/watch?v=B8Rl48hFxPw>

# Medical Imaging



3D imaging  
MRI, CT



Ultrasound

# Space Exploration

- Application: Cloud detection in astronomy imaging

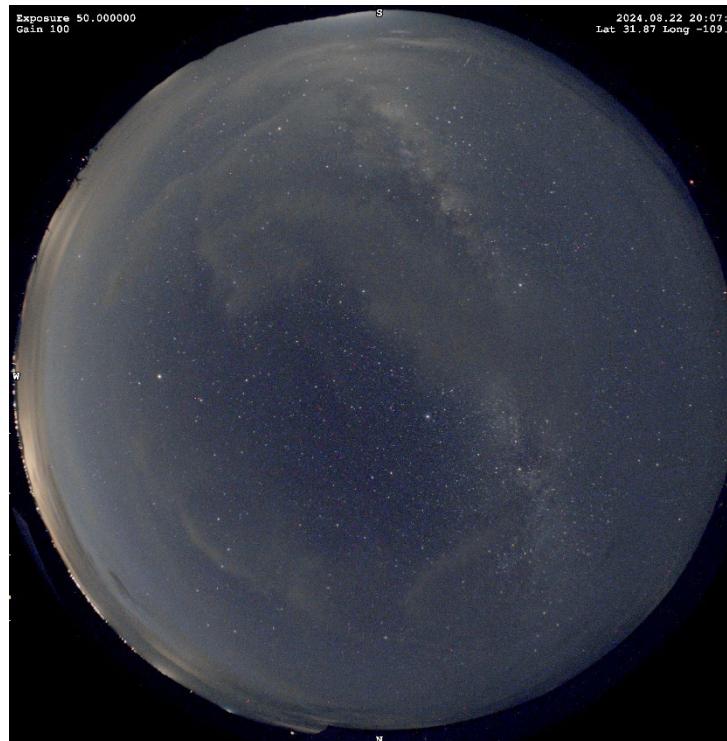
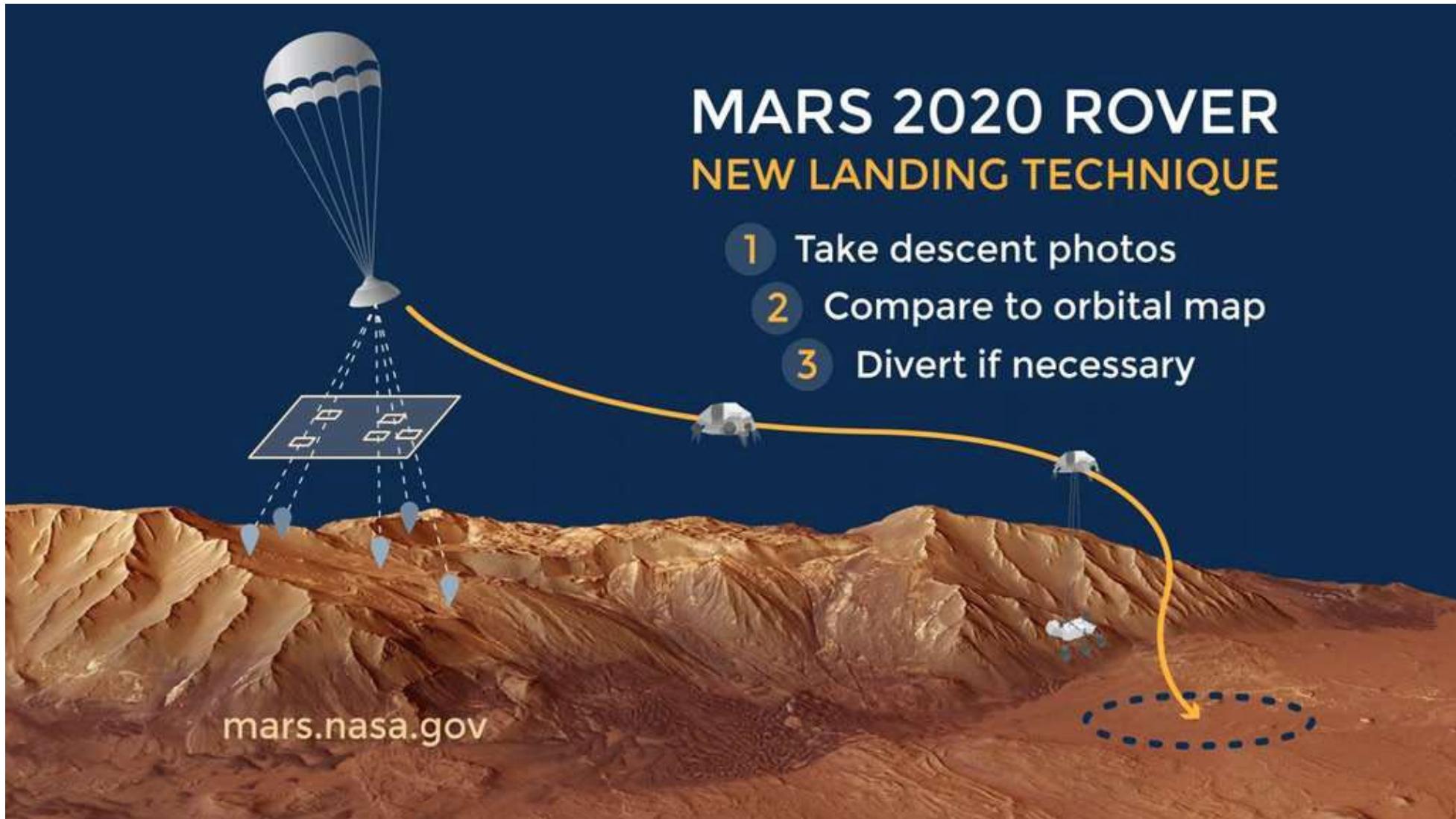
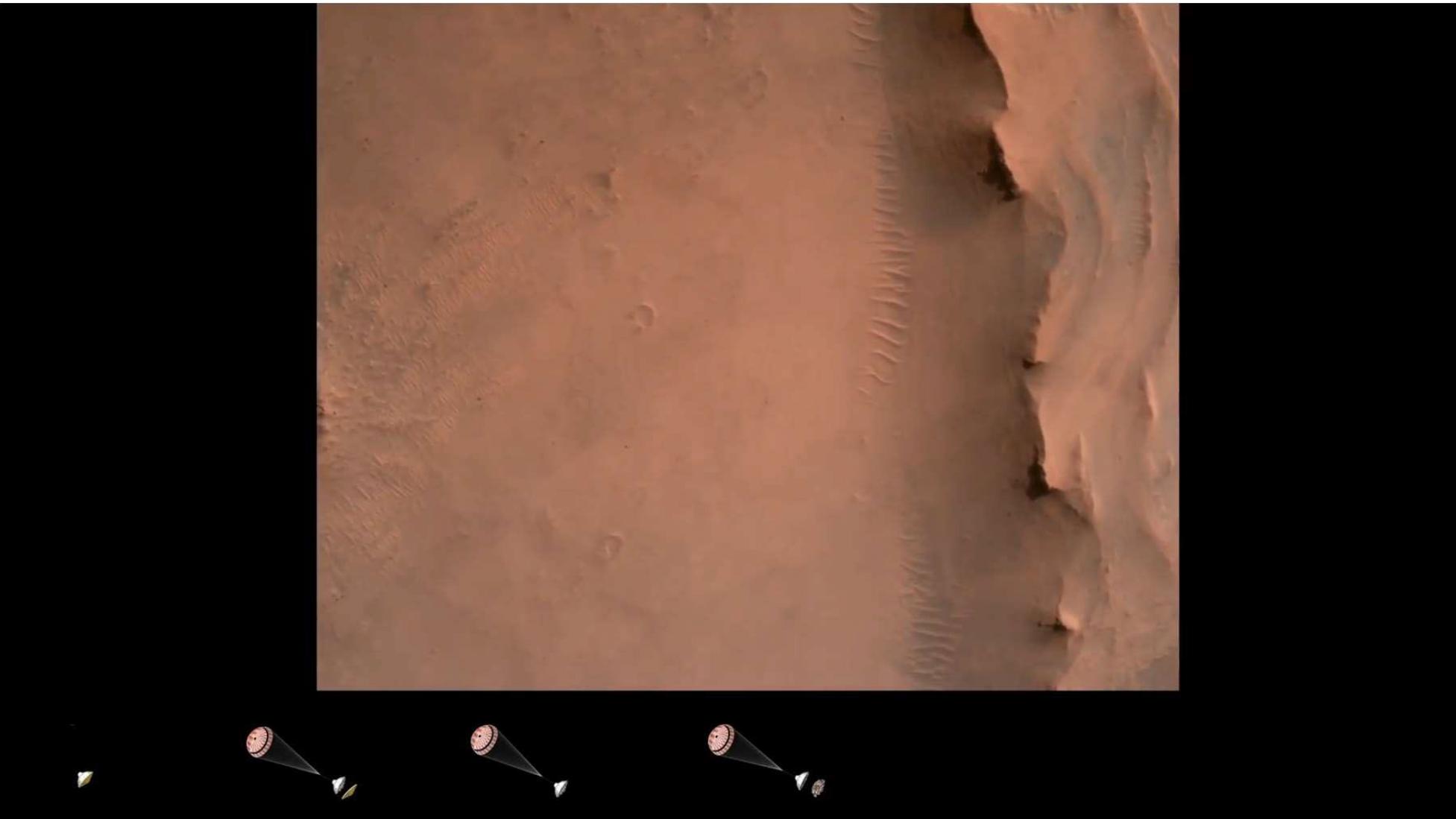


Image by Charlie Hagen (former Mines student); visit <https://www.nightphotons.com/>

# Space Exploration



# Space Exploration

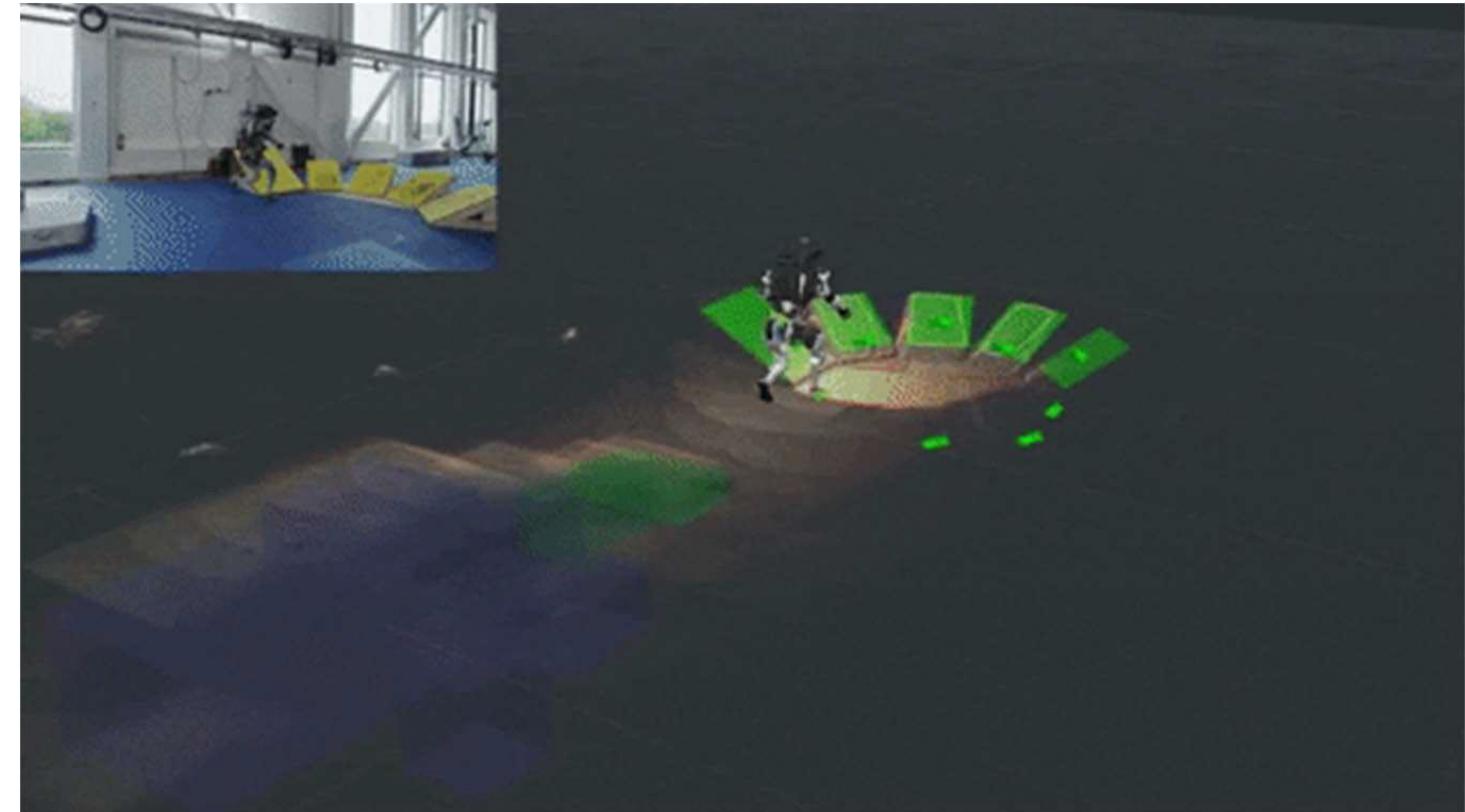


NASA. <https://www.youtube.com/watch?v=4czjS9h4Fpg>

# Industry: Robots



Boston Dynamics. <https://blog.bostondynamics.com/flipping-the-script-with-atlas>



# Creative: Text-to-Image Synthesis - GenAI



*“Teddy bears working on new AI research  
underwater with 1990s technology”*

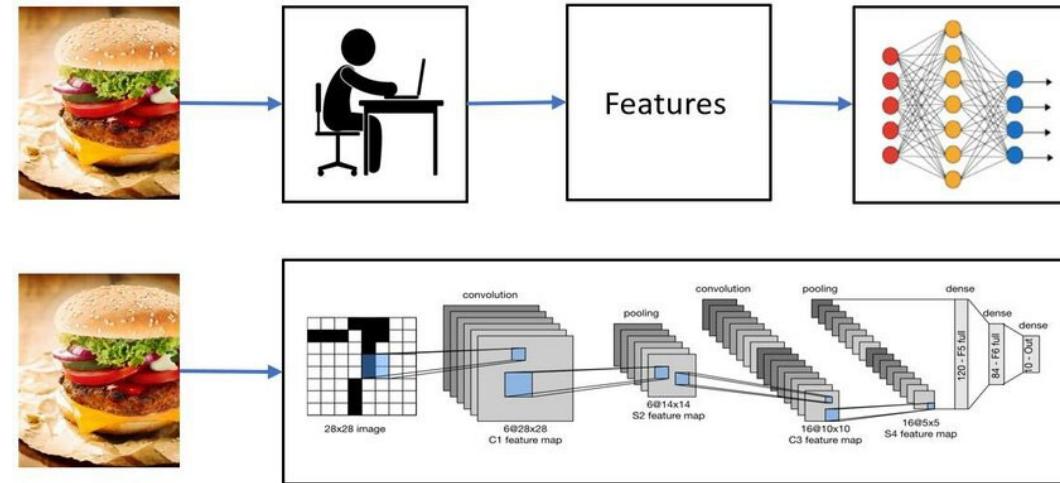


*“Cats playing chess”*



*“a teddy bear at Mines”*

# Course Structure



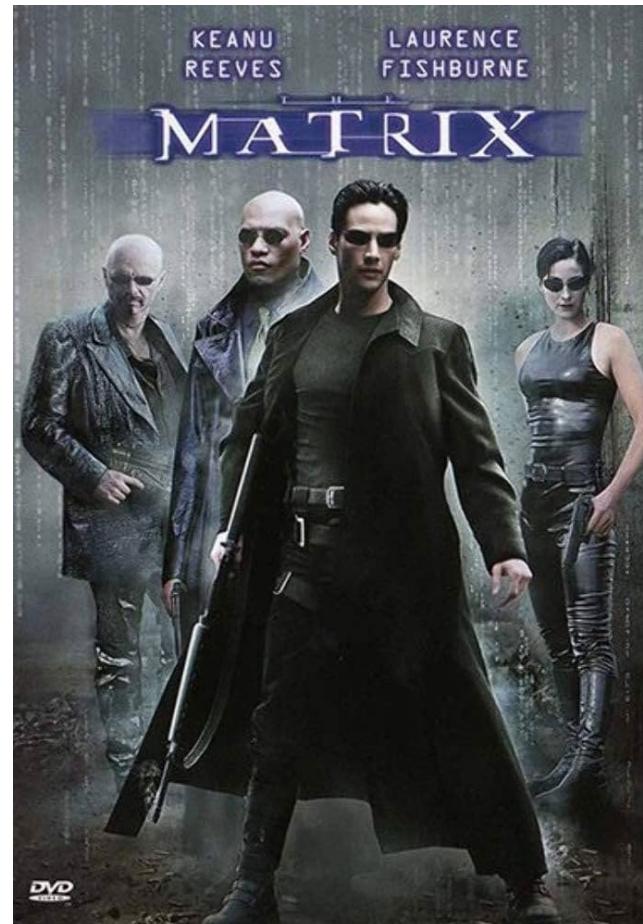
- The course is divided into 2 parts: **classical & modern** computer vision
  - **Classical:** Filtering; Fourier analysis; feature points
  - **Modern:** Machine learning; recognition/detection; deep learning
- Warning: This is not an ML course, but we will introduce/use ML in 2<sup>nd</sup> half of the course
- Note: The course is being updated this (and every) semester to incorporate latest CV techniques



# Warning!



- You must have **math** background: **linear algebra**, calculus,, probability, and statistics





# Warning!



- You must have **coding** experience!
- The main programming language used in the course is **Python** (C++ also allowed)
- No other languages are allowed (e.g., MATLAB, Java)
- We will practice and code during some of the lectures
- Python [tutorial Videos](#) (many more available on YouTube)





# Warning!



**Academic dishonesty will be taken very seriously!**

- Identical homework submissions
- Cheating or use of banned resources during exams
- Suspicious/undocumented excused-absence submission

# Course Logistics

**Course repo:** <https://github.com/ariarobotics/cv>

Syllabus, detailed schedule, and all other course material are (or will be) posted on the repo.

# Course Logistics

- **Homework (60pts):**
  - 6-8 graded homework
  - Lowest grade (or missed) will be dropped
  - *No late days & no extensions.* Late homework will receive zero grade
  - Should solve/submit homework individually, but allowed to help each other, use online resources, etc.
  - Identical submissions get zero
- **Exams (40pts):**
  - 4 exams
  - Will be in-person, in class (not remote)
  - Based on lecture slides, class discussion, & homework
  - Not allowed to use any resources during exam  
(e.g., cannot use lecture notes, phone, etc.)
  - Lowest grade (or absent) will be dropped
  - 2 or more missed exams leads to INC grade

# Course Logistics

- **Attendance:**
  - *Mandatory*, but not monitored
  - Some course material will only be discussed in class & will not be recorded or posted
- **Bonus points:**
  - May assign *bonus* assignments, projects, etc. to help grades

**Final grade:** Quizzes (40 pts) + Homework (60 pts) = 100 pts

**Bonus points:** *bonus* assignments, projects, etc. (10pts max)

**Amended final grade** = final grade + bonus points

**Rubric:** Based on amended final grade (capped at 100pts)

<b>Rubric</b>	
[93, 100]	A
[90, 93)	A-
[87, 90)	B+
[83, 87)	B
[80, 83)	B-
[77, 80)	C+
[73, 77)	C
[70, 73)	C-
[67, 70)	D+
[63, 67)	D
[60, 63)	D-
[0, 60)	F

# Course Logistics

- **Computers:**

- Bring personal **laptops** to take quizzes (in class, on Canvas).
- Can loan laptops from the CS department, Mines library, [ITS](#), if needed.
- Can use classroom computers

Fall 2025

[Home](#)

[Announcements](#) 

[Assignments](#)

[Grades](#)

[People](#)

[Syllabus](#)

[Rubrics](#)

[Quizzes](#)

[Submit Grades to  
Banner](#)

[Ed Discussion](#)

- **Communication:**

- ***Ed Discussion*** is our main way of communication/announcements
- Canvas or email will **NOT** be used for announcements/notifications

# Workload



- Between reading, homework, and reviewing for quizzes, I expect this class to take **~10 hours/week** on average
- 50% of you will spend **more time** than this! This will be especially probable if
  - You're unfamiliar with Python
  - You don't have strong coding or math skills

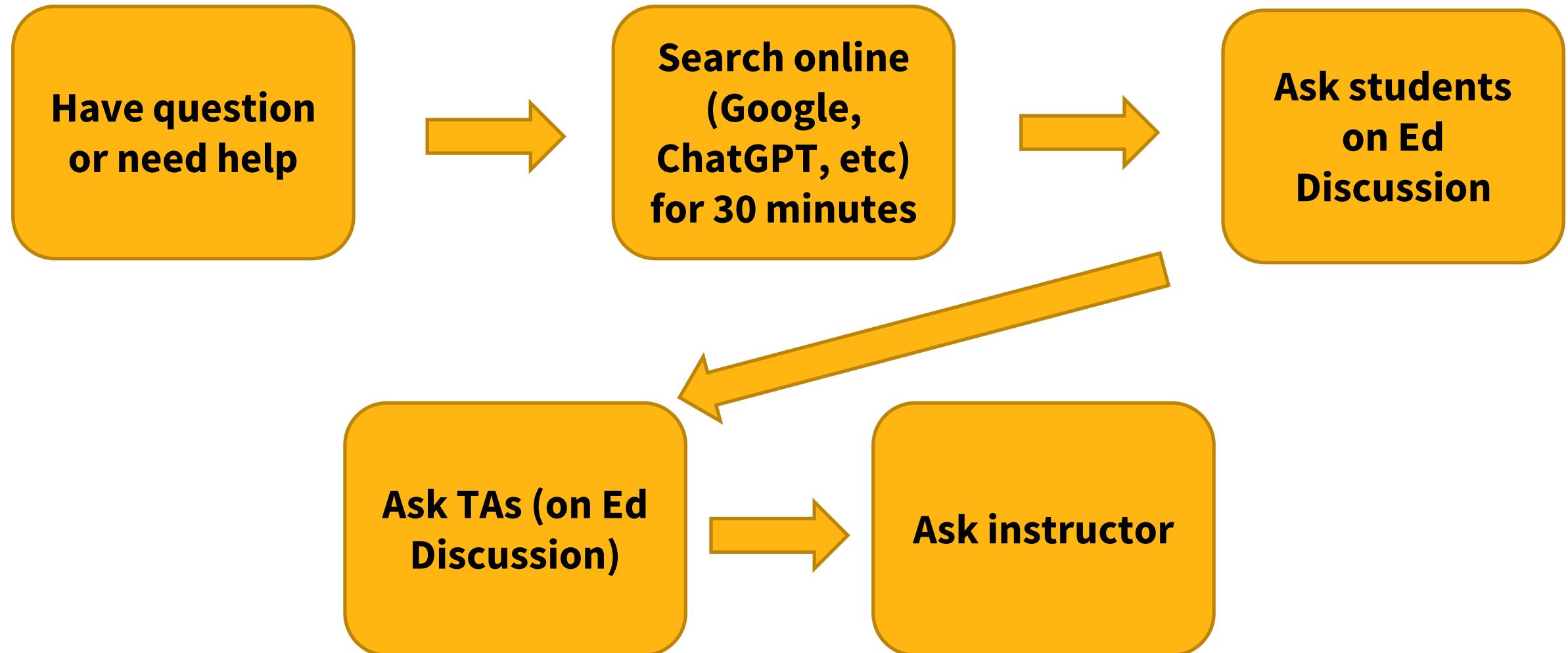
# TAs

- **Abolfazl Babanazari** ([abolfazl\\_babanazari@mines.edu](mailto:abolfazl_babanazari@mines.edu))
  - Office: TBD
  - Hours: TBD
- **Carson Cramer** ([ctcramer@mines.edu](mailto:ctcramer@mines.edu))
  - Office: TBD
  - Hours: TBD
- **Julia Luoto** ([jluoto@mines.edu](mailto:jluoto@mines.edu))
  - Office: TBD
  - Hours: TBD



# Getting Help

This is a **large class**, so we need a process to answer questions and provide help:



# Resources

- **No required** textbook.
- Lecture slides & other course material will be available at <https://github.com/ariarobotics/cv>
- **Recommended books:**
  - *Computer vision:*
    - **Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010 (online draft)**
    - **Klette, Concise Computer Vision: An Introduction into Theory and Algorithms, 2014**
    - Hartley and Zisserman, Multiple View Geometry in Computer Vision, Cambridge University Press, 2004
    - Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice Hall, 2002
    - Palmer, Vision Science, MIT Press, 1999
  - *Learning:*
    - **Goodfellow, Bengio, Courville, Deep Learning, MIT Press, 2016**
    - Mitchel, Machine Learning, McGraw-Hill, 1997
    - Duda, Hart and Stork, Pattern Classification (2nd Edition), Wiley-Interscience, 2000
    - Sutton & Barto, On-line book. The classic reference to the field of reinforcement learning.
  - *Graphical models:*
    - Koller and Friedman, Probabilistic Graphical Models: Principles and Techniques, MIT Press, 2009

# Summary



## In this course:

- You need knowledge of **linear algebra**, basic calculus & probability
- You need knowledge of algorithms, and **Python** (or C++)
- You will learn about **classical & modern CV** techniques
- In-person class **attendance** is mandatory
- **Academic dishonesty** is taken very seriously
- **Professional language & etiquette** are expected. Report to the instructor if you feel that inappropriate conduct or behavior has occurred