

CSE 518A

Human-in-the-Loop Computation

Instructor: Chien-Ju (CJ) Ho

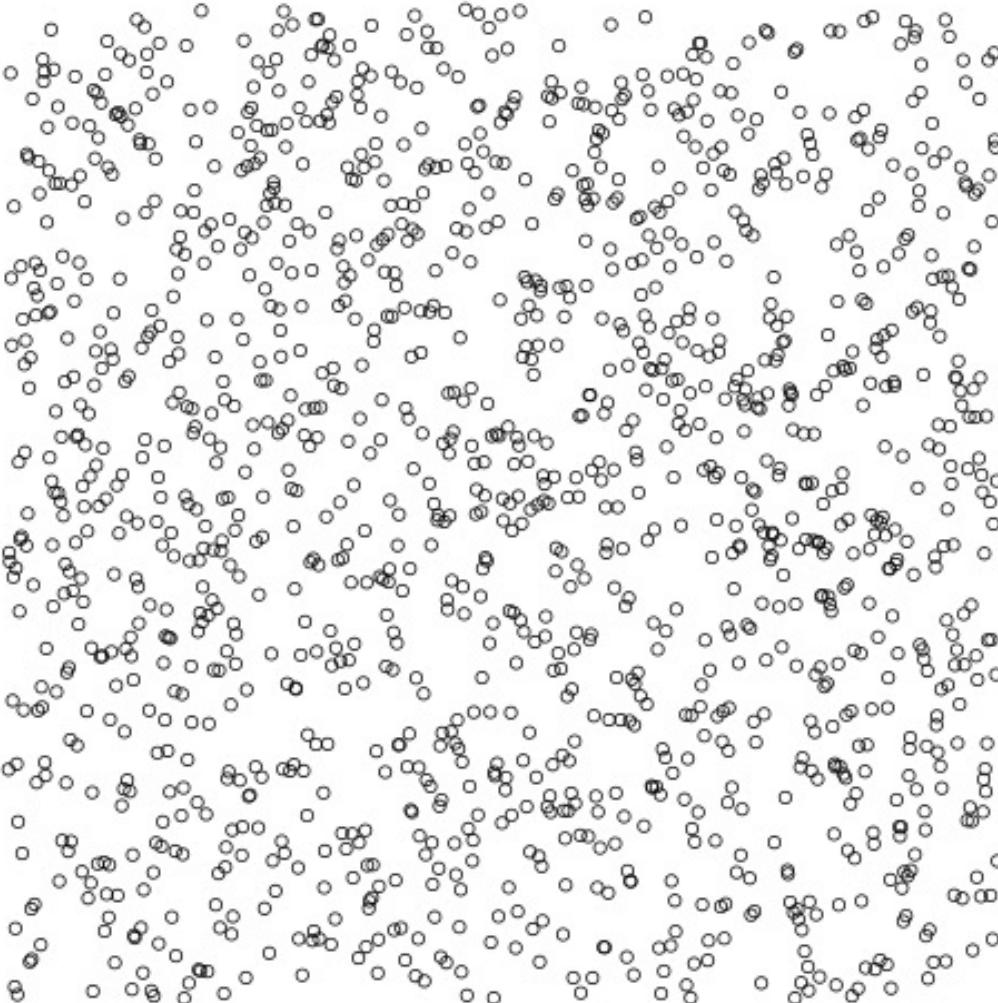
Course Information

- Announcements and discussion
 - Website: <http://chienjuho.com/course/cse518a>
 - Piazza: <http://piazza.com/wustl/spring2024/cse518a>
 - Please check the website and Piazza regularly
- Time and location
 - Mon/Wed 2:30 – 3:50pm
 - Weil / 010

Plan for today

- Welcome and introduction
- What's the class about?
- Logistics

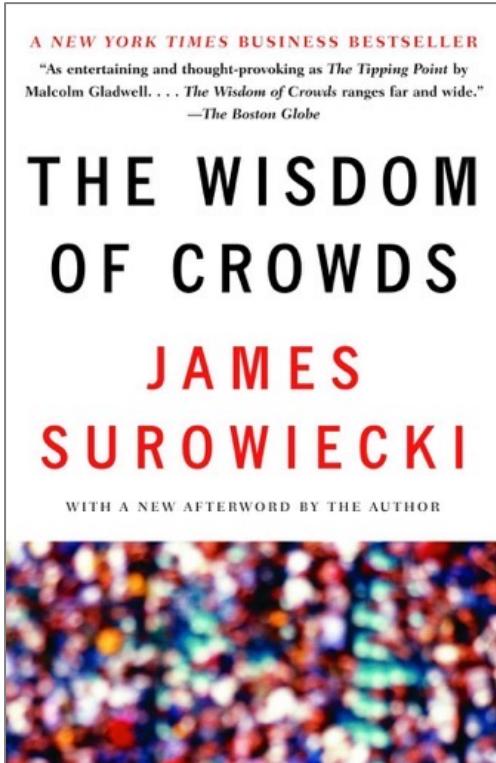
How many circles are in the image?



Input your guess:

<https://ppt.cc/fAaeTx>

The Wisdom of Crowds



- At a 1906 country fair, ~800 people participate in a contest to guess the weight of an ox.
- Reward is given to the person with the closest guess.
- The average guess is 1,197lbs.
The true answer is 1,198lbs.

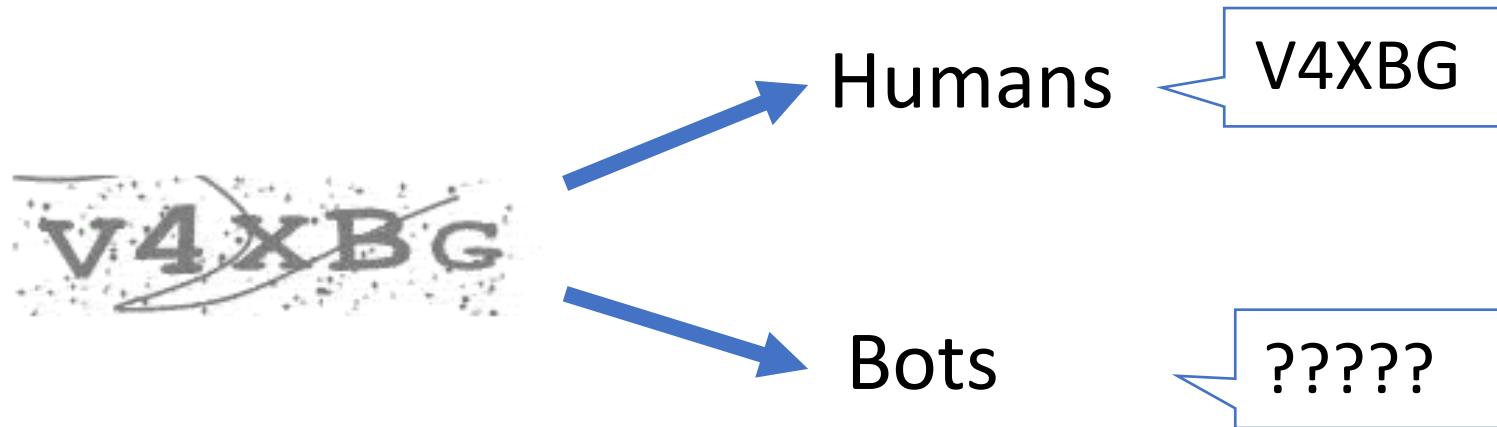




Image credit: ChatGPT

CAPTCHA

Completely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part



Показывать информацию обо мне

Всем
 Только зарегистрированным пользователям
 Никому

Защита от автоматической регистрации

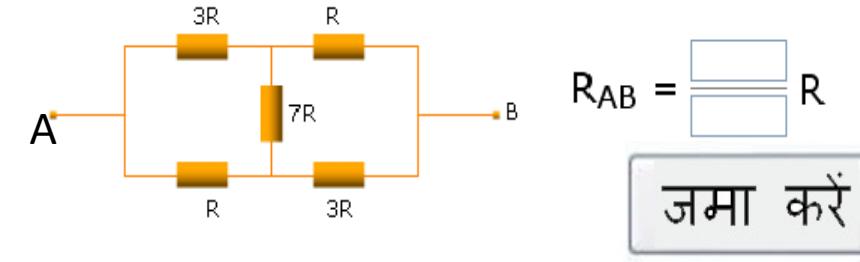
$\lim_{x \rightarrow 0} \ln \left(2 + \sqrt{\operatorname{arctg} x \cdot \sin \frac{1}{x}} \right)$

Введите ответ

X Очистить

Всё верно

<http://forum.academ.org/>



Humanity wastes about 500 years per day on CAPTCHAs. It's time to end this madness

05/13/2021



Thibault Meunier

Can we utilize this wasted human computation power?



The Norwich line steamboat train, from New-London for Boston, this morning ran off the track seven miles north of New-London.

morning

morning overtoRs

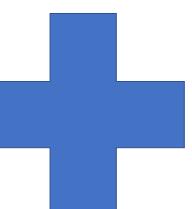
Type the two words:



reCAPTCHA
stop spam.
read books.

Word 1: an OCR task to solve

Word 2: tell apart humans and bots



“reCAPTCHA has completely digitized the archives of The New York Times and books from Google Books, as of 2011”

von Ahn et al. reCaptcha: Human-based Character Recognition via Web Security Measures. Science, September 2008

More than OCR

- Google acquired reCAPTCHA in 2009.

Type the characters that appear in the picture below.
Or [sign in](#) to get more keyword ideas tailored to your account. 



eineedit

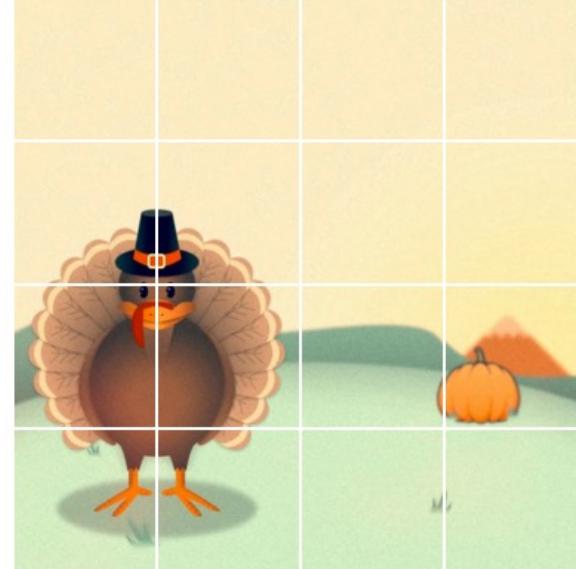
Select all images with sandwiches.



The grid contains the following images:
Row 1: A sandwich with meat and cheese, a bowl of soup, and a pizza slice.
Row 2: A burger with lettuce, tomato, and cheese, a sandwich with eggs and cheese, and a salad.
Row 3: A sandwich labeled 'PICKLED SMOKEHOUSE', a drink in a glass, and a sandwich with meat and cheese.
Row 4: A sandwich with meat and cheese, a drink in a glass, and a sandwich with meat and cheese.

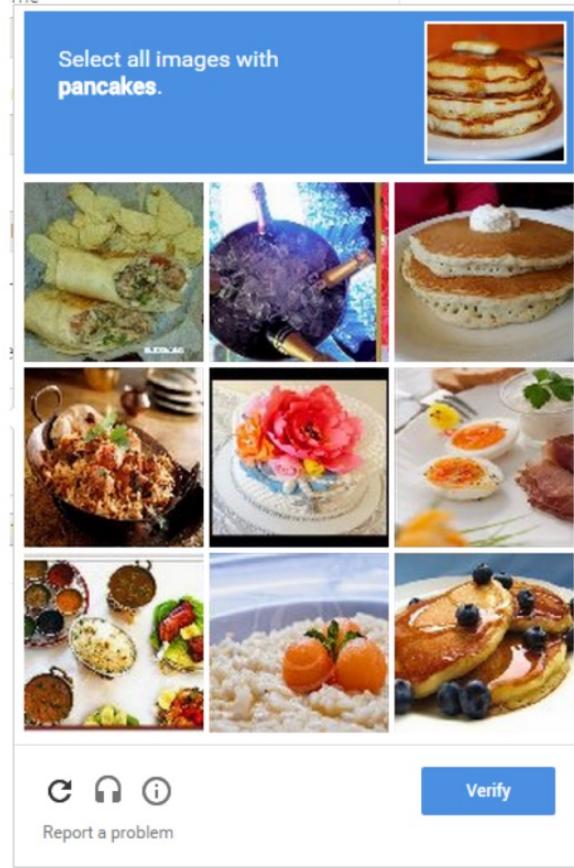
C Report a problem Verify

Select all squares with Turkeys.



The grid contains the following images:
Row 1: A large cartoon turkey standing on a green surface, a small orange pumpkin, and a green surface.
Row 2: A green surface, a green surface, and a green surface.
Row 3: A green surface, a green surface, and a green surface.
Row 4: A green surface, a green surface, and a green surface.

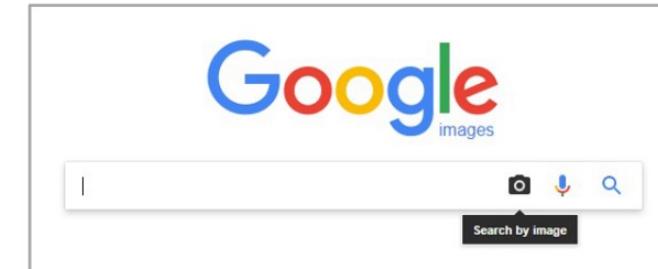
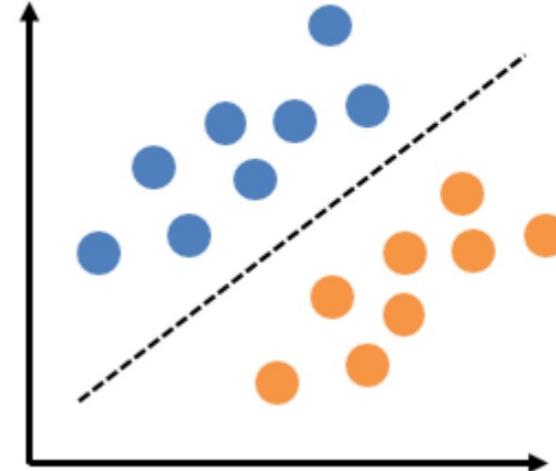
C Report a problem Verify



Training Data



Hard Tasks



More Examples



WIKIPEDIA
The Free Encyclopedia

Article [Talk](#)

Read

Edit

View history

Search Wikipedia



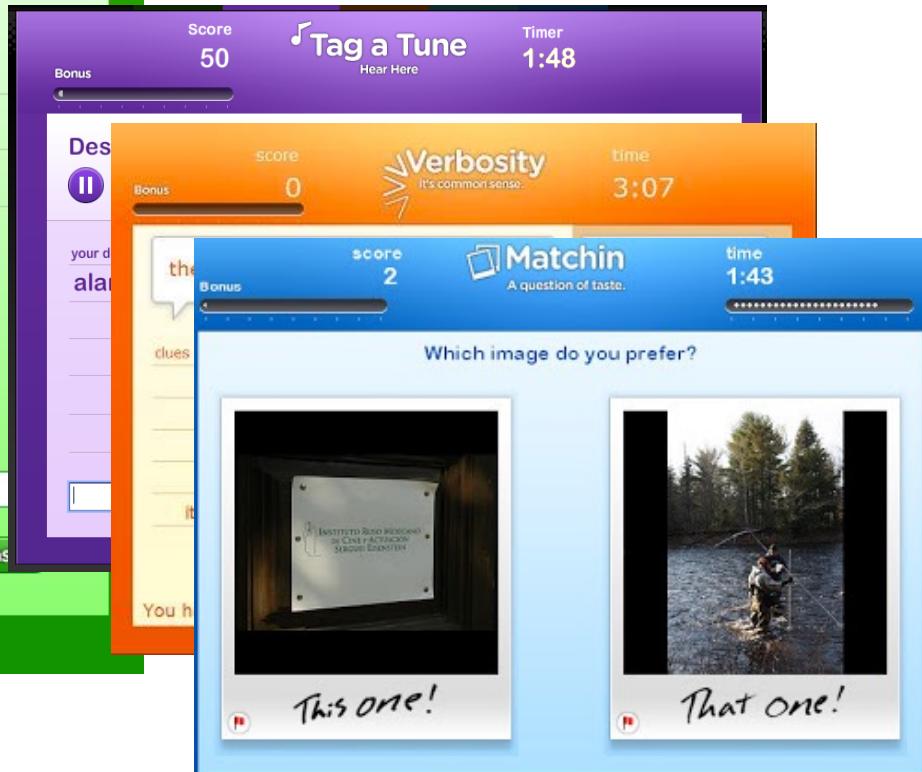
Crowdsourcing

From Wikipedia, the free encyclopedia

Crowdsourcing is a [sourcing model](#) in which individuals or organizations obtain [goods and services](#). These services include ideas and finances, from a large, relatively open and often rapidly-evolving group of [internet](#) users; it divides work between participants to achieve a cumulative result. The word crowdsourcing itself is a [portmanteau](#) of [crowd](#) and [outsourcing](#), and was coined in 2005.^{[1][2][3][4]} As a mode of sourcing, crowdsourcing existed prior to the digital age (i.e. "[offline](#)").^[5]

There are major differences between crowdsourcing and outsourcing. Crowdsourcing comes from a less-specific, more public group, whereas outsourcing is commissioned from a specific, named group, and includes a mix of bottom-up and top-down processes.^{[6][7][8]} Advantages of using crowdsourcing may include improved costs, speed, quality, flexibility, scalability, or diversity.^{[9][10]}

Some forms of crowdsourcing, such as in "idea competitions" or "innovation contests" provide ways for organizations to learn beyond the "base of minds" provided by their employees (e.g. [LEGO Ideas](#)).^[11] Tedious "microtasks" performed in parallel by large, paid crowds (e.g. [Amazon Mechanical Turk](#)) are another form of crowdsourcing. It has also been used by [not-for-profit](#) organizations and to create [common goods](#) (e.g. [Wikipedia](#)).^[12] The effect of user communication and the platform presentation should be taken into account when evaluating the performance of ideas in crowdsourcing contexts.^[13]



HEALTHY LIVING 09/19/2011 03:37 pm ET | Updated Nov 19, 2011

Gamers Decode AIDS Protein That Stumped Researchers For 15 Years In Just 3 Weeks

von Ahn and Dabbish. "Labeling Images with a Computer Game". 2004.



39 or fewer
39.POTUSTWEETS.020717

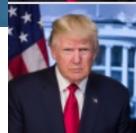
1¢  1¢

2¢

1¢

99¢

98¢



40 - 44
40.POTUSTWEETS.020717

2¢  5¢

3¢

2¢

98¢

97¢



45 - 49
45.POTUSTWEETS.020717

12¢  11¢

14¢

12¢

88¢

86¢



50 - 54
50.POTUSTWEETS.020717

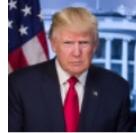
19¢  7¢

21¢

19¢

81¢

79¢



55 - 59
55.POTUSTWEETS.020717

24¢  1¢

25¢

23¢

77¢

75¢



60 - 64
60.POTUSTWEETS.020717

26¢  12¢

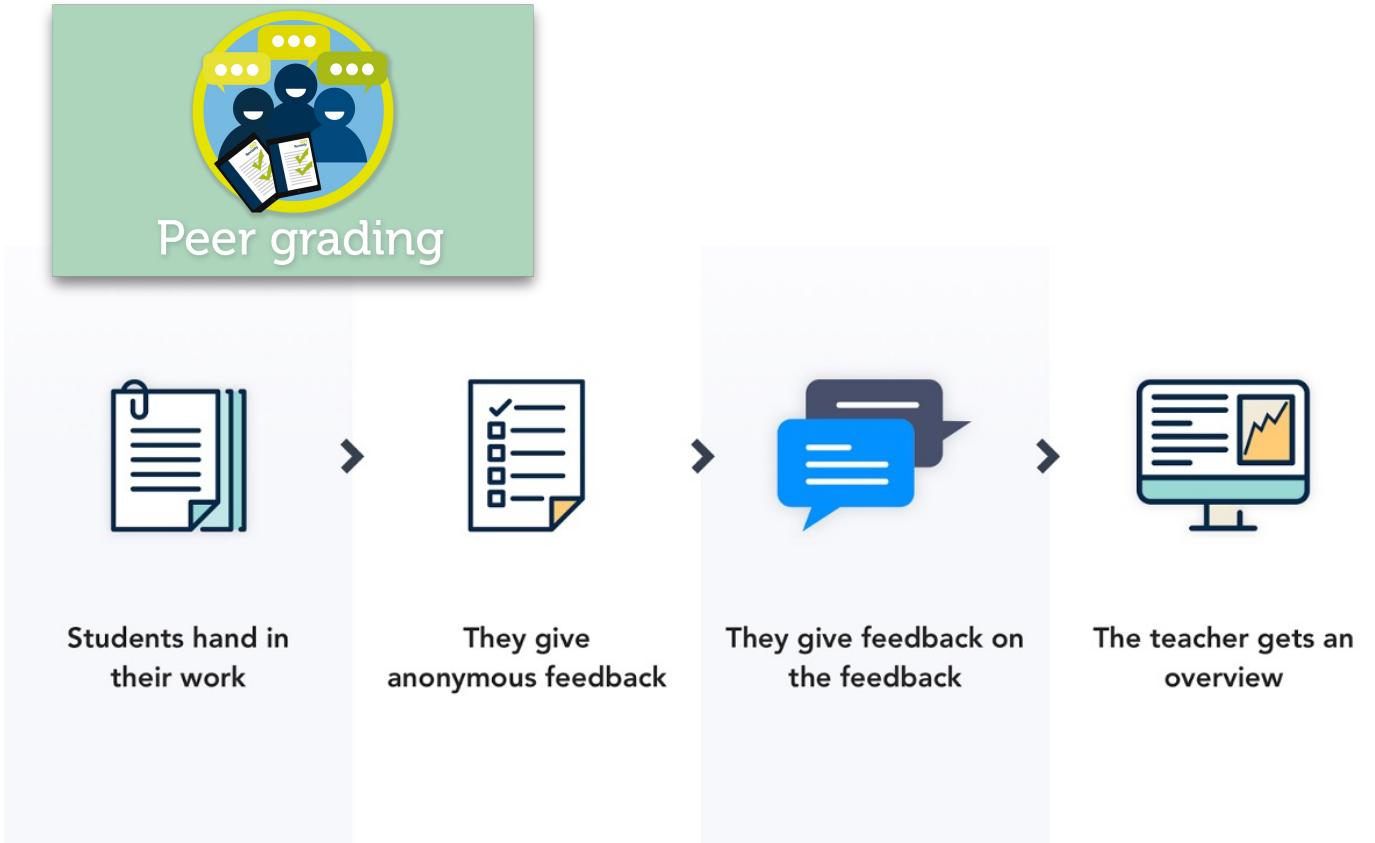
25¢

23¢

77¢

75¢

Education



General-Purpose Platform: Crowdsourcing Markets



HIT Groups (1-20 of 1318)

[Show Details](#)[Hide Details](#)

Items Per Page:

20

Requester	Title	HITs	Reward	Created	Actions
+ Megan	Categorization	45,696	\$0.01	1h ago	Preview Qualify
+ Perch Mturk	Kitchen Appliance Classification	14,958			Qualify
+ Sandra Dodson	Find email address and first/last name of Office Manager	9,327			Work
	Find email address and first/last name of Office Manager	8,677	\$0.11	1d ago	Preview Accept & Work
	Why is this review positive?	7,965	\$0.01	6d ago	Preview Accept & Work
	Why is this review negative?	7,058	\$0.01	6d ago	Preview Accept & Work
	Market Research Survey	6,680	\$0.01	1h ago	Preview Accept & Work
	Find email address and first/last name of owners or ge...	4,511	\$0.11	1d ago	Preview Accept & Work
	Security Classification	4,200	\$0.02	2m ago	Preview Accept & Work

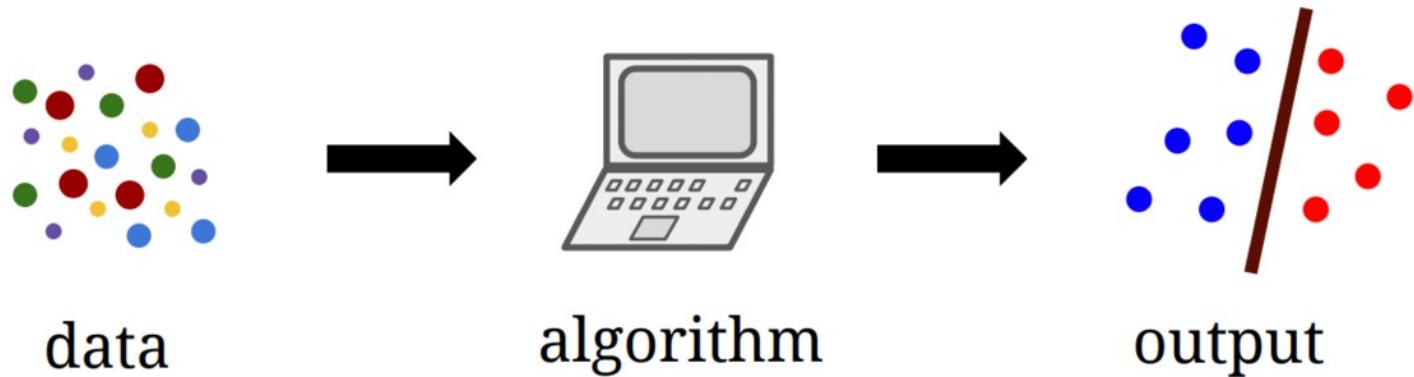
Post Tasks:

- Audio transcription
- Image tagging
- Relevance evaluation
- Handwriting recognition
- Product information collection

[Alexandra Dodson](#)**Specify payments**

In the Context of Machine Learning

- Standard setup of (supervised) machine learning



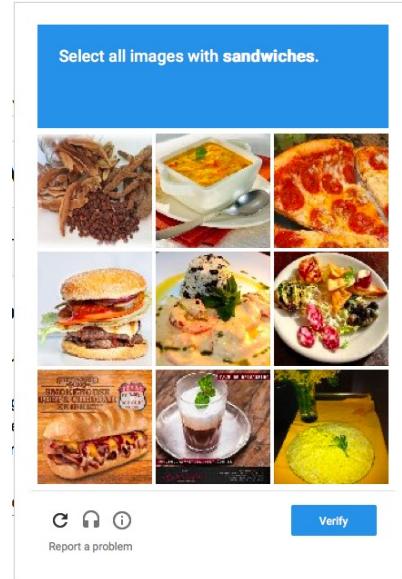
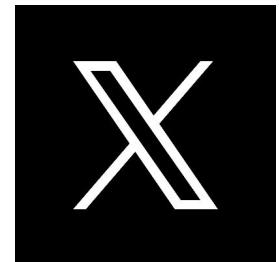
- Finding patterns from the given training datasets
- Use the pattern to make predictions on new test data
- Common assumption:
 - Training and test data points are i.i.d. drawn from the same distribution

Data is often generated/annotated by humans



Google

facebook



kaggle™



gwap

reCAPTCHA™

99 designs®

[topcoder]™

PredictWise

Predictious

Large Language Models



ChatGPT

Step 1

Collect demonstration data and train a supervised policy.

A prompt is sampled from our prompt dataset.

Explain reinforcement learning to a 6 year old.

A labeler demonstrates the desired output behavior.

We give treats and punishments to teach...

SFT
📝
📄📄📄

This data is used to fine-tune GPT-3.5 with supervised learning.

Step 2

Collect comparison data and train a reward model.

A prompt and several model outputs are sampled.

Explain reinforcement learning to a 6 year old.

A In reinforcement learning, the agent is...
B Explain rewards...
C In machine learning...
D We give treats and punishments to teach...

A labeler ranks the outputs from best to worst.

D > C > A > B

RM
📝
📄📄📄

This data is used to train our reward model.

Step 3

Optimize a policy against the reward model using the PPO reinforcement learning algorithm.

A new prompt is sampled from the dataset.

Write a story about otters.

PPO
Once upon a time...
RM
 r_k

The PPO model is initialized from the supervised policy.

The policy generates an output.

The reward model calculates a reward for the output.

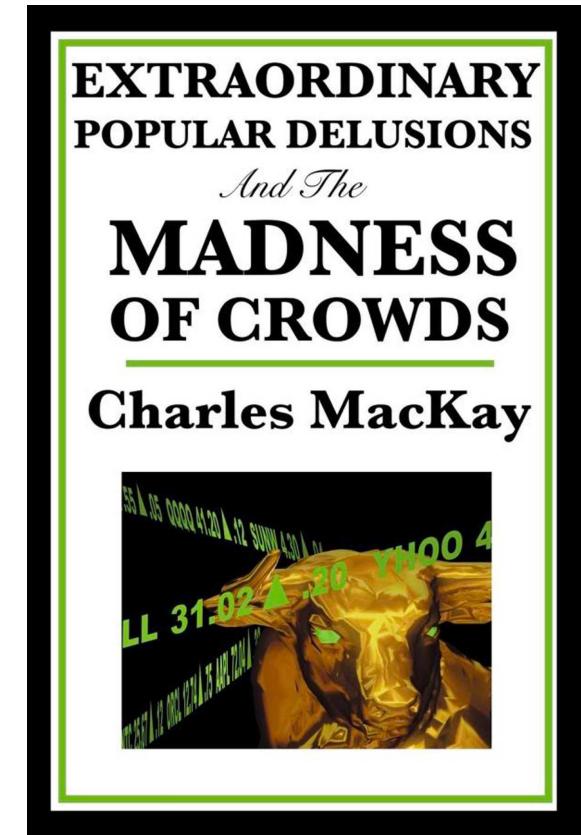
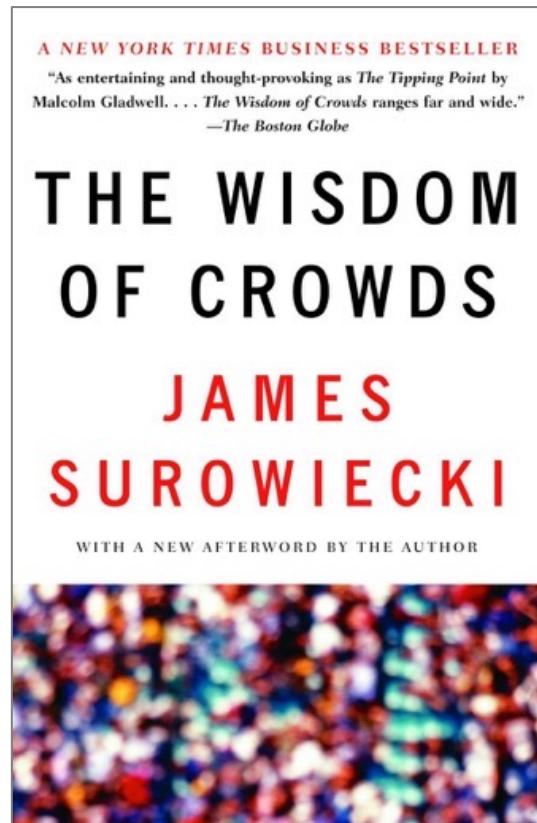
The reward is used to update the policy using PPO.

What is this course about?

Investigate the design and analysis of human-in-the-loop systems

Explore the growing role of AI and study human-AI interactions

Revisit: When is the Crowd Wise?



Discussion

- Under what conditions is the crowd wise?
- How should we (mathematically) **model** the crowdsourcing process?
 - How to combine the results?
 - Can we estimate how accurate the combined result is?
 - Can we better design the process to motivate higher-quality data?
 - ...
- Notes about the discussion
 - Please spend a moment introducing yourselves to others!
 - **Be prepared to share** what you have discussed. We will ask volunteers and also randomly pick people to share.

When is the Crowd Wise?

- Some general “beliefs” for the crowd to be wise
 - Informed individuals
 - Diversity of opinions
 - Independence
 - Good aggregation
 - Aligned incentives
 - ...
- Can we make these ideas more formal?
 - Can we “model” the process?

*All models are wrong
but some are useful*



George E.P. Box

Example Model on Aggregation

- People have unbiased estimates of the true answer

user guess = true answer + Gaussian noise

Observations

Latent values we
want to know

Zero-Mean Noises

- What can we do with this model?

- Assume the model somewhat captures the reality,
 - we can infer the **true answers** from the **user guesses** we observe (mean is a good estimate)
 - we can further analyze the "number of guesses" we need to achieve certain accuracy
- Does this model capture the reality?
 - what if everyone has different abilities in guessing? How do we perform inference?
 - what if there are some unknown biases?

Example Model on Incentives

- People choose effort level in generating their true answer

$$\text{user-answer} = \text{true-answer} + \text{noise(effort)}$$

$$\text{user utility} = \text{reward} * \Pr(\text{getting reward} \mid \text{effort}) - \text{cost}(\text{effort})$$

user chooses effort that maximizes their utility

- What can we do with the models

- Designing the optimal incentive schemes
- How much we should pay, should we offer a bonus?
- What to design non-financial incentives (badges, leaderboards, etc).

What is this course about?

- Design and analysis of human-in-the-loop computation
 - Develop “models” of how humans take actions in our systems
 - Based on the model,
 - design methods to **aggregate** user information
 - design **incentives** to encourage high effort and truthful reports
- Exploring the interactions between humans and AI
 - **Large language models (LLMs)** as a proxy for the crowd?
 - Enable **human-AI collaborations**
 - Explanations, trust, optimization, ethics.

Let's take a look at the course schedule

- <https://chienjuho.com/course/cse518a>

Logistics

Grading

- **Course Project: 40%**
- Homework assignment: 20%
 - 4 homework assignments
- Paper reviews and class participation: 20%
- Paper presentation and leading of discussion: 20%

Course Project

- The main component of the course.
- Could be an **original research project** or an **extensive literature survey**.
 - You are encouraged to start with a research project. You will have the chance to convert the project to literature review if things don't go well.
- Tentatively, you should work in groups of 2 (or 3 if the class size is large).
 - Will announce the detailed guidelines next week after the class size is finalized.

Tentative Timeline of Project

- Mar 1: Project proposal (and deciding team members)
 - Brief description of the proposed project (1~2 paragraph)
 - Citing at least one paper that's relevant to your proposal
- Mar 21: Milestone 1
 - A brief literature review and the description of your plan (one page)
 - Last chance to change the topic of the project
- Apr 3: Milestone 2
 - Summary of your current progress (up to 2 pages)
 - Last chance to convert the research project to (a more extensive) literature review
- Apr 22/24: In-class project presentations
- Apr 26: Project report due

Grading

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- **Homework assignment: 20%**
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Homework Assignments

- Assignment 1
 - Programming assignment
 - Implement label aggregation algorithms covered in class on a given dataset
- Assignment 2
 - Math assignment
 - Using game theory to analyze some given human-in-the-loop mechanisms
- Assignment 3
 - Scripting assignment
 - Examining the idea of leveraging LLMs as the crowd
- Assignment 4
 - TBD
- No TA in this course
 - You are expected to be able to work independently

Grading

- Course Project: 40%
- Homework assignment: 20%
 - 4 homework assignments
- **Paper reviews and class participation: 20%**
- Paper presentation and leading of discussion: 20%

Paper Reviews and Class Participation

- Before each lecture, finish the required reading and submit a review (including a summary and answers to additional questions).
 - Due by the **midnight before each lecture** on **Gradescope**.
 - The first review is for next Wednesday (due next Tuesday)

Label Aggregation: EM-based Algorithms

Required

[Whose Vote Should Count More: Optimal Integration of Labels from Labelers of Unknown Expertise.](#) Whitehill et al. NIPS 2009.

Optional

[Learning from Crowds](#). Raykar et al. JMLR 2010.

[Maximum Likelihood Estimation of Observer Error-Rates Using the EM Algorithm](#).

Dawid and Skene. Applied Statistics. 1979.

Required Reading and Review

- You should be ready to answer the following questions:
 - Summary the paper in 3~4 sentences.
 - What's the research question the paper is solving?
 - What's the proposed approach?
 - What are the results?
 - Illustrate what you like/dislike about the paper.
 - Answer additional questions related to the paper.
- Try also to think about your project during reading
 - It might be hard in the beginning. Try to think about what assumptions they make, and whether you can relax some of those? Can you apply the method/approach of the paper in different domains/applications, etc?

Class Participation

- Participation is important for this course
- Most students will either get full credits or 0 credits for participation.
 - Attend every lecture but rarely participate in discussion: 0 credits for participation
- Starting mid-semester, I'll send notifications to low-participating students
 - Student receiving notifications are expected to actively participate for almost every lecture for the remaining semesters.

Grading

- Course Project: 40%
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- Paper reviews and class participation: 20%
- **Paper presentation and leading of discussion: 20%**

Paper Presentations and Leading of Discussion

- You will need to sign up to present the paper(s) and lead the discussion, in groups of 2~3 students (again, more to come next week).
 - Take a look at the current schedules
- Presenters:
 - Read the required paper and additional optional papers for the assigned class
 - Discuss with me (one week before class) about the presentation and the reading questions
 - We will talk more about the presentation format next week
- Non-presenters:
 - Submit reviews on time and engage in the discussion in class.

Grading

- Course Project: 40%
- Homework assignment: 20%
 - 4 homework assignments
- Paper reviews and class participation: 20%
- Paper presentation and leading of discussion: 20%

More on The Grades

- Homework assignments / reviews will be lightly graded
- Condition on you complete all other requirements satisfactorily, your final grades are determined by your final project
 - A+: Your project is close to be published in top venues
 - A: I'm happy to use your project as model projects in the future
 - A-: Overall good, but there are minor flaws (in reports/presentation/approaches/...)
 - B+ or lower: There are more significant flaws in the project (e.g., poorly motivated problems, etc)
- Your final grades will be decreased from the above for missing reviews / homework issues / non-participation using the grading scheme (following the standard mapping)

Academic Integrity and Late-Day Policy

- Academic integrity and collaboration policy
 - You are encouraged to collaborate.
 - But all assignments/reviews **must** be written entirely on your own.
- Late day policy
 - Assignments
 - 4 late days in total. No 2 late days per assignment.
 - Reviews
 - No late submissions. But you can skip 2 of them without penalty.
 - Project-related reports
 - No late submissions.

Is the course for you?

- Need to be comfortable with several math concepts and programming
 - Probability
 - linear algebra
 - calculus
 - basic concepts about computer science and ability to program
- If you are not sure, please take a peek at the papers for the next few weeks
 - You should at least be able to understand the formulation and main results
 - You will need to implement some algorithms in these papers

Questions?