

CHARLES UNIVERSITY PRAGUE

faculty of mathematics and physics



Human Computation

Le Khanh Chuong, 2012

Seminar of Artificial Intelligence

Teached by prof. R. Barták



Research

Areas

General Information

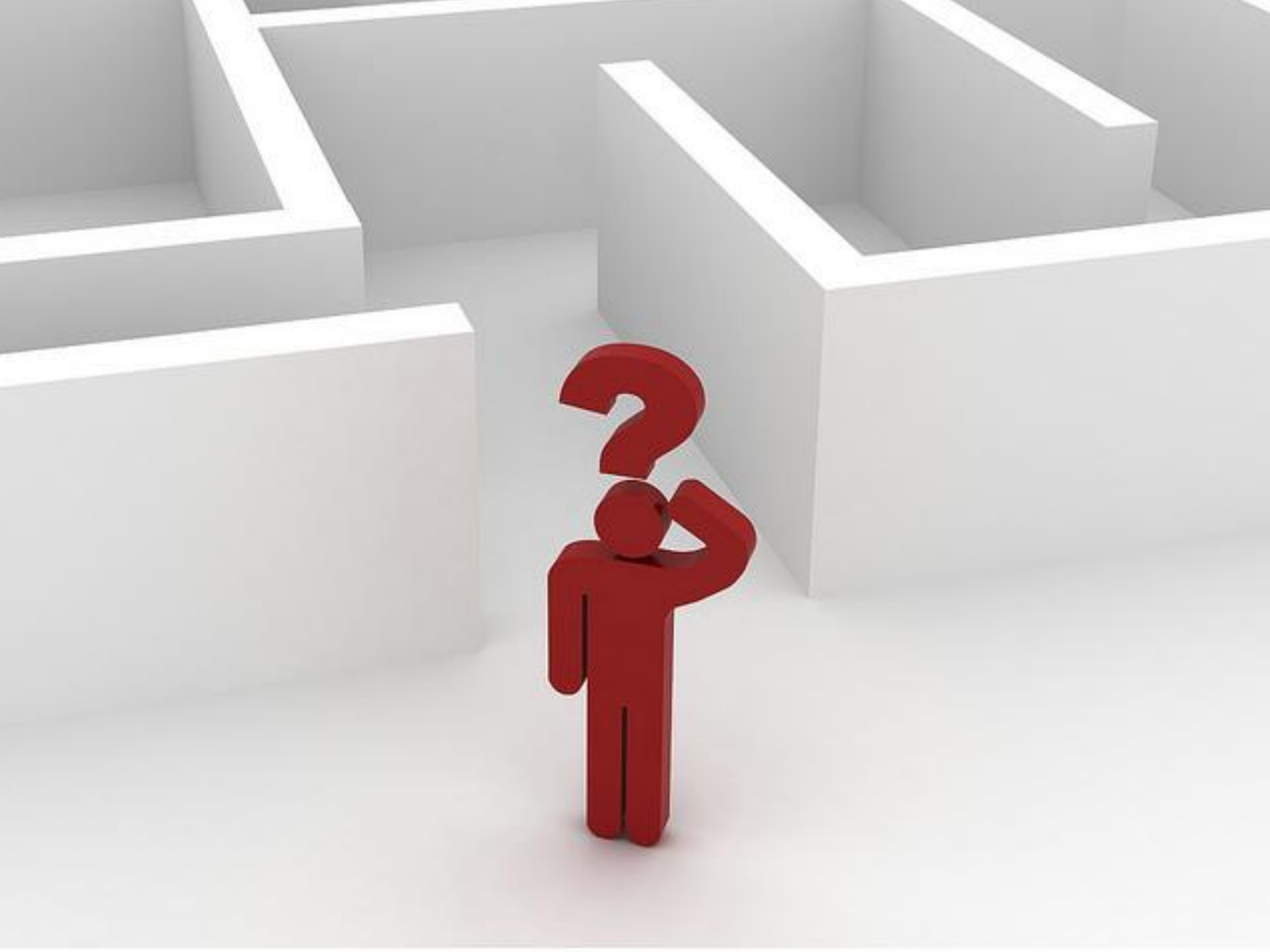


id
impulsive
conscious
western
northwestern USA
idea noun 1 a plan or
by thinking. 2 a m



DISCIPLINE

MASTERING OTHERS IS STRENGTH. MASTERING YOURSELF IS TRUE POWER.





OUTPUT





What is **Human Computation** (HC)?

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New and **evolving** research area **based on human intelligence to solve computational problems.**

Definition of Computation

- lat. *computare*, to “count, sum up or reckon together”
- loosely defined: **Process of mapping** of some **input representation** to some **output representation** using an **explicit, finite set of instructions** (i.e. *an algorithm*).

The idea behind digital computers may be explained by saying that these machines are intended to carry out any operations which could be done by a human computer.



[A. M. Turing ,*Computing machinery and intelligence*, October 1950]

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Human computation is computation that is carried out by humans



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Human computation is computation that is carried out by humans

HC systems are intelligent systems that organize humans to carry out the process of computation.



[A. M. Turing ,*Computing machinery and intelligence*, October 1950]



Humans as CPU

Muli Koppel, Architecture to Go Ltd.
<http://mulikoppel.blogspot.com>

Related concepts to HC

Crowdsourcing

Collective Intelligence

Social Computing

- ✓ None of these concepts emphasize the idea of **explicit control**; implicitly assume the outcome is determined by coordination and competition
- ✓ No explicit designed mechanism for ensuring that the HC人 tell the truth, e.g. Wiki uses rules, protocols and standards

Various genres

The logo features a stylized graphic above the text. It consists of two curved, magenta lines that meet at a point above the letter 'w'. The right-hand curve extends further to the right and ends in a solid white circle.

gwap

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ESP Game

Concentrate...

What do you see
in an image?
Do you have ESP?



PLAY NOW

score
100

ESP Game

Concentrate...

time
2:21

What do you see?

taboo words

peace

lay



guesses

sheeps...

sheep

+ submit

→ pass

Peekaboom

PEEK : GUESS WHAT YOUR PARTNER IS REVEALING

TIME LEFT
2:23

SCORE
300

peek
HINT

guesses

fur	100
cat	100
dog	100
sheep	100
horse	100

GUESS HERE

PASS

HINTS HELP YOU GUESS

PASS FOR DIFFICULT IMAGES

BOOM : REVEAL PARTS OF THE IMAGE TO YOUR PARTNER

TIME LEFT
2:23

SCORE
300

boom
CLICK THE IMAGE TO REVEAL AREAS TO YOUR PARTNER.
RIGHT-CLICK TO FIND AN AREA OF THE IMAGE.

cow

guesses

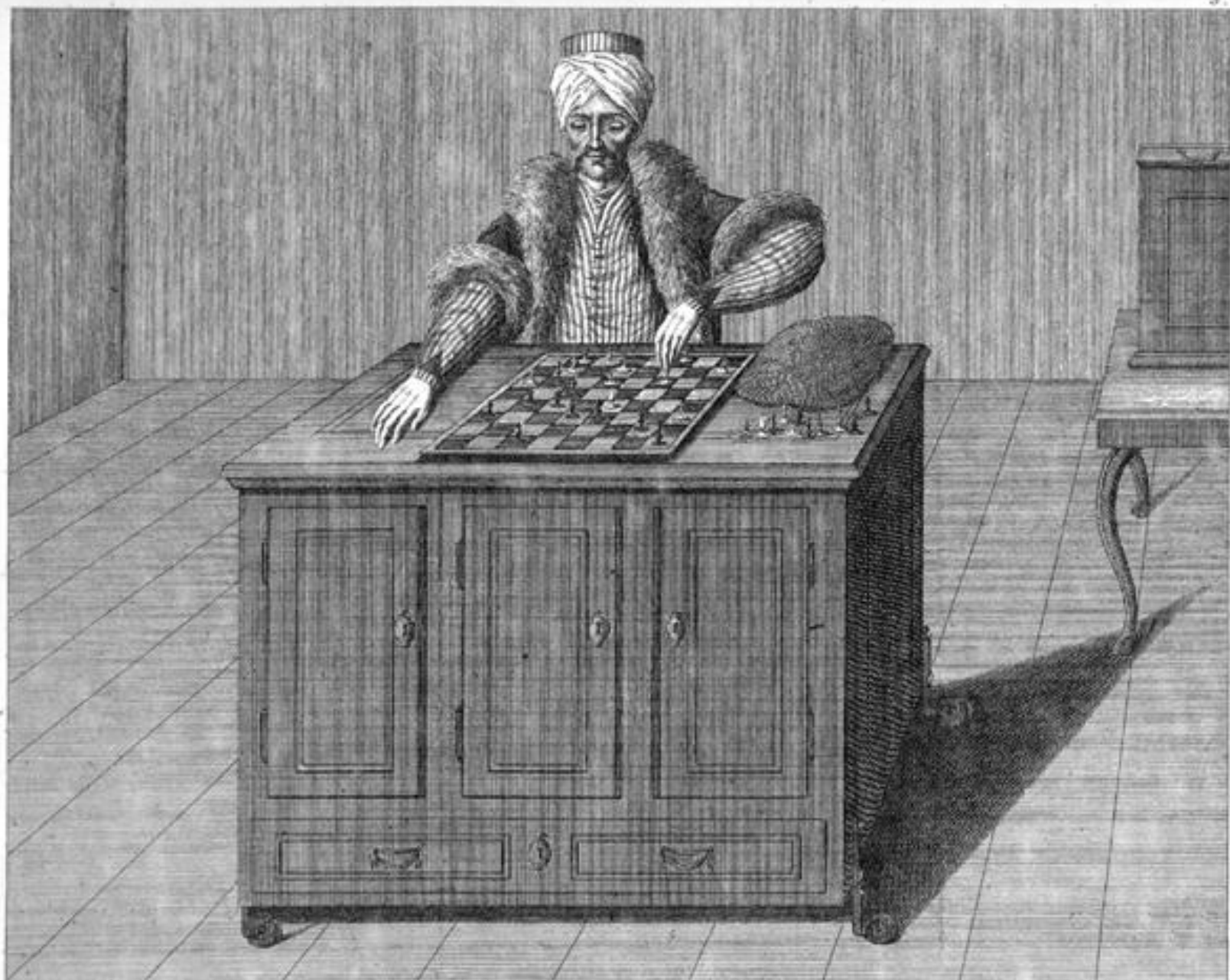
fur	100
cat	100
dog	100
sheep	100
horse	100

HINTS

PASS

GIVE HINTS IF NECESSARY

TELL YOUR PARTNER IF A GUESS IS **HOT** OR **COLD**



W. de Kempelen del.

Chr. à Meckel excud. Basilea.

P. G. Riety, sc.

Der Schachspieler im Spiele begriffen. | Le Joueur d'Échecs tel qu'on le voit pendant le jeu.

Make Money by working on HITs

HITs - *Human Intelligence Tasks* - are individual tasks that you work on. [Find HITs now.](#)

As a Mechanical Turk Worker you:

- Can work from home
- Choose your own work hours
- Get paid for doing good work



Get Results from Mechanical Turk Workers

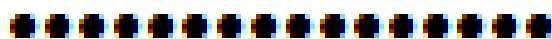
Ask workers to complete HITs - *Human Intelligence Tasks* - and get results using Mechanical Turk. [Get started.](#)

As a Mechanical Turk Requester you:

- Have access to a global, on-demand, 24 x 7 workforce
- Get thousands of HITs completed in minutes
- Pay only when you're satisfied with the results



Password:



[Forgotten your password?](#)

$(\pi_t^{-1}(\uparrow$



Type the two words:



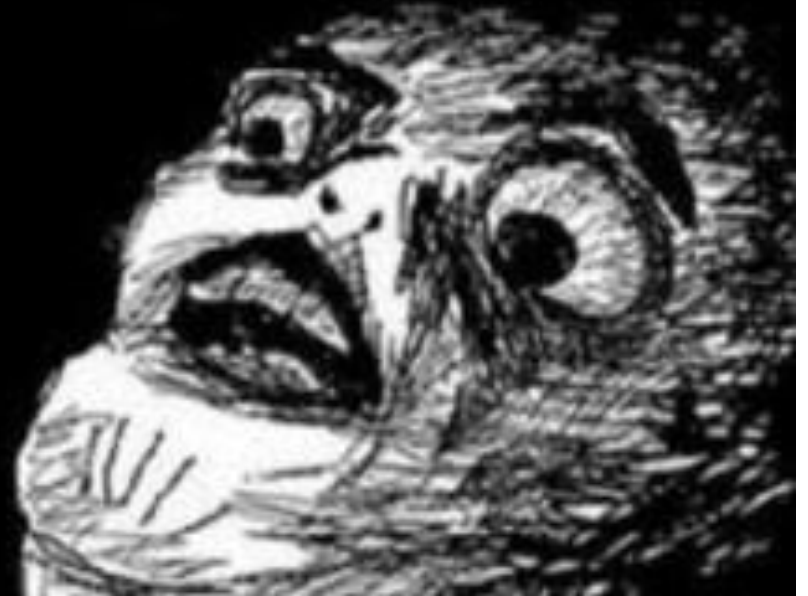
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read books.

Login



As you wish,
my lord.

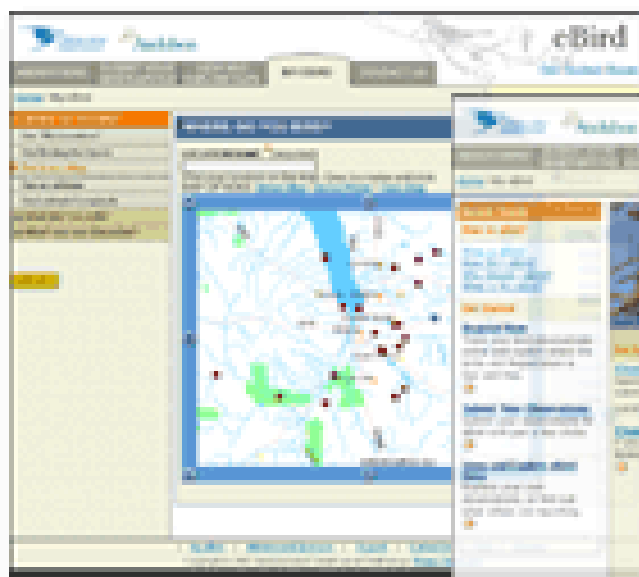




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any place, any time!







science for
citizens
.net

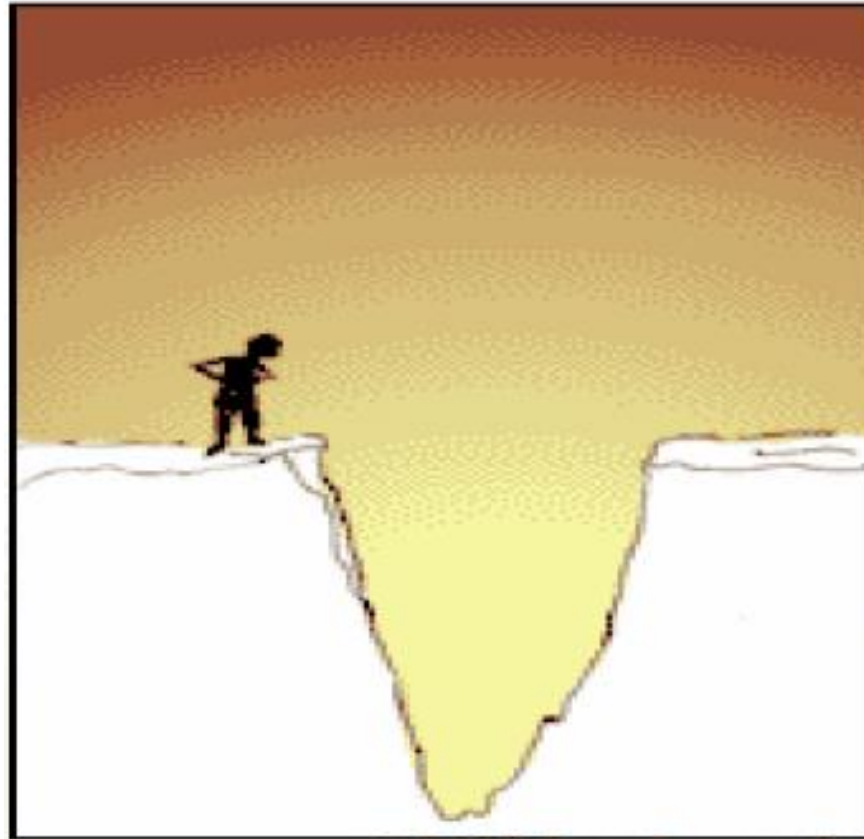


duolingo



Many research issues

In Deep www.deepcanyon.com



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HOW TO'S

design mechanism for querying HC人 to generate truthful outputs?

- Questionar: *What is the answer to 1+1?*
- Machine: 2
- Toddler: ?
- Spammer: 364
- Computer Scientist: 1
- Philosopher: it depends ...

- aggregate noisy outputs and complex tasks to HC人 in the absence of ground truth?
- effectively assign tasks to HC人 in order to satisfy the objectives of both the system (quality, budget, time constraints) and the workers (to learn, to entertained, desire to succeed)?



WHAT?

What:

- problems **can be efficiently answered** using HC?
- are **paradigms for designing** HC algorithms?

How can HC systems leverage the
join effort of both machines and
human?

Should it be processed by a human worker or by a machine?

- **Active learning** algorithm
- It's model of ML, where **learner chooses data** from which he wants to learn.

Should it be repeatedly processed by multiple workers?

- In order to be confident about the obtained labels

Comparing HC Algorithms

- ❑ **Correctness.** Does the algorithm lead to a solution of the problem in a finite number of steps?
 - The outputs can be **noisy**.
 - Alternative way how to compare HC algorithms may involve evaluating the *robustness* of the algorithms in producing the correct answer in the presence of noise.

- ❑ **Efficiency.**
 - Time complexity – number of operations and clock time
 - Query complexity – number of queries to human oracles
 - Cost-effectiveness – total amount of monetary costs is closely related with T & Q complexity.

Lets play a game ...

... at the end of presentation

Aggregating outputs

- ❑ Redundancy of outputs is bad or good?
- ❑ Objective VS Cultural truth
- ❑ We assume that there is a **hidden objective truth** that can be approximated by aggregating the outputs of many workers, given that at least some workers are accurate.

Classification problem

Put a set of objects into a **fixed number** of categories



Latent class models

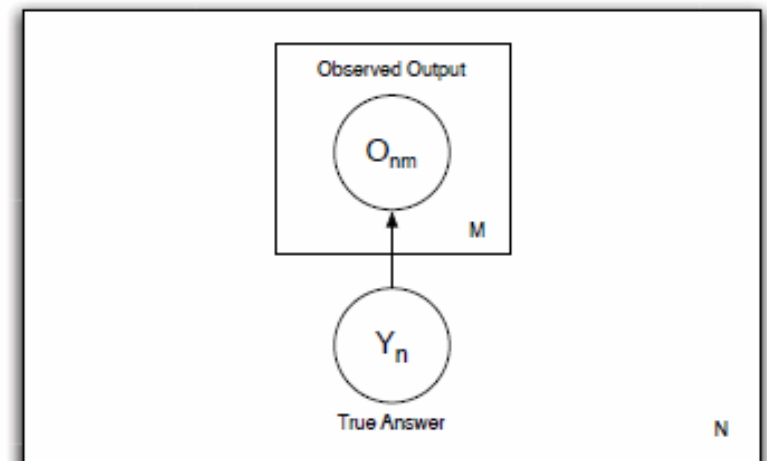
- Automated output aggregation method
- e.g. *majority votes* is based on LCM
- These models assume that what is
 - *observed* are the outputs
 - *latent* (i.e. hidden) are the ground truth and other factors (i.e. Worker's competence, the difficulty of the task)

Formally LCM:

- i. N computational tasks
- ii. *true* output Y_n for each task is unknown
- iii. Our goal is to estimate Y_n given an output matrix O (it has many missing values)
- iv. from M workers

		computational task			
		1	2	...	N
1	worker	O_{11}	O_{12}	...	O_{1N}
2		O_{21}	O_{22}	...	O_{2N}
...	
M		O_{M1}	O_{M2}	...	O_{MN}

Majority vote



Mathematics behind Majority vote

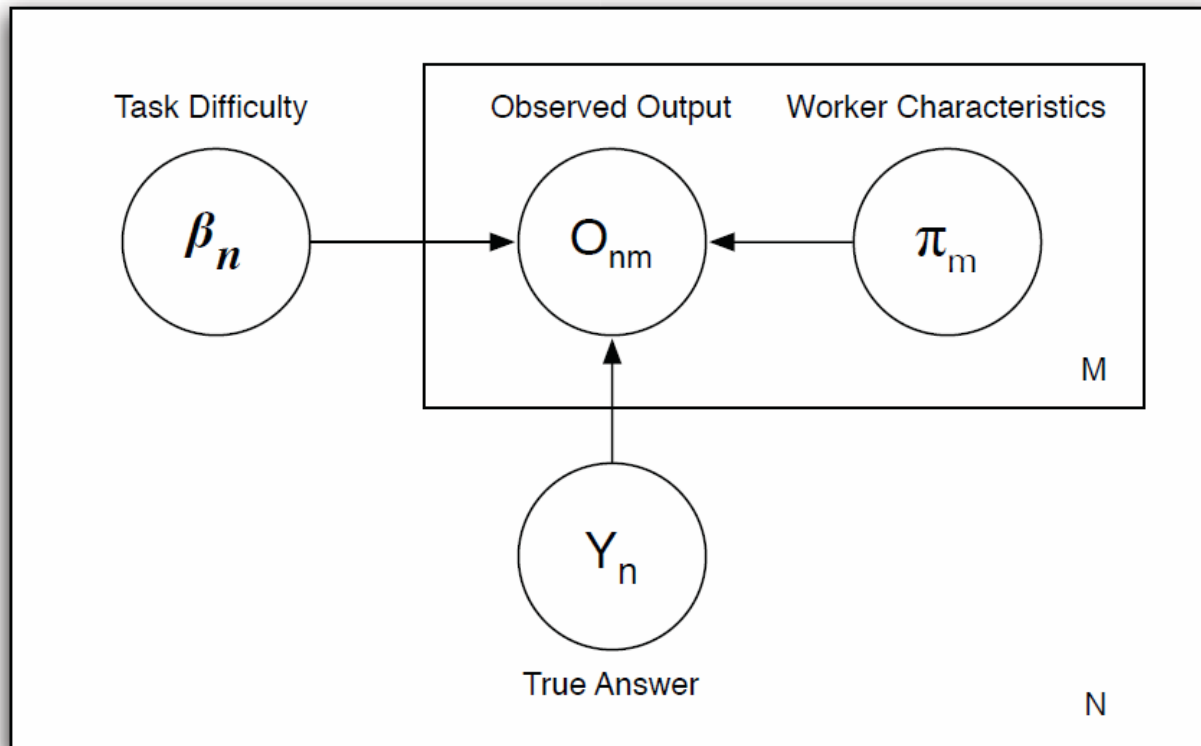
- Uniform probability $P(Y_n = j) = 1/J$
- Assuming that each worker outputs the correct answer with the same fixed probability $1 - \epsilon$, where $\epsilon < \frac{1}{2}$

$$\begin{aligned} Y_n &= \operatorname{argmax}_j P(Y_n = j | O) \\ &= \operatorname{argmax}_j \frac{\prod_{m=1}^M P(O_{n,m} = o_{n,m} | Y_n = j) P(Y_n = j)}{P(O)} \\ &\propto \operatorname{argmax}_j \prod_{m=1}^M P(O_{n,m} = o_{n,m} | Y_n = j) \\ &\propto \operatorname{argmax}_j (1 - \epsilon)^{\sum_{m=1}^M \mathbf{1}(o_{n,m} = j)} \cdot \epsilon^{\sum_{m=1}^M \mathbf{1}(o_{n,m} \neq j)} \end{aligned}$$

Problem with previous representation

- ❑ It doesn't account that workers can make random guesses or make mistakes and still agree.
- ❑ Output also depends on set of hidden variables θ for classifying the true states of health of patients.
- ❑ See paperwork by Dawid and Skene,

LCM, example





Game time



Empty slide



References

- Edith Law, Luis von Ahn – Human Computation
- www.wikipedia.org
- images.google.com
- <http://scistarter.com/>
- <http://www.gwap.com/>