

Human Computation and Crowdsourcing

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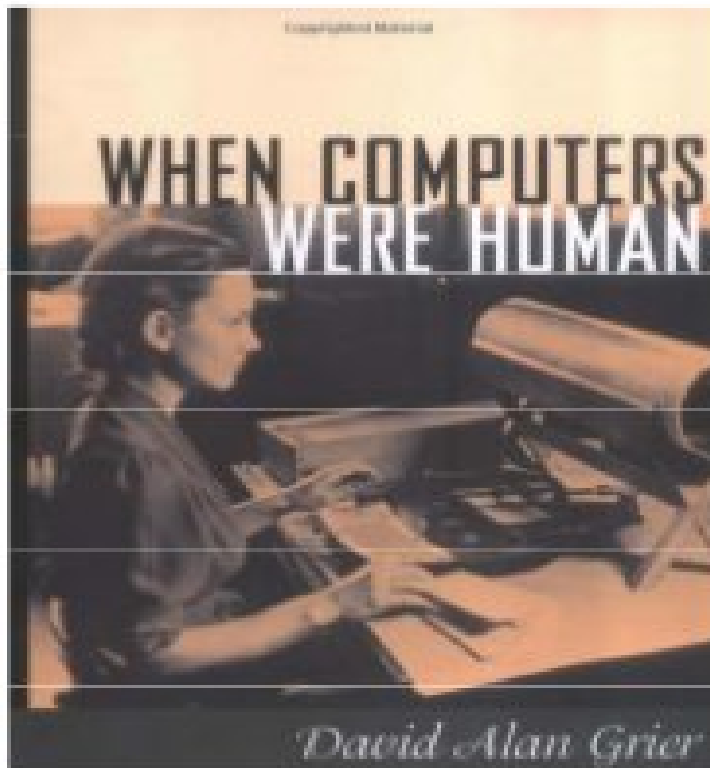
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- Machine and human computation
- Crowdsourcing and human computation
- Conceptual Foundations
- Progress in crowdsourcing research
- Toward better integration of machine and human computational services
- Experiments in integrating machine and human computation.

Human Computation, Round 1



- Humans were the first “computers,” used for math computations

Grier, *When computers were human*, 2005
Grier, *IEEE Annals* 1998



Long history and pedigree of human computation:

- Astronomic computations
- Creation of logarithmic and trigonometric tables – De Prognny in 1794 used unemployed hairdressers (who only knew addition and subtraction) through division of labour and detailed workflows,
- Stock market computations,
- Automated computers arrived only in the 1940s!

Internet provides the affordance for harnessing the computational power of millions for certain classes of problems!

A more recent description of computational thinking:

- › Computational thinking builds on the power and limits of computing processes, whether they are executed by a human or by a machine (more generally by combinations of humans and machines). Computational methods and models give us the courage to solve problems and design systems that none of us would be capable of tackling alone. Computational thinking confronts the riddle of machine intelligence: What can humans do better than computers, and what can computers do better than humans? Most fundamentally, it addresses the question: What is computable? Today, we know only parts of the answer to such questions. Jeanette Wing (2007)

- › Harnessing the combined power of computers and human intelligence to solve complex problems that are beyond the scope of existing AI algorithms (typically involving conceptual thinking, perceptual skills etc.)
- › Problems that generally defy closed system solution
- › Opportunity to leverage the abilities of large number of people made possible by the Internet and the World Wide Web.



Web 1.0

- Mainly for information dissemination, e-commerce, web as vector of exposure, read-only web.

Web 2.0

- Participative web, read-write web, user-contributed web

Web 3.0

- Service web, read-write-execute web, semantic web

- › Web 2.0 spawned the crowdsourcing phenomenon,
- › Initially as a means for gathering ideas and sourcing content from the crowd,
- › Crowdsourcing refers to the idea that the web can facilitate the aggregation and/or selection of useful inputs from a potentially large number of people connected to the internet,
- › Has evolved into diverse applications including:
 - distributed problem solving (involving human computation) over the internet,
 - open innovation (Crowd contests)
 - Games with purpose (human algorithm games)
 - Crowdfunding, crowdsensing
 - mass collaboration
 - including problem solving thru micro-tasking (using platforms like Mechanical Turk)

- › The aspects that seem to be common across these are
 - a. the assignment of a problem or the distribution of some work to a large number of independent (volunteer or paid) individuals or groups through the internet,
 - b. some mechanism for aggregation and selection
 - c. optional offer of rewards or payment.
- › Seen as a more robust alternative to the use of in-house teams of experts or a chosen group of contributors for a wide array of problems.
- › The basic assumption is that the crowd can bring interesting, non-trivial, and non-overlapping information, insights, or skills, which, when harnessed through appropriate aggregation and selection mechanisms, can add to the quality of the solutions.

- › On-demand global workforce completing short tasks online
- › Who logs on to complete microtasks?
 - Millions of workers available online at any time from
- › Who can create tasks for workers?
 - Anyone (on many platforms, Amazon Mechanical Turk or Crowdfunder)
- › What kind of tasks can you create?
 - Breakdown the task into micro human intelligence tasks - anything embeddable in a browser or phone – programmatic interfaces

Human Computation and Crowdsourcing

- › Human agents provide all or part of a badly needed service, typically in combination with one or more computational services.
- › Balanced integration of diverse services provided by the machines and human agents over the world wide web,
- › General assumption – the ‘augmentation’ provided by human computation can produce better results (than either the machine or the human regime)



Origins in cybernetics in the writing of Ashby, Licklider, Wiener, among others,

- *Intelligence Amplification (Ashby, 1956)*

Synthetic amplification of human intellectual power (of appropriate selection)

- *Man-Computer Symbiosis (Licklider, 1960)*

Tight coupling of human intellect and computing machines; the resulting entity can potentially perform at a level superior to each of the subsystems.

- *Augmenting the Human Intellect (Engelbart, 1962)*

Developing technologies for manipulating information to improve individual and group processes

› *Cognitive Comparative Advantage* (Simon, 1961)

Humans assigned tasks they are better equipped thru evolution (judgment in situations of ambiguity and surprise/spatio-temporal perception and locomotion) and machines crowded into tasks with reasonable structure.

- › Augmentation to machine intelligence provided by the aggregate sentient human judgment.

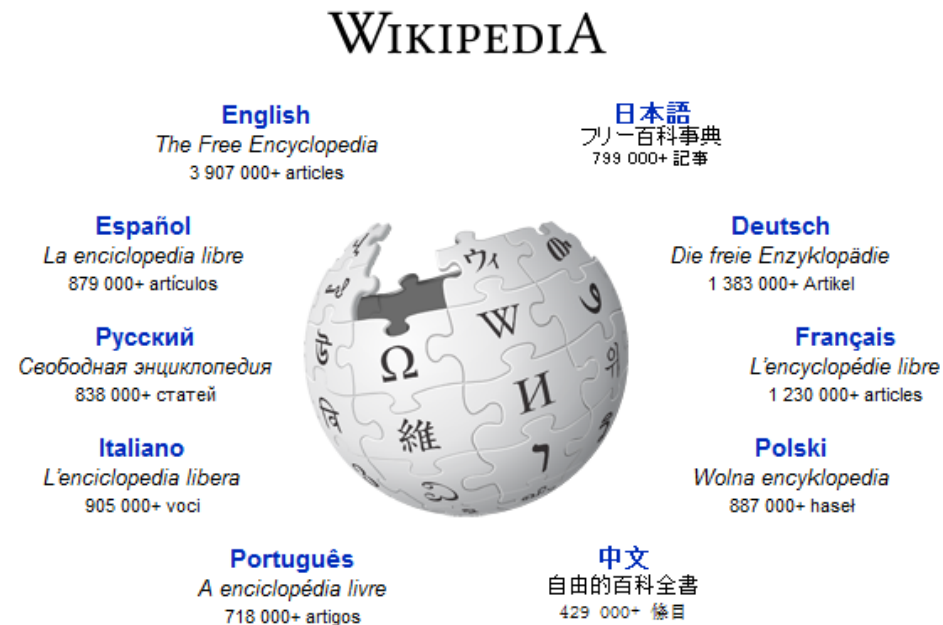
- › Captcha/recaptcha (von Ahn et al, 2000, 2008)
- › Originally started as a security procedure to tell humans and machines apart
- › Subsequently used for human-based character recognition and digitizing books!

(Over 200 million captchas filled out each day!)



Wikipedia contributions and annotations

- › Good example of an extensive online encyclopaedia created through crowdsourcing.
- › Both contributions as well as editing by the crowd.
- › Vandalism is an issue but confined to less than 2% of the contributors



- › CrowdDB – human computation for DB query processing (Franklin et al, 2011)



- › Provides APIs for requesting and managing work , ~~connect~~ directly to the CrowdDB query processor.
- › Microtasks (HITs) and HIT groups
- › Reward
- › Assignments
- › HIT Groups

AMT basic workflow:

A requester packages the jobs into HITs, determines the number of assignments (replicating each HIT into multiple assignments) and posts the HITs with additional constraints.

Requesters approve or reject each HIT completed by a worker

- › The essential complementarity between the machine and human,
- › Synergy of the hybrid system

Key Issues:

1. Performance and variability,
2. Task Design and Ambiguity
3. Affinity and Learning
4. Worker pool size
5. Open vs. closed world

Predicting Protein Structures with a Multiplayer online game

- › Foldit - crowdsourcing thru 'games with purpose' (from University of Washington)
- › Good example of a complex scientific problem solved with human directed computing.



- › • **Protein folding:** Proteins fold from long chains into
- › small balls, each in a very specific shape
- › • Shape is the lower-energy setting, which the most
- › stable
- › • Fold shape is very important to understand interactions
- › with out molecules
- › • Extremely expensive computationally! (too many
- › degrees of freedom)

- › Players interact with protein structures using direct manipulation tools to fold the protein into a minimal energy state – exploit human skill for reducing the search space
- › Players working collaboratively able to develop new strategies and algorithms,
- › Good example of the integration of human visual problem solving and strategy development with traditional computational algorithms.



› Results of preliminary experiments:

In three of the 10 challenges the best Foldit players and the best current simulations performed similarly—that is, the two approaches got about equally close to the final folded shape of the protein.

In five other challenges, the best result from Foldit was substantially better than the best a superfast computer alone could do.

In only two of the 10 cases did the simulation do somewhat better. These appeared to be the two hardest puzzles; neither Foldit players nor computers alone were able to get very close to the correct shape.

› Likely strengths of human computation:

- Strong spatial reasoning
- Intuition based on experience
- Greater adaptivity, emergent expertise
- Collaboration and knowledge sharing in teams and high degree of self-organisation

Massive new venture activity:

<https://angel.co/crowdsourcing>

Many well known and successful start-ups

Waze <file:///C:/Users/jdavis/Desktop/id323229106.htm>

Utest – in-the-wild software testing service based on crowdsourcing. Global professional community of 60,000 professional software testers

99Designs.com, Topcoder.com

- › Integration of computation and crowd-based human computation provide formidable problem solving capabilities,
- › Logic is that certain unique features of human computation which complement machine-based computation.
- › Logic of breaking down complex problems into microlevel (typically ~10 second) chunks which can be performed by millions of people and the results can be aggregated.
- › Mass collaboration among millions of internet users can further amplify this problem solving capability

