Wisdom of Crowds

DD3364

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The collective knowledge of a diverse and independent body of people typically exceeds the knowledge of any single individual and can be harnessed by voting.
Crowd wiser than any individual

- When?
- For which questions?

See *The Wisdom of Crowds* by James Surowiecki published in 2004 to see this idea applied to business.
Consider this scenario

Ask each person in the crowd:

Will Mr. X win the general election in country Y?

Crowd’s prediction:

MAJORITY answer.

⇐ This crowd predicts Yes.
(Mr. X will win the election.)
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Has crowd made a good prediction?

If composition of crowd:

30% **EXPERTS**.
70% **NON-EXPERTS**.

and their level of expertise:

\[ P(\text{correct prediction} \mid \text{expert}) = p_e \]
\[ P(\text{correct prediction} \mid \text{non-expert}) = p_{ne} \]
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Let $p_e = .8$ and $p_{ne} = .5$

For random person from crowd:

$$P(\text{correct pred.} \mid \text{individual}) = .3p_e + .7p_{ne} = .59$$
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\[
P(\text{correct pred. | individual}) = p_i = .59
\]

If crowd contains 50 independent people:

\[
P(\text{correct pred. | crowd}) = \sum_{k=26}^{50} \binom{50}{k} p_i^k (1 - p_i)^{50-k}
\]

\[= .8745\]
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$P(\text{correct pred.}|\text{individual}) = p_i = .59$

If crowd contains 50 independent people:

$P(\text{correct pred.}|\text{crowd}) = \sum_{k=26}^{50} \binom{50}{k} p_i^k (1 - p_i)^{50-k} = .8745$

This crowd has made a prediction with probability .875 of being correct which is $> p_e$.

It is wiser than each of the experts!
Another scenario

Ask each person in the same crowd:

How much does the pig weigh?

Crowd’s prediction:

AVERAGE of all predictions.

⇐ This crowd predicts 99.8333.
(The pig weighs 99.8333 kg.)
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(Say pig’s true weight is 100 kg)

\[
P(\text{pred. weight} | \text{expert}) : \mathcal{N}(100, 5^2)
\]

\[
P(\text{pred. weight} | \text{non-expert}) : \mathcal{U}(70, 130)
\]
Has crowd made a good estimate?

If crowd contains independent 50 people:

\[ P(\text{predicted weight} \mid \text{crowd}) \]

\[ \uparrow \]

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If crowd contains independent 50 people:

\[ P(\text{pred. weight} | \text{crowd}) \] and \[ P(\text{pred. weight} | \text{expert}) \]
Has crowd made a good estimate?

If crowd contains *independent* 50 people:

\[ P(\text{pred. weight | crowd}) \text{ and } P(\text{pred. weight | expert}) \]

On average this crowd will make better estimates than the experts.

It is wiser than each of the experts!
Why didn’t I just asked a bunch of experts??

- Large enough crowd $\implies$ high probability a sufficient number of experts will be in crowd (for any question).
- Random selection $\implies$ don’t make a biased choice in experts.
- For some questions it may be hard to identify a diverse set of experts
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For a random crowd

Given a random question expect each person to have a different level of expertise.

Will it rain tomorrow?

⇐ redness proportional to expertise.
For a random crowd

Given a random question expect each person to have a different level of expertise.

Will Obama be re-elected as president?

⇐ redness proportional to expertise.
What makes a crowd wise?

According to James Surowiecki there are four elements required to form a wise crowd

- **Diversity of opinion.** People in crowd should have a range of experiences, education and opinions. (Encourages independent predictions)
- **Independence.** Prediction by person in crowd is not influenced by other people in the crowd.
- **Decentralization** People have specializations and local knowledge.
- **Aggregation.** There is a mechanism for aggregating all predictions into one single prediction.
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The crowd must be careful

In the analysis of the crowd it is implicitly assumed:

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If this is not adhered to the crowd runs the risk of...
Rational bubbles! Crowds can also be stupid

Rational bubbles have occurred when the crowd has had very bad judgment:

- *Tulip mania*, Netherlands 1630’s,
- *Tech stock bubble*, 1990’s,
- *Housing bubble*, Ireland in the 2000’s,
- *Ponzi schemes*, Ivar Kreuger (famous KTH graduate), Bernie Madoff et al.

See *Extraordinary Popular Delusions and the Madness of Crowds* by Charles Mackay from the 1840’s.
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- The non-experts will predict a completely random wrong answer - these will somewhat cancel each other out.

- However, there may be a systematic and consistent bias in the non-experts’ predictions.
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This can lead to...
If the crowd does not contain sufficient experts then truth by consensus (rather than fact) leads to Wikiality!

Back to machines
This course considers different types of classifiers/regressors instead of a crowd of humans.

- None of these classifiers is as clever, flexible or has the wealth of experience as a human but

- their simplicity makes them easier to analyze!

**Note:** sometimes when I write *classifier* the idea also holds for *regressors.*
Back to machine learning

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But will use labelled training data
• to identify the **expert** classifiers in the pool;
• to identify **complementary** classifiers;
• to indicate how to best combine them.