Information Cascades

Machine Learning Seminar (WS 10/11)

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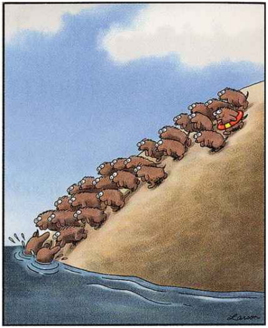
Overview

Topics covered in this presentation:

- Crowd behavior
- Experiment
- Cascade model
- Individual decisions
- Properties of cascades
- Applications

Crowd Behavior

In a **network of people** there is always influence over decisions and behavior.



Is this necessarily bad?

Crowd Behavior

Advantages

Some things work better when everyone takes the same decision.

Information from other people's actions can improve our own decisions.

Experiment

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A bag has 3 colored balls:

- 2 of one color, 1 of another
- The majority color is equally likely to be red or blue

People are going to sequentially draw a ball out of the bag and try to guess the majority color.

They draw a ball, announce their guess to the others, and put the ball back into the bag.

Experiment

Assumptions

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The participants cannot see each others' results.

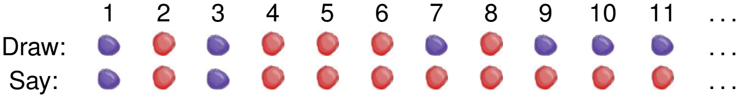
Participants who correctly guess the majority color win something.

- Therefore we assume that everyone tries to guess the correct color.

No one cheats.

Experiment

A possible outcome



After step 6, a **cascade** begins, no matter what color is drawn.

Experiment

Conclusions

The participants:

- have access to very limited information
- and are easily influenced

This is what leads to **cascades**!

How can we make the best decision given these conditions?

- We will see a **model** that can also be used in more complex situations.

Cascade Model

What is a cascade?

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An information cascade is the occurrence of a **chain of equal decisions**, when people:

- observe the actions of others
- make the same choice that the others have made
- and act independently of their own private information

It may seem rational: why should all the others be wrong?

- However, this often leads to wrong decisions, as we have seen.

Cascade Model

Basic concepts

A group of people will sequentially make a **decision** about an option:

- Accept, or...
- Reject

The model is composed of 3 parts:

- **World State**
- **Payoffs**
- **Signals**

Cascade Model

World States

The world is in a random state out of 2:

- G, where accepting the option is good
- B, where it is bad

Each individual knows that:

- **G** has probability p
- **B** has probability $1 - p$

Cascade Model

World States - Calculations

Let the decision be ”guess majority blue“

Pr[G] denotes the probability that accepting the decision is a good idea:

- $Pr[G] = p = 0.5$
- Symmetrically, $Pr[B] = 1 - p = 0.5$

Let’s also say that there are **more blue balls** than red ones in this example.

Cascade Model

Payoffs

Taking the correct decision brings something positive:

- Rejecting an option: $v = 0$
- Accepting a good option: $v_g > 0$
- Accepting a bad option: $v_b < 0$

Expected payoff in absence of other information is 0:

- $v_g \cdot p + v_b \cdot (1 - p) = 0$

Cascade Model

Payoffs - Calculations

We know the probabilities of the possible states of the world.

- $Pr[G] = Pr[B] = 0.5$

Therefore our initial expected payoff is given by:

- $0.5v_g + 0.5v_b = 0$

In other words, $v_g = -v_b$

Cascade Model

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Signals

A signal represents private information about taking a decision

Idea: if accepting is in fact a **good** idea, **high signals are more frequent** than low signals

Probability of a signal given a state:

- $Pr[H|G] = Pr[L|B] = q$
- $Pr[L|G] = Pr[H|B] = 1 - q$

Cascade Model

Signals - Calculations

There are 2 blue balls and one red ball:

- We expect that blue and red balls are drawn at a ratio of 2:1
- If accepting is a good idea, then high signals should be **2x more frequent** than bad signals

Therefore we have:

- $Pr[H|G] = Pr[L|B] = q = \frac{2}{3}$
- $Pr[L|G] = Pr[H|B] = 1 - q = \frac{1}{3}$

Individual Decisions

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So far we have seen that the initial expected payoff is given by

- $v_g \cdot Pr[G] + v_b \cdot Pr[B] = 0$

But this equation does not take private knowledge into account

- How does a signal influence a decision?

Individual Decisions

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Influence of a Signal

In the presence of a high signal we see a shift in the probabilities:

- $payoff = v_g \cdot Pr[G|H] + v_b \cdot Pr[B|H]$

Using Bayes' Rule: Pr[G|H] > Pr[G]

- Therefore the high signal reinforces that accepting is likely to be a good decision.

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Influence of a Signal - Calculations

From Bayes' Rule it follows that:

- $Pr[G|H] = \frac{p \cdot q}{p \cdot q + (1-p) \cdot (1-q)}$

In our experiment:

- $Pr[G|H] = \frac{2}{3}$
- $Pr[B|H] = \frac{1}{3}$

Shift of expected payoff:

- $payoff = \frac{2}{3} \cdot v_g + \frac{1}{3} \cdot v_b$, but $v_g = -v_b$, so:
- $payoff = \frac{1}{3} \cdot v_g > 0$

Individual Decisions

Influence of Multiple Signals

After a sequence S of signals:

- $Pr[G|S] = \frac{Pr[G] \cdot Pr[S|G]}{Pr[S]}$

Given *a* positive signals and *b* negative signals:

- $Pr[G|S] = \frac{pq^a \cdot (1-q)^b}{pq^a \cdot (1-q)^b + (1-p)(1-q)^a q^b}$

Comparing the calculated value to $Pr[G]$ we can see if the signals favor accepting or rejecting the decision.

Individual Decisions

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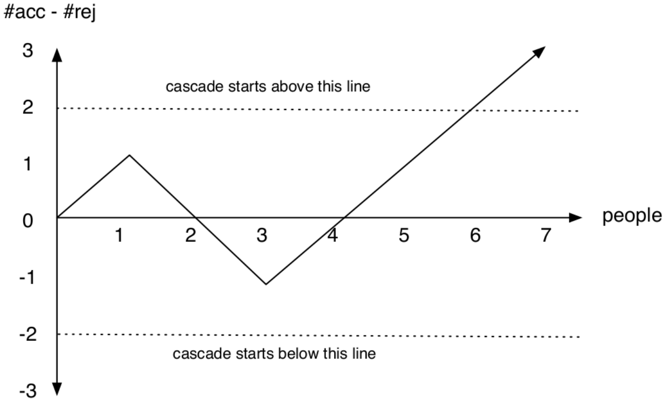
Influence of Multiple Signals - Visualization



Properties of cascades

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Cascades:

- can be based on little information
- can be wrong
- are easy to start
- but are also easy to overturn

Applications

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Modeling:

- The adoption of new technologies
- Choice of a product/brand over another
- Market crashes (variable price model)
- . . .

Overview

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We have seen:

- Crowd behavior
- Experiment
- Cascade model
- Individual decisions
- Properties of cascades
- Applications

Questions?