

Opinions, choices, influence: A general framework

André C. R. Martins

NISC – EACH – Universidade de São Paulo – Brasil

A few easy questions:

God exists?

How will stock A perform tomorrow?

Should I buy it?

Is String Theory correct?

What is the exact mass of a neutrino?

Should individual B , according to his beliefs, commit a terrorist action?

And a few problems in Opinion Dynamics:

What does an opinion mean? A belief, a choice, an action?

If there are subtle differences between those concepts, how should we work with each one?

How do I incorporate other sources of influence in an opinion, such as simple facts or observations?

Structure of the Presentation:

- 1 Opinion Dynamics
- 2 Theoretical Framework
- 3 New Effects
- 4 Heterogeneous agents
- 5 Conclusions

Opinions are everywhere

- Social structures and decisions are always influenced by some kind of opinion.
- Different problems, as religion, prices in a stock market, politics, and even the acceptance of scientific (or pseudo-scientific) theories are influenced by people opinions.
- While not the only influence in those problems, the spread of information from one person to the next can have important effects in all of these areas.

Opinion Dynamics Models

- We try to understand how opinions spread in a society.
- People are modeled by simple rules.
- The descriptions are not meant to be realistic; one investigates which details of the interaction are crucial for the large scale social phenomena.
- But different questions might imply different types of opinions.
- Most models are based on the idea that people tend to agree with their neighbors.

Traditional Families of Models

- Different independent models can be used for different aspects of the problem.
 - Discrete Opinions: few options, can represent decisions well.
 - Continuous Opinions: more useful to represent choices of numerical values.
- What about decisions that have a strength of opinion attached to them?
- Can inflexibles be a consequence and not an initial condition?
- How can contrarians be incorporated naturally in a general framework?

My first attempt at this game

Continuous Opinions and Discrete Actions

- Definition: Opinion means the subjective probability that a certain statement is right.
- Opinions are not observable, but discrete actions or choices are.
- The observable actions are a function of the internal opinion.
- Agents update their opinions based on the observation of other agents choices by using Bayesian rules.

CODA model

Martins, André C.R., Continuous Opinions and Discrete Actions in Opinion Dynamics Problems. IJMP C, 19, p. 617-624, 2008

- Local consensus emerges, but not global!
- Opinions get stronger and islands of similar behavior appear, but not consensus.
- Barriers to changing choices become increasingly stronger and freeze islands eventually.
- Extremists appear everywhere and opinions are particularly extreme away from the interfaces.

Our questions again

God exists?

How will stock A perform tomorrow?

Should I buy it?

Is String Theory correct?

What is the exact mass of a neutrino?

Should individual B , according to his beliefs, commit a terrorist action?

We also gain some insight into the first and second of the problems in Opinion Dynamics I proposed earlier:

What does an opinion mean? A belief, a choice, an action?

If there are subtle differences between those concepts, how do I deal with each one?

How do I incorporate other sources of influence in an opinion, such as simple facts or observations?

Structure of the Presentation:

- 1 Opinion Dynamics
- 2 Theoretical Framework**
- 3 New Effects
- 4 Heterogeneous agents
- 5 Conclusions

A Theoretical Framework for Update Rules.

- We need a theoretical framework for Opinion Dynamics.
- Physicists love to be able to work from first principles!
- ideally, the framework should be capable of dealing with all proposed applications and have answers to the problems.
- It would be good if it were also:
 - General enough
 - Easy to make generalizations and to introduce more complex details.
 - There were experimental evidence that humans behave somehow close to the description of the framework.

My Proposal

- All the applications and the problems presented so far can be dealt with in a general model built on older ideas.
- Those ideas are those presented in the model proposed by myself
- I did have an opinion that assigned a large probability to the assumption that my model was good. Therefore, my action was to keep working on it.
- Opinion Dynamics should also be able to deal with self-interest...

Bayes Theorem and real people

- Define an opinion as the subjective probability assigned to the possibility that a given statement is true.
- New data can be anything, from the result of an experiment to the observation of the opinion of others.
- Real humans make mistakes when dealing with probabilities (heuristic and biases, bounded rationality).
- There is evidence people reason in a way similar to that dictated by Bayes Theorem (good approximation).

How it works

- In a general framework, different models should be possible for different circumstances.
- Bayesian reasoning means that other influences can, in principle, be easily incorporated. Everything is treated as new data.

What are you talking about? (finally)

The issue

- First thing is to identify the characteristics of the issue whose dynamics one is studying.
- Assign a variable x to that issue (continuous or discrete? what range? one issue or a cultural problem, with several dimensions?).
- The objective of each agent is to improve its inference about x .

What do you think about it?

The opinion

- Each agent i needs to have a subjective opinion about x , represented by a probability distribution $f_i(x)$.
- The function indicates agent i belief on how likely each possible value of x is.
- $f_i(x)$ can be continuous or discrete, depending on the characteristics of x .

How do you talk about it?

Communicating

- Communication does not necessarily means stating a value for x ! Each agent has a full distribution in its mind and a complete description of his state of knowledge would only be given by the distribution $f_i(x)$.
- Communication could be observing a choice between two alternatives by the neighbor j .
- Or the agents can provide some point estimate for x^* , per example, the average $E[X]$.

How do you talk about it?

Communicating

- By definition, communication will mean the statement of a value A_j by agent j , such that $A_j[f_j]$ is some functional of $f_j(\mathbf{x})$.
- In principle, agent j could communicate more than one value and, in this case, A_j would be a vector.
- Reminder: Issue is x , opinion of agent i about x is $f_i(x)$ and what is communicated by agent j is $A_j[f]$.
- Important: Communication does not need to be intentional, it could be a an observed behavior of j , represented as A_j

How do you talk about it?

Not simply what you think it is more likely

- There is no need to really says what one is thinking.
- Some observable decisions (a form of communicating) can require very strong beliefs before they are observed.

What did you expect to hear?

Likelihood

- The agents must have in their minds a relationship between the true value of x , x^* , and the stated value A_j , given by a probability distribution $p(A_j|x^*)$.
- That is, given that a possible value x^* were the correct value, how likely it would be that the neighbor j would communicate A_j .
- This model could be as simple as a fixed probability, or as complex as a full evaluation of the inference process of j .

How do you change your mind?

Bayes rule?

- The probability distribution $p(A_j|x)$ plays the role of a likelihood of the observation A_j and thus defines a Bayesian update rule.
- Agent i already had a prior opinion $f_i(x)$, obtaining its posterior opinion $f_i(x|A_j)$ is a simple task of applying Bayes Theorem.

How do you change your mind?

Bayes rule

- Multiply and renormalize.
- The posterior becomes the new opinion of i .
- Of course, the communicated values $A_i[f_i(x|A_j)]$ might have to be updated, to reflect the new opinion.
- Changing variables might lead to considerably simpler model.

Who do you talk to?

Networks or other rules

- Of course, the model wouldn't be complete if there was no definition of who interacts with whom and how often.
- Usually implemented by some network of neighbors, interactions can be synchronous or not.

Existing applications of the framework

- Continuous Opinions and Discrete Actions (CODA) – emergence of extremism.
- Diffusion of innovations – a variation of the CODA, where observing non-adoption soon after release of a product was considered not important.
- Continuous communication, as Bounded Confidence models - possible generalizations. The model also naturally proposes the existence of a network of trust - one can get convinced that other people know nothing.
- Multi-cultural settings - more than one issue debated at a time.
- Theory choice in Science

Do our problems bellow fit in the framework?

God exists?

How will stock A perform tomorrow?

Should I buy it?

Is String Theory correct?

What is the exact mass of a neutrino?

Should individual B , according to his beliefs, commit a terrorist action?

Structure of the Presentation:

- 1 Opinion Dynamics
- 2 Theoretical Framework
- 3 New Effects**
- 4 Heterogeneous agents
- 5 Conclusions

New problems

- Some information is easy to be identified as a piece of data and thus incorporated. But not always.
- As communication becomes better defined, we can introduce more details.

Communication

- In the CODA model, all the agents know only the choice of their neighborhoods.
- In real life, agents with a stronger belief are likely to be more eloquent when defending their points of view. Real communication can include hints on the strength of the belief.

Easy to add more

- Many different details can be important to the opinions of people.
- Agents can reason about their own influence in the opinions of others. In the limit, this can take us back to traditional discrete models.
- Defending some ideas or adopting certain actions might require very strong beliefs. This comes naturally in a probabilistic setting.

Other influences

- Agents can also be subject to influences other than those from other agents: cultural values, media, observations of real world.
- Influences on all agents or part of them can be easily introduced as external fields.
- Not every agent needs to be influenced by these fields.

Traditional models

Martins, André C.R., Discrete opinion models as a limit case of the CODA model. Physica A 395, p. 352-357, 2013

- Bounded Confidence can be recovered as approximation to a model where there is a chance the other agent knows something and a chance its choice is random.
- Discrete models are a limit case of the situation where an agent considers its own influence on the neighbor
 - Agreement can be due only to own influence.
 - Steps of different sizes for observing agreement or disagreement.

Structure of the Presentation:

- 1 Opinion Dynamics
- 2 Theoretical Framework
- 3 New Effects
- 4 Heterogeneous agents**
- 5 Conclusions

Inflexibles

Martins, André C. R. and Galam, Serge, Building up of individual inflexibility in opinion dynamics. PRE 87, p. 042807, 2013

- With reinforcement, inflexibles are trivial: agents who start with such a strong opinion they are unlikely to change it.
- Moderates have opinions closer to change but can eventually become inflexibles.

Inflexibles

- Model confirms previous results.
- A minority of inflexibles can indeed change the opinion of the majority (even though they could eventually be convinced).

Contrarians

Martins, André C. R. and Kuba, Cleber D. . The importance of disagreeing: Contrarians and Extremism in the Coda Model,

Advances in Complex Systems, 13, p. 621-634, 2010

- If neighbor is considered to be more likely wrong than right, its influence reverses sign: Contrarians!
- Existence of some contrarians decrease extremity of opinions.
- Some tendency towards 50% (weaker) is also observed.

Trust

Martins, André C R, Trust in the CODA model: Opinion Dynamics and the reliability of other agents, Physics Letters A, 377, p.

2333-2339, 2013

- Different chances of neighbor being correct: trustworthy and untrustworthy individuals.
- Phase transition from polarization to agreement depending on strength of initial trust.

Structure of the Presentation:

- 1 Opinion Dynamics
- 2 Theoretical Framework
- 3 New Effects
- 4 Heterogeneous agents
- 5 Conclusions**

Conclusions

- Bayesian inference can be used as a very general tool.
- It does not tell us which model is correct but allows us to create models that will fit different circumstances.
- Some of these models can be very simple, if one is lucky to find a nice variable.
- There are no guarantees.
- Easy to introduce different types of agents from dynamics: not by hand.

I hope your opinions about me have improved!

Thank you!