Communication amid Uncertainty

Madhu Sudan
Microsoft, Cambridge, USA

Based on:

- Goal-Oriented Communication – Goldreich, Juba & S. (JACM 2012)
- Compression without a common prior ... – Kalai, Khanna, Juba & S. (ICS 2011)
- Efficient Semantic Communication with Compatible Beliefs – Juba & S. (ICS 2011)
Uncertainty in Communication?

- Always has been a central problem:
  - But usually focusses on uncertainty introduced by the channel
- Standard Solution:
  - Use error-correcting codes
  - Significantly:
    - Design Encoder/Decoder jointly
    - Deploy Encoder at Sender, Decoder at Receiver
New Era, New Challenges:

- Interacting entities not jointly designed.
  - Can’t design encoder+decoder jointly.
  - Can they be build independently?
  - Can we have a theory about such?
    - Where we prove that they will work?

- Hopefully:
  - YES
  - And the world of practice will adopt principles.
Example 1

- **Intersystem communication?**
  - Google+ ↔ Facebook friendship?
  - Skype ↔ Facetime chat?

- **Problem:**
  - When designing one system, it is uncertain what the other’s design is (or will be in the future)!
Example 2

- Heterogenous data?
  - Amazon-marketplace spends N programmer hours converting data from mom-n-pop store catalogs to uniform searchable format.
  - Healthcare analysts spend enormous # hours unifying data from multiple sources.

- Problem: Interface of software with data:
  - Challenge:
    - Software designer uncertain of data format.
    - Data designer uncertain of software.
Example 3

- Archiving data
  - Physical libraries have survived for 100s of years.
  - Digital books have survived for five years.
  - Can we be sure they will survive for the next five hundred?

- Problem: Uncertainty of the future.
  - What systems will prevail?
  - Why aren’t software systems ever constant?
Modelling uncertainty

Semantic Communication Model
Classical Shannon Model

New Class of Problems
New challenges
Needs more attention!
Nature of uncertainty

- $A_i$'s, $B_j$'s differ in beliefs, but can be centrally programmed/designed.
  - [Juba, Kalai, Khanna, S.'11]: Compression in this context has graceful degradation as beliefs diverge.

- $A_i$'s, $B_j$'s differ in behavior:
  - Nothing to design any more.
  - Best hope: Can highlight certain $A_i$'s (universalists) that can interact successfully with many $B_j$'s
  - [Juba, S.'08; Goldreich, J, S.'12; J, S.'11]: “All is not lost, if we keep goal of communication in mind”
  - Details don’t fit in margin ...
Future?

- Understand human communication?
  - How does it evolve
  - What are influencing factors?
    - (My guesses): Compression, Computation, Survival of fittest.

- Extend to other “distributed design” settings.

- Architecture/Program for preserving Data?
  - Blend safe assumptions, with “likely-to-be-fast” performance.
Thank You!