Social Cognition: Memory Decay and Adaptive Information Filtering in an ACT-R Simulation

Christian Lebiere & David Reitter

Carnegie Mellon University

Collaborators Katia Sycara, Paul Scerri, et al. Programming: Yury Vinokurov, Antonio Juarez, et al. **Funding** AFOSR MURI 7



Friday, July 27, 12

Teamwork: No one is as dumb as all of us.

One solution to inefficient collaboration? **Forgetting.**

Forgetting as a factor of task success





Geo Game: A Joint, Communication-Based Task



Reitter, Sycara, Lebiere, Vinokurov, Juarez, Lewis (BRIMS, 2011)

Communication Network



Distributed Lexical Memory



Communication

Each node (player) broadcasts to its network neighbors Physical location (which town) does not matter.

Externalization

information storage is outsourced to network held transiently in distributed memory

What is stored?

label-location associations

Simulation

- Decay
 - How does task-performance correlate with base-level learning decay?
- Metacognitive Communication Filtering
 - When individual agents adapt their "verbosity" and filter information, does it increase task performance?

Cognitive Model of the Geo Game



- Declarative memory:
 - item X at location Y
 - item X is needed

• Decisions:

- forward a given message?
- send observed fact (X-at-Y)?





Gregame - tod In Motion... Get Wench Lader Wench Score: Offers fourd: 0 Lader Score: Offers fourd: 0 Later 23:15:17 - Moving from Maccow, Duration: 5 seconds You have machine Maccow 23:17:44 - Moving from Maccow, Duration: 18:1 seconds Send to Team Lag get

Base-level learning implements decay in individuals.

Adaptive Filtering implements decay at the network level.

Scalable ACT-R implementation: ACT-UP. (Reitter & Lebiere, ICCM 2010) http://act-up.psy.cmu.edu/

Simulation of large communities (n=500)

Questions:

Does adaptive filtering increase task success? What is the role of base-level decay?

A Rational Basis for $\alpha = 0.5$?

- Memory decays with the need for information in the environment
- The environment is the result of human decisions (based on memory and more), but also of a network of humans producing information.
- Exposure to information (and need to recall/use it) is a result of one's position in the network, the other participants, the network structure, and the task.
- **Hypothesis**: Improved performance for plausible values of α and plausible networks (small-world networks).



Effect of base-level decay

Friday, July 27, 12



Metacognition

- How much communication is needed in a network setting?
- Attentional trade-off:
 - Maximal communication: players send all available information, and forward each message (stochastically dampened)
 - Filtered communication: players decide whether a piece of information is needed by the message's recipients
- Model: Instance-based learning (Gonzalez et al. 2003)
 - When an item is found, we correlate it with a previous communication about that item. If we find an item without prior communication, we take it as evidence against the utility of communication.
 - Communication is throttled (stochastically) according to its estimated utility.

Adaptive Filtering in Small World Networks

Adaptive filtering: pass message based on recent success of communication non-adaptive targeting: keep track of requested information



Reitter & Lebiere, AAAI 2012

Dumping vs. Targeting



Basic manipulation: dumping vs. targeting of information

Dump condition (Full information - external storage)

Post all relevant information – items in cities Maximize information at cost of overloading attention/memory

"chicago is empty", "radio fork wrench in paris"

Target condition (Filtering - more internal storage)

Specify needs and only answer/forward relevant information

Minimize overload at cost of opportunities

"wheres knife????", "ladder in pittsburgh!!!!"

Reitter, Sycara et al., BRIMS 2011

Empirical: Filtering increases task success

If human networks serve as useful information filters, then a targeted communication policy should

- increase the overall performance (points)
- increase efficiency (points per message)







Figure 4: Agents send more unnecessary messages when internal memories decay too slowly or too quickly.





Figure 8: Metacognition allows agents to make use of larger network neighborhoods. (Random graphs behave like small worlds and are omitted for clarity.

Successful Teamwork: Conclusions

Forgetting (information decay) increases task success at different levels

- Activation decay in individual, declarative memory
- Network-level filtering in message-passing paradigms
 - Can social norms evolve to promote filtering?

