Critic Networks for Commonsense Problem Solving

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Diversity of Common Sense

- Predict events (What happens if I let go of a porcelain vase?)
- Use analogies (Can I use a vase as a paperweight?)
- Experiment (From how high can I drop the vase without breaking it?)
- Learn from mistakes (Let’s not drop that vase again)
- Make discoveries (Wonder if there’s anything inside the vase?)
- Generalize (Porcelain things crack easily from impact)
Complement Knowledge with Processing Programs

- Knowledge items are important…
- …but implementing our generic methods for processing, structuring, complementing, storing and deleting information is as important
- Critic-Selector pairs (Minsky 2006)
Critics and Resources

- Critics are mini-programs that detect problem types.
- They then activate resources that have been useful for dealing with that type of a problem.
- Critics normally feed-forward, but can also form loops or backtrace.

no known plan: search by subgoals
multiple possible actions to take: decide
something unexpected happened: backtrace
there are no goals: search for a new one

from Emotion Machine, Minsky 2006
EM-ONE
(Singh 2005)

- First testbed for Emotion Machine theories
- Two robots build a table in simulated world
- Involves knowledge and processes in physical, social, mental realms
- Implements a 3-layer Critic-Selector structure
Knowledge represented in commonsense narratives

Execution based on processing in two languages, Narrative-L and Critic-L

Kernel written in Common Lisp. Prolog-like system for pattern matching and databases

(defnarrative attaching-stick
  (sequential
    (observes pink (not (is-attached stick board)))
    (does pink (attaches pink stick board) [1])
    (observes pink (is-attached stick board) [2])
    (causes [1] [2]))

(defcritic (delib*unknown-action-consequence*hypothesize-by-analogy ?H ?N)
  (in narratives ?N
    (sequential
      (does :actor ?ACTOR :prop
      (observes :actor ?ACTOR :prop
        (?RELATION :subject ?OBJECT :object ?TARGET) [RESULTST]))))

(in hypotheses ?H
  (together
    (intends :actor ?ACTOR2 :prop
      (?ACTION :actor ?ACTOR2 :object ?OBJECT2 :target ?TARGET2) [BEFORE])
    ((follows [BEFORE] ?AFTER))
  )=>
(lisp ?NEW_H (extend-hypothesis ?H))

(in hypotheses ?NEW_H
  (assert (observes :actor ?ACTOR2 :prop
    (?RELATION :subject ?OBJECT2 :object ?TARGET2) [[S]]))
  (assert (subsit ?NEW_H [[S]]))
  (assert (subsit ?AFTER [[S]]))))
(defnarrative attaching-stick
(sequential
(observes pink (not (is-attached stick board)))
(does pink (attaches pink stick board) [1])
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(defcritic (delib*unknown-action-consequence*hypothesize-by-analogy ?H ?N)
(in narratives ?N
(sequential
(does :actor ?ACTOR :prop
(?ACTION :actor ?ACTOR :object ?OBJECT :target ?TARGET) [ACTIONSIT])
(observes :actor ?ACTOR :prop
(?RELATION :subject ?OBJECT :object ?TARGET) [RESULTSIT])))
(in hypotheses ?H
(together
(intends :actor ?ACTOR2 :prop
(?ACTION :actor ?ACTOR2 :object ?OBJECT2 :target ?TARGET2) [BEFORE])
((follows [BEFORE] ?AFTER)))
(=>)
(lisp ?NEW_H (extend-hypothesis ?H))
(in hypotheses ?NEW_H
(assert (observes :actor ?ACTOR2 :prop
(?RELATION :subject ?OBJECT2 :object ?TARGET2) [[S]]))
(assert (subsit ?NEW_H [[S]]))
(assert (subsit ?AFTER [[S]]))))
Pink wants Green to help him build the table, but Green misinterprets the situation as Pink wanting to disassemble the table.

High-level Critics detect the miscommunication as external behavior that went contrary to prediction.

A high-level Critic debugs the problem and inserts a ‘fix’ to check for a precondition in the future.
EM-ONE revival effort

- Singh passed away in 2006
- Bo Morgan built a similar program [SALS AI, Morgan 2013]
  - improved on traceability
- Reprogrammed original EM-ONE for education & easier experimentation with open source components
EM-ONE problem points

- Adding preconditions to Critics decreases generality -> weighting/scoring system for pattern elements
- Original Selector model was very situation specific -> Critic Networks for broader analyses
- Omniscient viewpoint - too easy to ‘cheat’
- No model of time - durations for changes and persistence of states
- Increasing number of Critics (and in some cases, knowledge) exponentially increases runtime
Some additions

- Inclusion of optional and weighted Critic elements
- Metacritic -> Critic Network
- Inspiration from Minsky’s K-lines, but strictly on a meta-cognitive level
- Viewpoint: omniscient -> actor-specific
- New Critics (physical, mental, language realms)
Critic Network structure

(necessarily
  (has-goal :actor ?SELF :prop (observes-class :class ?ITEM)))
(preferably
  (fbagof ?OBJECT (required-ingredient ?ITEM))
  (observes :actor ?SELF :prop ?OBJECT)))
(optionally
  (fbagof ?N (narrative-contains-goal (observes-class :class ?ITEM)))
  (evaluate-positive
    (delib*deliberate-to-achieve-goal current-conditions (first ?N)))
  (optionally
    (evaluate-positive
      (delib*unknown-action-consequence=>hypothesize-by-analogy
        (observes-class :class ?ITEM))))
Critic Networks

example 1

- Building a chair
- Binary decisions insufficient
- More challenging physical modeling (need to support a robot etc)

Predicates: func-support, struct-support
Extractor: plane-height
Narratives about chairs...

…”
Critic Networks

example 2

Decorating natural language texts containing ambiguity into narrative forms

When decorating, Critics leave a trail of what they have done and why

Pink wanted the stick to be attached to the board, so he did it.

* detect-goal
* detect-temporal-relation
* normalize-tense
* same-sentence-actor-pronoun=>disambiguate
* goal-action-hypothesis=>elaborate
* relation-achieving-action=>elaborate-observations

(desires pink (is-attached stick board))
(sequential
 (observes pink (not (is-attached stick board))))
 (does pink (attaches pink stick board) [1])
 (causes [1] [2]))
Learning a Critic Network

- Hand-built Critic base
- Release a collection of Critic-Selectors and goals into a limited system; through brute force application, gather knowledge of which of them help with which goals (write a ‘critic narrative’)
- Reflective Critics modify the network base by necessarily, optionally, preferably predicates
Summary

- Critic-L provides a language for expressing general inference rules
- Organizing critics in networks allows us to attack a wide range of problems
  - networks can be learned to an extent
- Critics can modify each other. Big question: could we learn entirely new Critics?
Acknowledgements

*In Memoriam:*

Marvin Minsky

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