A Reader

We show in Figure 1 a particular instance of Reader, including the components and the information flow among them. This particular Reader has three symbolic processors (namely, Symbolic Matching, Symbolic Reasoner, Symbolic Analyzer) and a Neural Net Controller (with Policy-net as the sub-component). All the components in Reader are coupled through intensive exchange of information as shown in Figure 1. Below is a snapshot of the information processing at time $t$ in Reader.

- **STEP-1**: let the processor Symbolic Analyzer to check the Action History ($M^t_{act}$) to construct some symbolic features for the trajectory of actions;
- **STEP-2**: access Matrix Memory ($M^t_{mat}$) to get an vectorial representation for time $t$, denoted as $s_t$;
- **STEP-3**: access Inline Memory ($M^t_{inl}$) to get the symbolic representation $x_t^{(s)}$ (through location-based addressing) and distributed representation $x_t^{(d)}$ (through location-based addressing and/or content-based addressing);
- **STEP-4**: feed $x_t^{(d)}$ and the embedding of $x_t^{(s)}$ to Neural Net Controller to fuse with $s_t$;
- **STEP-5**: get the candidate objects (some may have been eliminated by $x_t^{(s)}$) and let them meet $x_t^{(d)}$ through the processor Symbolic Matching for the matching of them on symbolic aspect;
- **STEP-6**: get the candidate objects (some may have been eliminated by $x_t^{(s)}$) and let them meet the result of STEP-4 in Neural Net Controller;
- **STEP-7**: Policy-net combines the result of STEP-6 and STEP-5, to issue actions;
- **STEP-8**: update $M^t_{obj}$, $M^t_{mat}$ and $M^t_{inl}$ with actions on both symbolic and distributed representations;
- **STEP-9**: put $M^t_{obj}$ through the processor Symbolic Reasoner for some high-level reasoning and logic consistency.

Note that we consider only single action for simplicity, while in practice it is common to have multiple actions at one time step, which requires a slightly more complicated design of the policy as well as the processing pipeline.

B Experiments: Logical consistency

Suppose at time $t$, the ontology in $M^t_{obj}$ contains the following three facts (among others)

- **fact-1**: John (a PERSON-object) is in kichten (a LOCATION-object);
- **fact-2**: John carries apple (an ITEM-object);
- **fact-3**: John drops apple;

where fact-3 is just established by Policy-net at $t$. Symbolic Reasoner will add a new is-located-atB link between apple and kitchen based on domain logic*.

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*The logic says, an item is not “in” a location if it is held by a person.
Figure 1: A particular implementation of Reader in a closer look, which reveals some details about the entanglement of neural and symbolic components. Dashed lines stand for continuous signal and the solid lines for discrete signal.