Towards models for collective memory

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> I saw this man years ago: now I have seen him again, I recognize him, I remember his name. And why does there have to be a cause of this remembering in my nervous system? Why must something or other, whatever it may be, be stored up there in any form? Why must a trace have been left behind? Why should there not be a psychological regularity to which no physiological regularity corresponds? If this upsets our concept of causality then it is high time it was upset.
>
> Ludwig Wittgenstein

Wittgenstein strongly attacked any structural conception of memory. He was against considering memory as a notebook, and remembering as looking it up. Scholars like Sutton ([Sutt]) have discussed this at length. For Wittgenstein, social acts were important in shaping memory, and based on this, scholars like Rusu ([Rusu]) even talk of *social time*, and modern theories of connectionism and distributed memory build on many such notions.

For us, these remarks are relevant from two viewpoints. The 1950's saw the development of automata theory as a study of *memory structures*, and in theory of computation, automata provide a model of memory that Wittgenstein might have approved of. In this view, memory is not a table to be looked up, but is constituted by states of being of the automaton. Observations cause changes in state, some states remember (some of the past) and some forget. Thus, memory is built into system structure. Such a view is important for seeing memory and reasoning as *interdependent* rather than as separate (as psychologists used to consider). Logicians are used to equating automata and logics (as in the case of monadic second order logics of order).

The other viewpoint relates to distributed memory, where interacting agents rely on memory external to them. Computer science has evolved impressive models of highly flexible interaction and memory that has literally changed the everyday life of much of humanity in the last few decades.

In social theory, there is yet another highly influential notion related to societies and memory: that of *collective memory*. Maurice Halbwachs ([Halb])

talked of how an individual's understanding of the past is strongly linked to a group consciousness, which in turn is a form of *group memory* that lives beyond the memories of individuals that form the group.

This raises an interesting challenge for automata theory: is there a model of group and individual memory based on automata where interactions lead to some collective memory, which in turn influences behaviour of individual automata ?

Why should one bother ? In ([Pa]) Rohit Parikh speaks of *cultural structures* providing an infrastructure to social algorithms (much as data structures do for computational algorithms). A queue is one such structure according to him, and we can see how it enables a specific kind of social behaviour. Epistemic reasoning is an essential component of social algorithms, as persuasively argued by Parikh. We can then see collective memory as an essential gradient of its infrastructure creating the 'common ground' in which social objectives and communications are interpreted.

We offer a simple definition of group interaction among automata, inspired by the study of *population protocols* in distributed computing ([Pop]). Let N denote a fixed finite set of agent names.

Definition 0.1 *A* collective automaton *is a tuple* $M = (Q, \delta, \iota, \omega)$ *over alphabet pair* (Σ, Γ) *where* Σ *is the input alphabet,* Γ *is the output alphabet,* $\iota : \Sigma \to Q$*,* $\omega : Q \to \Gamma$*, and* δ *is a finite family of transition relations* $\delta_I \subseteq (Q^k \times Q)$*, where* $I \subseteq N$ *and* $|I| = k$*.*

We can consider all agents initially receiving an external input and assuming states. Interactions occur nondeterministically and the transition relation specifies how group interactions cause change of state. They produce outputs as well. Thus we can consider sequences of configurations that take us from Σ^N to Γ^N, among which we look for *stable* configurations where the output is stabilised.

These are preliminary ideas as yet, and while we have no impressive results, we can offer interesting examples that show simple ways of building collective memory in systems of formal agents.

References

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