Trees as Representation of human-like adaptive systems

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Dynamic networks are systems in which the number of nodes and connexions are not constant, they undergo an evolution in which new nodes and connexions appear and existing ones are deleted. In this paper we study a kind of growing networks which defines a collaborative software development by pieces built by different persons or teams. We focus on the growing dynamics of systems driven by stimulus-response, like chatbots and AI games.

Chatbots are programs which imitate the responses a human would produce in a chat. Several approaches are used and we focus in the storage of stimuli-responses[1].

Stimuli are inputs to the bot and responses are outputs. The overall interaction is described by a generalized directed tree graph in which nodes are stimuli and branches are responses. A conversation can then be represented as a path along the tree.

Similar mechanism is found in some AI turn-based games, where the machine must react to human inputs with a new move. Again, this can be represented by a directed tree graph in which new branches correspond to new strategies, linking two existing nodes equals to using the same strategy when the situation is similar and where specific game is a path across the tree. A word of caution here: this linking of two existing nodes is not always desired, it happens because some lack of coordination between builders, and can originate unpredicted behaviour like an absurd answer.

These systems are particularly interesting due to several reasons. They are widespread and useful, and they are capable of either mimicking (passing a Turing test) or beat humans in strategy games. It is very interesting to ascertain whether a qualitative change is produced at some point in their evolution which enables their success in such tasks and we approach it as a phase transition[3], in some ways similar to the manifestation of the "small world" behaviour.

Our complex network model, which matches the building process of a chatbot, is based on a recursive tree starting from a root node, which is an initial seed or test conversation. Then the process consists in adding subtrees: in each step an existing node is selected by a probability based on its clustering coefficient[2] -higher probability for lower clustering coefficients- and spans new nodes with a non constant branching factor, selected between 1 and k by a Poisson distribution. Additionally, in each step two existing nodes i,j are selected randomly and linked together. The Nodes with higher clustering coefficient have more chances of being linked. This is behaviour is found in chatbots where general topics are linked together much more easily than very specific topics. This kind of growing model has never been explored to our knowledge. All the work we are aware of considers linking a new node to existing nodes by different preferential schemas. Yet to be explored is also the effect of linking existing nodes. The goal is to have a "world" as big as possible, for it enables longer paths. The resulting structure is like in the following figure:

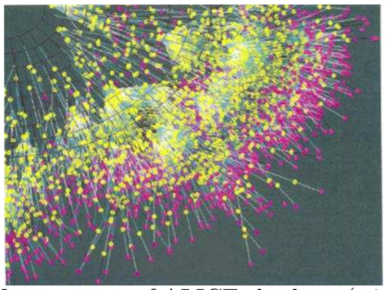

FIG. 1. Memory map of ALICE chatbot. (with permission of ALICE foundation for Artificial Intelligence)

We use a bottom top approach, vary the spanning probability which determines each step branching factor and the probability of linking existing nodes. We use a generating function approach to derive the rate equations for the population of layers and to derive the dynamics of node in-component and out-component, where in-component of a node is the set of all nodes from which current node can be reached and out-component is the set of all nodes reachable from current[4].

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