

## **Automatically Predicting Causal Inferences in the Modified Event Indexing Model**

**James Niehaus and R. Michael Young**  
**Department of Computer Science**  
**North Carolina State University**

Previous research has simulated the activation of narrative elements according to theories of discourse processing (Kintsch 1988; Langston, Trabasso and Magliano 1999). However, these studies have often relied upon the experimenter to encode not only the causal relationships between events in the narrative but also the plausible inferences. The work presented here extends an Artificial Intelligence (AI) narrative planner (Riedl and Young 2004) to predict the encoding of causal inferences by simulating the reasoning process of the reader.

This work formalizes aspects of the foregrounding of the Event Indexing (EI) model (Zwaan, Langston, and Graesser) to measure activation and predict the encoding of causal inferences. The resulting model is named the Modified Event Indexing (MEI) model. The MEI model analyzes a causally annotated (without inferences) representation of a text and computes 1) the situation model for simulating activation and 2) a representation of the reader's knowledge of the narrative, the *reader's plan*, for simulating causal inferencing.

The situation model is a semantic network represented as a connectivity matrix, and it is used to compute activation. It is constructed incrementally as each element from the text is processed, maintaining the connections between elements along the dimensions of space, time, causality, protagonists and objects, and intentions. Much like the Construction Integration (Kintsch 1988) and Connectionist (Langston, Trabasso and Magliano 1999) models, the MEI model uses these connections to model how activation spreads from one element to the next during comprehension. The network is treated as a Continuous Time Markov Chain, and the steady state distribution is computed. Hence, the activation value of a node in the network a result of the activation values of its neighbors and the strength of the connection between them. The strength of the connection between nodes is partially due to co-occurrence of activation. However, differing from the Connectionist Model, the weight given to the EI dimensional connection (whether the elements are related in space, time, etc.) also contributes to connection weight.

The MEI model also computes the *reader's plan*, a data structure to maintain the reader's understanding of the narrative. The reader's plan contains the narrative elements that have already been encountered in the text. It is the starting point for predicting inferences.

To simulate causal inferencing, the current state of the reader's plan is treated as an AI planning problem. The reader's plan may leave gaps in the event structure of the narrative when not all of the events have been told to the reader. Given a sufficient set of planning operators to describe the possibilities of events in the narrative, the AI planner can provide the causal reasoning to infer which events may have occurred in the intervening period. In a similar fashion, the planner can be used to predict inferences about the actions of characters once their intentions are known. The situation surrounding the character constitutes the planning problem initial state. The intentions of the character are the planning problem goals, and the action which the character may take are the planning problem operators.

The planning process has been modified to better simulate the reading context. When determining the inferred events, the planner is bounded in the number and depth of events it may infer, since readers rarely make unconstrained predictive inferences when the possibilities are large. The planner also prefers inferences that contain elements that are more activated, since they are presumed more available to the reader for such reasoning.

Thus the MEI model automatically makes two types of predictions when given the causal structure of a narrative: which elements are most salient in the reader's mind and which causal inferences are likely to be encoded.

## **Method**

To judge the effectiveness of the MEI model as a predictor of both activation and causal inferencing, experimentation will begin with two small studies. In Experiment 1, participants will read 5 stories and be tested for both reading times and word recognition response times involving just the content presented in the text. These will be correlated with the predictions of activation by the MEI model. In Experiment 2, participants will read 5 stories and be tested for both reading times and word recognition response times involving the content presented as well as possible inferred content. These will be correlated with the predictions for the encoding of causal inferences by the MEI model.

## **Results**

The experiments are ongoing, and we will present our initial findings as well as a comparison to the findings of similar theories at the conference.

## **Discussion**

The automatic encoding of causal inferences may allow researchers to be more explicit when defining theories of narrative discourse comprehension. Investigators can define when and under what circumstances these inferences are likely to occur, and allow the unbiased algorithm to compute which inferences are likely to be encoded.

This preliminary work may widen the application of theories of narrative discourse comprehension. The ways and means by which readers understand and represent narrative text directly affect the narrative's capacity to teach, and systems which can automate more of these processes are better able to judge and construct narratives towards such purposes.

## **References**

Walter Kintsch. The role of knowledge in discourse comprehension: A construction integration model. *Psychological Review*, 95:163–182, 1988.

Mark C. Langston, Tom Trabasso, , and Joseph P. Magliano. A connectionist model of narrative comprehension. In *Understanding Language Understanding*. MIT Press, 1999.

Mark O. Riedl and R. Michael Young. An intent-driven planner for multi-agent story generation. *Proceedings of the 3<sup>rd</sup> International Joint Conference on Autonomous Agents and Multi-Agent Systems*, New York, 2004.

Rolf A. Zwaan, Mark C. Langston, and Arthur Graesser. The construction of situation models in narrative comprehension: An event-indexing model. *Psychological Science*, 1995.