The Internal World Models Needed to Perform Situation Estimation

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Abstract

One of the dangers in building cognitive architectures is modeling biological phenomena that do not exercise a large portion of the cognitive machinery. Focusing on situation awareness or situation estimation avoids this problem, since it requires iterating between sensory processing and reasoning. A system doing situation estimation must include the ability to explain and predict the events produced by sensory processing. Prediction requires that perceived information not influencing the principal actors be ignored. However, novel and unanticipated sensations cannot be safely ignored by situation estimation and must trigger a switch in the reasoning frame in which predictions are being formed. While extraneous information needs to be ignored, the missing portions of objects or activities supporting anticipated situations must be filled-in.

Internal world models are needed for recognizing objects and events, filling-in unseen portions of the world, and predicting how executing a behavior will affect the world.

Discussion

When a driver pulls over at the sound of a siren, his/her situation estimate involves: switching reasoning frames in response to an unanticipated sensation, filling-in the incomplete sensory information about the event, and ignoring the music playing on the radio. Each of these actions requires a priori knowledge about the world.

A series of psychological researchers, starting with Tolman (1948) and his concept of cognitive maps, have tried to characterize a person's internal world models. Fauconnier and Turner's (2002) Mental Space is an example that is particularly relevant to situation estimation because of three mechanisms it includes:

1. Blending – combines portions of existing Mental Spaces into a new Space with emergent properties.
2. Compressing – removes the stereotyped parts of a causal sequence, but leaves enough information to understand the gist of the sequence.
3. Switching – constructs Mental Spaces on-the-fly as the current task or local environment changes.

A computational model of Mental Spaces can be built on a database of relational information. The complex relational data is divided into four classes:

1. Spatial memory captures geometric relationships.
2. Functional groupings are things that can be used for the same task, i.e. saws, axes, and logs are all associated with getting firewood (Luria 1974).
3. Episodic memory captures causal sequences (Tulving 1985).
4. Category hierarchies capture ontological relations.

A Mental Space is an active subregion within the linked relational data that acts as an attentional focus and a context in which to compute explanations or predictions.

By pairing each type of relational information with an inference mechanism, different types of partially perceived information can be filled-in. For example, spatial memory allows the presence and location of unseen objects to be inferred, while functional groups allow activity in a video sequence to be inferred from the presence of objects in the same group. Eilbert and Hicinbothom (2006) used episodic memories (or cases) to infer the missing portions of causal sequences in analytic data.

Currently under development is a mechanism for Mental Space switching that can select the portion of the relational web appropriate to the task at hand. Appraisal-based models of emotion (Read, et.al.2006) are being adapted for this purpose, since the dimensions relevant for differentiating emotions (i.e. expectedness, agency, certainty of outcome, and control over outcome) also provide a rational basis for Mental Space switching.

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