
JAVA CAUSAL ANALYSIS TOOL

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Introduction

JCAT provides two major extensions to conventional Bayes Net/Causal Modeling technology. The first is the ability to model synergistic (and other) relations among causes without overwhelming the modeler with required parameters. The second is modeling plan evolution over time including plans of operationally significant size (e.g. Enduring Freedom). These extensions are driven by the three dialog boxes to be described below. The Event Editor dialog encapsulates modeling causal relations. The Timing dialog encapsulates modeling of time. The section on Analysis explains the third dialog and how to generate analysis from the model.

Event Editor Overview

JCAT allows users to model direct uncertain causal relations among events (taking an action is a type of event) and then propagates these direct uncertainties throughout the model.

The Event Editor allows the description of one event in the model. The major purpose of JCAT is to model uncertainty related to the process by which an event responds to and produces signals. It may never be certain that any set of causal signal will initiate the event, or that, once initiated; the event's internal process will actually produce the expected effect signals. A major feature of JCAT is how probabilities can be specified for various sets causal effect and even inhibiting signals.

The Event Editor is composed of three panels: The "General" panel accepts both the name of an event and optionally the name of a particular event or object involved in this event. The "Default Probabilities" panel establishes a probabilistic relationship among the event and it's signals until the modeler provides more tailored probabilities. The "Specified Probabilities" panel allows the user to override the default probabilities for specific signals of the event.

General Panel

Taken together, an event name along with an object name, describe a specific event in a model. For example, "Damage Bridge" is an example of an event name. "Memorial Bridge, Washington DC" could be the object name. So together, "Destroy Bridge: Memorial Bridge, Washington, CD" is a particular event for a model. These two names are completely arbitrary and do not effect the computation of your model in any way.

The general panel also accepts the "leak" probability for the particular event. The leak probability is a function of the entire model and cannot be determined from just knowledge of the event alone. If all possible causes of an event are included in the model, the leak probability is, by definition, zero. It is zero because the leak probability is the probability that the particular event will occur from causes which will *not* be included in the model. For example if the model is about an air attack on Washington DC, the model may not include explicit reference to earthquakes, terrorist attacks etc. as possible cause of the destruction of Memorial Bridge. The probability of such un-modeled causes can be lumped into the "leak" probability.

Default Probabilities Panel

Any signal which has never been assigned a specified probability will use its associated default probability. So it is possible to build a Bayes Net using one set of defaults, change the defaults, re-build the Bayes Net and the new default values used. However any probability which has been specified by the model builder (using the “Specified Probabilities” panel) will not change as a result of changes to the defaults.

There are no defaults for groups of signals. Rather, the default for a group is a number signals acting together and are computed using the "Noisy OR" rule. However, as with the alone probabilities, if the model builder has specified a value for a particular group, the specified value overrides the default computation.

Specified Probabilities Panel

Note: At the present time, effect probabilities cannot be changed by the user. This is a current research topic.

The "Specified Probabilities" panel is the component of JCAT which enables building meaningful and precise models. It is through this panel that JCAT models can easily be made more realistic than is possible with other tools modeling uncertainty. Its purpose is to override probabilities provided in the Default Probabilities panel.

An Event, for the purposes of JCAT, is characterized by a process which is caused (initiated) by signals and which in turn produces other signals (effects). The process can also be inhibited by various signals. These three categories of signals: causal, effect, and inhibiting, are listed and their probabilities can be modified on the three tabs of the "Specified Probabilities" sheet. New signals of any of the three types can also be added on these tabs. (New signals will be added to the Event and its process when building the model by selecting the connect tool and dragging from the causal event to effect event and completing the dialog that pops up)

As stated previously, a major purpose of JCAT is to model uncertainties related to events' signals. It is usually never certain that any set of causes will initiate the process, or that, once initiated; the process will actually produce its effect signals. Therefore in JCAT, probabilities can be specified for various groups of signals. For example, 'a' may have little chance of causing 'z' when ‘a’ is the only active signal. Likewise 'b' may have little chance. But together, the group {'a', 'b'} acting together may be very likely to cause 'z'. Setting probabilities for selected sets of causes such as this is unique JCAT technology and allows causal concepts such as synergy, necessity, sufficiency and the like to easily modeled in JCAT. SIAM does not allow such concepts to be expressed. Conventional Bayes Net tools can allow such expression but only at the expense of the model builder needing to provide an exponentially increasing number of probabilities.

There are two types of probabilities which can be provided on this panel: 'alone' probabilities and 'group' probabilities. The 'alone' probability is the probability that this signal, with no other signals active, will cause the event to happen. The alone probabilities are entered into the text area beside each signal in the column headed 'alone'. Use the spinner arrows or type directly into the text area to change the probability value.

A 'group' probability is the probability that a group of signals, acting together and in the absence of any other signals, will cause the event to happen. In the example above 'a' and 'b' are a group

and the probability of them together causing 'z' is the group probability. If the 'alone' probability of both 'a' and 'b' were zero, and the group probability were one, these values would specify a (logical) 'AND': "a and b will cause z." To enter a group probability, first click the "New Group" button. In the resulting popup dialog, check the signals to be included in the group. Click "Create Group". You may optionally assign a descriptive name for the group. A column containing this group will have been added to the list of signals. Enter the probability for this group at the bottom of the column.

Temporal Modeling

Temporal modeling in JCAT is enacted through the Timing Dialog. Three temporal concepts are embedded in the timing dialog: scheduling, delay, and persistence. All three can be used to introduce temporal dynamics into models. Scheduling is 'forcing' a particular event to occur at a particular time, e.g. with .9 probability, we will bomb a particular bridge at time 3. Persistence is the length of time the event will remain true or, (equivalently) the amount of time a signal will remain active. For example, "Bridge Destroyed" will remain true until the bridge is repaired. Delay is the length of time between the causes of an event occurring and the event itself occurring. For example, if food supplies are destroyed, it will be some time before a military unit becomes ineffective.

The Timing Dialog can be accessed by right clicking on any event or mechanism in the model and choosing "Timing" from the context menu which pops up.

Scheduling

An event can be scheduled to occur at multiple times within a model. Each scheduled occurrence is created by entering the time for the occurrence in the 'time' text field and the probability of this occurrence in the 'probability' text field, then clicking the "Schedule" button. Note that the time field does not designate any particular unit of time and is completely up to the modeler. Because of this, the same time units (hours, days, or, weeks, etc) should be used anywhere in the model where time is input. The occurrence has a probability because, despite the best of intentions things, do not always happen. For example, weather can have a large impact on planned air attacks.

Note: Be sure to press the 'Schedule' button after creating the entries for each occurrence. The occurrence is not effective until it appears in the table to the left of the text entry fields.

Persistence

Persistence is the number of time units an event will continue to occur after it has initially occured. The persistence applies to all occurrences of the event, including but not limited to all manually scheduled occurrences. The default persistence is one; persistence zero has no meaning.

Continuation

A continuation probability as entered in the 'Continuation' field, is the probability that if the event occurred in the previous time slice, it will occur in the current time. The continuation probability is applied only after the minimum persistence period is complete. Note that if the continuation probability is 1.0, then the event will continue forever.

Delay

Delay is the number of time units the event occurs after its cause(s) occur. The delay, like the persistence, applies to all occurrences of the event. The default delay is zero.

Model Analysis

The major output of a JCAT model is an estimate, as a function of time, of the probability of occurrence for model events. This makes JCAT, in some respects, similar to a spread sheet. A spread sheet aggregates individual numeric entries in to sums, products and the like. JCAT aggregates the individual, local probabilities assigned to various elements in the model into an overall global estimate of uncertainty while taking into account the many interactions implied in the model and by the rules of probability. While many people can easily estimate the results of a spreadsheet aggregation, many studies have shown that most people are terrible at making global uncertainty estimates. JCAT provides assistance in doing this.

Running the Analysis

To begin computation and analysis of a model, clicked the 'play' button appearing in the tool bar on the right hand side of the application window. This will pop up a dialog to be discussed below. When this dialog is closed, a double left click on various events will display their probability of occurrence as a function of time in the probability profile graph.

The dialog appearing after the play button is clicked asks for the "Estimated model Length". The estimated model length requested in the dialog is the number of time units over which events of interest will occur as a result of the model. The time units should be the same as was used throughout the model. For example if the last scheduled event is scheduled for time t= 10, and, due to delays and persistence, other events will be occurring 5 time units after this event, then 15 or more would be a reasonable value for the estimated model length.