Influence diagrams to support decision making

Industry Representatives:
Simon Goss, Samuel Sedgman
Defence Science and Technology Organisation, Melbourne, Australia

Problem Moderators:
Winston L. Sweatman, Graeme C. Wake
Massey University, Auckland, New Zealand

Student Moderator:
Haydn Cooper
Massey University, Auckland, New Zealand

Influence diagrams are used as a tool to aid decision making. They are formed by a map which is composed of events situated at nodes with directed links between these points to represent the direct influence between events. The overall purpose of the MISG project was to explore such structures, analyse them and their interpretation.

The group found a variety of sources of literature that related to these kinds of structure. Some of the members of the group were familiar with some of these approaches and shared their experiences with the group. The group also did some new investigations of its own. The industrial representatives encouraged the group to keep discussion open-ended, open-minded and not too focused in order to think about a variety of ideas and generic concepts.

A variety of uses of diagrams were identified: they may be tools to aid a ten second insight to a problem or else be the basis of two weeks of planning of a project. Aspects of working with the diagrams is their original generation which may be an iterative process with "bad guesses" identified by some kind of validation process. It may be possible to isolate parts of a diagram as a sub-network. In fact diagrams could be constructed and considered as hierachial structures in some cases, perhaps hiding some of the detail for an easy overview but maintaining the opportunity to call upon it if required. The influence passed along links may be known to differing degrees of precision.
It may be identified qualitatively or quantitatively.

Two aspects of such diagrams, that were identified early on to be of importance, were the identification of the multi-link connections between nodes (events) and the concept of cumulative influence or the transmission of influence between such nodes that may not be directly connected. A program was generated that explored this problem and found long and short connections. Connections which included a loop and ones where both positive and negative influences were present. A measure was made of whether a node has a more positive or a more negative influence on an identified event. The program provided a visual display that itself nicely illustrated the power of using influence diagrams to convey ideas. Simulations using this program were used to identify the end states of some example progressions of influence. This led to a dynamical system model of the evolving states of each variable, with increments of time at first held as equal to the step between adjacent boxes. Then the nature of the whole system (typically tens of state variables) can be evaluated.

The dynamical system model underpins the influence diagrams by an algebraic concept. It enables the identification of the end-states of progressions of influence found earlier by the simulation program. The end-states relate to eigen-functions of the system. This result means that whatever the initial decision the end-state is the same unless of course these are neutrally stable (as they are likely to be), and then the endpoint is determined by the initial condition. In either case the eigenvalues of the linear system give an indication of the relative growth or decline of the system state. The end states only depend upon the network of influences. To avoid a stable dominant end-state in our model will require continual intervention or a change in the influences and the events incorporated. It is likely there should be feedback loops in the model, which would introduce multiple steady-states and confine the solution long-term to a practical finite part of the state-space. This has yet to be explored.