MOTIVES AND EMOTIONS IN A GENERAL LEARNING SYSTEM

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ABSTRACT

The relationship between motives, emotions and learning in the design of intelligent systems has received relatively little consideration to date. Clarification of the relationship involves tackling fundamental questions such as the survival value or adaptive function of motives and emotions in intelligent systems, the nature of motivational and emotional processes which are features of 'innate' endowment, the learning of additional motives and emotions as a result of environmental interaction, and the results of the influence of motives and emotions on learning processes and, conversely, the effect of learning processes on the nature of motives and emotions.

Introduction

The relationship between motives, emotions and learning in the design of intelligent systems has received relatively little consideration to date. Sloman and Croucher (1981) include mechanisms for changing the current set of motives and the need to learn motives in their list of constraints on the design of intelligent systems which determine what would make them well adapted. They, also, point out that a complex and changing collection of motives and the emotions they generate must have a profound effect on what is learned when and contribute to enormous variations between individuals. Pfeiffer (1982) in presenting the general framework of a theory of emotion in cognitive science terms lists learning processes and evolutionary considerations among the important issues which have not yet been addressed. His theory has been partially specified in a computer simulation model called FEELER which is implemented in an extended version of PRISM (Langley and Neches, 1981).

Clarification of the nature of the relationships between motives, emotions and learning in intelligent systems involves tackling an agenda of fundamental items which can be conveniently described in terms of human development. It is necessary to explore the survival value or adaptive function of motives and emotions in intelligent systems from an evolutionary perspective. What motivational and emotional processes must be assumed to be wired in as features of innate endowment? How does the learning of additional motives and emotions proceed as a response to environmental interaction? What are the results of the influence of motives and emotions on learning processes and, conversely, the effect of learning processes on the nature of motives and emotions? The remainder of this paper reports a preliminary exploration of these issues employing BAIRN, a general learning system, and adopting a perspective on motives and emotions derived from the work of Sloman and Croucher and Pfeiffer.

BAIRN: A General Learning System

As a comprehensive account of BAIRN has been provided elsewhere (Wallace, 1982) only the features directly involved in the construction and representation of motives and emotions will be described. The BAIRN project is aimed at the construction of a theory of cognitive development in the form of a self-modifying information processing system in which productions are employed as the units of cognitive analysis. The specific objective is the construction of a computer program as a completely explicit and demonstrably sufficient version of the theory.

The BAIRN system comprises general learning processes and a world model which governs the nature of its interaction with the environment. An integrated form of representation for procedural and declarative knowledge is adopted in the long term memory (LTM) world model. It is composed of a network made up of nodes at which are stored production systems. The mode of operation of the network is based on three levels of consciousness (focal, peripheral and unconscious) which permit a limited number of nodes to be active in parallel. Each node in the network has prepotency values which define the strength of its bid to be allowed to operate when specific inputs suitable for its activation are present. This feature provides an opportunity to explore the effects of variations in motivational structure on the system's operation.

The approach adopted in the BAIRN project maximises emphasis on general learning procedures. The learning processes are responsible for the creation and addition of new productions to LTM. Discharging this function requires the ability to monitor the results of environmental interaction. The mechanism adopted is a time line or episodic memory which contains a sequential record of the system's activity. If any regularities exist in interaction with the environment they are represented in the time line. Self-modification takes place through the detection of this regularity by the learning processes and the subsequent addition to LTM of productions which will capitalize upon it. Regularity detection involves two probabilistic features which constitute dimensions of individual difference. The first is the M(atching) I(ndex) C(riterion) which has a constant value for each individual. The MIC determines the level of agreement before two sequences are regarded as a match. The second probabilistic feature is the C(ritical) C(onsistency) L(evel). Unlike the MIC, the CCL exhibits variations within a band characteristic of the individual. It reflects both the number of novel sequences and the degree of agreement between them which comprise a level of consistency warranting modification of the LTM world model.

Adaptive Function of Motives and Emotions

In information processing terms the existence of motives can be attributed to the need for determination of directionality in intelligent systems endowed with a high degree of flexibility or adaptability. Appropriate constraints on the wide range of possible courses of action are essential for the establishment and maintenance of successful environmental interaction. The first step towards fulfilling this function in BAIRN is the addition of motive generators to the system's initial repertoire of processes. Motive generators bias the construction of the system's representation of its world in particular directions and, as a result, constrain and direct its behaviour. They operate by scanning the time line trace for sequences representing experience falling within the area of their motives and initiating appropriate additions or modifications to LTM. This process is conducted both on-line and off-line.

Emotions can be regarded as 'hard wired' sources of information that assist in a continuing process of discrimination which is crucial in canalising the behaviour of the system in appropriate directions. Episodic records of physiological activity associated with emotions assist motive generators in performing their function by facilitating rapid detection and discrimination of time line segments both on-line and off-line. These records initially reflect the operation of primary emotion generators included in the system's 'innate' repertoire. These are productions linking sensori-perceptual conditions with physiological actions defining primary emotions such as pleasure, fear, anger and so on. The physiological trace data is detected and reacted to by 'innate' motive generators. Their conditions include patterns of physiological activity defining primary emotions, indications of the level of emotional intensity derived from the intensity of sensory stimulation, and other situational features defining the area of the motive. In innate motive generators these situational features are of a relatively global nature, such as the perception of human contact.

The assignment of distinct, physiological definitions to emotions via primary emotion generators is at variance with the approach adopted in FEELER Since a general level of autonomic arousal is assumed the physiological component in FEELER cannot be used to distinguish between different emotions. This objective is achieved by means of distinctions in the cognitive-evaluative aspects of emotions. In addition to employing specific variations in physiological arousal the present approach retains a fundamental function for the general level of autonomic arousal. It is assumed that it contributes to determining the nature of the spread of activation that occurs in the LTM network during each cycle. High arousal produces the lowest level of contextual inhibition and the least constrained spread. Low arousal is associated with the most constrained spread and contributes to 'concentrated attention' while intermediate arousal leads to a controlled spread of activation well suited to complex processing such as problem solving.

Interaction between the initial repertoires of emotion generators and motive generators determines the episodic records which are selected as starting points for off-line processing of the time line in the search for consistent sequences. In some cases motive generators representing highly significant motives directly determine that a new node will be added to LTM on the basis of a single occurrence of a sequence. In others the decision depends on the result of time line processing by the consistency detection processes employing the MIC and CCL parameters carried out after a motive generator has indicated the starting point for analysis. When an addition to LTM occurs an initial prepotency value is assigned to the new node by the motive generator(s) involved in its creation. The prepotency reflects the status of the motive generator(s) in a hierarchy of primary motives and specific values of the emotional intensity and situational feature variables included in the sequence.

Since records of the operation of primary emotion generators are included in sequences giving rise to new nodes, productions providing direct access to the generators are incorporated in the definition lists of the new nodes. This ensures that future activation of the nodes will be accompanied by experience of the associated emotions.

Assigning of prepotencies is not confined to newly created nodes. Individual nodes compare the results of their activations with expectations based on previous input/output conjunctions stored on their description lists. Unexpected or novel outcomes are flagged in the time line record to enable processing by motive generators and assignment of a prepotency value. The effect of this procedure is to provide each node with a range of context linked prepotencies as environmental interaction proceeds. This replaces the initial global prepotency.

General functional characteristics desirable for effective environmental interaction and facilitation of learning can be conferred on the system by additions to the initial repertoire of motive generators. Frequent activation of newly constructed nodes encourages detection of their relationships with other nodes and contributes to further modification and enrichment of the LTM world model. This effect can be produced by a motive generator which temporarily increases the initial prepotency level of new nodes on a decrement with repetition basis.

A similar approach can achieve the selective attention to new environmental features characteristic of human performance. In BAIRN repeated activation of nodes within a parameterised range of cycles is indicated by markers on the time line records of the repetitions. If 'newness' is defined as the absence of repetition markers, a motive generator monitoring time line entries on-line can produce a focussing of attention by temporarily increasing the prepotency level of the nodes responsible for the 'new' time line records. Such increments would disappear with fewer repetitions of activation than the temporary increases accorded to new nodes.

Learning of Emotions and Motives

Interaction of the 'innate' repertoires of emotion and motive generators not only contributes to construction of the system's world model but results in the learning of further emotions and motives. Representations of higher level or compound emotions are derived from time line sequences containing activations of two or more primary emotion generators or two or more nodes with generators featuring on their definition lists. Higher level motive generators capable of processing the more complex physiological trace data produced by the compound emotion generators are derived from time line sequences including associated activations of the initial motive generators which process primary emotions. These compound motive generators provide a capability to assign initial prepotency values to new nodes derived from sequences featuring compound emotions.

Interaction of Emotions, Motives and Learning Processes

BAIRN provides illustrations of the effect of learning processes on emotions and motives as well as the influence of emotions and motives on learning processes. The settings of the MIC and CCL parameters determine the generalisation/discrimination boundary (Bundy, 1982) that operates in the construction of new nodes. As a result wide individual differences in the specifics of the representations of compound emotions and motives constructed by a system will be produced by varying the combinations of MIC and CCL values involved in detecting the sequences from which they are derived. Combinations emphasising the extremes of generalisation or discrimination will result in emotions and motives which in humans are associated with pathology.

This interaction offers the prospect of endowing self-modifying intelligent systems with the basis of distinctive 'personalities' that will emerge as construction of their world model proceeds. This would be achieved by manipulation of the initial repertoires of emotion and motive generators and the values of the learning parameters. The possible membership of the generator repertoires is not restricted to the range of human emotions and motives. It is defined by the range of features of intelligent systems which are functionally equivalent to emotions and motives. The objective of providing intelligent systems with emerging personalities is to allow for self-modification within broad constraints. The system retains the flexibility and general learning capacity necessary to construct a world model and maximise the effectiveness of interaction on the basis of the specifics provided by the environment. The environment, however, does not dictate the overall emphasis in the system's operation. Systems designed on this basis would be suitable for the control of third generation robotic devices required to function for protracted periods without human supervision.

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ARTIFICIAL INTELLIGENCE IN THE CLASSROOM

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ABSTRACT

Various teaching strategies have been employed in attempting to overcome the difficulties experienced by students learning computer programming on courses held at the Bedford College of Higher Education,England.

The problem remains unsolved; the main difficulty encountered lies in the development of the algorithm, not in the syntax or semantics of the language. The contribution gained by the use of flowcharts has been negligible; the major contribution came from allowing the students to work in groups.

The essay follows the argument that, accepting the premise that programming requires logical thinking, a solution to this problem may be forthcoming if it is tackled by helping these students to develop problem solving skills from an early age; thereby placing the onus on the schoolteacher.

Use of educational tools, namely BIGTRAK, initially for the very young, followed by the TURTLE with LOGO programming, and latterly microProlog is advocated.

The paper is introduced by a brief discourse on the concept of knowledge, in order to confirm that to teach thinking is difficult, and hence that there is a role for some aspect of artificial intelligence in the classroom.

By definition, a teacher's role in the classroom must be that of one who teaches, imparting knowledge and guiding the studies of the pupils. But, the concept of knowledge is difficult to define and cannot be determined precisely in the way that some words can. In attempting to define the constituents of the concept of knowledge, various notions can be considered, for example: information, instruction, enlightenment, learning, or practical skills.

Attempts have been made to break knowledge into divisions, Hirst,(1973) put forward the suggestion that knowledge was separable into distinct forms, such as mathematics, physical sciences etc. But, if these forms are accepted then the concept of a particular branch of knowledge may even differ, depending on how it is presented. Polya,(1973) states, "Mathematics presented in the Euclidean way appears as a systematic deductive science, but mathematics in the making appears as an experimental inductive science."

The view that the four ways of thought: logical, empirical, moral, and aesthetic represent more fundamental divisions of knowledge, Philips,(1971) perhaps relates more closely to the aim of including more of the cognitive aspects of teaching in the classroom.

While the claim that knowledge is worthwhile on its own account, simply for the development of the mind, can be appreciated, as Cribble (1969) argues, forms of drill are not intrinsically worthwhile. And while this form of teaching perhaps cannot entirely be dispensed with, the question often arises relating to whether teachers actually teach children to think, i.e. to develop their ability for reasoning, experimenting, making moral reflection, or to achieve an appreciation of aesthetic principles. The knowledge that is planted in a child has to be brought into action.

Landa (1979) considers that some teachers do teach children to think but that some do not. He admits that to teach thinking is a problem, because the operations that have to be carried out on the knowledge present in the student's head, in order to be able to problem solve are not well developed.

The assertion that organised teaching is not required for learning to take place, is held by Papert (1980), who puts forward the analogy of how a child learns to talk.

The difficulty of teaching children to think then is evident, and while the computer can be a catalysing agent for promoting a different type of teaching to take place in the classroom, to-date the methods employed in computer-aided-learning, have on the whole, contributed little to further the pursuit to help children to think. Computer-aided learning techniques employed in schools generally follow the traditional method of classroom teaching, and if a child's development partially depends on this traditional approach to teaching, then present computer-aided-learning does seem to provide motivation and have a novelty value, albeit, possibly a temporary innovation.

But,Paperfs (1980) association of this use of a computer for drill and practice,(combined with the use of the BASIC language), with that of the QWERTY keyboard, exemplifies the dangers imminent when tradition takes a firm hold, and the ensuing difficulty encountered when endeavouring to bring about any change; in this case in the way that computers are used in the classroom.

Intelligent tutoring systems cater for the student more adequately, and aid research into learning, but are rarely found in schools. Also artificial intelligence programs which deal with aspects of human behaviour designed to simulate behaviour help to illuminate how children think.

In the classroom, a simple machine in the form of a toy tank, BIGTRAK, can be used by primary and infant teachers for mathematics teaching and to involve the children in logical thinking, besides providing an introduction to computer techniques. The tank can be programmed to move, turn, pause or fire and the children can think of their own problems and also how to solve them, and hence program the tank. They often act as BIGTRAK themselves in finding out the required movements, then logically assemble them to produce the program of instructions, which importantly, they realise may not be correct at the first trial. Hence, this toy enables a means of pupil-controlled investigation to take place, besides providing a by-product of introducing measurement and direction to them. The guidance of the teacher is required, as without this its value would diminish.

BIGTRAK then forms a medium for Papert's ideas,(1980) although a rather unrefined tool in some respects, learning is achieved through its use without formal teaching, and its advantage in schools lies in its comparative cheapness.

The object that Papert(1980) advocates for use with children, the TURTLE, has a cost disadvantage at present, but with the infiltration of the microcomputer in all schools in Britain, the concept of it, as an educational tool in the classroom, is rapidly gaining acceptance, even though many schools have to be content with "turtle" graphics on the screen, and it is expected that the cost will be lowered. But, even with "turtle" graphics, the child is in control and observations show that they usually enact the steps required to solve their particular problem.

The program language incorporating the use of the TURTLE, LOGO, evolved for applications by children by Feurzeig et al.(1969). The full version of LOGO provides additional facilities to the usual high level language, for example, list processing and recursive functions. But, in many schools in Britain only a subset of the language is in use which relate only to controlling the screen "turtle". This reduces the amount of storage required and the cost of the software. Programs are also written in BASIC which can provide a reasonably successful LOGO environment in the classroom.

While many school teachers in Britain are just beginning to be introduced to the potential of the use of LOGO as an educational tool, possibly because it was devised for such a purpose, a reasonable amount of research and evaluation has been carried out.

Preliminary observations in primary schools in Bedfordshire have revealed keen interest by both teachers and children in its use. The teachers have been impressed by the strategic skills shown by many of their pupils.

In their Evaluation Study: Teaching Mathematics through LOGO Programming,(Howe et al. 1980), the conclusion reached is that the understanding of mathematics by children who are less able can be improved by such programming-based activities.

An investigation into the claims made for the use of the TURTLE in the classroom, involving 15 special schools situated over a wide area of England and Wales terminates in July 1983. The research is co-ordinated by the Chiltern Advisory Unit, Hatfield, England; the final evaluation report should help teachers in deciding the contribution that the TURTLE can make to the development of children.

While it has been shown that girls generally do not achieve as high results as boys in computer studies, the opinion is emerging that they do marginally better than the boys when LOGO is used.

But, it is not only children who can benefit from using LOGO, du Boulay (1978) showed that student teachers who experienced difficulty with certain areas in mathematics gained a better understanding by writing LOGO programs to investigate the topics.

LOGO is used in British and American schools and developments in France, to ascertain its potential for use as an intrinsic part of their educational system, are taking place.

PROLOG-PROgramming in LOGic, designed by Colmerauer and colleagues in 1972, images human reasoning and utilises natural language. Papert enthusiasts support the use of PROLOG for children; a close relationship exists between LOGO and PROLOG.

PROLOG is now being made available for microcomputer systems in the form of microProlog, developed by Mc Cabe 1980. Relatively little work has been carried out on its use in the classroom, but, a project has been running since October 1981, "Logic as a Computer Language for Children", based at Imperial College, London. Evaluation is being conducted in a number of schools and colleges, and courses are being held for teachers in various parts of England.

This project is led by Robert Kowalski who considers that microProlog contributes to promoting logical thinking for use throughout the school curriculum and that it can stand as a subject on its own. He considers that because it is not tied to a particular machine structure, it. is more suitable for use by children than languages which are.(Ennels,1983).

Ennels (1983) has expressed surprise at the quickness that children are learning microProlog. The pupils build their own database and formulate queries, so promoting clear thinking and expresssion.

These then are some of the tools that can be used in assisting teachers to teach children to think; many other micro-technology aids are available and although many are considered to be simply computer toys, an investigation into their potential use in the classroom may reveal that some are more than toys. "Computer toys come closer to imitating the style of human intelligence than the teaching machines of the past and may well represent the educational wave of the future." (Gardner,1979).

In conclusion, the educational tools suggested for use in this paper are mainly just being introduced to schools in the Bedfordshire area, hence it will be some time before there can be any evidence to show that the children's capacity for clear thinking has improved and as a result the difficulties experienced by the ones who may eventually wish to include further computer programming as part, of their future studies may be lessened. Current research in this area suggests that this will be *so.*

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