Two roles for the computer in cognisant systems

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1. INTRODUCTION

This paper discusses two roles in which the computer can act as an aid towards human cognition. These two roles, the roles of the "cognitive mirror" and the "speculative interpretative participant" have been embodied in a number of interactive computer programs for developing personal models of the world (FOCUS, PEGASUS, CORE, SOCIOGRIDS, ARGUS).

The philosophy and ideology underlying this work has its origins in Personal Construct Theory (Kelly [8]). For many years psychologists have been interested in how an individual classifies his experiences and categorises his environment. The concept of "schema" has ranged widely from Kant to Bartlett [2], from Head [5] to Vernon [25], Bruner, Goodnow and Austin [3], and Skemp [19]. The commonality in these approaches suggests that an individual uses a system of organisation together with inter-relationships between components in the system, which in interacting with the structure produce interdependencies. If the person can become aware of the structure and the organisation within the structure, he becomes more able to make adequate predictions and act according to them. Osgood, Suci and Tannenbaum [13] suggested that each person has a unique system of dimensions which are used to perceive and judge the environment, and that some of these are common to all people. Kelly argues that each individual constructs his own version of reality using a hierarchical system of personal constructs. In the context of a person learning from experience, this theory is abut the way in which he can negotiate a viable position in his own reality, review it, revise it, and refine it within his own world. Enduring reality is non-conscious, and consciousness is merely a temporary construction within a specific situation. This thinking is part of a more general context of ideas put forward by people as widely ranging as McCulloch [12], Schumacher [17], Sir James Jeans [7], Wittgenstein [27], and Lorenz [10].

Each human being may be seen as a personal scientist, classifying, categorising and theorising about his world, anticipating on the basis of his theories and acting on the basis of his anticipation. Each personal scientist uses himself as participative subject matter and construes and interprets the results in a personally meaningful way. To do this effectively a conversational method must be used. A number of people have put forward models of "conversations". Jahoda and Thomas [6] have developed a "science of learning conversations" in which the learning experience can be viewed from the perspectives of the learner or teacher and evaluated prospectively or retrospectively; Luft [11] used the "Johari Window" which is a model of interpersonal awareness demonstrating the interaction of two variables "know/not known to self" and "know/not known to others". However, the most appropriate conversational model for this work is that of Pask [15], "Theory of Conversations and Individuals". Pask suggests that participants in a conversation cannot be regarded simply as distinct processors, but recognises an "M-Individual" or "mechanically characterised individual" which may be regarded as a biologically self-replicating system and is consequently a hardware distinction; and a "P-Individual" or "psychologically characterised individual" which "has many of the properties ascribed by anthropologists to a role" (Pask [14], p. 302), and is also a procedure executed in some M-Individual or processor and is therefore a software distinction.

Three aspects of conversation are therefore identified:

1. A conversation with oneself which may be generalised to a conversation between several P-Individuals each representing an important aspect of self.
2. A conversation between two P-Individuals in two distinct M-Individuals or processors.
3. A conversation in a group of M-Individuals which constitutes one or more P-Individual.

To build a technology to encompass a conversational method, the Kelly repertory grid was used as a base for articulating each of these aspects of conversation. This grid is a two-dimenstional "construction matrix" in which events are interlaced with abstractions. These abstractions or "constructs" are bipolar dimensions which group events into varying clusters according to their similarities and differences in the individual's frames of reference. This grid then represents the interpretation of the repertoire of experience that the individual has constructed from his personal observations of the world. These personal observations are known as "elements" and were originally constituted from the role titles of significant people in the life of the particular individual. These roles are still commonly used in psychotherapy, but are equally applicable to a person in industry or education.

However, the elements need not be role titles, but may be a set of people -- such as work

colleagues or subordinates (e.g. Thomas, Shaw and Pope [24]), things -- such as books used for learning or detergents in market research, events or experiences -- such as parts of a course of therapy, which span the area of the problem. For example, if the problem was one of choosing a future career the elements might be different jobs; if the problem was to become a "better" person the elements might be different aspects of self; if the problem was to evaluate the success of a training course the elements might be significant events which took place during the course. When choosing elements, care must be taken to ensure that each one is well known and personally meaningful to the elicitee. Each construct must be central to the person in the context of the particular problem. Thoughts and feelings, objective and subjective descriptions, attitudes and prejudices, all constitute valid constructs. The verbal descriptions of the construct and the labelling of the poles need not be a coherent statement to the outside world, but only a memory aid of the conversation. The mapping of the elements onto the constructs produces the two dimensional grid of relationships.

The grid is therefore a content-free structure which may be held by the computer whilst the system of constructs is elicited from the individual. As the conversation takes place the computer can monitor and record the process in a person-centred way without intruding on the content. A personal scientist uses structures and mechanisms in a necessarily "human" way, that is, in such a way that they enhance his power, not become his master. Coomaraswamy (cited in Schumacher [17]) draws the distinction between the machine and the tool, likening the tool to a carpet loom which helps the craftsman and the machine to the power loom which does the essentially human part of the work and is hence a destroyer of culture. To use the computer as a tool rather than a machine may be a new experience for some people; and to realise that interactive computing is not necessarily a branch of programmed instruction, but can be a content-free holder of structure which helps the user to express himself in his own terms about his own problems, in a conversation with himself. Gaines [4] goes even further by suggesting that the computer can be seen as a colleague, expressing sympathy and understanding to the user. This comes much closer than before to the hope of Wiener [26] when he spoke of "the human use of human beings".

2. THE COMPUTER AS A COGNITIVE MIRROR

The quality of a person's models, both specific and general, will determine the level of skill, coping, competence and creativity he will be able to achieve. PEGASUS or "Program Elicits Grids and Sorts Using Similarities" is an interactive computer program (Thomas and Shaw [23]) which elicits a grid from an individual, simultaneously acting as a psychological reflector by heightening his awareness and deepening his understanding of himself and his processes. This is done by the provision of continual real-time feedback commentary on highly related elements or constructs, together with the encouragement to differentiate between them. Before choosing his elements the user is asked to think about his purpose for eliciting the grid. This is of great importance for the interaction which is to follow, as it sets both the intentionalities and the universe of discourse. The mutual dependencies of the elements on the purpose, the constructs on the elements and the purpose jointly on the elements and constructs, contributes to the satisfaction and satisfactoriness of the interaction. By using combinations of reviewing the purpose, adding and deleting constructs and elements, a depth of interaction may be achieved which could not at the start have been envisaged. Thus the user is given the opportunity to reflect on his understanding of the area of the universe of discourse to examine and explore his thoughts and feelings in this atmosphere of heightened awareness of personal knowing. His perception may be changed in a way which by other means can take years to accomplish. The computer is acting as a cognitive mirror, reflecting back to the user his models of construing. The essence of learning is constructive and creative change. Learning is often measured in terms of behavioural objectives devised by the teacher, or one step further removed from the learner -- the course designer. For the learner himself, learning is the revision of his cognitive model in order to make his anticipation of events more effective, that is in the way he perceives and construes events and behaves in the situation. PEGASUS actively encourages the consideration and revision of tentative hypotheses of the personal scientist approach, hence supporting the reconstruction of cognitive models and the change which is the "seeing" and learning of constructive alternativism.

PEGASUS is therefore a content-free heuristic in a conversational mode, allowing the user to fill it with the content of his head and heart, and see it re-ordered and restructured in ways he was unable to achieve without the computer as a tool which he begins to use as a craftsman uses his carpet loom. The PEGASUS process gives to the user an enlightening experience which may not be visible in the results or the printout of the interaction. He may see himself through his own eyes for the first time; he may talk to himself through the computer in a more meaningful way than ever before.

ARGUS (Shaw [18]) or "Alternative Roles Grids Using Sociogrids" is a development of PEGASUS in which the conversational domain is articulated through the computer within which a group of P-Individuals in one M-Individual can interact.

It seems reasonable to hypothesise that a well-adjusted individual has recognised the existence of the personalities in his head, and allowed each a place to operate where it can be valued and made use of in the context of the whole person. Further, psychotherapy consists in creating a converation between these P-Individuals in which each may be recognised and valued. These P-Individuals may be roles, purposes, or centres of attention, but all are significant points from which to view the world. In extreme cases these P-Individuals may not share any constructs in certain areas. This may be due to variations in the ranges of convenience of the constructs used, or perhaps distinct and disjoint P-Individuals are brought into operation in different universes of discourse. Lewin [9]

uses the phrase "plurality of separate spaces" to express this same idea. By relating and cross-referencing the ways in which different elements and constructs are used by different P-Individuals, the computer is able to reflect back to the user subgroups of P-Individuals which operate similarly, and those which are uniquely different from the others.

Two people may come to an "understanding" of each other through the computer by each interacting conversationally with the other's constructs which are stored as an adaptable bank. This is known as PEGASUS-BANK and is based on the idea put forward by Thomas [20]. There are two ways in which it can be used: to explore shared construing of an area, and to interfere with an area construed by an "expert". The first use assumes that the two participants have equally valid views of the area; one produces a PEGASUS grid which is stored as a bank to be accessed by the other. As the second person elicits his own grid, comparison is made between his constructs and those already in the bank, high similarities provoking comment. The bank may then be modified in the light of the interaction before the first person, or possibly a new participant, uses it again. In this way it is possible to build up a coherent view of the universe of discourse, with an indication as to the amount of overlap between the participants.

In the second way of using PEGASUS-BANK, the bank of constructs stored in the computer represents an "expert" view of an area of public knowledge. As the processing takes place, continual comparison with the bank gives feedback to the user on the extent to which his constructs map on to the expert's construing of the same elements. Since the comparison is made in terms of how the construct orders the elements rather than in terms of the verbal labels, it is often found that although a person may have only a vague idea of the technical terms, he may actually be using very similar constructs.

The PEGASUS-BANK technique of storing in the computer a bank of constructs which represents an area of public knowledge or the construing of a group of specialists shows how an individual can use the grid methodology to interface between his early gropings and the articulate formulations of the group. When used in the form which encourages two participants to take on each other's construct systems by mapping out the similarities between the patterning, meanings can be exchanged between the pair. Alternatively, if each elicits a grid independently the overlap may also be compared using the patterning of the responses.

Whether or not the grids have been elicited on separate occasions, if the element and construct labels are the same in both grids they can be compared with respect to the similar or different uses of these names by examining the differences in the patterning in each grid.

CORE (Shaw [18]) or "Comparison Of Repeated Elicitations" is an interactive program which allows the user to investigate the extent and content of shared understanding exhibited by two grids. The computer successively reflects back the areas of most difference which are then removed from the grids at each stage, thereby increasing the similarity of the remaining portions. If these grids have been elicited from the same person at two separate times, CORE reflects a measure of change over the time interval; whereas if the two grids are from two different people, the reflection is of the degree of understanding between them. By exchanging constructs through the computer and learning to use them in the way another person intended them to be used, the levels of understanding and empathy may be increased.

In these ways the computer is acting as a cognitive mirror, reflecting back to the user an interpretation of his own meaning system by making explicit the analogies, cross-references and isomorphisms which he uses between the dimensions of his thinking. This enables him to see his modelling processes more clearly, and thereby to review and revise his cognitive model on the basis of this insight.

3. THE COMPUTER AS A SPECULATIVE INTERPRETIVE PARTICIPANT

Methods of grid analysis have for a long time constrained the use of grids as a modelling facility. Previously factor analysis and principal component analysis have extracted factors; more recently cluster analysis and multi-dimensional scaling have been used. FOCUS or "Feedback Of Clustering Using Similarities" was developed as a speculative interpretive method of identifying clusters of like elements and like constructs (Thomas and Shaw [22]). This is a method of grid analysis which systematically re-orders the rows of constructs and columns of elements to produce a focused grid showing the least variation between adjacent constructs and adjacent elements. This is done with respect to the way in which the constructs order the elements rather than to the verbal labels given to the poles of the constructs. The matching score between constructs, which is computed from a city block metric, then indicates the internal consistency of meaning within the cognitive model as exemplified in the grid. The results are presented in a form which lends itself to the conversational participative feedback of the clusters.

As a PEGASUS elicitation proceeds this FOCUS algorithm is used to offer to the user a possible explanation and interpretation of his meaning system in the terms of the similar patterns he uses in supposedly different circumstances. Cross-references are mapped across the grid and exhibited to the user in such a way as to offer him the facility to reconsider and change anything he feels to be inappropriate, which enables him to be more aware of the links he is implicitly holding in his cognitive model. Here the conversation can be seen as a feedback loop with the computer acting as the error regulator by representing the content of the conversation and the implicit links within the conversation. In this way the participative analysis extracts and displays the essence of the subjectivity and personally meaningful relationships in the grid.

In a similar way, two constructs from different grids may be compared, and the extent of similar patterning of shared elements by two people examined. If this is extended to the whole of the two grids elicited from two people using shared elements, the extent to which they

are using similar models will be roughly indicated by the degree to which the clusters contain constructs from each of the two grids. These two grids could be from two P-Individuals within the same processor or M-Individual, the extent of overlap then indicating the degree of intersection of the two systems. As the computer processes this type of data, feedback may be given on the areas where the sharing of meaning is high and on those aspects which are unique to the individual grid.

Having found a way of comparing grids from two people, this principle can be applied to all possible pairs in a group of P-Individuals, who may or may not inhabit distinct M-Individuals and who interact in a shared conversational domain. This is described by Thomas, McKnight and Shaw [21], and led to the development of a program called SOCIOGRIDS. The program produces a sequence of "socionets", which are sociometric diagrams showing how like-construing between individual members of a group can lead to the development of pairs of subgroups of people, or the identification of an isolated member who models the situation quite differently from the others. SOCIOGRIDS also identifies the content of the like-construing by selecting from individual grids the "mode constructs". These are the constructs which are common to the majority of the group members. This interpretation can be individually exhibited to each of the group members in turn, highlighting the specific contribution each has made, showing him which of the others have similar ways of perceiving the situation, and where his own ways are unique in the group.

In these ways the computer is acting as a participant in the presentation of the data to the individual, offering the results of the analysis in a provisional way in order to allow the individual as much choice as possible in the acceptance or rejection of the speculative interpretation.

4. CONCLUSION

The repertory grid is only the beginning of a technology for eliciting and developing personal models of the world, and helping each individual to be more effective in his aim to become a personal scientist. Many techniques have potential for developing this work beyond the structure of the repertory grid, especially data structures from computer science, graph theory and optimization from operational research, mathematical structures and forms such as Q-Analysis (Atkin [1]), the concept of cybernetic entities like P-Individuals, and developments in computer graphics. The computer can be used in a new and responsible way being truly interactive and content free but supporting a structure which is amenable to mathematical treatment thereby allowing the reconstruction of the conversational content.

In the field of education, computer-aided learning has been partially developed. The computer is programmed to adapt to an individual learner, record his successes and failures, and use these records as a basis for the selection of further material. However, much of what is called computer-aided learning is indistinguishable from computer-assisted instruction. If the philosophy of the personal scientist were to be incorporated into this process the learner could be offered tools which allow him to attempt new ventures with a firm basis and support in the system. This would be especially appropriate in the teaching of foreign languages, for which there is a greater need since many more people are travelling around Europe than previously. Such systems as those described offer a new light in which the learning of a language from French to PL/1 may be made less obscure.

Similarly, in industry the techniques have successfully been applied to learning and training, quality control (e.g. Pope, Shaw and Thomas [16]), and staff development, by recognizing that one must begin from the cognitive models displayed by the individuals concerned, not those specified by the regulations.

The recent development and availability of microprocessors indicates that the "personal computer" may soon be commonly available to the ordinary person. There is no technical reason why the techniques described here could not be run on these personal computers, offering to all people for the same cost as a pocket calculator these tools for raising personal awareness of one's cognitive models and processes, making explicit relationships on the world in a non-directive and supportive way, and enabling the individual to have an overview of his system in such a way as to allow him to review and revise his models in a non-threatening manner.

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