The sensitive interface*

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Abstract

One of the most important problems in human-computer interaction is that of maximising communication between the user and the computer. We claim that optimum communication will be facilitated when the computer can analyse and respond to the intentions of the computer user. We propose a philosophy for computer interface design in which the computer analyses the intentions of users through verbal and nonverbal media. With respect to verbal media we describe a computer program called Operating System CONsultant (OSCON) which can analyse users' intentions from English in the domain of computer operating systems. With respect to nonverbal media we argue that computers will be better able to analyse people's intentions when recognising the media of facial expression, touch, and sound. Some results and implications from a recent experiment on cross-cultural emotions in faces are discussed. We describe the IDIOMS (Intelligent Decision-making In On-line Management Systems) project which implements a design philosophy for capturing users' concepts and intentions. We argue that this approach will ensure that computers will become more understanding of their users and this will result in a more sensitive human-computer interface.

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1 Introduction

One of the most important problems in developing computer technology is to ensure that human-computer communication is maximised at the interface. The best interface will result in optimum communication between a computer and its user. We believe that one of the most important factors in good communication is the development of interfaces which maximise the analysis (recognition and representation) of users' intentions. The best interface will be one which operates a large number of media for communication with its user. We will be mainly concerned here with communication media in the form of language and facial expressions.

In many situations the whole interpretation of an utterance is qualified by the accompanying facial expression, or prosodic information such as the tone of originator. Notwithstanding sophisticated video-conferencing this is generally lost in computer-mediated situations and in reclaiming this information it is surely preferable to base the semantics of intelligent models on universally shared understandings rather than imposing the values of a dominant culture. Particularly for international communication it is important that the representations of intention or affective state through expression are culture free and unambiguous. Whilst video-conferencing technology can be expected to supplant simulated faces in certain groupware applications, until this technology is stabilised and cheaply available conveying affective content will remain problematic. Furthermore, there is likely to remain a general requirement for conveying affective information in effective cooperative working and in electronic communication.

Here, we consider the expression of emotional state in terms of both language and vision and address the cross-cultural stability of the latter. We note the effectiveness of faces as a concise representation for complex or hard-to-describe information. We propose that if the affective context of a message can be represented stably in a small set of icons this information can be attached to computer mediated messages to enhance their interpretation in general situations requiring collaboration. Given an ongoing requirement for conveying affective information through iconic representations we consider contexts where the use of iconic information has properties which can enhance the use of verbally mediated language. In fact, people have been using icons of faces for years in order to add emotional content to their electronic mail (E-mail) messages. A list of such icons is given in Appendix A. These ASCII icons are schematic and indicate the acknowledged intent of the sender. Whilst the ASCII character set has limited expressiveness, in future, drawings from a standard set or photographic images may well accompany written messages which better express the sender's emotional intent. These may be useful in aiding interpretation.

We suggest that, if not definitive, our icon set shown in Appendix B is at least representative as that in A and we would claim that for particular applications some appropriate set can be identified. Linking the ergonomics of the interface with culture is seen as a long term goal of the work presented here (see Wang 1993). Although being able to communicate such information can be expected ultimately to help in groupworking applications there are many problems to be resolved. Here, it is of more interest to examine how such information can be mapped by an Artificial Intelligence (AI) regulating the interface.

Leaving aside questions of social desirability, if technology is to empower all sections of society in environments such as the SuperInformationHighway, access must be made available through interfaces which disadvantaged users, such as the physically disabled or the computer- or otherwise illiterate, can easily use. This, at least in part, involves increasing the sensitivity and adaptability of the interface to human characteristics. In addition, for facilitating

international working an over-reliance on a single dominant language is likely to lead to impoverished interaction and cultural misunderstandings. If instead, intelligence can be applied to recognising the user's intent and to incorporating that within message processing, work in machine translation will result in more effective interactions. Effective translation however involves more than simple substitutions and mappings. A deep semantic understanding is implicated, which requires the integration of information from various sources, both verbal and nonverbal. It is to the development of such a model that the present work points.

We divide human characteristics of intention display into two types: *verbal* and *nonverbal*. First, we describe linguistic characteristics or the requirement for seeing beyond utterances to the intentions of a human communicator. We describe some ways in which this can be practically achieved. We then discuss human nonverbal communicative characteristics such as facial expression exhibiting emotion which could be accommodated by interfaces in the future. We describe a study examining the perception of iconically-represented emotional expressions in two groups (British and Chinese subjects) and look at the similarities across the two cultures. Next, a particular philosophy for interface design is described. This philosophy, *anthropocentrism* or *human-centredness*, stresses situatedness and accommodates flexible initiative in computer use. Finally, a particular interface implementation in the domain of credit control illustrates some of these principles. It is our goal here to indicate some directions for human-computer interaction which lead to the truly sensitive interface.

2 Background

People frequently have the perception that computers are stupid, insensitive or unresponsive. This causes alienation, resistance and apathy. A major reason for this can be attributed to the fact that the computer lacks emotional capability, particularly the lack of ability to understand where the human is "coming from". As communication between people and machines is mediated through the interface it may be instructive to examine some points of difference between human-human interfaces and human-computer interfaces as a guide to directions for improvement. The first is that whereas machines are literal, humans seek meaning. Asking a creative person to read from a page of newsprint is illuminating. Often they will paraphrase the text, missing or substituting words, and this is often unconscious. Contrast the pedantry of the average computer. Analogously, when someone speaks to you it is intelligent to perceive the intention behind the utterance, and respond to that, not merely to the words. We can go on to look at methods for detecting intentions in language and in vision.

2.1 Intentions in language

There are a number of theories of natural-language discourse processing and various computational models of these theories exist. Theories concentrate on the themes of semantics, structure, and intention. A common principle of all approaches is that they provide a model of the coherence of discourse. Semantic theories argue that the coherence of a discourse is a feature of its meaning and that if you model the meaning the coherence falls out of that. For example, there are theories regarding the coherence of semantics in discourse such as those proposed by Fass (1988), Schank (1972, 1973, 1975), Schank and Abelson (1977), and Wilks (1973, 1975a, 1975b, 1975c).

Structure-based theories argue that a discourse can be modelled in terms of structural units which can be recognised and marked out in the discourse. These theories have given names like *topic* and *focus* to such units. Examples of such theories are proposed in Alshawi (1987), Dale (1988, 1989), Grosz (1983), Grosz et al. (1983), Grosz and Sidner (1986), Sidner (1983, 1985), and Webber (1978).

Classically, *openness* within systems refers to those systems which interchange material, energy or (particularly) information with their environment (von Bertalanffy 1950). For the intelligent understanding of the communication environment contextual operators must be brought to bear on the logical formulations of the base language. Collen et al. (1994) examine the general concept of openness within such systems concentrating particularly on its logical aspect. According to their analysis, information exchange lies at the first level of a hierarchy where metalevel logical computational reflection has been analysed and formalised and the context operators are passive. This level of the logical hierarchy presumes objectivised, observer-independent and static worlds which are unrealistic for natural language applications. Instead, Collen et al., noting the introduction of reflexive systems in formal logic and computer science (see Maes and Nardi 1987), propose a hierarchy culminating in reflexive openness characterised by active and evolving processes which include the observer as part of the system. Such a system can design, adapt and utilise communication strategies for interaction with other systems, of which it may construct a model, along with the relevant contextual consideration of both systems.

Collen et al. indicate applications in robotics, and in the study of language, where "the ability to produce statements is contrasted with the ability to represent and process meaning" (p. 70). This leads to a reformulation of the semantic retrieval problem in AI as changing from "the grammar generating the text" to "the text (social usage) generating the grammar" in which the human being is theoretically central to this process. Such work has implications for structure-based approaches to intention analysis.

Finally, other theories model the coherence of discourse from the point of view of intention, or the goals, plans and beliefs of the participants in the discourse. These approaches argue that people's intentions underlie their use of language and that by modelling these intentions one can model language. Examples of such approaches are given in Allen (1983), Appelt (1981, 1985), Carberry (1989), Cohen et al. (1982), Hinkelman and Allen (1989), Hobbs (1979), Litman and Allen (1984), Schank and Abelson (1977), and Wilensky (1983). The approaches do not argue that intentions in people's brains can be seen but that people's intentions can be recognised and inferred from the utterances they use. Although intentions can't be seen, they can be detected electrographically (see Libet 1985), a fact used in the development of thought-based interfaces (see Normile and Barnes-Svarney 1993). Ideas here emerge from claims made by philosophers of language such as Austin (1962) and Searle (1969). Such philosophers argue that the motivation for people to use language is to achieve their intentions.

Structure-based theories by themselves are inadequate for capturing intended meaning since they rely on well-formed sentences. Yet the psycholinguistic literature enumerates many instances of effective understanding of intended meaning when the utterance is not well-formed or even inconsistent. When a common understanding is shared the words are less relevant, and equally when other (paralinguistic) clues countermand a verbal message perceived intention governs the interpretation. It has long been recognised in the social sciences that a substantial amount of communicative information can be inferred.

2.2 Intentions in faces

As an area of Psychology, *face recognition* is of immense theoretical and practical interest. Long before formal studies were conducted folk theories relating facial expression to emotional states were established. The Chinese raised face reading to an art form, known as *siang mien*, a skill which still survives, and is recorded in both popular and scholarly books describing observable correspondences which betray character and temperament[1] (see Tao 1989). Also, of popular note is that the Ministry of International Trade and Industry (MITI) in Japan have promoted computerised secretaries that recognise their bosses' voices and have six different facial expressions. The cyborgs specifically do jobs like taking messages and making the day go more sweetly so the boss doesn't get bored (see Computer Weekly 1995 (1/6/95)). Darwin (1872) was also interested in the relation of emotional state to facial expression and although his account suggested inborn human universals anthropologists and others have noted cultural differences which can radically modify the interpretation of expressions (see Eibl-Eibesfeldt 1972). For this reason it is important to establish widely understood expressions of emotional content.

Ekman (1993) summarises cross-cultural work on facial expression and emotion and raises numerous questions for further research. Citing evidence for universality in facial expressions he notes that there is no strong evidence for cross-cultural disagreement on the interpretation of *fear, anger, disgust, sadness* or *enjoyment* expressions.

In the world of computer mediated communication where communicators are distanced from one another some simulacrum of the sender's intentions provides helpful interpretive context. Such a situation would recognise that conveying *universally understood* information is not possible using only words and a restoration of lost context is required. Representing facial expressions may give fairly unambiguous culture-free clues to emotional state but respecting those aspects of expression which are culture-specific is also required.

Since pictorial forms allow for the interrelationship among parts to be grasped along with the simultaneous perception of multifarious aspects there is an increase in efficiency of information transmission which in Japan has resulted in learning several times more efficient than learning in verbal form (see Maruyama 1986). Maruyama suggests that encoding complex information in pictorial form allows business people to process recorded messages more rapidly and with reference to the combination of character parts in Classical Chinese describes a general scheme for keyboard input of *pictemes* which are basic components of picture coded information systems. Keyboard interfaces based on simplifying classical idiographic characters have met popular resistance in China and Japan and developing picture-coded representations is seen as an important extension to the often isolating and (currently) communicationally impoverished world of networked organisations.

Within AI, vision-based face recognition by computer is also undergoing a revival after 20 years (see Brunelli and Poggio 1993, Pentland 1993) and this has applications in security, criminology and other areas. The algorithms involved traditionally tend to view face recognition as part of visual processing and consider the face purely as a geometric image to be distinguished from others. However, the features used in the model described by Brunelli and Poggio (1993) which achieved perfect recognition on their test set are interesting. Taking anthropometric standards as initial measures, and then refining them mathematically, 35

[1] Such correspondences can be extended and for example in Japan the radiator grilles on cars are sometimes perceived as faces expressing say, *aggression*, and car sales have been affected by this. (Equinox, -Zen on Wheels, British Television, Channel 4, 1/11/92).

facial features are extracted. Of these, 4 concern the eyebrows' thickness and position and 11 concern the arch of the left eyebrow. Thus almost half of the distinguishing features concern the eyebrows. The eyebrows are one of the most expressive parts of the face and this has implications for differentiating among emotions as Ekman (1993) has suggested.

By basing vision processing work on humanly meaningful features there is a potential for linkage to an integrated model constructed in terms of human semantics. Every division of the human nervous system has some physical structure related to emotion with the limbic system (the emotional core of the nervous system) regulating the information being communicated along various channels (see Cytowic 1992). Effective visual scene interpretation must likewise relate to a semantic context and for Human Computer Interaction in particular one constructed along humanly meaningful lines.

The image analysis techniques developed in vision processing systems have direct implications for user interface design. The literature suggests that difficult or long tasks are characterised by increased grimacing and other cues to indicate stress (see Delvolvé and Queinnec 1983). Sheehy et al. (1987) examine nonverbal behaviour at the computer interface using an image analysis approach to categorise detected gestures and looking behaviours along with frowns, grimaces and other facial expressions. Detecting and acting upon this information can avoid failures and suggest remedial action. In addition to facilitating the social interpretation of visually transmitted information one implication of linking face recognition with interface design lies in the intelligent processing of information within specialised human-computer interaction. With cameras built into faster machines, and by using intelligent automated image classification, the possibilities of conveying richly differentiated information to a machine are realistic.

Research at the Science University of Tokyo has resulted in a program which can distinguish among human expressions such as *anger, surprise* and *fear*. Already *seeing chips* have been developed which can be programmed to recognise faces and respond appropriately (see Davidson 1993). Dolls with such seeing chips behind their eyes can recognise their owners and respond to their expressions. Naoko Tosa at Musashino Art University has already developed, *Neuro Baby*, a 3-D digital child which simulates emotional patterns based on those of humans (see Graves 1993). Neuro Baby responds to inflections in human voice input, and if ignored will pass the time by whistling, and when addressed directly will respond with a cheerful *Hi*. Intelligent applications can then be programmed to respond appropriately and this line of work is liable to lead towards more sensitive interfaces in future computer based information systems.

Having summarised some work on the analysis of intentions in both language and vision. We now go on to look at some work we have done in each of these areas.

3 Analysis of intentions in language

In any research on natural language processing the variety of domains one can investigate is enormous. We have chosen the domain of natural language consultancy as it a common application for natural language dialogue technology. We also limit the domain to that of computer operating systems to narrow down the enormous set of possible natural language utterances. We use the domain of computer operating systems, as it is a domain of natural-language consultancy which is well-defined, and has been used before by a number of researchers investigating theories in natural-language processing. A Unix Consultant (UC) (see Chin 1988,

Wilensky et al. 1984, 1986, 1988), implemented in Lisp, acts as a natural-language consultant on the UNIX operating system. Another natural-language consultant, implemented in Lisp, called the Sinix Consultant (SC) (see Hecking et al. 1988 and Kemke 1986, 1987) has been developed for the Sinix[2] operating system. Both of these systems are similar in scope and intent to the OSCON system.

The OSCON (Operating System CONsultant) program is a natural-language dialogue interface which answers English queries about computer operating systems (see Mc Kevitt 1986, 1988, 1991a, 1991b, Mc Kevitt and Wilks 1987 and Mc Kevitt et al. 1992a, 1992b, 1992c, 1992d). OSCON enables a user to enter written English queries and then answers them in English. The program is written in Quintus Prolog and runs on a Sun-4 computer in real-time. OSCON can answer queries for over 30 commands from each of the UNIX[3] and MS-DOS[4] operating systems and handles four basic query types. OSCON can also answer queries about options on UNIX commands and complex queries about command compositions. The system is intended to be used by varying types of users with different levels of expertise. The architecture of OSCON is modular, so that it is easily updated, and can be easily mapped over to other domains.

The OSCON program currently answers four basic query types, queries about options, and command composition queries, for both the UNIX and MS-DOS Operating Systems. The fact that queries are of a given type aids in understanding and generating answers to them. Understanding queries is a combination of both filtering the query type and then understanding the query.

The architecture of the OSCON system consists of six distinct basic modules and two extension modules. There are at least two arguments for modularising any system: (1) it is much easier to update the system at any point, and (2) it is easier to map the system over to another domain. The six basic modules in OSCON are as follows: (1) ParseCon: natural-language syntactic grammar parser which detects query-type[5], (2) MeanCon: a natural-language semantic grammar (see Brown et al. 1975, and Burton 1976) which determines query meaning, (3) KnowCon: a knowledge representation, containing information on natural-language verbs, for understanding, (4) DataCon: a knowledge representation for containing information about operating system commands, (5) SolveCon: a solver for resolving query representations against knowledge base representations, and (6) GenCon: a natural-language generator for generating answers in English. These six modules are satisfactory if user queries are treated independently or in a context-free manner. However, the following two extension modules are necessary for dialogue-modelling and user-modelling: (1) DialCon: a dialogue modelling component which uses an *intention matrix* to represent intention sequences in a dialogue, and (2) UCon: a user-modeller which computes levels of user-satisfaction from the intention matrix and provides information for context-sensitive and user-sensitive natural language generation. A diagram of OSCON's architecture is shown in Figure 1.

We have described a system which can determine user intentions in natural-language dialogue and in turn use that to determine the level of user satisfaction. Now, we shall move on to describe alternative nonverbal means of modelling intention in human-computer

[2]Sinix is a version of UNIX developed by Siemens AG in Germany.

[3]UNIX is a trademark of AT&T Bell Laboratories.

[4]MS-DOS is a trademark of Microsoft Corporation.

[5]ParseCon uses a grammar, in the Definite Clause Grammar (DCG) formalism of Prolog. Definite Clause Grammars (DCG's) were first developed by Pereira and Warren (1980) as a tool to be used in Prolog for natural-language processing.

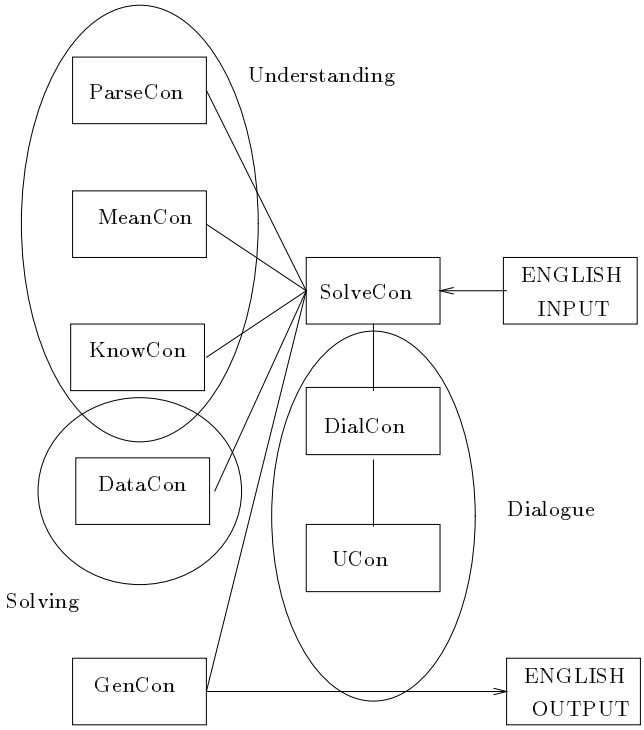

Figure 1: Architecture of the Operating System CONsultant (OSCON) system

interaction.

4 Nonverbal means of analysing intention

There are many more dimensions to communication than merely the verbal or linguistic. There is a whole realm of semiotics which the computer in its current form does not begin to touch and for users who prefer to operate through channels other than the superficially verbal the computer is frustrating in its insensitivity. It is not our intention to get into a sophomoric debate about whether computers can have emotions, rather to consider what might be realistic in enabling them to have a more sensitive response.

First, is sensitivity to the expression of the user. Humans can usually tell from nonverbal cues if someone is tense, angry or impatient. This gives clues to formulate a response that is neither long winded nor patronising but considered and calming. This would be particularly useful in help or consultant systems. There is both an existing science and an ancient lore of how to read faces to detect such characteristics (see Tao 1989).

Other cues to the mood of the user may be indicated by touch. For example, a user who is in a bad mood might indicate this by over-vigorous keypresses or bashing the mouse and this could be detected. Sensors can readily detect this sort of symptom and use it in forming a user model. Another cue which indicates user-intention is *sound*. User satisfaction levels such as irritation, hesitancy, and other personal characteristics can potentially be detected through voice interfaces.

Although perhaps fanciful, there is a serious point behind these ideas which has a defin-

ite message for design: typewritten interaction is a very superficial level of communication and limits the experience of interaction for many users. Although work in natural language processing is beginning to address intentions which underlie utterances, this is only one dimension of communication available to humans, and if computers are to be really user friendly they have to become a lot more sensitive to their users' needs. Some skeptical and empirical studies might indicate an agreed codified basis for recognising expression information and we have begun some cross-cultural work in this direction.

In an initial study, Wang and Gammack (1995) set out to investigate how context-free representations of facial expressions would be perceived in two distinct cultures. A group of Chinese and a group of British subjects were shown 70 iconic drawings of different facial expressions and their patterns of labelling and association were examined (see Appendix B). Assuming that each expression outwardly betrayed a characteristically intended emotional state Wang and Gammack examined the cross-cultural agreement in the identification of this. For the major theoretical categories of emotion, such as *happiness, sadness* and *fear*, there was good cross-cultural agreement in line with previous studies. Since the faces were drawn simply it would seem that a few facial characteristics may be enough to form a basic model of someone's emotional state, or the quality of intention, and pattern recognisers already exist which discriminate faces effectively using humanly meaningful (rather than purely statistical) parameters (see Brunelli and Poggio 1993). Similar findings for voice tones and other paralinguistic information imply that incorporating nonverbal information into user models can allow intelligent responses to be formulated: a critical requirement in a world where household appliances and gadgets will increasingly include intelligent processors.

Other work on the nonverbally mediated computer recognition of intention is described by Radin (1993) and has many potential outcomes in human machine interaction applications. Radin's study confirmed previous work showing that an artificial neural network can learn to associate machine generated random data with the mental intentions of specific individuals who are not physically connected to the machine. Humans forming a conscious intention somehow affect the interaction with a random number generator to produce non-chance, person-specific patterns. Such findings have implications for intention based interfaces such as robots operating remotely in environments with impaired conventional communication facilities, or to controlling the wheelchairs of quadriplegics.

Thought or intention based interfaces are also being researched in various countries, summarised by Normile and Barnes-Svarney (1993). Researchers in New York are training users to emit brain signals which control cursor movement, and in Illinois, typewritten output is being produced by people spelling out words in their minds. In Japan, research concerns the mental formation of syllables before actually being voiced, and researchers can determine accurately when subjects prevocally form a particular syllable. Such work relies on the brain producing varying electrical signals just prior to action: such signals can then be detected and matched with specific actions.

Having now looked at the analysis of intentions from both a language and vision point of view we can now go on to provide our general philosophy of interface design.

5 A philosophy of interface design

We argue that one key to effective usability lies in system interfaces designed to allow the maximum responsiveness to the user's intentions, however expressed. The human centred

philosophy (see Gill 1991) of users as designers fits well with such requirements, taking advantage of the symbiotic relationship between human and machine in information systems. In this the strengths of the computer in numbercrunching and memory aspects complement the situated awareness and contextual judgment of the human. For effective communication between human and machine there must be some provision for a shared appreciation of the context of action and the assumptions which the user brings to the interaction. Work on user modelling (see Kobsa and Wahlster 1988) and the research of Suchman (1987) on "communicating" with photocopiers indicates some directions for this work. *Spreadsheets*, probably the most useful and versatile applications in organisational life, owe this status largely to their making minimal assumptions about the user and thus not constraining the interaction.

Some of these principles were adopted in the design of the interface to the IDIOMS[6] (Intelligent Decision-making In On-line Management Systems) management information system (see Gammack et al. 1989, 1991, 1992) which is summarised below. In this project a major aim was to allow any decision support system generated within the development environment to embody the assumptions, meaningful semantic categories, contextual concerns and temporal exigencies of the situated user or application developer. In effect, this provided a qualitative and semantic processing environment analogous to the quantitative manipulations of spreadsheets.

We believe that a good interface design will take advantage of the strengths of both the computer and the human. These may be roughly characterised as:

(1) the computer having a huge memory and powerful numbercrunching ability

(2) the human having an ability to judge the appropriateness of rule-based advice in a given context

The contextual awareness and subjectivity in (2) is extremely difficult (if not impossible) to model in advance of the context of use but for many information systems it is not an issue which can be ignored. It can be facilitated by the analysis of intention as mentioned already.

We have applied this philosophy in the design of a *human-centred* interface to a decision support system accessing a massive corporate database. The system discovers implicit patterns in the database and reports the variables which best predict some attribute of interest. This, in effect, is a database classifier which generates a decision model. The design allows both *objective* description of information in the data to be reported for inspection and evaluation and the *subjective* judgements and contextual considerations of the human to be communicated to the decision-making software.

Effective management decision making is a combination of lessons from past experience and judgement of the current situation. How can these be combined in a human-computer system? Our solution is to divide the labour of decision making along the lines of these complementary strengths. The human-computer interaction becomes an issue of detailing how this design goal can be achieved.

In an example domain of *credit control* the likely outcome of granting a loan application can be determined by examining the historical database to find the best predictors (see Fogarty et al. 1992). This information, once extracted from the database can be represented to the user, who can then use it immediately for inference, can fine tune it in various ways, or

[6] The IDIOMS project is being undertaken by the Bristol Transputer Centre at West of England University (formerly Bristol Polytechnic), The National Transputer Centre at Sheffield, Strand Ltd., and a well-known British high street retail bank.

can actively introduce new influences into the decision model. The next section describes an example interface which facilitates this along with some of the criteria considered in choosing the design.

5.1 Designing the interface

In keeping with current trends we developed a graphical user interface (GUI) using XView and keeping in mind the standard *look and feel* which makes transfer of training relatively painless. We also retained the developer's interface as a *set up* option which is text and cursor based. This allows transfer to environments which do not yet support windows, and gives relatively unsophisticated computer users a more guided dialogue. There is some evidence that certain classes of user prefer text-based interfaces and greater guidance in the interaction (see Fowler and Murray 1987) and so a choice is provided. However, the GUI is more interesting and forms the basis of our discussion.

The next issue concerns the amount of user involvement with the system. The interface to a piece of application software does not exist in isolation: it is there to facilitate the use of the software and to help the user gain power and freedom in its use without obstructing the user's intentions. The amount of control exercised over the software in our design is left to the user's discretion: minimally, the user may simply run the unprocessed (*objective*) output from the database classifier, or, at the opposite extreme, override it completely by building his/her own (*subjective*) model. Something in between is more typical and of course different decision models can be experimentally compared. Rather than have a fixed level of involvement, such as usually found with expert system interactions, our design aim was to allow the system to be used compatibly with the user's own volition and to adapt to represent his/her intentions.

Econometric modellers and business decision analysts routinely adjust the outputs of decision support models to take account of current circumstances and their own experience. These post hoc adjustments offer little scope for finely principled decision making. For a true interaction there should be some to-ing and fro-ing where the best decision is negotiated. This is likely to be a function of both empirical data and subjective opinion. We now illustrate this general problem by way of an example which brings out the features of interface design which we alluded to earlier.

5.2 Credit scoring for loan applications

The IDIOMS project is one which uses techniques from AI to detect patterns in large databases and to convey this information in a humanly understandable manner. Although supporting rule-based descriptions of expertise, IDIOMS represents a break from traditional expert system developments in several important regards. First, it uses a more flexible representation of knowledge, allowing the same knowledge base to conclude on numerous goal variables, and has straightforward extensibility and maintainability. Second, it allows the user to take the initiative and alter the thresholds and criteria for decision making. This *human centred design* coupled with an adaptive machine learning component allows many of the traditional problems of expert systems development to be overcome, such as knowledge acquisition, insensitivity to context and inevitable obsolescence, while retaining the desirable features of heuristic processing, natural-language like communication, and reasoning transparency. The underlying hardware, a powerful parallel processing engine, allows fast management access to information without interfering with routine processing jobs and empowers complex decision

making.

The IDIOMS project has been applied to the domain of credit control. A typical problem for a bank manager or insurance underwriter involves looking at the entries on a loan application form and deciding whether it is a good or a bad risk. This is a complex function of predictors such as salary or outgoings, but may also be affected by indications such as phone ownership and length of time at an address. The bank manager has a certain amount of experience with particular cases, the insurance underwriter rarely receives direct feedback, and in both cases a database has a massive history of example forms and their outcomes. Figure 2 shows the sorts of criteria in the database which can influence a decision to grant a loan. An arc shows a dependency of some sort between a pair of attributes.

Figure 2: Example criteria for granting loans

The manager, however, may wish to add some relevant information to that available from the database as Figure 3 illustrates. In this case although the applicant's salary is high and other indications are good the manager knows that the applicant is likely to be made redundant soon and that this may affect the outcome. A mechanism for introducing this into the decision making is provided as a menu option and new classes can be subjectively built into the model.

Conversely, existing classes can be ignored: if a globetrotting millionaire of independent means applied for a loan categories such as *time at address* and *salary* might be considered irrelevant. Figure 4 shows the sorts of adjustment that the user can make. The classifications of a category are provided by optimising the data for discriminability. However, the user may have reasons to alter this prior to decision processing. In the example the value of 30 for age provides a good discrimination for marital status with the probabilities distributed as shown, but the user may be interested in whether it is worth targeting 40 year olds with inducements

Figure 3: Addition of information to the database

to take out family protection loans as survey data might have shown. By adjusting the value using a slider and doing a database recount with the new category values a new pattern of dependency between the relevant categories can be shown and its effect on some goal attribute established. By adding or deleting boundaries at will the user may arrive at a model that predicts the likely effect of targeting 35-40 year olds. The graphical slider and the accompanying textbox are coupled such that updating either automatically updates the other. This is useful in cases of changes in the law, such as raising the school leaving age to 16, where typing in a number to adjust a boundary may be easier than adjusting a slider.

So far, we have discussed only some features implemented in the GUI which is essentially intended to be used by business modellers to aid decision making. However, we should close by noting that our system is intended to go beyond this to allow the model which has been built and tested to be more generally used. For this, software was written which takes the classification rules implicit in the data model which predict a goal variable of interest and translates them into the format used by an expert system shell (see Oates and Gammack 1992).

The advantage of this is that it allows the automatic generation of an expert system from information available in a database, reporting such information in a natural-language like manner through an already familiar interface. This enables a business model to be ported to personal computers in branch offices or onto, say, smart cards. This automatic generation allows the development of the end-user interface to be restricted to filling in the appropriate textual explanations cutting down the knowledge acquisition effort.

The IDIOMS environment represents one approach to intention based interfaces in which the environment of application development and use is adapted to the users' intentions and

Figure 4: Adjustments to the database

situated judgements. Allowing users to design the use of systems as they develop represents a change from designs based on the third party assumptions of a system designer. We hope to extend this philosophy through our research on the integration of language and vision in interface design, in bringing intelligence to the default settings and configuration of the interface, through learning about user characteristics and modelling local semantics to anticipate the user's intent. Although groupware systems such as the *Coordinator* (see Winograd and Flores 1986) based on speech act theory have been perceived as too constraining and inflexible the introduction of more sophisticated processing and transmission of intentions will surely enhance communication.

6 Conclusion and future work

We started out with the assumption that the optimum human-computer interface will be one which maximises communication between users and computers. We claimed that the analysis of human intentions will be a method by which communication is maximised. It was pointed out that intention analysis will be maximised in an environment where there are a number of media of communication between the human and computer.

We discussed the fact that communication media can be categorised into two major types: verbal and nonverbal. The analysis of intention in verbal communication was discussed with respect to work on a computer program called OSCON which answers questions about computer operating systems. Then we discussed nonverbal communication with respect to recognising emotions in facial expression and indicated the potential of this work for intelligent

interfaces with integrated semantic processors and user modelling capability. We argued for a philosophy of interface design which brings the human and computer closer to analysing each other's intentions. Finally, we discussed the IDIOMS project and an example case study of loan application where verbal and nonverbal intention analysis could be incorporated.

Future work will involve designing an interface which will enable the computer to analyse intentions in utterances, facial expressions, touch, and sound. Representations which assimilate all these means of communication of intent will need to be developed. This will help in enabling the computer to better analyse human intentions. This work can then be incorporated into interfaces such as Le-Mail which acts as an animated/iconic network communication E-mail system across language boundaries (see Yazdani 1995) and integrated with iconic languages such as Icon-Text (see Beardon 1995).

The analysis of intention can be used to build better computer programs which can communicate with people through dialogue whether that dialogue be in natural language or otherwise. With such techniques people will be nearer to communicating with computers in their own natural ways rather than having to learn some abstract computer language. The hope is that, if they are communicating in the same language, computers will be better able to understand people's intentions, and likewise, people will be able to use computers more effectively.

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Appendix A

Face icons used with E-mail

This Appendix shows ASCII face icons which can be used by computer users while sending E-mail messages. The smileys are available on a smiley server from DaviD W. Sanderson (dws@cs.wisc.edu) ((C) Copyright 1991 by DaviD W. Sanderson) as shown (see Sanderson 1993). We have only shown around 100 of the full set here.

```
From pa.dec.com!decwrl!uunet!sparky!kent Tue Oct 22 12:55:00 PDT 1991
Article: 2864 of comp.sources.misc
Newsgroups: comp.sources.misc
Path: pa.dec.com!decwrl!uunet!sparky!kent
From: dws@cs.wisc.edu (DaviD W. Sanderson)
Subject:  v23i102:  smiley - smiley server, version 4, Part01/01
Message-ID: <1991Oct22.033215.1939@sparky.imd.sterling.com>
Followup-To: comp.sources.d
X-Md4-Signature: 30ae782918b11808204e363618389090
Sender: kent@sparky.imd.sterling.com (Kent Landfield)
Organization: Sterling Software, IMD
Date: Tue, 22 Oct 1991 03:32:15 GMT
Approved: kent@sparky.imd.sterling.com
Lines: 2158

Submitted-by: dws@cs.wisc.edu (DaviD W. Sanderson)
Posting-number: Volume 23, Issue 102
Archive-name: smiley/part01
Environment: UNIX
Supersedes: smiley: Volume 20, Issue 73

smiley(1) is a "smiley server" I wrote for my own pleasure.
Its list of smileys is more comprehensive than any other I have seen;
it subsumes all the smiley lists I have ever seen posted to the net.

This version has about fifty more smileys than version 3,
(589 faces, 818 definitions) and a better README file.
Keep those smileys coming!

DaviD W. Sanderson (dws@cs.wisc.edu)


:-)   Willie Shoemaker
-(   always should wear safety glasses, especially in the laser burn-in room
     [entropy@fluke.UUCP]
!-(   black eye
!.'v   (profile) flat top
#-)   partied all night
#:-)   smiley done by someone with matted hair [figmo@lll-crg.ARpA]
#:-o   "Oh, nooooooo!" (a la Mr. Bill) [figmo@lll-crg (Lynn Gold)]
#:-o   smiley done by someone with matted hair
```

```
#:o+=   Betty Boop
$-)   Alex P. Keaton (from "Family Ties")
$-)   won big at Las Vegas
$-)   won the lottery
$-)   yuppie
%')   after drinking a fifth for lunch
%*@:-(   hung over
%*}   very drunk [jeanette@randvax]
%+{   lost a fight
%-(I)   laughing out loud
%-)   Elephant man
%-)   after staring at the terminal for 36 hours
%-)   broken glasses
%-)   cross-eyed
%-)   drunk with laughter
%-)   long bangs
%-6   braindead
%-<I>   drunk with laughter
%-\   hungover
%-^   Picasso
%-{   sad variation
%-|   been working all night
%-}   humor variation
%-~   Picasso
%\v   Picasso
&-|   tearful
&.(..   crying
&:-)   curly hair
'-)   one eyed man
'-)   only has a left eye, which is closed
'-)   wink
':-)   accidentally shaved off one of his eyebrows this morning
':-)   one eyebrow
'~;E   unspecified 4-legged critter
( o ) ( o )   hooters
(-)   needing a haircut
(-)   needs a haircut
(-:   Australian
(-:   Don Ellis from Tektronix
(-:   left-handed
(-::-)   Siamese twins
(-:|:-)   Siamese twins
(-E:   wearing bifocals [jeanette@randvax]
(-_-)   secret smile
(-o-)   Imperial Tie Fighter ("Star Wars")
(00)   mooning you
(8-)   wears glasses
(8-o   Mr. Bill
(8-{)}   glasses, moustache and a beard
(:  (=|   wearing a ghost costume
(:)-)   likes to scuba dive
(:)-)   scuba diving
(:+)   big nose
```

```
(:-   unsmiley frowning
(:-#   I am smiling and I have braces (watch out for the glare!)
(:-#   said something he shouldn't have
(:-$   ill
(:-&   angry
(:-(   frowning
(:-(   unsmiley frowning
(:-)   big-face
(:-)   no hair
(:-)   smiley big-face
(:-)   surprised
(:-)   wearing bicycle helmet
(:-*   kissing
(:-...   heart-broken
(:-D   blabber mouth
(:-I   egghead
(:-\   VERY sad
(:-{~   bearded
(:-|K-   formally attired
(:<)   blabber mouth
(:=)   TWO noses (?)
(:>-<   thief: hands up!
(:I   egghead
(:^(   broken nose
(@ @)   You're kidding!
(O--<   fishy
(V)=|   pacman champion
([(   Robocop
)   Cheshire cat
)8-)   scuba smiley big-face
):-(   unsmiley big-face
):-)   smiley big-face
*!#*!^*&:-)   a schizophrenic
*-(   Cyclops got poked in the eye
*-)   shot dead
*8-)   Beaker (the Muppet lab assistant) (from James Cameron)
*:*   fuzzy
*:**   fuzzy with a fuzzy mustache
*:o)   Bozo the Clown
*<.'v   (profile) wearing snow cap
*<:-)   Santa Claus
*<|:-)   Santa Claus (Ho Ho Ho)
*<|:-))   Santa Claus
*L*   blotto
+-(:-)   Religious leader
+-(:-)   the Pope
+-(:-)   the pope
+-:-)   priest
+:-)   priest
+:-)   smiley priest
```

Appendix B

Face icons for emotions

The following 70 face icons were used in an experiment to compare British and Chinese emotion classification (see Wang and Gammack 1995).

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