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Graduate Research in the Cognitive and Computing Sciences at Sussex

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Contents

Dedication

The editors would like to dedicate the Ninth White House Papers to Jo Brook for her many contributions to COGS over the years—particularly LaTeX above and beyond the call of duty. Jo has recently left Sussex to work in Edinburgh and we wish her all the best.

Preface

Each year since 1988, COGS graduate students have been meeting at Sussex University's conference centre, the White House, located at the Isle of Thorns, near Haywards Heath. Students are given the opportunity to give presentations on their work, exchange ideas, and most importantly, socialize. Out of this annual event arises a collection of short papers that have come to be known as the White House Papers. This is the ninth edition.

This summer, all postgraduate students at COGS were invited to submit papers of around 2000 words for inclusion in the Ninth White House Papers. The resulting collection reflects work in diverse areas of research, such as artificial life, cognitive psychology, compiler design, computer supported cooperative work, computer vision, developmental psychology, evolutionary computation, health psychology, linguistics, medical education, philosophy of science, and software design.

This year's workshop was organised by Sara Parsowith who wishes to thank Stephen Eglen and Jo Brook who are both veteran organizers. Their guidance helped ensure that the workshop was a success. The editors would like to thank all the DPhil students who contributed for making the workshop both intellectually stimulating and loads of fun. Thanks also to Theo Arvanitis for being our guest speaker this year. We are grateful to Professor Matthew Hennessy and the COGS Graduate Research Centre for funding the workshop.

Jason Noble
Sara Parsowith
December 1996

> It is of the utmost importance that we recognize and nurture all of the varied human intelligences, and all of the combinations of the varied human intelligences. We are all so different largely because we all have different combinations of intelligences. If we recognize this, I think we will have at least a better chance of dealing appropriately with the many problems that we face in the world. (Gardner, 1987)

The next section addresses the combination of intelligences in medicine, and the technology designed to support them. A large number of combinations of intelligences occur during the development of medical skills. Therefore, the following section will study some of these combinations only.

2.1 Linguistic and interpersonal intelligences

Linguistic intelligence refers to an individual's capacity to use either written or spoken language effectively as a vehicle of expression and communication. Interpersonal intelligence refers to the capacity to communicate appropriately and effectively, and to respond to other people and understand their feelings.

Technology has advanced quite effectively in this field: for instance, in electronic mail and groupware. Groupware encourages collaborators at different locations and time zones to communicate and discuss issues through language. There is increasing research on computer supported collaborative writing and on how students can write high quality documents collaboratively.

In medical education the combination of these intelligences is very important. Medical students need to communicate as well as to respond and to understand the feelings of their patients. They also need to communicate effectively and work co-operatively with their colleagues and patients. Interpersonal intelligences can also be combined with musical and visual intelligences: for example, recent developments include communication via audio and video on the computer screen.

2.2 Musical and logical intelligences

Musical intelligence refers to the ability to use and understand music and rhythm with precision. It may be exercised by listening to a variety of sounds and by engaging in rhythmic activities or by composing and conducting music. Bodily intelligence refers to the ability to use body movements in a precise and skilful manner.

These two processes are combined when training medical students in diagnosis by using the audio

2.3 Spatial, kinaesthetic and logical intelligences

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The Developmental Prerequisites of Self-Presentation

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Abstract Self-presentation—verbal and non-verbal behaviour intended to control others' impressions of the self—has been the focus of much social psychological research for several decades. Its role in children's social-cognitive development, however, has been largely ignored. This discussion considers the developmental prerequisites of self-presentation. Special attention is paid to the developments in self-awareness, the increasing sophistication of mental-state understanding, and the changes in motivational interests that trigger the self-presentation processes so important for social interaction in childhood and adulthood.

1 What is self-presentation?

We may start with the basic premise that in any social interaction we present ourselves in a certain way, whether we do so consciously or unconsciously. However, the concept of self-presentation becomes vacuous if used to cover all behaviours in a social interaction. Accordingly, most authors have limited their definitions of self-presentation by emphasising the basic motive of *attempting to control others' impressions of the self* (Baumeister, 1982; Goffman, 1959).

Self-presentational motives can manifest themselves in a variety of ways: through speech, through expressive features and gestures, through material displays, and through purposive behaviours (Schneider, 1981). Most of the existing social psychological literature on self-presentation in adults has focused on verbal self-presentations, for example, looking at self-descriptions in mock job interviews (e.g., Jones, Gergen & Davis, 1962). However, it is clear that non-verbal behaviour—facial expression, posture, appearance, clothing, material possessions, altruistic acts, conformity—is an equally important means by which we attempt to manipulate the impressions others have of us (see Schlenker, 1980). All of these self-presentations must obviously be intentional, but they may or may not be conscious. For example, an automatic polite smile triggered by a boss's over-used joke may be motivated by a desire to convey a particular impression of the self to the boss, yet this intention may not have been in conscious awareness at the time of the act (cf. Schank & Abelson's (1977) work on scripts, and Goffman's (1959) work on roles).

Before we move on to the developmental prerequisites of self-presentation, it should be noted that self-presentations need not be deceptive. Self-presentations may or may not match current or "plausible" self-concepts (Rhodewalt, 1986). For example, when we are actively trying to create a favourable impression on a job interviewer, we sometimes may make deceptive claims about ourselves, but will often simply concentrate on selectively projecting what we see as the positive aspects of our self-concepts.

2 Can children be self-presenters? Cognitive prerequisites

Despite the vast literature on the role of self-presentation in adult social processes, little attention has been paid to the developmental origins of self-presentation. It seems clear that public face—the projected self-image—is of great importance to preadolescents and adolescents (Fine, 1988), and observational work suggests that even kindergartners use primitive versions of adult face-work strategies to "repair" a damaged public face after being criticized or threatened (Hatch, 1987). Indeed, Sluckin (1981) concluded from his observation of school-children in the playground that children's self-esteem, like adults, depends greatly on their "reputation," or public face. Unfortunately, while a handful of experimental studies have investigated various aspects of self-presentational behaviour in children, none has been informed by a theoretical understanding of the prerequisites of self-presentation. We start with a discussion of the cognitive prerequisites of self-presentation, in the areas of self-awareness and mental-state understanding.

2.1 Self-awareness

At the very least, a self-presenter must be aware of the self as an acting, thinking, and feeling entity distinct from others. This self-awareness is thought by many to show itself first in the form of visual self-recognition. Work by Lewis and Brooks-Gunn (e.g., 1979) using photographs, mirror images, and video images suggests that a recognition of the self through categorical cues (i.e., stable and enduring categorical features of the self) appears in the second year. Also at this time, infants are able to refer to themselves by name, age, and sex, and are starting to reflect not just upon their physical characteristics and actions (e.g., "red hair," "I play"), but also on their current perceptions, cognitions, feelings, and motivations (e.g., "I see a car," "I don't believe it that Brian went to A. . . ", "I'm sad I popped it," "I wanna take nap"—Bretherton & Beeghly, 1982; Dunn & Brown, 1991; Shatz, 1994).

Furthermore, as children grow older, their self-concepts undergo several qualitative shifts. Their self-descriptions will refer not just to enduring physical characteristics and momentary mental states but also to regular activity patterns and stable dispositions (e.g., Yuill, 1993). The capacity to conceive of the self in this way is clearly important, since dispositional characteristics form the subject matter of many self-presentations (e.g., presenting the self as confident, friendly, or generous). Indeed, we may expect that developmental changes in the content of self-descriptions will be directly associated with shifts in the kinds of self-presentational goals generated by children. In a similar vein, we will later see that the nature of the self-concept, and consequently the nature of self-presentations, is also shaped by changes in motivational concerns, as social comparison processes increase in importance (e.g., Butler & Ruzany, 1993).

2.2 Understanding of mental states

In addition to having the capacity to reflect privately on the self, a self-presenter must understand that s/he is a public object that is perceived and evaluated by others. Besides being able to remark on their own beliefs, attitudes, desires, and emotions, 3–4-year-olds seem able to comment on others' mental states as well: Brown (1973) and Wells (1985) report that toddlers make reference to both their own and others' intentions, and research on children's theory of mind and on their understanding of emotion has shown that pre-schoolers regularly refer to others' beliefs and emotions (see Harris, 1989; Perner, 1991a). The use of self-presentation would appear to require the capacity to attribute mental states both to the self and to others, for the child must understand others' beliefs or evaluations about his/her own physical or psychological characteristics. Unfortunately, little systematic research has specifically examined the development of the capacity to attribute evaluations of the self to others. However, we may turn to the flourishing literature on children's understanding of mental states in order to formulate hypotheses about when and how this capacity is likely to emerge. An understanding of mental states is clearly a requirement for self-presentation: to be aware of how one is evaluated by others, one must be able to conceive of the mental states of others.

Research on mental-state understanding has taken many angles. Firstly, observation of children in natural settings indicates that children behave as if they are aware of others' expectations, intentions, and emotions. For example, Reddy (1991) describes how infants in their first year will offer an object and then teasingly withdraw it, thus seeming to deliberately create and play on a false expectation. Similarly, Dunn (1991) writes of the comforting, helping, and joking behaviour of infants in their second year, which is responsive to others' mental states (e.g., distress, goals). Studies of everyday conversations have also demonstrated that children in their second and third year reflect on their own and others' mental states (e.g., Bretherton & Beeghly, 1982), often strategically as part of excuses and justifications for transgressions (e.g., Dunn, 1988). Finally, work on pretence indicates that 2-year-olds are perfectly capable of understanding and behaving in accordance with a framework of pretence set up by others (e.g., Dunn & Dale, 1984). This kind of work provides convincing evidence that young infants have at least

knowledge about a new toy selectively to only those people who were not present when the new toy was introduced, suggesting an awareness of who knows what about reality. From this, it may be only a small step to selectively projecting different facets of the self to different people. A full understanding of self-presentation, however, is likely to rely on more sophisticated mental-state understanding, as discussed above.

3 Do children care about self-presentation? Motivational prerequisites

Even if a child is cognitively capable of using or understanding self-presentation tactics, s/he clearly needs to experience or understand the *motivation* to control others' impressions of the self. In other words, the use and understanding of self-presentation presume a concern about social evaluation. Although there are likely to be individual differences in the extent of this concern (cf. Buss's (1980) work on public self-consciousness; Graziano, Leone, Musse

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what can be called soft biases or straight preferences that can be expressed as a probability distribution over the hypothesis space. Biases, of course, are needed by any sort of learners—human or machine ones—and in both cases they are part of the induction mechanism.

For both humans and machines, the difficult part is to find the right (soft and hard) bias for a given learning problem. In machine learning, this difficulty is made apparent both in choosing the right learner for a given task and in finding the right initial configuration of a learner for a given task (the right network architecture for instance). In both humans and machines, different tasks require different biases but usually we don't know in advance which bias is the most convenient one.[2] The human solution to the difficulty is to rely on related previous experience. Hence, we don't consider the hypothesis that the number of tunnels in the railroad between New York and Pittsburgh is a function of the number of bananas we eat on the way and we don't assume that next year all the emeralds will look blue.[3] Similarly, we understand that if some disciplines are taught earlier in school, they can help the learning of others, later.

learning of a main task. The multitask network is a three layer feed-forward network with one output node for each task to be learned. The inputs for the different tasks are provided to the network and the shared hidden layer aims to represent the structure common for all tasks—the internal representation or the common bias for the task class. The network is trained by backpropagation (Rumelhart, Hinton, & Williams, 1986). Caruana reports results in learning problems such as that of predicting the mortality chances of pneumonia patients given the prior to hospitalization test results as input and after-hospitalization test results as helping tasks (predicted by output nodes). The performance is reported to be better than the performance of the single output node network with the same inputs.

The process of learning internal representations by multitask learning and synchronically transferring knowledge among the tasks can illuminate what goes on when a scientific theory is used to add confirmation to an empirical law. There is a long discussion in philosophy of science about the dispensability of theories (Hempel, 1965; Craig, 1953; Putnam, 1962; Ramsey, 1990) where one part claims that scientific theories can be dispensed with and we can recontruct science by using merely empirical laws. This assumption is challenged by Putnam (1963) by saying that theories are needed to discover and confirm some empirical laws and therefore they are at least heuristically necessary. Putnam's example is the statement P saying that "when two subcritical masses of uranium 235 are slammed together to produce a single supercritical mass there will be an explosion" before the first large nuclear explosion. By that time, the only support for P was to be found in the nuclear theory, by itself supported by some empirical evidence. The nuclear theory is part of the inference that enabled the prediction of P before any large nuclear explosion.

Theories, therefore, are used not only to unify the different pieces of evidence and empirical laws but also as a heuristic guide for discovery and confirmation. In other words, a theory might be seen as an internal representation or a bias common to a task class. Sometimes, as in Putnam's example, the bias is so strong and adequate that no further evidence is needed to learn a different empirical law. To view theories as internal representations or as biases for a class of empirical phenomena might help to explicate conscilience—the scientific reliance upon theories for learning empirical laws (see Hesse (1968) for a discussion of conscilience). Conscilience is what explains the additional support gained by Kepler's second law due to its unification with the law of falling bodies by Newtonian mechanics. Theories, by providing a learning bias, guide the discovery of related empirical phenomena. Theory construction can therefore be compared to bias learning and understood as second order induction. In a specific analogy with Caruana's multitask network, we can view the need for a theory as something that adjusts the bias for the main task aimed at, i.e., the empirical law that is to be found. In any case, the infeum ctima

I-366.966(l)-7.8234(177(y)-4.10691]TJ-270.48-13.45.64366(o)-4.1097(n)-2.69781(h)-4.11026(i))5.64311(a)5.64422(s).

learned tasks are used as initial weights for a new, related task. The authors report being able to reduce the number of examples required for safe learning of a sequence of Boolean problems.

In diachronic transfer, an already learned bias is used to speed up learning. This is precisely what seems to happen when scientists make use of previously accepted theories to guide generalizations. The previously accepted related laws and theories are used to determine the shape and the language for the new laws and theories. Theory construction is guided by previously accepted theories that, given the continuity of science, act as a bias by preventing some conclusions while emulating others. Boyd nearly describes the process as a diachronic transfer when he considers the body previously accepted scientific theories as

> ...establishing principles of scientific rational inductive reasoning which, sometimes, dictate conclusions which we must accept, given that we accept a particular theory. [...] Existing theoretical knowledge often sets a sharp constraint on the methodologically acceptable responses to new data...(Boyd, 1985, p. 247–8)

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Health Anxieties and the "Worried Well": Locating and Defining an Elusive Population

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Abstract The threats associated with serious illness make it a natural object of fear. Some recent literature has focused upon the "Worried Well", a term most recently used to refer to

theoretical basis for research, these notions of health anxiety provide little insight into the aetiological mechanisms underlying concerns about HIV and AIDS.

population, if such an entity exists, is questionable). Thus we might turn to previous populations presenting with concerns about a specific illness in order to ascertain an appropriate course of research in this area.

8 Parallels between the worried well and syphilophobics

The closest analogy to the WW has been drawn with “syphiliphobics” (those presenting with concerns about syphilis)(Knapp and Vandecreek, 1989; Vuorio et al, 1990). Syphilophobia was first reported in medical literature in 1586 (cited in MacAlpine, 1957), and became a common complaint during the 18th and 19th century (Baur, 1988). The similarities in presentation between those labelled syphilophobic and those considered WW are manifold. Parallels between syphilis and HIV/AIDS in terms of modes of transmission and characterization by stages, including a long latency period, and a final stage of physical and mental deterioration and ultimately death can be drawn. Additionally, similarities between the conceptualization of these illnesses within the cultures in which they arose might be noted.

9 The cultural values, illness and the media

Like cholera in the 1830’s, syphilis and HIV have been associated with so called “immoral” lifestyles and resultant blaming of the victim (Dworkin and Pincu, 1993; Herek, 1990). Muir (1991) highlights the image of HIV and AIDS associated with immorality, illegality, infidelity and illness. Fears of contagion are heightened by “plague” metaphors used (Sontag, 1990), and like syphilis, AIDS has become the contemporary metaphor for corruption, decay, and malignant destructive consummate evil (Enlow, 1984). This powerful characterization, created by media interpretation and public attention within a framework of the dominant religious and cultural values of the era, might exacerbate concerns about illness. HIV and AIDS have received media coverage of an unparalleled intensity in the history of disease (Davey and Green, 1991). Whilst health promotion techniques have undoubtably had a positive impact in terms of curbed transmission rates for HIV, the impact of these campaigns on those individuals predisposed, or susceptible to, excessive concerns about illness has been neglected in research. Increases in presentation with concerns about HIV and AIDS following high impact campaigns is not surprising. However as findings indicate that there has been little increase in those testing HIV positive (e.g., Beck et al., 1990) might indicate that media campaigns may have played some role in precipitating irrational fears, and that the research area would benefit from some empirical focus into this possibility.

10 Conclusion

Our understanding of fears about illness in general, and HIV and AIDS in particular is far from complete. It would seem imperative that a widely accepted theoretical structure for such concerns is outlined, in order to facilitate powerful empirical research. Considerable research is needed in order to ascertain the

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2 ALife as a tool for theoretical biology.

Complex computer simulations do not define a new science by themselves, in any case, they are a technique which may provide new ways of doing an existing science. In the case of ALife, Miller assumes that this science is theoretical biology and I will not argue with that for the moment.

As with any new technique there is always the hope of resolving old controversies over issues that have long remained the battleground of academic disputes (think for example of Zeno's Paradox and the invention of the calculus of infinite series). This may or may not happen in the case of ALife, but the chances of it happening will remain small unless an appropriate methodology is defined for this task. The starting point for this definition must be an understanding of the general character of the sciences in question (which, as we will see, will not necessarily be complete by achieving an understanding of the way these sciences are actually practised in our particular time.)

According to Miller:

> A powerful way of using A-Life simulations is to take an existing formal model from theoretical biology and relax the assumptions (preferably one at a time) that were required to make the mathematics tractable. (Miller, 1995)[2]

There is little doubt that such a method will tend to enrich current models in theoretical biology with new answers too hard (or even impossible) to obtain analytically. However, more often than not, this same method will tend to charge the ALife work with many of the methodological and philosophical assumptions of those same theoretical models. This would not be much of a problem in principle, genetics, etc.: concepts such as fitness and adaptation are never questioned, agent and environment are separate things, the latter being of a much more static nature.)

Conjecture: ALife and computer simulation techniques in general, if properly applied, may have the potential for resolving scientifically at least some of the c

4 Conclusions: looking for a starting point.

Miller addresses the question of ALife's methodology by progressing in an ever more restrictive approach, first specifying the role of ALife only as a tool of research, then restricting its use to problems in theoretical biology and finally to those problems in which an existing formal model can be found. With each step the question of methodology seems to become less fuzzy and easier to solve. I have shown, however, that even if one agrees with all this there are still problems in the universal applications of his guidelines.

My opinion is that the question of methodology must not be resolved by restricting it to a tractable size. While I believe that work in ALife can be used successfully as a tool for extending formal models in theoretical biology. I also believe that it can be used to do research in areas where no formal model exist and also "belonging" to other scientific disciplines.

Taking all this into consideration we must then consider the question of whether ALife is best treated as a tool or as a (potential) scientific discipline in its own right. This is a very difficult question with no straight answer.

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Goodwin, B. C. (1994).

From my perspective, Minerva-2 takes the initial input vect

Heit E. (1992). Categorisation using chains of examples. *Cognitive Psychology, 24,* 341–(h)-4.1091R24 10.95 Tf114(l)-

Girosi, 1992; Musavi, Ahmad, Chan, Faris, & Hummels, 1992; Ahmad & Tresp, 1993; Bishop, 1995). Its main characteristics are first, its computational simplicity (only one layer involved in supervised training which gives fast convergence), and second, its description by a well-developed mathematical theory (resulting in statistical robustness). RBFs are seen as ideal for practical vision applications by (Girosi, 1992) as they are good at handling sparse, high-dimensional data (common in images), and because they use approximation which is better than interpolation for handling noisy, real-life data. RBF networks are claimed to be more accurate than those based on Back-Propagation (BP), and they provide a guaranteed, globally optimal solution via simple, linear optimization. An RBF interpolating classifier (Edelman, Reisfeld, & Yeshurun, 1992), was effective and gave performance error of only 5–9% on generalization under changes of orientation, scale and lighting. This compares favourably with other state of the art systems such as the Turk & Pentland scheme. In contrast to more deterministic methods using warping based on registration of features, eg (Craw, Costen, Kato, Robert-4.10914(f)-258.76 0 T691(e)5.64534(l)-6.93404(m)10

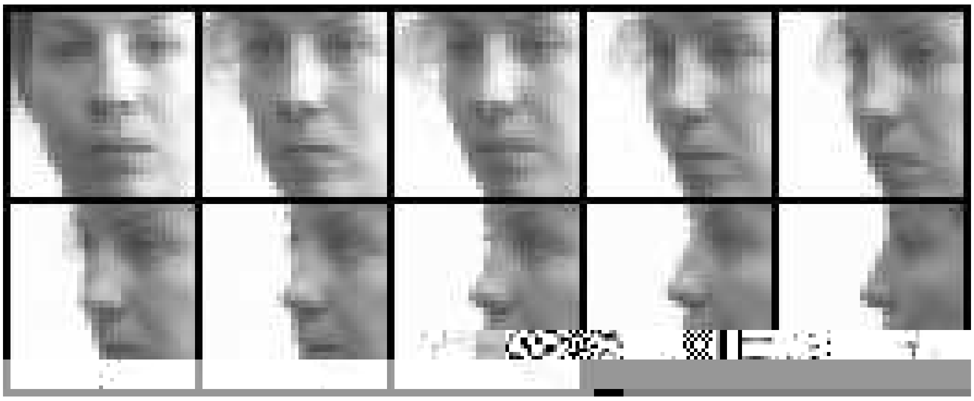


Figure 1: Entire 10-image range (rotating around the y-axis) for one person before preprocessing

output unit i, the output is:

$$o_i(l) = \sum_h w_{ih} o_h(l). \quad (2)$$

Whilst the weights w_{ih} can be adjusted using the Widrow-Hoff (Widrow & Hoff, 1960) delta learning rule, the single layer of linear output units permits a matrix pseudo-inverse method (Poggio & Girosi, 1990a) for their exact calculation. The latter approach allows almost instantaneous 'training' of the network, regardless of size[2]. The RBF network's success in approximating non-linear multidimensional functions is dependent on sufficient hidden units being used and the suitability of the centres' distribution over the input vector space (Chen, Cowan, & Grant, 1991).

2.1 'Face unit' RBF model

For the following tests, two types of network were used: a 'standard' RBF model and a 'face unit' RBF model. The standard network is trained with all possible classes from the data with a 'winner-takes-all' output strategy, whilst the 'face unit' network produces a positive signal only for the particular person it is trained to recognize. For each individual, a 'face unit' RBF network can be trained to discriminate between that person and others selected from the data set, using 'pro' and 'anti' evidence for and against the individual. Details can be found in (Howell & Buxton, 1995c). Although this second approach increases complexity, the splitting of the training for individual classes into separate networks gives a modular structure that can potentially support large numbers of classes, since network size and training times for the 'standard' model quickly become impractical as the number of classes increases.

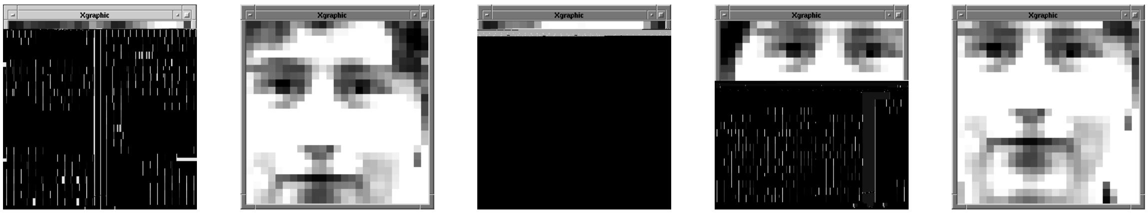
3 Form of test data

Lighting and location for the training and test face images in these initial studies has been kept fairly con-

5 aceo-202.775(i)]TJ254.639 0 Td[(n)-201.37(t)-6.93181(h)-4643119 Td[(s)-5.5srtiiceinfgg(e)5.64534(r)4.23177(sf)4.2
.4(g)-2.1116(e)5.64422(a)5.64311(c)5.64326(n)-1.14.11146e-0.6326(n)-1-4.11137(:)-335.706(a)-257.378(')4.0914()5'f938(i)-6.(cc)5.64

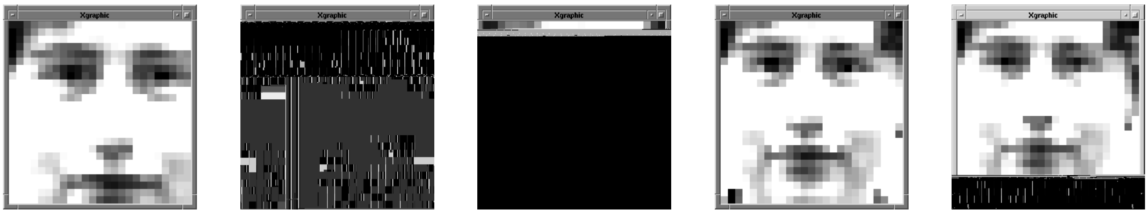
a is the number of ‘anti’ hidden units. Tests were made on a range of network sizes from 1+1 to 6+12 (which are effectively 2/98 and 18/82 networks).

3.1 Pre-processing methods



(a) (b) (c) (d) (e)

Figure 2: **Shift-varying** data for the ‘face on’ view of one individual: (a) top left (b) top right (c) normal view (d) bottom left (e) bottom right



(a) (b) (c) (d) (e)

Figure 3: **Scale-varying** data for the ‘face on’ view of one individual: (a) +25% (uses 111×111 window) (b) +12.5% (107×107) (c) normal view (100×100) (d) –12.5% (94×94) (e) –25% (87×87)

- A scale-varying data set with five copies of each image: one at the standard sampling ‘window’ size, and four re-scaled at ±12.5% and ±25% of its surface area, ranging from 87×87 to 111×111 (see Figure 3).

5.1 Inherent invariance - training with original images only

These experiments used only the original from each group of five for training, using all the varied ones (and the remainder of the original ones not used for training) for testing. This gives a measure of the intrinsic invariance of the network to shift and scale, *ie.*the invariance not developed during training by exposure to examples of how the data varies.

Network	Pre-processing	Initial %	% Discarded	% After Discard
Standard 100/400	DoG	14	84	21
	Gabor	35	82	47
10+20 Face Unit	DoG	51	30	51
	Gabor	57	38	52

Table 2: Effect of pre-processing methods on **shift-varying** dataset (the original from each group of five used for training)

Network	Pre-processing	Initial %	% Discarded	% After Discard
Standard 100/400	DoG	58	63	78
	Gabor	77	46	95
10+20 Face Unit	DoG	69	40	69
	Gabor	83	36	88

Table 3: Effect of pre-processing methods on **scale-varying** dataset (the original from each group of five used for training)

5.2 Learnt invariance - training with shift and scale varying images

These experiments again used a fixed selection of positions for training examples, using all five versions of each original image. This gives the network information about the shift and scale variance during training to help in learning this kind of invariance.

Network	Pre-processing	Initial %	% Discarded	% After Discard
Standard	DoG	72	46	94

7 Conclusion/future work

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You'll Never Walk Alone in Vygotsky's Zone

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Abstract The title of this paper emphasizes the need for collaboration between the more able and the less able partner in a learning relationship which aims to create and maintain a "Zone of Proximal Development" (ZPD). If correctly constructed during instructional interaction, even after that interaction has ceased, the collaborator should be "invisibly present" as a helper in the learner's performance. One way to use the notion of a ZPD in software design is to investigate how the computer can perform the role of the more able partner in a collaborative relationship. This paper looks at the implications of using the ZPD as a basis for software design with particular reference to the problems involved in quantifying and adjusting the assistance offered to the user in the process of providing collaborative support.

1 What Vygotsky wrote about the ZPD

There are two presentations of the ZPD available in English translation. Each takes a slightly different approach and emphasis. The first source is "Thought and Language"(1986). The introduction of the concept of the ZPD here is set in the context of an investigation into the search for a working hypothesis to explain the development of scientific concepts in childhood. In particular, Vygotsky is concerned with the clarification of the relationship which exists between instruction and mental development. An area which Vygotsky feels has particularly lacked attention is the measurement of a child's mental development. Previously this had been done in terms of the child's ability to solve standardized problems unassisted. However, Vygotsky suggests that this method only measures the completed part of the child's development and that this is not the whole story. The ZPD is presented as a dynamic assessment metric, designed to assess the child's potential through their collaborative performance capability as opposed to their individual performance ability. The second place where Vygotsky discusses the ZPD is in "Mind in Society" (1978). Here the concept of the ZPD is introduced as a response to questions about the nature of the relationship between learning and development when a child is at school. In order to understand the relationship between learning and development it is insufficient to determine a single developmental level representing the development that has already taken place. Success depends upon the determination of at least two developmental levels, in addition to the actual developmental level, the level which a child can attain with assistance must be identified. The ZPD defines the mental functions that have not yet matured. In order to understand the child' s mental development it is essential to identify the two levels: "the actual developmental level and the zone of proximal development." (Vygotsky 1978). The creation of the ZPD is the essential feature of learning, it 'awakens' the internal developmental processes which can only operate when the child is interacting. A fundamentally important aspect of the ZPD from both versions is the necessity for collaboration or assistance from another, more able partner. However there is no detailed account of the form that this assistance should take.

> Different experiments might employ different modes of demonstration in different cases: some might run through an entire demonstration and ask the children to repeat it, others

might initiate the solution and ask the child to finish it, or offer leading questions. (Vygotsky, 1978)

. . . the first step in a solution, a leading question, or some other form of help. (Vygotsky, 1986)

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Automatic Acquisition of the Argument Structure and Semantic Preferences of Verbs.

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Abstract An important aspect of a verbal lexical entry concerns the structural and semantic relationships between a verb and its arguments. This includes the surface syntactic expression of arguments, alternations between these expressions and semantic preferences between

This information is required by natural language processing systems in order to avoid spurious ungrammatical parses.

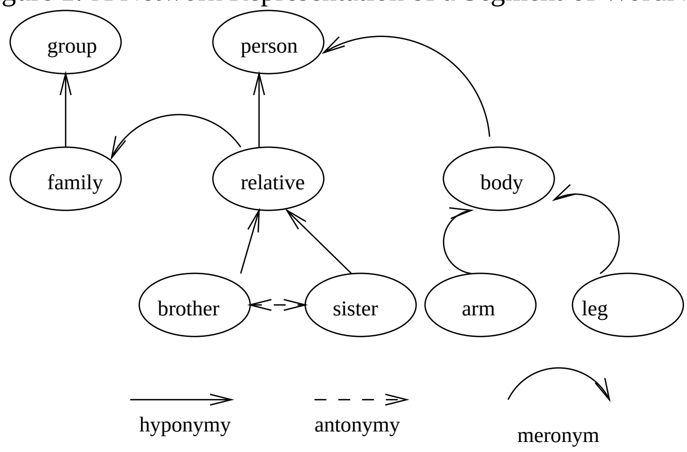
Diathesis alternations are regular variations in these surface expressions of arguments. For example the verb 'gave' can alternate between the two subcategorization frames exemplified in 2A and 2B. This is known as the dative alternation and occurs for verbs sharing the appropriate semantic components such as verbs of 'giving' e.g. 'give', 'loan', and 'serve' and those expressing instantaneous cause of ballistic motion e.g. 'bash', 'hurl' and 'throw' (Levin, 1993).

2A John gave a bone to the dog.

2B John gave the dog a bone.

These alternations provide useful organizational informa

Figure 1: A Network Representation of a Segment of WordNet.



for an example of what a small section of the hierarchy might look like as a network representation (Felbaum, Gross, & Miller, 1991), (Miller, Beckwith, Felbaum, Gross, & Miller, 1993).

The alternative is to use automatic clustering of words based on distributional information as this means that the classification is tailored to the data at hand. Pereira et al (Pereira, Tishby, & Lee, 1993) do this using co-occurrence data from specific syntactic relationships classifying nouns acting as direct-objects by the distribution of verbs that they occur with. Pereira et al then perform hierarchical clustering using this distributional information with relative entropy as the similarity metric between classes. A similar approach uses proximity to the target word instead of syntactic relationships for the co-occurrence data. Scütze does this using the cosine between co-occurrence vectors as the similarity metric (Schütze, 1992). The problem with automatic clustering is that the words in the classes produced are not always semantically similar. For example from Pereira et al's work although coherent clusters such as one including the words 'conductor','vice-president','chairman',and 'director' are obtained, clusters are also formed with less obviously related words such as 'state', 'modern' and 'farmer'.

I propose to use an automatic method for deriving a semantic c way, whilst semantic interpretations that have strong associations between predicate and argument are preferred, it is still possible to allow interpretations that have weaker associations. Thus in example 4 though the association of the verb ‘rob’ with the ‘FINANCIAL INSTITUTION’ sense of ‘bank’ is strongest it is not inconceivable to think of a viable situation such as where a thief was stealing rare plant species from the side of a river. In this way rather than trying to find the exact semantic features required by arguments of verbs I shall instead use a statistical measure of association to estimate the preference of verbs for particular arguments.

It would be an unmanageable task to try and store associations between verbs and all the individual words occurring in argument positions in a lexicon. Some degree of generalization will be needed and for this I shall use the word classes provided by the semantic representation described above. My work resembles that of both Resnik and Ribas (Resnik, 1993a) (Ribas, 1995) in that I shall probably use an

4 Diathesis alternations

The results of both subcategorization frame and selectional restriction acquisition are planned to provide the basis for deriving the set of diathesis alternations available to verbs. The work that has been performed on extracting diathesis alternations has been on the whole performed manually (Nicholls, 1994) or semi-automatically using MRDs (Sanfilippo, 1994). To my knowledge the only other researcher who has attempted to get diathesis alternations automatically from naturally occurring text is Resnik (Resnik, 1993a). He looks at the set of implicit-object alternations where the direct-object can be dropped in English. for example:

5A Joe ate the sandwich.

5B Joe ate.

His approach rests on the assumption that objects are dropped where they are more easily inferable from the verb. For example the object of the verb 'eat' is more easily inferable than that of 'need'. He presumes that the strength of the selectional constraint of a verb for its direct-object will indicate participation in this 'object-drop' alternation. To measure this strength he uses the association measure described in equation 1 on page 51 between verbs and their direct objects which are obtained using the Penn Treebank parses (Santorini, 1991a), (Santorini, 1991b). The results are promising but there are a few evident problems. One source of error is that of erroneou

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desire not to appear species-chauvinist, and recent resear

- Other-reporting signal

The vast majority of animal signals are egocentric, i.e. report something about the internal state of the signaller. Aggressive or territorial signals and sexual displays are clearly giving information (or misinformation) about the signalling animal. The much-studied bee dance, on the other hand, is giving information about the environment.

Maynard Smith and Harper next discuss the process by which the reliability of a signal is maintained. Game theory suggests that signals must be of some benefit to the signaller or they will not get started. If a signal manipulates the behaviour of others, to the advantage of the signaller, then the ***signaller's*** behaviour will be selected for, but what about the behaviour of the receivers? Why do they pay any attention to a signal that serves to take advantage of them? What stops a continue to trust the signal if, in the long run, it pays for them to do so because there are lots of honest versions of that signal around. As Maynard Smith and Harper put it, “There are a lot more worms than angler fish lures.” Thus, dishonesty will be an ESS under the right circumstances.

Finally, there are going to be situations such as the peacock’s tail, where the males are under pressure to cheat and exaggerate their quality, and have presumably tried various ploys and short-cuts over evolutionary time, but they are of course co-evolving with the females, who are under even greater pressure not to get fooled. Honesty, too, can be an ESS.

6 A biologically informed methodology for artificial life

I hope that it is obvious from section 5 that the field of theoretical biology contains much of value to an ALife study of the evolution of communication. Miller (1995) has argued strongly that work in theoretical biology and related fields is the best starting point for those who wish to model communication and other biological phenomena *in silico*

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2 Intra-group collaboration

McCarthy, Miles, and Monk (1991) highlight the fact that co-operative working is both advantageous and difficult; co-working is advantageous as the processing capabilities of a group are greater than that of the individual since there are an increased number of viewpoints and skills. However, the presence of multiple viewpoints means that it is necessary to co-ordinate these varying expectations and views. Within the context of co-operative working it is therefore productive to consider how to make maximum use of the increased opinions and abilities available to group members. At the same time the aim should also involve minimising the problems of co-ordinating joint activity and facilitate successful collaboration.

2.1 Common ground

As previously mentioned, communicating individuals come to a group with a set of diverse notions and ideas that need to evolve into a developed shared perspective for successful collaboration. By obtaining "common ground" group members are able to anticipate the beliefs and actions of their co-workers which in turn functions to guide co-operative work. Clark and Schaefer (1989) consider "common ground" to be the mutual knowledge, beliefs and assumptions held by group members. This notion is concerned with the way two or more people relate their common background and experiences to form a composite understanding of the beliefs held by others. Common ground is apparent when individuals understand the differing views held by others and hence are in a position to re-define their own notions in the light of newly presented perspectives. Individuals are still able to hold divergent views. However, there will be an ongoing, developing core knowledge of common understandings between the group as a whole.

2.2 Breakdowns

Having asserted that individuals have obtained a shared understanding, it is necessary to gain insight into the "claims we are making about the mental representations and cognitive states of those two people" (Easterbrook, 1994). Thus a mismatch between one participant's expectations and the actions of another can be due to an error of communication or of perception by either party. Such breakdowns can also occur due to a difference of understanding of the situation. For example, Schrage (1990) points out that confusion often arises because "the same words meant different things to different people." Breakdowns therefore force individuals to "consider explicitly what had previously been assumed: that they share an understanding of the situation" (Easterbrook, 1994), when in fact a misunderstanding has arisen. Thus a breakdown in communication can lead to intra-group conflict.

2.3 Conflicts

Conflict is often identified with fighting, with implications of winning or losing. In a group situation where conflict occurs, participants need to "move from seeing each other as opponents to working together as collaborator7(k)-4.11138(w)-4.10914(i)8.90055]7(n1(p)-4.11123177(e)-257.3)-6.9318oth toa1(n)-4.10914(g)

4.1 The Coordinator

Grantham and Nichols (1993) carried out studies with The Coordinator[1], a computer-based system to facilitate the exchange, clarification and negotiation of commitment between co-workers within organizations. The system design is based on the notion that language is an activity and not merely a transmission of information.[2] The design is also based on the assumptions that conflict arises from misunderstandings, is inevitable and "possibly the belief that conflict itself is productive" (Easterbrook, Beck, Goodlet, Plowman, Sharples, & Wood, 1993). However, The Coordinator are doing. The WWW can therefore be perceived as a sprawl of information that requires additional awareness features to support synchronous collaborative work.

There are a large number of systems designed for asynchronous collaborative work already existing on the WWW. A good example is the Basic Support for Cooperative Work (BSCW) shared information system (see Bentley, Busbach, & Sikkel, 1996). The BSCW system is integrated into the existing structure of the WWW; a workspace can be accessed directly with common WWW browsers. However, as previously discussed, asynchronous collaboration is not conducive to promoting awareness of co-workers. 'Real-Time' working enables users to see exactly what other users are doing and enables the concurrent collating of ideas and notes, giving them the perception that they are working "in the same room" (Grenier & Metes, 1992).

Dix (1996) points out that the WWW is already a successful application and that it is important not to lose this success. Hence rather than design a completely new system, it is sensible to merely develop extensions to the WWW in order to accommodate the demands of synchronous collaboration. WWW browsers are not platform specific and thus form a good basis for distributed inter-organizational working. Also there is a copious amount of information available on the WWW making the sharing of distributed information relatively simple. The WWW already has a critical mass of users (Dix, 1996) hence it is important to create 'add-ons' to the web to support group working rather than redesign an already successful application. This is supported by Grudin (1994) who suggests that there is a need to incorporate existing features of single-user applications into CSCW applications in order to take advantage of user familiarity with these particular aspects.

5.2 Systems on the WWW for synchronous collaboration

There are several systems already functioning on the WWW that aim to support synchronous collaboration. Here is a brief overview of some of these:

Frivold, Lang, and Fong (1994) have combined the asynchronous access to information offered by the WWW with a synchronous conferencing tool called COMET (Collaborative Multimedia Environment Technology). Their rationale is that such a combination enables users not only to "browse through a wealth of static information, but also to contact the authors and discuss this information with them as a natural extension of the browsing process." The result is the creation of a shared workspace that permits users to 'talk' to each other as well as see and interact with each other's applications. The system is an example of how to successfully 'bridge the gap' between synchronous and asynchronous methods of working.

Roscheisen, Mogensen, and Winograd (1996) have introduced the concept of SOAPs (Seals of Approval). This is a peer review of ideas and a critique of any shared information, described as being a source of "meta-information" since it involves creating a document containing a rating that describes another document. The shared comments consequently become available on the WWW; icons provide a link to an HTML page with the annotation text. This system is thus a good example of how awareness features can be incorporated into a CSCW system; it provides access to an ongoing store of collaboratively developed information.

Alliance (Decouchant & Romero Salcedo, 1996), permits several users located on different WWW sites to co-operate and produce documents in a structured way. It assigns users with different 'roles' such as the reader role (permits read-only access of a document) and writer (allows modification of a fragment). The same user can have different roles on different fragments. The system highlights the fact that it should be possible to permit or deny access to a given document as necessary. This ensures that collaborating groups can have a degree of privacy when working.

Ingvarsson (1995) discusses how Java[5] can play an active role in extending the WWW for synchronous collaboration. Java eliminates the need to send information from the client to the server for due to its platform independent nature.

Systems on the WWW designed for synchronous collaboration are starting to emerge:

GroCo is an Electronic Meeting System (EMS) developed by Walther (1995). It consists of shared interactive WWW pages which are displayed in a browser for each participant. The system is implemented in Java and conference applets enable a controlled textual chat between members as well as use of a shared whiteboard. The system is thereby designed to support synchronous work and awareness of other participants.

Another development is TeamRooms (Roseman & Greenberg, 1996). The system uses the metaphor

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Appendix: Preliminary Design Plans

Aim

To utilize WWW extensions to support the processes underlying synchronous collaborative writing, particularly brainstorming activities and to promote awareness and shared understandings amongst users.

Features

The following features will be implemented:

- The system will be WWW-based
- The programming will be in Java
- Support for brainstorming will be provided
- The system will have built-in awareness facilities
- Shared editing of documents will be supported
- Whiteboard facilities will be implemented
- Real time conversations will be supported
- Concurrent viewing of HTML documents will be possible
- Video communication (eg: MBone) will be incorporated
- Security add-ons will provide authentication of users and restricted access to documents

Requirements

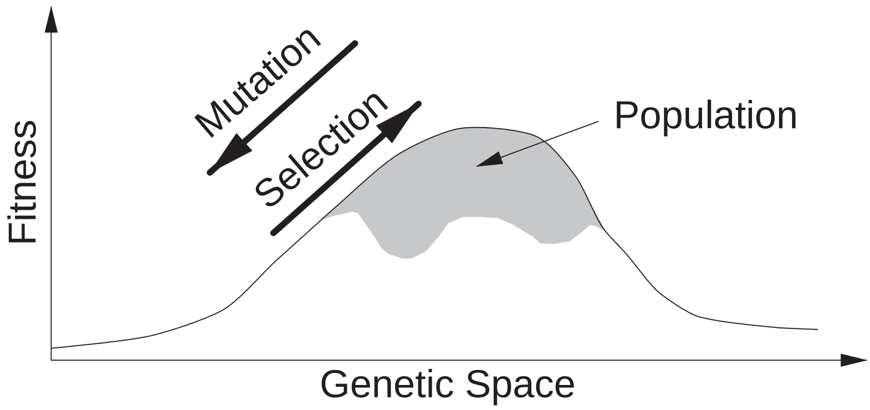
- co-authoring
- brainstorming
- awareness
- chatting
- concurrent document viewing
- videoconferencing

Users

- Distributed groups who are co-authoring written documents both in academia and in industry.

Strategy

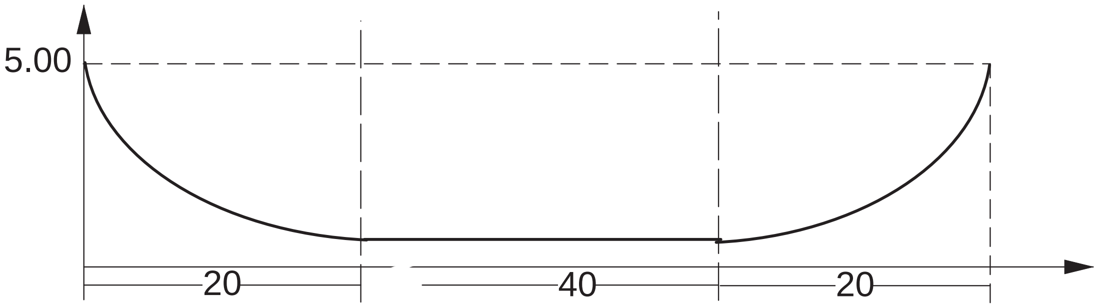
A hybrid approach between user-based and software engineering methods of design will be taken. The initial prototypei nndustrsg


Mutation
Selection
Population
Fitness
Genetic Space

of constant rate GAs each with a different mutation rate. Effectiveness is measured here as the average fitness achieved by the GA after a given time. It has to be average because GAs are a stochastic search method. The GAs will be tested on various landscapes of differing ruggedness. Since two NK landscapes with the same values of N and K can have different distributions of hills and valleys across the search space harbouring optima of differing absolute fitness values, hence a comparison between the success of two GAs over two different landscapes is meaningless. Therefore all the test runs that are to be compared must be performed on exactly the same fitness landscape.

5.1 The control GA

The constant mutation rate algorithm is being used as the control in the experiment against which the effectiveness of the DMRGA can be measured. So the only diffe


5.00
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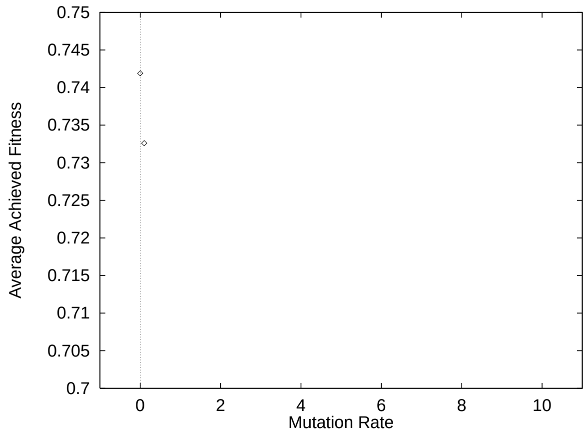
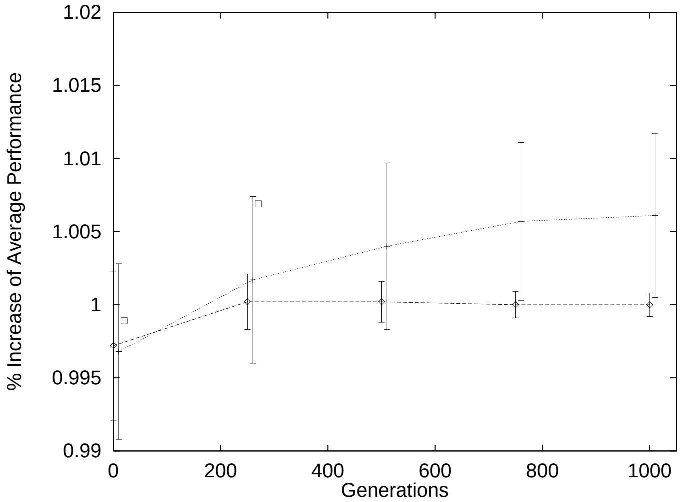
40
20

5.3.3 The leave phase

The leave phase is characterized by **last_success** = -1. In this phase the offspring of an individual inherits only the **mutation_rate** of its parent and the offspring's **last_success** is set to 0. After every time that an individual reproduces, its own **mutation_**



Average Achieved Fitness
0.75
0.745
0.74
0.735
0.73
0.725
0.72
0.715
0.71
0.705
0.7
0
2
4
6
8
10
Mutation Rate



% Increase of Average Performance
1.02
1.015
1.01
1.005
1
0.995
0.99
0
200
400
600
800
1000
Generations

populations of different size.

It is only speculative to suggest that the success of the DMRG

2.1 From spaces to surfaces—invariants

Classic perception theory is based on the idea of space perception; Gibson focuses on the importance of *surfaces*. He argues that vision takes place in the context of an enviro floor and ceiling and a black perimeter wall of constant height. Fitness is defined in terms of the proportion of time that the robot spends in the centre of the arena. The robot has two 'eyes', each a single

5 Conclusion

The concept of affordances is flawed in several crucial ways by its realism. By focusing on the agent "picking up" a pre-existent reality, it removes attention from the way that an agent's behaviour *creates* the possibility for "invariant" relations to emerge. By its emphasis on the unchanging nature of the relationship between affordance and agent it ignores the way that 'ecological reality' is in constant flux. The next step is to develop a conceptual framework which is able to account for the aspects of behaviour that are most interesting: how agents negotiate environments of constantly shifting possibilities and threats.

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approach. For this reason, I have concentrated my work on the analysis of optimizing techniques for virtual functions.

Optimization techniques currently concentrate on optimizing for the speed of code; this is due to the relatively small cost of space in comparison to 6–8 years ago and the large cost of processor power. Processor power is more expensive so the compiler writers have had to take advantage of what is available and produce code that will run as fast as possible, without being overly concerned about the size of the executable code. Optimizing code for embedded systems has the opposite priorities. The size of the executable code is usually of paramount importance due to the cost of the real-estate on an integrated chip (Liao, Devadas, Keutzer, Tjiang, Wang, Araujo, Sudarsanam, Malik, Zivojnovic & Meyr, 1996). Reducing the size of the code produced by a compiler can therefore keep down the size of ROM and reduce the cost of the chip by several pence. In a market with high turnover and small profit margins, this can make a considerable difference to the profitability of the product.

Some methods concentrating on virtual-function optimization have already been introduced and I will discuss these along with ways in which they can be altered in order to improve the size of the produced code as well as the running time.

In the next section, I will introduce virtual-functions in more detail and show why they are such an important area for optimization. Section 3 will concern the techniques that have already been used. In Section 4, I will outline the future work which will make up my thesis. Finally, in Section 5, I will outline my conclusions. I have included an appendix which gives the definitions of many of the terms used in the paper.

2 Virtual functions

2.1 Introduction to virtual functions

Virtual functions are very powerful and enable polymorphism. They are functions that can be applied to objects of many different types. It is the task of the compiler to find the appropriate version for each call.

Virtual functions are defined in a base class as virtual, and can be redefined in a derived class. The type of the function is declared in the base class and the derived version cannot redefine it. If the derived function differs in the arguments that it takes then the virtual mechanism will not be invoked.

This is a useful mechanism for programmers because it means that code can be written for different classes using the same procedure names (an example might be a print function which when called on objects of the circle class will display a circle and when called for squares will display a square). This makes programming class interfaces easier as well as making the interfaces look the same, and it keeps the implementation of the procedures hidden and therefore more abstract. An example of the code to implement a small hierarchy of classes with virtual functions is shown in figure 1. The virtual function here is the peel function; there could be code for a generic fruit which would involve using your fingers to remove the skin, and this would be specialized in Apple to indicate using a fruit knife to remove the skin.

Virtual functions make the methods[†] in a derived class preferred over those of the base class, but still allow the base class ones to be used if derived ones have

the virtual tables for all subclasses of a class. Each method call can be mapped to a virtual table offset at compile time. At runtime, the call is made indirectly through the pointer at the appropriate offset. Multiple inheritance requires a slightly more complicated scheme with another layer of indirection (van der Linden, 1994).

In an optimizing compiler, the only time a call to a virtual function need generate different code

3.2 Dynamic analysis

4.2 Overall view

My research will be concerned with writing an optimizing compiler for C++. This will concentrate on optimizing for size because I hope to be doing some work in conjunction with a major microprocessor manufacturer, and the code produced would need to go on embedded chips where code size (ROM) is of importance, due to the cost of real estate on the integrated controller chips (Liao et al., 1996). The introduction of the object-oriented programming approach should be of benefit to this field because it encourages modular design and code re-use. It will enable more portable code to be written because the machine dependent parts of the code can be factored out and kept separately from the machine independent parts (Maclean, 1995). This is currently difficult to achieve because of the reliance on C (where the machine dependent and independent parts are inter-mingled) and assembly code programming.

My short-term aim is to do a feasibility study, using the research that I have already looked at to determine whether or not C++ is a feasible programming language for 8-, 16-, and 32-bit chips where the size of the executable is important. I will need to examine the techniques for optimization of code size and even examine the possibility of excluding the use of some features of the language (such as multiple inheritance) that would help to keep the code small while not losing too much of the functionality of the language. Another example would be to allow only one level of indirection.

Plevyak and Chien (1995) have shown that object-oriented programs need both inter-procedural optimization and intra-procedural optimizations (i.e., whole program optimization). This is more important than for procedural code where examining basic blocks can sometimes be enough to satisfy requirements. Obviously any optimizations specifically for object-oriented languages would show best results

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How Do I Check My Software Designs?

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Abstract Reviewing software designs is both a *hard, error* problem, and worth automating. This problem is often tackled by calculating various metrics relating to modular structure, in particular cohesion and coupling. We present a novel approach based on statistical cluster analysis. This is illustrated by looking at a software design for a set of traffic lights at a cross-roads.

1 Introduction

Modern software systems are very large and complex: sizes of hundreds of person years of effort are not uncommon. We need to manage and control the interactions which occur in such systems—this can be achieved via modular construction.

Modules enable information hiding, and hence reduce unwanted interactions between components. Moreover, such an approach simplifies the problem by breaking the problem into smaller sub-problems. Modules also ease the problems of managing the production process by identifying required components. This also helps by allowing easy identification of what has and has not been completed.

We also know from empirical studies that the cost of correcting software problems tends to rise by at least an order of magnitude as we progress along the production process. Therefore, we are particularly interested in the early stages, such as requirement capture, specification and design.

We are interested in the later part of the complete design, when the complete system is available for consideration.

2 The problem

The traditional method of checking software designs, still the mainstay in industry, is a series of design reviews. Design reviews have several disadvantages:

- Hard work;
- Requires skilled labour;
- Error prone;
- Time consuming;
- Very expensive;
- Frequently shallow.

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Not surprisingly, a number of researchers are keen to find ways to use computers and automated techniques to relieve human involvement.

An obvious first question involves how a design is presented—since it is clear that a design is only a blueprint of something which is going to be built.

Looking at current best practice provides only limited guidance. There is a wide spectrum of notations, ranging from the highly mathematical to natural language with varying degrees of graphical support. Mathematics can be difficult to understand, and relatively expensive to use, such that it is best

- Will it *work*?

Some of these questions can be answered by ‘compiler-type’ tools, but some are very hard problems even for humans.

One approach adopted by several researchers, ourselves included, is to develop measures of the design’s structure, and *hope* that these measures capture intangible properties of the design such as complexity, understandability and ease of modification etc.

Major objections to this approach follow from the obvious impossibility of using similar measures to capture different properties, and further, why should one metric be a good predictor of several different properties? Additionally, the intangible nature of these properties makes them impossible to define, let alone measure. Such objections are, of course, valid and cause for concern. However, ceteris paribus, the more complex a design becomes the less attractive it becomes. This may be due to being harder to understand, change and debug, etc.

The two most common properties looked for are cohesion and coupling. *Cohesion* measures how well an object[4] has a singleness of purpose, i.e., it has one single, well defined purpose, to which every part of the object contributes. *Coupling* measures how inter-dependent two objects are. Not surprisingly, we would like a system to have strong cohesion and loose (weak) coupling. It is clear that, in some sense, these two properties are closely related, but it is far from obvious exactly what this relationship is. Consider, for example, a single object (identified at some level of decomposition). As a single object, it should have high cohesion, i.e., all its parts contribute to but a single purpose. Now decompose the object into a set of component objects, these must have loose coupling, and yet still contribute to a single purpose.

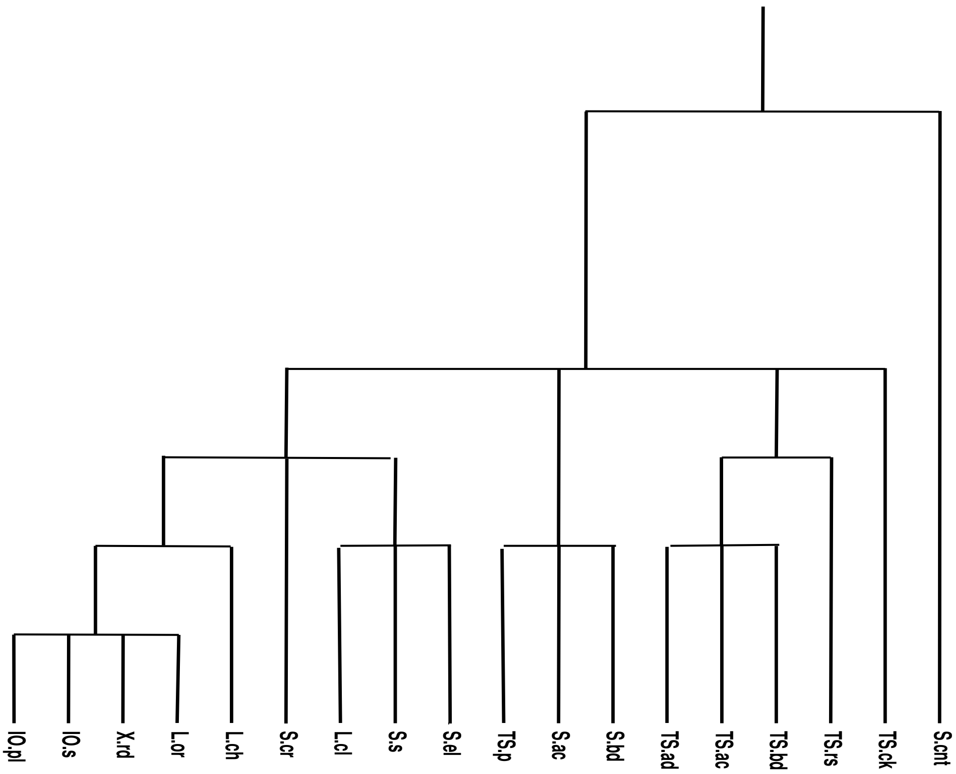

Figure 3: Cluster analysis of traffic junction design

between design components, rather than being necessary a prior.

The use of cluster analysis for examining software designs is unusual, see for example Neil and Bache (1993) and Hutchens and Basili (1993). Neil and Bache (1993) are interested in the organization of programs, as we are, however Neil and Bache perform their analysis at the source code level not the design level.

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