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## ANIMATING COMPLEX CONCEPTS<sup>1</sup>

George R S Weir, John D Ferguson & John N Wilson

Department of Computer and Information Sciences  
University of Strathclyde  
Glasgow, UK

**Abstract:** Techniques in computer-aided learning offer significant benefits for explaining difficult concepts in a way that is both stimulating and efficient. In the context of the STORM system, we have employed computer-based animation as a means of elucidating complex concepts in the educational domain of Internet and communications technology. Our experience reveals two important lessons for the application of computer animated instruction. Firstly, there is an essential requirement in the design process to ensure that the ontology and manner of presentation accurately conveys the intended message, whilst avoiding ambiguity and false or 'hidden' information. This focuses upon concise and disambiguated animations. Secondly, this requirement is best achieved through an iterative group-based development cycle of specification, testing and implementation.

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## 1. INTRODUCTION

The increasing availability of powerful computer systems, both within educational institutions and in student domiciles, combines with growing computer literacy in the student population, to motivate further the use of computers in education. Incentive from a different perspective arises in the context of teaching wherever we require delivery of complex ideas in a cogent and comprehensible fashion. The prospect of providing colourful animated representations as alternatives (or supplements) for complicated explanations is an appealing application for such technology. Such animations are a form of simulation. When used in conjunction with Web technologies, we have a facility for distributing access to powerful illustrations that may aid student comprehension and ease the learning process.

Such motivation lay behind our involvement with the 'Scottish Teachers On-line Resource Modules' (STORM) project. STORM deployed Web-based delivery of teaching materials for use by Computing and Information Systems teachers within Scotland. A particular objective in this work was the delivery of concise information in a fashion that would aid comprehension. On the grounds that 'actions speak louder than words', we sought to use animations as a basis for delivering key aspects of the content. Macromedia Flash™ was the facility employed to produce these animations, which were embedded within Web pages.

Subject matter for these pages fell in to three areas: Database Systems, Computer Networking and Multimedia. Three authors contributed these materials and worked together on the design and presentation aspects of the content. Two other participants provided design and implementation using Macromedia Flash. Following initial work on the Database material, in which relatively little animation was included, increasing enthusiasm for animated content emerged with the Networking and Multimedia components. The present paper outlines several issues that arose during our development of animations and discusses possible ways of tackling these concerns.

## 2. THE PROBLEMS

Developers of animated learning resources may experience a variety of obstacles in creating effective materials. In the present context, we focus on two specific issues, both related to ambiguity. The risk that an onlooker will misinterpret the intended message in an animation cannot be ignored. The endemic nature of this possibility is nicely expressed by Thomas Carlyle, who notes that 'in every object there is inexhaustible meaning; the eye sees in it what the eye brings means of seeing' (Carlyle, 1989). Since interpretation depends in large measure upon the eye of the beholder, the designer must recognise this threat and seek to minimise the prospect of misunderstanding.

When teaching, the need for clarity and comprehension is of foremost concern, consequently, the risk of ambiguity and ensuing miscomprehension is a vital issue for the design and presentation of teaching materials. Although the scope for ambiguity (variable interpretation) is a natural part of any communication system, animations may be more prone to variable interpretation than other forms of expression. The pictorial nature of animations may provide an effective representational facility but may be less transparent in the intended meaning. Thus, any child may appreciate that an animated ball represents a ball moving in the real world, but specific messages, e.g., about the influence of gravity on ball motion, are less directly exhibited by the animated objects.

One further feature distinguishes animations in the teaching context from less formal applications (e.g., cartoon entertainment). When used for teaching, animations serve as

simulations. Their role is to express salient features and relationships between animated objects as analogues of real world counterparts. Since any simulation is a simplification of real conditions, the onlooker is expected to grasp the significant aspects whilst suspending disbelief (or at least ignoring) any absent characteristics. This is a challenge to the animator/educator. They must employ representations expressing significant features that will be apparent to the viewer, whilst handling irrelevant aspects in a fashion that enables the viewer to construct an appropriate perspective on salient and non-salient features.

For the animation designer there are two problems associated with ambiguity. The first problem is to recognise the presence of any 'strong distracters' (features or combinations of features that will draw the viewer toward a misinterpretation). The second problem is to employ techniques that aid in eliminating such misdirection. In what follows, we introduce and discuss a variety of approaches that offer hope in addressing these problems of ambiguity.

### 3. ADDRESSING THE PROBLEMS

In the present context, our primary concern lies with the first of the problems of ambiguity, viz., how to recognise the presence of significant risk factors that will affect variable interpretation. We will not discuss the second problem (eliminating ambiguity) in detail. Suffice to say that a facility to determine risk of ambiguity should yield a major tool for elimination of such ambiguity.

A number of possible strategies are available as means to determine (and perhaps, eliminate) ambiguity risks in animations. For convenience, we have classified these into three types of approach:

1. Effective specification
2. Formalised content
3. Group interaction

#### 3.1. Effective specification

The principle underlying such approaches is the assumption that we can detect or avoid ambiguity through a thorough approach to the specification of our intended animations. Several techniques come to mind as ways of developing such specifications. Storyboarding is a commonly adopted means of specifying the content and layout for successive screens when developing interactive system designs and is also used in the entertainment world, when planning the look and organisation of movie scenes.

Within computer programming, we find a similar approach related to program design and documentation. For instance, literate programming (Knuth, 2001) seeks to provide extensive detail on the purpose and rationale associated with the program code. Literate programming is a methodology that combines a programming language with a documentation language in order to make programs more robust, more portable, and more easily maintained. A similarly motivated approach to thorough description and capture of purpose might seek to address the ambiguity issue for animations.

Such specification approaches share the assumption that sufficient attention to the detail and purpose of a project description will assist in minimising or eliminating problems with interpretation (ambiguity).

### 3.2. Formalised content

Our next strategic approach to addressing the ambiguity problem shares the previous presumption that adequate description is the key to successful disambiguation. Where this approach differs is in its commitment to formalisation of content and description.

Adopting a formal representation is appealing since this should allow the designer to manage more strictly how terms and their qualities are applied. While the programmatic nature of animation seems to lie some distance from a mathematical, logical or programming formalism, there may yet be scope to express the proposed constructs and relationships for an animation in a suitable formal language. Thereby, analysis and management of the representation may be furthered by applying formal analysis and scope for ambiguity may be reduced or eliminated.

By adopting a formal representation as a basis for animation we may facilitate ontological analysis of the animation content and so confirm programmatically the range of objects and relationships that are assumed and manipulated in our animation design. Perhaps formalism such as the Universal Modelling Language (UML) could apply to describe, represent and facilitate analysis of our animations.

### 3.3. Group interaction

Our third approach to determining or avoiding ambiguity in animation is explicitly informal in nature. This strategy takes the view that identification of potential ambiguities is best recognised by inspection of the intended animation. This reflects techniques often adopted for interface analysis and evaluation. In this latter context, the design of a 'meaningful' and usable interface is often determined by user testing. One reason for this approach is the avowed difficulty of anticipating all the possible misunderstandings that may arise when an interactive system is used in earnest.

Heuristic evaluation is such an approach that employs a group of 'experts' to put a design 'through its paces' (Neilson & Mack, 1994). The group of analysts apply reasonable heuristics and their own experience to determine a view on the acceptability of the design.

A reasonable step beyond such 'expert' analysis is the use of alpha and beta system testing with 'real' users. Such testing phases allow designers to secure realistic insight on the viability of a design through sustained feedback from members of the intended user population. Such approaches to system evaluation may be applied to working prototypes rather than final versions of a design and form part of an iterative process of design, prototyping and evaluation. This iterative prototyping is common for interface design evaluation.

This approach seems appealing in our animation context. When creating an animation as a means of expressing a point of learning there is an inevitable risk of 'design myopia'. This syndrome can also arise in the broader context of interactive system design and is characterised by short-sightedness on the part of the designer(s). Having set out with an intended end in view, designers may produce a solution that appears to them ideal. When they view their solution it appears to fit the requirements perfectly. Sadly, the designer's view of the system is coloured by their familiarity with the aims and objectives that motivated the design. With the designer's expert knowledge, the design may appear suitable, even ideal. Yet, to the novice user, lacking design insight, the system may seem obscure and far from obvious.

Such design myopia may also be evident in animation design. Our experience of animation design in the STORM context brought to light several examples where the individual responsible for expressing the teaching objectives produced animation designs that they thought ideal but which proved problematic when viewed by other, less influenced, eyes. So, the incentive of the 'group interaction' approach is to bring 'fresh eyes' to bear on the proposed design as a means of flushing out potential problems in interpretation.

#### 4. APPROACH LIMITATIONS

Each of the three approaches described above aims to counteract the threat of ambiguity in animations by detecting the risk or eliminating the possibility. The first two standpoints (effective specification and formalised content) aim to provide descriptions that detail the animation in sufficient depth that ambiguity ceases to be a prospect. The third approach (group interaction) is less ambitious, seeking merely to engage many individuals in reviewing the content and purpose of the animation.

Effective specification is plausible as an ambiguity deterrent on the assumption that it assists the designer in maintaining consistency in use of concepts and relations in the design. We must appreciate that this assumption mistakes the basic cause of ambiguity. Misunderstanding of an animation's message results from a difference in perspective on the nature of objects and relations between the designer and the audience. Maintaining consistency in use and application of animation content may eliminate some potential sources of confusion but will not eliminate fundamental misinterpretation of the message being delivered.

Another way of seeing this point is to realise that the specification approach proceeds on the assumption that we have a single unambiguous message that is expressed by the animation content. But this is precisely the point at issue. If we are certain that the expression embodied in the animation is unambiguous then we have reached our objective. Sadly, we cannot make this assumption.

Adopting a formal representation for the content and behaviour of an animation also seeks to eliminate potential for misunderstanding and ambiguity. The assumption of the formalised content standpoint is that we can begin with an unambiguous use of the primitive terms (objects) and relations and by rigorous application of rules and transformation generate expressions (animations) that remain unambiguous. As with the effective specification approach, the presumption of non-ambiguity is an untenable premise. How can we determine that specific primitive components or relations will permit us to convey a monotonic message that no viewer will misinterpret?

This point can be re-expressed for the use of formalisms such as UML. The meaning that is attached to the objects and relations is not inherent in the formalism; rather it is dependent upon the interpretations that we place upon them. Mellor notes that 'for UML to be a family of languages, semantic variation must be strictly controlled in the specification' (Mellor, 2002, p.77). The fact that semantics are not controlled in the formalism is a reflection of precisely our point. Just as effective specification cannot give surety of non-ambiguity, likewise, neither can formalised content.

#### 5. CONCLUSION

We are left with the third approach to the ambiguity problem – group interaction. This standpoint makes no presumption of initial monotonicity. Neither does this approach claim infallibility. The basis of this technique is the view that ambiguity depends upon different points of view. Consequently, we aim to address the problem by providing a variety of

individuals who each provide their own perspective and in so doing shed light on the potential variability of interpretation.

This approach provides an informal methodology that does not guarantee success. There is no specific number of viewers that ensures identification of all possible interpretations. On the positive side, this technique benefits from the involvement of diverse individuals. Ideally, the group who provide feedback will be varied in background and experience.. Expert insight is no benefit in this context. The comprehension of a naïve viewer may generate greater insight than any expert since the latter is more likely to be influenced by prior knowledge.

Despite the initial plausibility of the effective specification and the formalised content approaches these techniques are unlikely to address the fundamental problem of ambiguity. Certainly, they may assist in managing the consistent use of objects and relations in our animations but cannot serve to determine monotonicity at the outset.

Our work on the STORM system led us to the view that only group involvement could provide sufficient breadth of perspectives to derive confidence in our animations. In consequence, we opted for a process of iterative prototyping in which the animation designer produced initial versions for review. This review was not exclusively peer-based but included contributors from the potential audience group. Feedback from this process detected and allowed us to eliminate a large number of potential problems that were not initially apparent to the ‘myopic’ designers.

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