Unfair Competition: Static Cues in Animated Graphics

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Abstract. Application of the visuospatial cues used in static graphics to complex animations may not result in the hoped-for improvements in learning. This paper examines potential limits on the effectiveness of static cues in animated graphics and proposes an alternative spatiotemporal approach for guiding learner attention.

Keywords: Static graphics; animations; cueing; attention direction; perceptual salience; dynamic contrast.

Introduction

Extracting task-relevant information from animations of complex content can be problematic for learners who are novices in the depicted domain. Their lack of background knowledge makes it difficult for them to direct their attention appropriately, especially if the high-relevance aspects they should be targeting are relatively inconspicuous (i.e., they have low perceptual salience). Domain novices' attention tends to be directed primarily according to the raw perceptibility of the information in a graphic display. As a consequence, they can fail to extract visually-subtle information that is nevertheless essential for building a high quality mental model of the referent content. In essence, this less conspicuous information loses the competition for the learner's attention.

One approach to ameliorating these difficulties is to employ visual cueing that changes the perceptibility profile (Lowe & Boucheix, 2008) of the display. The use of cueing designed to increase the perceptual salience of target aspects relative to their context is well established with static graphics. Various time-tested techniques have evolved over the hundreds of years that these graphics have been used to explain and instruct. These techniques have long been a standard part of the graphic designer's repertoire for directing viewer attention. The basis for this attention direction is the heightening of the target aspect's perceptual contrast with its surrounding graphic entities. In static graphics, this is achieved by alterations in the visuospatial characteristics of either the target or its context. When the perceptual salience of the target is raised, this is conventionally termed 'cueing'. However, an alternative is to lower the perceptual salience of the contextual material – we term this approach 'anti-cueing'. Specific techniques include the emphasis of high-relevance aspects by colour highlighting and the de-emphasis of low-relevance aspects by fading.

Visuospatial Cues in Dynamic Graphics

The widespread use of animated graphics in education is a relatively recent phenomenon. Because designers of educational animations lack the legacy of experience to draw on that is available for static graphics, they have borrowed techniques from that legacy and applied them to animations. This seems to be a reasonable idea, especially for animations that depict complex content. On the basis of what happens with static graphics, the addition of cues to animations could attract the learner's attention to high relevance, low salience aspects that would otherwise be missed. However, this approach neglects a key difference between static and animated graphics with respect to direction of attention.

Animated graphics typically have perceptual properties that are very different from those of their corresponding static graphics. While animated graphics may have the same visuospatial contributors to perceptibility as are present in static graphics, their effects can be greatly modulated by the display's dynamic attributes (Schnotz & Lowe, 2008). The introduction of dynamic information can re-order the relative perceptual saliencies of the graphic entities because of the way our perceptual system privileges temporal change. For example, a graphic entity that is relatively insignificant in a static depiction becomes highly noticeable if it is made to flash repeatedly in an animated display. The flashing of this entity changes the perceptibility profile. In static graphics, *visuospatial* contrast is the basis for direction of attention. In animated graphics, *dynamic* contrast can effectively 'wash-out' cueing effects of visuospatial properties that would be expected in a static display. Visuospatial contrast cannot match the unfair competition for attention provided by dynamic contrast.

How Can We Cue Animations?

If cues that are based on visuospatial contrast alone cannot handle the competition for attention provided by an animation's dynamic character, how can we guide learners to task-relevant information they may otherwise miss? This question comes down to one of increasing the perceptual contrast between the targeted aspect of the animation and its environment. One possible way to do this is to recruit the very characteristic that can make visuospatially-based cueing ineffective in dynamic contexts. The principle underlying the types of cueing used in static graphics is manipulation of the display's *visuospatial* properties. However, in an animated graphic, it may be more appropriate to use *spatiotemporal* manipulation. In static graphics, the use of cues modifies visuospatial realism in the interests of improving learning. Perhaps the modification of an animation's behavioural realism could have a similar effect. Unfortunately, designers of animated graphics currently tend to preserve this aspect of realism at all costs, even when the material they are animating is highly diagrammatic in appearance. In their enthusiasm to make full use of animation's capacity to depict dynamics directly, designers seem to have overlooked its potential to guide learner attention.

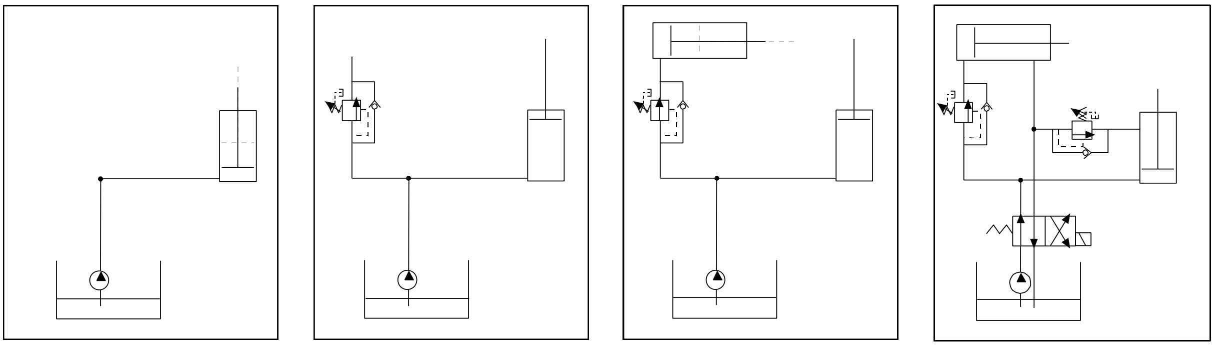

Figure 1. A possible approach for using spatiotemporal manipulation to direct learner attention

Figure 1 summarizes a hypothetical example of how spatiotemporal manipulation might be used to help direct learner attention more productively in an animated display. It is based on the hydraulic circuit diagram, a highly abstract way of depicting systems that use controlled pressurized fluid to perform mechanical operations. The diagram on the far right is a full hydraulic circuit diagram of a system for clamping then drilling a workpiece. Although hydraulic engineers can interpret the dynamics involved from a static diagram, this would be difficult or impossible for those without their domain-specific background knowledge. In principle, an animated version of such a diagram could be used to help a learner's interpretation because it provides an explicit depiction of the dynamics. However, if the diagram was merely animated, the structural and behavioral complexity of the depiction coupled with the fleeting nature of animated graphics is likely to result in problems due to competition for attention.

The spatiotemporal cueing approach considered here is indicated by the first three diagrams in the row (which represent only its initial stages). The process described would continue in a cumulative manner until the full diagram with all its dynamics was finally depicted. Frame 1 represents an animation of hydraulic fluid being pumped from the reservoir (bottom left) through piping to an actuator cylinder (top right) where it moves the piston upwards. To reduce competition for attention, all other aspects of the diagram are omitted. Once the cylinder's movement is complete, a sequence control valve is introduced into the animation (top left in Frame 2) then its opening portrayed by shifting the arrow to the left. Next, a further actuator is added above the open valve and its piston is moved to the right. This process continues with valves and movements being added until the full system is depicted and all operations have been performed. The last diagram in the row depicts its final state. Note that despite some superficial resemblance to earlier sequential approaches (e.g. Jamet, Gavota & Quaireau, 2008), spatiotemporal cueing is fundamentally different because it is used with animated not static pictures and involves events not entities.

Two types of spatiotemporal manipulation are used to provide the cueing in this example. One manipulation (temporal) involves dividing up the animation into individual *event units* (Lowe & Boucheix, 2008). This requires that event boundaries are determined for groups of related graphic entities (Zacks, Speer, Swallow, Braver, & Reynolds, 2007). These are presented cumulatively (no overlap in time) to minimise competition for attention. The other manipulation (spatial) involves portraying only those graphic entities that are involved in the current event unit. Rather than only presenting the whole diagram from the outset, the display space is progressively populated by the graphic entities involved in the cumulatively presented event units. These manipulations are intended to shift the learner's attention along the route of the causal chain while providing a minimally disruptive perceptual context for the introduction of each new task-relevant aspect. The hypothesised cueing action would be produced by the attention-attracting effect of the *transitions* (appearance of new entities) and *translations* (movements of the relevant parts of those entities).

Although the implementation of a spatiotemporal approach appears feasible for the hydraulic circuit diagram example given here, it would not suit all types of animations. For example, it probably could not be applied to animated depictions of many biological systems (such as a hopping kangaroo) in which multiple events occur simultaneously in a highly interrelated manner. The cueing technique presented here is intended to stimulate consideration of more principled approaches to this important aspect of learning with animations. These approaches should be based on an understanding of the processing affordances and constraints that animations in general offer, the different types of demands that various types of content impose on the learner, and the distinctive requirements of particular learning tasks. As yet, no empirical investigation has been completed of the proposal described here but there is clearly scope for investigating the effectiveness of this approach compared with visuospatially-based forms of cueing.

References

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