Redundancy in Multimedia Systems

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ABSTRACT New technologies permit complex combinations of media, sensory channels and interaction metaphors. These combinations introduce the likelihood of semantic and structural overlap over a temporal domain. This overlap, or redundancy, is often considered useful in complex and cognitively laden tasks. Redundancy has some history in human factors, but its nature is not well formulated. This research examines redundancy form an HCI perspective and attempts to apply it to multimedia systems.

KEYWORDS multimedia, media, mode, metaphor, language, redundancy

1. BACKGROUND

Multimedia systems are often described by their use of metaphors, modes, channels and media (Hutchins 1991, Alty 1991, Frohlich 1992). Hutchins, Hollan & Norman (1986) identifies two fundamental interaction metaphors, model world and conversation. Frohlich (1992) describes these two basic human activities (renamed action and language respectively) as interface modes. He also identifies the media which corresponds to these interface modes. The media for the language mode are speech, text and gesture. The media for the action mode are sound, image and motion.

Frohlich (1992) exemplifies the difference between the two modes by using the typical task of deleting a file within an operating system. This task might be achieved by the linguistic activity of typing 'Delete <filename>' or by the physical action of dragging an icon of the file over to a wastebasket icon and 'releasing it'. Therefore the combined use of the language mode and the action mode in human computer interaction is a description of the *redundancy* of user activity. That is, interface modes are states across which different user actions have the same outcome. Consequently multimodal interactions exploit some inherent redundancy.

The use of more than one mode (or media or channel) in a computer interface can create obvious semantic overlap and may allow for the possibility of redundancy in the interaction.

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A traditional approach to interface design suggests that this overlap generates unnecessary information which should be avoided; but many studies (Marmolin 1992, Alty 1994, Wickens 1984, Lang 1995) show that manipulating redundancy is an important component of improving human-machine interactions.

Marmolin (1992) states that interactions which involve complex information flow (especially multimodal and multimedia interaction) have mathematically redundant information, but he acknowledges that this mathematical redundancy bears a complex relationship with human perception and information processing.

One of the Alty's (1994) eight guidelines for multimedia interface design is 'the principle of apparent redundancy'. He states that people generally prefer too much rather than too little information. Unfortunately he does not reify this principle.

Edwards (1992) outlines the potential importance of redundancy for physically impaired users. Wickens (1984) says that interface redundancy gives users the flexibility to capitalise on a format that best suits their needs. Lang (1995) performed an extensive analysis of existing literature in an attempt to find whether audio/visual redundancy improves memory for television messages. A similar analysis has not been applied to improving human-computer interactions.

Many of these researchers (Hutchins 1991, Alty 1991, Frohlich 1992, Marmolin 1992, Lang 1995, Edwards 1992) agree that redundancy is a significant phenomenon in multimodal and multimedia interactions. This suggests that it is important to control interface redundancies in order to maximise usability of multimedia systems. Presently there is insufficient knowledge to help designers manipulate these redundancies to improve interactions.

2. UNDERSTANDING REDUNDANCY

Redundancy is the result of a synergistic phenomena. Redundancy can be considered to be the semantic overlap between two or more messages distributed over time or space or both. It typically refers to the repetition of some action or information and so is an indicator of the potentially acceptable loss in information (Wickens 1984), but it also refers to an increased 'dimensionality' of information (Lang 1995 quoting Garner).

Redundancy can occur in two ways. Within-channel redundancy (eg colour coding, illustrated text) occurs when information is presented in one sensory channel. Between-channel redundancy (eg a documentary video which shows an event and simultaneously uses speech to describe it) occurs when information is presented across two or more sensory channels. The two sensory channel are usually auditory and visual but could also include haptic.

Haptic acts are essentially nonverbal — where nonverbal is defined as any movement or position of the face and/or the body. In describing the occurrences of nonverbal acts, Ekman & Friesen (1969) outline the relationship between nonverbal and verbal behaviour. They identify a semantic relationship (the nonverbal act can repeat, augment, illustrate, accent, contradict or be unrelated to the words) and a temporal relationship (the nonverbal act can anticipate, coincide, substitute for or follow the verbal behaviour).

Basil (1994) recognises these categories as five forms of overlap between sensory channels: Redundancy (information in one channel *repeats* what is said in another channel), Substitution (information in one channel *replaces* something in another channel), Complement (information in one channel *adds* information to another channel), Contradictory (information in one channel is the *opposite* to some information in another channel), and Emphasis (information in one channel is used to *underscore* information in another channel)

Basil (1994) adds a sixth technique, Counterpoint, proposed by film theorists. Counterpoint occurs when channels are combined (according to rules) to achieve a desired effect (eg mood music and dim lighting in film). Lang (1995) defines four operational distinctions for redundancy; Single-channel, Multiple-channel Redundant, Multiple-channel Conflicting and Talking Heads.

These categorisation of redundancy are useful because they enable us to compare research and help to establish a deeper understanding of redundancy. However the categories are described in broad terms. There is a need for a common characteristic which allows a more detailed comparison between categories and perhaps place them on a continuum of redundancy.

The term *semantic fit* is introduced to give a measure of the 'relationship', 'match' or 'correspondence' (Lang 1995) between (or within) channels (or media or modes). Semantic fit spans from highly positive (repetition) to highly negative (contradiction). A semantic fit of zero refers to a set of information which is entirely unrelated.

It may then be possible to represent human-computer interactions which exploit redundancy on a Multimedia Interaction Space (MMIS) (Vetere, Howard & Leung, 1997). The semantic fit would be the metric and MMIS would be the diagrammatic notation for redundancy in multimodal interactions.

3. RESEARCH QUESTIONS AND OUTCOMES

This research aims to model redundancy in order to obtain generic guidelines and improve multimedia interactions. It is motivated by the following questions:

- What is the form and function of a theory of redundancy in computer-human interactions?
- What are the operating characteristics of a methodology for the development of redundancy when designing multimedia systems?
- How can multimedia systems successfully exploit redundancy to improve usability?

A framework has been established (Vetere et al. 1997) to model redundancy. This framework will help to formulate a theoretical base for the understanding of redundancy within HCI and to develop an interface design methodology (or component thereof) for the design of redundancy in multimedia systems.

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