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User Interfaces for Cooperation

This thesis suggests cooperation as a design paradigm for human-computer interaction. The basic idea is that the synergistic co-operation of interfaces through concurrent user activities enables increased interaction fluency and expressiveness. This applies to bimanual interaction and multi-finger input, e.g., touch typing, as well as the collaboration of multiple users. Cooperative user interfaces offer more interaction flexibility and expressivity for single and multiple users.

Theses

- The information capacity of single channel direct manipulation interfaces, e.g. one-handed input, is limited.
- The development of more expressive and more effective user interfaces requires the combination of multiple input and output streams.
- The theory of perceptual integrality and separability of dimensions cannot be directly applied to human motor control because the latter implies specific synergies of movement on perceptually separable dimensions, e.g., rotation and translation, due to body-based frames of reference, e.g., skeletal joints.
- Interaction with abundant degrees of freedom provide more flexibility and a basis for synergistic cooperative action.
- The efficient coordination of cooperative actions often requires extensive training.
- The coordination of bilateral cooperative action and of multiple people build on similar foundations: temporal synchronization based on perception-action coupling, hierarchical control, and mutual error compensation.
- The paradigm of cooperation can be applied to the design of multimodal, bimanual and collaborative user interfaces.
- Cooperation patterns from multimodal interfaces can be extended to bimanual user interfaces and the collaborative interaction of multiple users.
- Interface support for cooperative action is beneficial for single users and, at the same time, facilitates the collaboration of groups.
- The combination of concurrent user actions enables improved workload balancing, higher interaction fluency, more flexibility, and extended interface functionalities.

- The design of cooperative user interfaces can be successfully informed by three high-level design principles to support workspace coherence, emergent territoriality, and complementary capabilities.
 - Workspace coherence supports awareness of oneself and others as well as consistent perception-action couplings in a joint workspace through spatial, temporal, and semantic relationships that can be readily perceived and traced by all cooperating parties. Joint perception, common sense, or mutual agreements can provide a suitable foundation for workspace coherence. When inconsistencies are unavoidable, the focus should be on a coherent representation of the workspace, i.e., areas of common relevance, joint interests, and current activities.
 - Complementarity capabilities encourage cooperation and reduce potential interaction conflicts by providing multiple parallel options for user engagement and extended interface functionalities based on their combination.
 - Emergent territoriality facilitates frequent transitioning between loosely and tightly coupled cooperation through user-defined partitioning for different levels of privacy and group exchange.
- Bimanual cooperation with position control offers higher precision than one-handed position control and bimanual cooperation with a velocity-controlling interface.
- Most current user interfaces lack meaningful interpretations of concurrent user input.
- User interfaces can distinguish symmetric and asymmetric bimanual cooperation based on their temporal patterns.
- User interfaces that enable symmetric as well as asymmetric cooperation are advantageous over those enabling only symmetric cooperation due to a lack of input differentiation.
- Multi-view 3D display technology enables the shared perception of a coherent mixed reality by multiple users.
- Mutual exchange about a shared 3D scene confirms the perceptual illusion of virtual reality and improves the perception of details in the environment.
- Spatial overlapping of real and virtual environmental features can lead to conflicts of spatial affordance.
- It can be beneficial to relax temporarily the geometric consistency of a shared virtual environment in order to avoid collisions and conflicts with cooperation partners and application content that result from non-conforming spatial affordances of the real and the virtual interaction space.