CPS: Small: Mathematical, Computational, and Perceptual Foundations for Interactive Cyber-Physical Systems

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Our goal is to create interfaces that enable people with impaired sensory-motor function to control interactive cyber-physical systems such as artificial limbs, wheelchairs, automobiles, and aircraft. Our approach is based on the premise that performance can be significantly enhanced merely by warping the perceptual feedback provided to the human user. We have been addressing a number of underlying mathematical and computational challenges that will result in a systematic way to design this feedback. Local performance criteria like stability and collision avoidance are encoded by potential functions, and gradients of these functions are used to warp the display. Global performance criteria like optimal navigation are encoded by conditional probabilities on a language of motion primitives, and metric embeddings of these probabilities are used to warp the display. Together, these two types of feedback facilitate improved safety and performance while still allowing the user to retain full control over the system. If successful, our research could improve the lives of people suffering from debilitating physical conditions such as amputation or stroke and also could protect people like drivers or pilots that are impaired by transient conditions such as fatigue, boredom, or substance abuse.