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Attenuation of the Speed-Accuracy Tradeoff Through Learning

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Highly skilled movement is impressive to behold but a challenge to exhibit. MÆANDER models the *acquisition* of motor skills through unsupervised observation and the *improvement* of acquired skills through self guided practice. This abstract highlights the novelty of the model and the tasks it addresses. We also touch upon the model's behavior with respect to one particular phenomenon of human skills – the speed-accuracy tradeoff.

The Tasks We make several key claims: interesting skills are complex movements involving a sequence of controls, a skill is initially acquired through observation and recognition, and acquired skills are then improved through practice.

Much of the work in modeling human motor behavior has focused on simple, ballistic, short-duration movements where the termination is either spatially or temporally constrained but where the movement itself is unconstrained (or irrelevant). In contrast, MÆANDER addresses the trajectory following task. Movements of this type include tai-chi exercises and figure skating compulsories. Think "where you end up" vs. "how you get there." Despite the need to understand the primitive building blocks of human motor behavior (the predominant concern of human skill work), our research assumes these primitives are available at some lower-level and focuses on the representation, acquisition, and improvement of complex movements having extended duration.

Trajectory following may be thought of as an extended sequence of simple time and distance matching movements. However, traditional approaches and representations for simple movements would have considerable difficulty with these tasks and the necessary representations would be unwieldy. Also, skills must be representationally invariant with respect to execution speed (among other invariants). MÆANDER provides a sparse yet powerful representation scheme, which in conjunction with integrated recognition, generation, and learning mechanisms, addresses complex movements and accounts for numerous psychological phenomena pertaining to movement such as the speed-accuracy tradeoff, transfer of skill between limbs, power-law of learning, confusion errors with highly similar motions, etc.

The Model – MÆANDER We summarize the model as a representation, memory management scheme, and an execution repair and improvement module. MÆANDER's representation sparsely stores movements as *motor schemas* using motion boundaries defined as discontinuities in speed and acceleration. This representation uses both viewer-centered and joint-centered reference frames. An unsupervised learning mechanism (derivative of COBWEB) stores motor schemas in memory and allows recognition of observed movements, prediction of unseen or future movement, and retrieval of joint-centered motor schemas for movement generation. A repair module takes feedback corrections (with respect to the previously acquired concept that is being executed) and generates revised candidate schemas, the best of which is stored in skill memory.

Evaluation In previous studies with MÆANDER, we predicted that the severity of the speed-accuracy tradeoff in human skill behavior should be attenuated by practice or increasing levels of expertise. In one experiment, we varied the speed at which a movement was executed together with the number of training trials from which MÆANDER had had the opportunity to learn. We measured absolute error averaged over trajectories and multiple movement types. The results confirmed our expectations; for the lines connecting different speeds at a single level of learning, the slopes steadily decreased as training increased. Subsequently, we found evidence in the literature supporting our prediction (Sugden, 1980). Sugden showed that movement speeds increased with age groups (for a constant error). That is, subjects can reduce error at a given speed through experience.

Our current and future work will extend and test MÆANDER by increasing the number of movement skills by an order of magnitude and comparing model behavior to other psychological results. In the near future, we expect to modify MÆANDER towards a more realistic and accurate model of human behavior. For now, MÆANDER represents perhaps the only model of human learning for complex movement skills.

References

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