Spatiotemporal Movement Planning and Rapid Adaptation for Manual Interaction

Abstract:
Many everyday tasks require the ability of two or more individuals to coordinate their actions with others to increase efficiency. Such an increase in efficiency can often be observed even after only very few trials. Previous work suggests that such behavioral adaptation can be explained within a probabilistic framework that integrates sensory input and prior experience. Even though higher cognitive abilities such as intention recognition have been described as probabilistic estimation depending on an internal model of the other agent, it is not clear whether much simpler daily interaction is consistent with a probabilistic framework. Here, we investigate whether the mechanisms underlying efficient coordination during manual interactions can be understood as probabilistic optimization. For this purpose we studied in several experiments a simple manual handover task concentrating on the action of the receiver. We found that the duration until the receiver reacts to the handover decreases over trials, but strongly depends on the position of the handover. We then replaced the human deliverer by different types of robots to further investigate the influence of the delivering movement on the reaction of the receiver. Durations were found to depend on movement kinematics and the robot’s joint configuration. Modeling the task was based on the assumption that the receiver’s decision to act is based on the accumulated evidence for a specific handover position.
evidence for this handover position is collected from observing the hand movement of the deliverer over time and, if appropriate, by integrating this sensory likelihood with prior expectation that is updated over trials. The close match of model simulations and experimental results shows that the efficiency of handover coordination can be explained by an adaptive probabilistic fusion of a-priori expectation and online estimation.

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