Interpersonal Coordination and Synchronization in Human-Machine Teams

Mustafa Demir and Nancy J. Cooke
Center for Human, Artificial Intelligence, and Robot Teaming, Global Security Initiative, Arizona State University, Tempe, Arizona, USA
Human Systems Engineering, Arizona State University, Mesa, Arizona, USA

Project overview. The current study focuses on the interpersonal coordination dynamics (human-human vs. human-machine dyadic interaction) within all-human and human-machine teams (HMTs) in a simulated remotely piloted aircraft (RPA) systems task environment. In this research, three heterogeneous team members communicated via a text-based communication system to photograph target waypoints. Each team member had a different role: (1) navigator – informs the pilot regarding a flight plan with speed and altitude restrictions of each waypoint; (2) pilot – controls the RPA and negotiates with the photographer regarding correct altitude and airspeed to take a good photo of the targets; and (3) photographer –monitors camera settings and sends feedback to the other team members regarding the status of the target's photograph. Although the pilot communicates and coordinates with both other roles, the navigator and photographer barely communicate with one another based on the nature of the task interdependencies. Therefore, the pilot role is the central role in this task in terms of communicating with both roles. We simulated a synthetic agent with natural language and learning abilities by having a human as a "synthetic agent." This was achieved by manipulating the beliefs of the other two team members such that they believed the third team member was a synthetic agent (Demir et al., 2018; Demir & Cooke, 2014). The main question is whether manipulating this belief can impact dyadic coordination between the team members. Two conditions were created based on manipulating the pilot role: (1) Synthetic condition – the pilot was a randomly selected participant and never met with other two team members; (2) Control condition – the pilot was a randomly assigned participant and met with the other two team members. In the previous study from the same experiment (Demir et al., 2018), we found that teams in the control condition performed better than those in the synthetic condition.

Method. In this experiment, there were 20 teams (ten teams for each condition): both conditions were composed of three participants randomly assigned to each role. The experiment consisted of five missions (each 40 minutes) in which teams needed to take as many "good" photos as possible of ground targets while avoiding alarms and rule violations. Several measures were obtained from this research, including team performance scores (mission and target level), team process measures (situation awareness, process ratings, communication, and coordination), and other measures (teamwork knowledge, workload, and demographics). This study used a dyadic communication flow measure to quantify dyadic interaction dynamics measures. Dyadic communication flow is a multivariate binary measure recorded once at any given time for team members to indicate if at least one message was sent (dyadic communication flow = 1) or not (dyadic communication flow = 0) by each team member. We applied cross-recurrence quantification analysis (CRQA; Coco & Dale, 2014) to each pair's dyadic team communication flow data to investigate team interaction dynamics by addressing how each two-team member's coordination is related to one another within each condition? We extracted four measures from CRQA: (1) percent determinism - serves as an index of flexible behavior, (2) recurrence rate – indicates coupling strength; (3) maximum line strength – shows stable behavior; (4) diagonal recurrence rate – serves as leading, following, or synchronization of dyads (Dale et al., 2011).

Results and discussion. The study findings are threefold: (1) the synthetic teams demonstrated more rigid dynamics than the control teams; (2) though there was a synchronization between human and human team members in both conditions, that synchronization was not observed between human and machine team members in the synthetic condition, (3) in synthetic condition, human team members led the machine teammate when they were interacting with it (i.e., more supervisory control). One of the reasons the human and machine pairs interacted that way is that the human team member may have considered the machine teammate to be a tool rather than a machine team member (Demir & Cooke, 2014) or lack of trust in the machine teammate. Overall, these findings indicate that even if the machine team member communicates in a natural language, the belief that a machine is a teammate changes the interpersonal coordination dynamics in this specific task.

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