This paper mentioned a lot of performance downgrade which might come from a poor shared mental model between human and robot, though they never said a word of "mental model".

The roles of humans and robots in a team are a little different from those in ours. In their case, humans are still in the loop of decision making with robots. They are still operators, so there exists bi-direction information flow between two sides in decision making.

H

R

I assume in our case, humans are only in roles of managers. Humans give commands and robots plan and execute.

H

R

However, this problem is extendable. Especially if we have a waypoint layer, this is something visual for humans to modify or correct, assuming humans are less concerned with how the curvature is like (how the waypoints are connected). This reserves the manageability for humans.

This paper provides a good example on introducing a story on human robot collaboration by below sequence

(a) The need of single human interacting with multiple machines

(b) The existence of "operator cognitive saturation"

(c) The need of human management in knowledge incompleteness, prior inaccuracy and environment uncertainty

(d) The problems from human managing machine (automation bias) -> the need of a shared mental model

There are several interesting hypotheses stated.

(1) Because of the likely nonlinear evaluations made by the human and the unavailability of all information necessary for the algorithm to make a decision, it is difficult to express the complete objective function of a human through a priori coded objective function.

=> Why we need to import multi-objective function.

(2) Based purely on "mission time" and "target value", the best plan comes when human operators are unable to modify the objective functions, assuming human will consider additional factors, like risk or distance metrics.

Automation is excellent at optimizing a solution for specific goals, but it takes less consideration on the factors that could influence the success of a complex command and control mission in an uncertain environment.

=> Why the command are from human verbal when working but not preset.

(3) The framework of human robot collaboration is scalable and robust. Because additional agents also add computational capability and single point failure has little influence on global performance.

=> We probably can make same assumption.

(4) Allowing human to modify objective function in real time promotes collaboration to achieve “superior” multi-UV system performance.

A dynamic objective function increases automation transparency (manageability to human) and reduces automated planner’s brittleness (robustness and adaptability of a machine).

=> Since the objective function can be changed, there is not an identical criterion to measure the performance. I think here the author evaluate this performance weighting more by the satisfaction from the manager. Here humans are managers; almost none of managers like to lose manageability in chasing higher team performance. However, this is a factor almost immeasurable to the machines.

(5) Developing an appropriate level of trust between human and machine is crucial for successful collaboration. And providing the capability to modify the objective function for multi-objective optimization can aid in developing the trust.

=>This also looks like something relevant with manageability. Humans tend to trust things that they can influence on. But what about the trust of the machines’ side? Can a human correctly express his/her intention?

In this paper, they mentioned a CBBA algorithm on a multi-objective problem, but not given in details. I looked at the reference papers, which models the problem as optimal allocation on a global objective from the scalarization of multiple objectives in a multi-agent system. The essential idea is similar with any consensus making process, in which there is an iteration process on information exchange between agents to reach consensus. This is a pure multi-machine intelligence problem without human factor.