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Coalition formation based on task-oriented collaborative ability

Key words: Collaborative vector; Task allocation; Multi-agent systems; Artificial intelligence

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Motivation

- In distributed environment, multiple agents cooperate with each other to execute an indivisible task, where agents need to know the collaborative capabilities of the agents. Thus the collaborative capabilities need to be modeled.
- The decision-making times of agents are preferably not at one time, otherwise excessive and blind competitions are occurred. Meanwhile, the decision time intervals are preferably not fixed, otherwise cooperation may be reduced. Thus a proper time mechanism is necessary.
- Human may always make a higher or lower estimation than actual task requirement. Thus the cognition of agent need to be improved to understand the commands from human.

Main idea

1. Considering the differences of the tasks, task related factors are introduced to generate task-oriented vectors for agents.
2. To reduce the excessive and blind competition, a stochastic mechanism is produce.
3. The concept of Cognitive Inertia is introduced and the cognitive compensation is made for agents to improve the recognition about the commands from human.

1. Models of task-oriented collaborative vector

Different tasks need different capabilities and the factors that effect the capabilities are task-oriented.

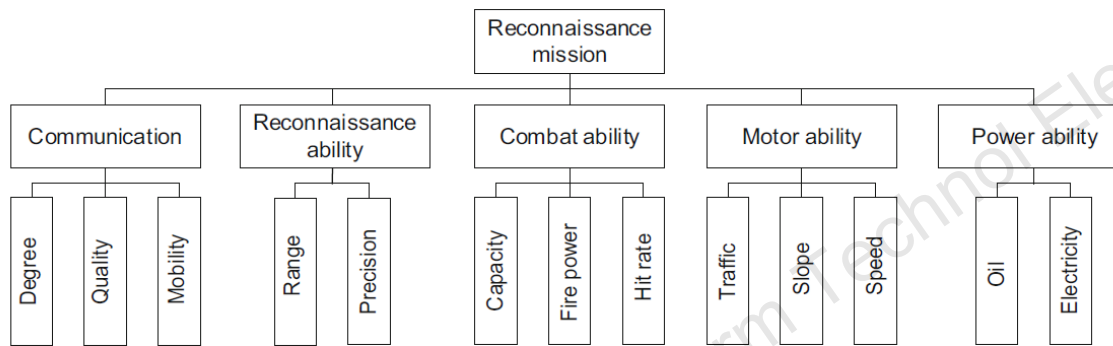


Fig. 1 Relationships between abilities and factors

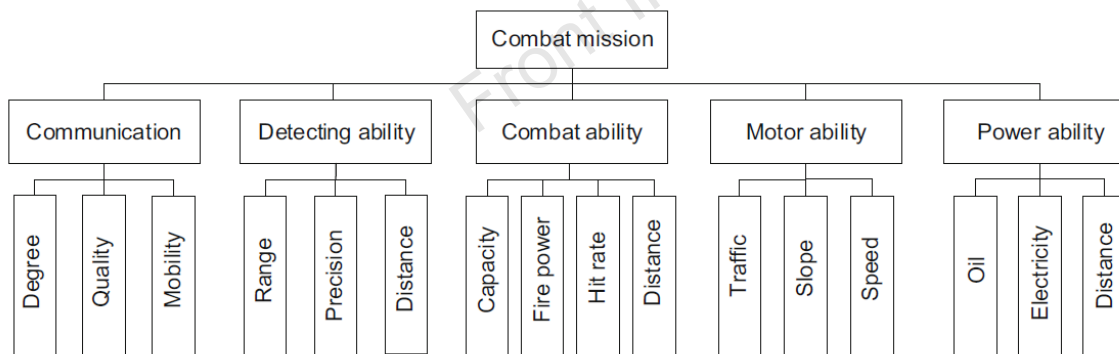


Fig. 2 Relationships between abilities and factors

Taking the reconnaissance task and the combat task for examples, the relationships between the factors and the capabilities, the relationships between the capabilities and the task are given as shown.

2. Stochastic mechanism

To reduce the excessive competitions, agents are preferably to make decisions at the time with a little difference. In addition, agents are preferably to sense the situation of the coalitions.

$$t_s^i = \frac{1}{|N_i| + 1} \sum_{j \in \{N_i, i\}} t_{s-1}^j + (1 + \varepsilon)$$

stochastic time interval

with a little difference

almost the same time

$$\tilde{TR}_k^i = (\omega_{k1}^i(t_s) \cdot TP_k^i + \omega_{k2}(t_s) \cdot TF_k^i) \frac{RT_k - CA_k(t_s)}{RT_k}$$

the knowledge of the situation

**sensing the situations
of the coalitions**

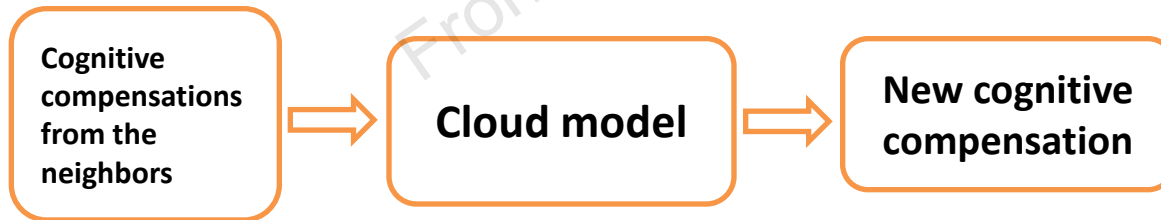
3. Cognitive compensation

Concept of the Cognition Inertia

Definition 1 The fact that a human always calculates the task requirement using his/her own evaluation standard which will not change to a large extent for a human being is called the cognitive inertia.

$$\gamma_i^l = \frac{RT_k^l - (C_k^l - \tilde{C}_k^l)}{RT_k^l}, \quad \forall l \in [1, m]$$

Cognitive compensation calculated by agent i for task l



Generation of new cognitive compensation

Illustrative demonstration

1. Model of collaborative vector

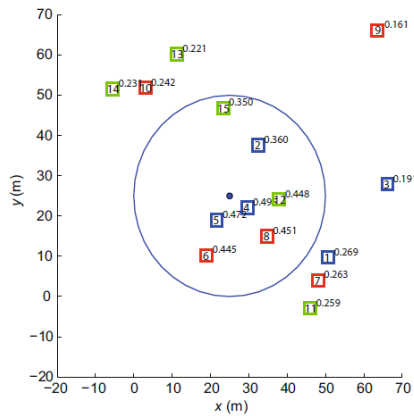


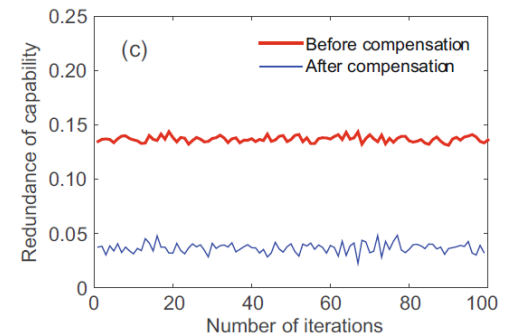
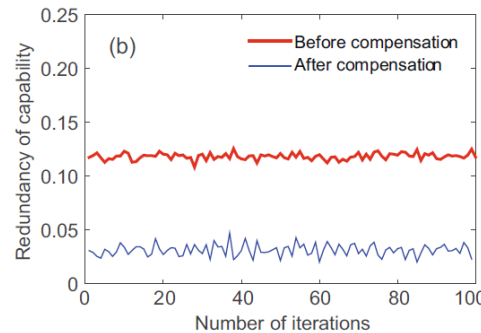
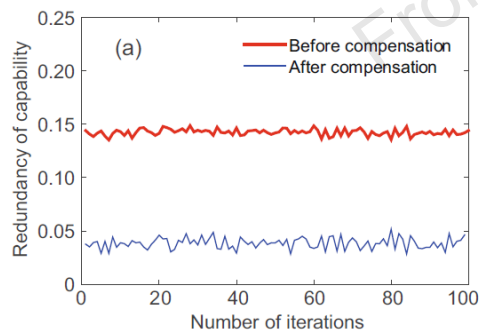
Fig. 4 Desire for the combat mission

2. Stochastic mechanism



Fig. 5 Simulation of task execution

3. Cognitive compensation



Redundancy of the first (a), second (b), third (c) capability before and after compensation

Conclusions

- The proper models for the collaborative vector make a foundation for agents to chose tasks.
- The stochastic mechanism can reduce the excessive competitions.
- The cognitive compensation could help the agents to understand the commands from human.