A User Interface Design for Collaborations between Humans and Intelligent Vehicles

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Abstract. Intelligent vehicles have been widely applied in the industry, academia, and our daily lives, to complete various tasks. However, existing AI that drives intelligent vehicles sometimes falls short as they may not ensure completeness or optimality, leading to issues like local optima or infinite loops. In response to these limitations, we proposed a user interface design for online crowdsourcing tasks, which enables collaborations between crowd workers and intelligent vehicles. This design aims to bolster existing intelligent vehicles' AI with human intelligence as external support, while also leveraging AI predictions to minimize human effort. This research provides significant insights into the design of collaborative systems that effectively integrate human and artificial intelligence.

Keywords: user interface · crowdsourcing · human-AI collaboration · intelligent vehicle

1 Introduction

Research on intelligent vehicles has become an important domain in the fields of AI, robotics, and cybernetics. Researchers and practitioners have used intelligent vehicles in a variety of applications, to complete tasks that humans are not willing to do. Such tasks could be either highly dangerous or repetitive, like searching for the fire source and hazardous gas source. These intelligent vehicles can autonomously move and complete tasks, driven by AI algorithms. However, existing AI algorithms sometimes fall short as they may not ensure completeness or optimality, leading to fatal problems that they cannot handle on their own[6].

Crowd-powered systems and human-AI collaborations [1] provide a new perspective on improving existing AI models and algorithms. These approaches enable humans to participate in processes that would otherwise be fully automated or intelligent. Currently, human-AI collaborations have been applied in various fields and have been shown to be effective in improving AI's effectiveness. Therefore, we are interested in whether human intelligence can improve intelligent vehicles' AI algorithms.

In this work, we provided a user interface design to enable human-AI collaborations that could improve the existing intelligent vehicles' AI algorithms.

The user interface can be used on a web crowdsourcing platform where online crowd workers are paid to complete microtasks that assist AI in solving specific problems. The user interface is also responsible for explaining the fatal problems detected in AI algorithms, and then giving suggestions to workers. Our work provides a feasible application and valuable insights into leveraging human-AI collaboration to improve current AI algorithms for intelligent vehicles.

2 User Interface Design

In this section, we introduce the design of the human-AI collaborative user interface for intelligent vehicles, and explain how human intelligence can be used through crowdsourcing, to improve the effectiveness and efficiency of AI.

In the initialization step, we define the goal, parameters, and configurations of the vehicle's AI. Then, in the execution step, we enable AI to drive the vehicles, or to solve problems autonomously. During the execution, the fatal problems can be detected (e.g., by setting some heuristic rules). To this end, crowdsourcing tasks can be generated using our designed user interface to enable crowd workers to solve the problem.

On the user interface[1], the explanation of the problem and solution suggestions are given as task instructions. The user interface features a map showing the environment where intelligent vehicles are moving. On the map, the current status (e.g., current moving directions, destinations) is displayed to let crowd workers understand the current situation and understand the problem that intelligent vehicles are encountering. Crowd workers are asked to operate intelligent vehicles through mouse-clicking on the map, in order to change vehicles' status or alter their destinations. Once the problem is solved, crowd workers can submit the task.

Upon task submission, the AI execution resumes. Finally, the execution ends after the stopping criteria are met.

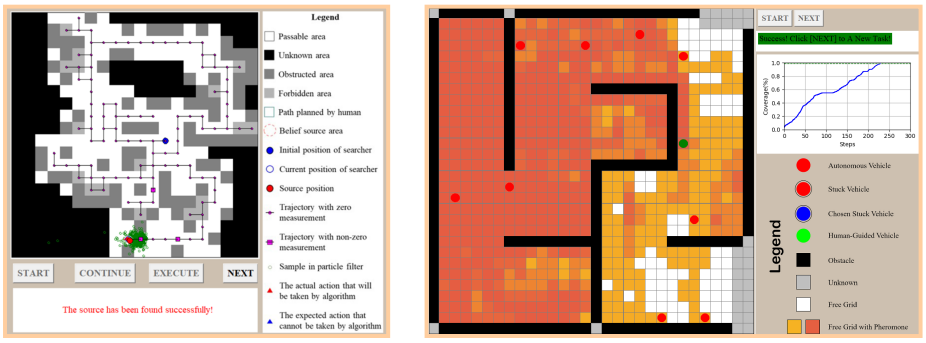
3 Application I: Source Search

A source search problem aims to enable intelligent vehicles to autonomously find and move to the locations of sources (e.g., fire source, gas emission source, etc.) [3]. Since the source environments become increasingly complex, traditional search algorithms can no longer meet the requirements of the existing source search applications. Therefore, various novel heuristic search algorithms combined with human cognition have been proposed [2,5]. However, these search algorithms still have problems in terms of search completeness and optimality. In this application, we study the feasibility of our proposed human-AI collaborative user interface in a source search scenario (where an intelligent vehicle autonomously searches a gas emission source).

[1] The video of the designed interface can be found at https://osf.io/4e8pb/

We designed a prototype crowdsourcing task interface following the proposed idea. The interface has two control modes: `FULL` control mode and `AIDED` control mode. The former allows users to take over the vehicle and the search process entirely, providing maximum flexibility for problem-solving. The latter enables users to set temporary destinations for the vehicle, aiding the vehicle without fully taking over control.

The source search algorithm used in this system is Infotaxis [4], which is one of the most popular novel source search strategies. The screenshot of the prototype crowdsourcing task is shown in Fig 1 (a). We asked 10 participants to test the prototype user interface. The outcomes of this study underscore the efficacy, efficiency, and user-centric design of the proposed human-AI collaborative user interface. Independent of the participants' pre-existing knowledge regarding source search challenges, they were able to rapidly acclimate to the interface's operations and complete the tasks. Furthermore, during post-experiment interviews, several participants expressed a desire for more human-computer interaction modalities within our user interface, such as conversational interaction. The details of this study have been published in [6].



(a) The user interface for source search

(b) The user interface for collaborative exploration

Fig. 1. Screenshots of web crowdsourcing tasks generated by the prototype system.

4 Application II: Collaborative Exploration

Cooperative exploration is another important research direction in the field of intelligent vehicles, which controls multiple vehicles to explore an unknown environment. This is also important in terms of search and rescue in emergencies. Traditional cooperative exploration methods are proposed based on swarm intelligence algorithms. However, they also have problems with regard to local optima, particularly in complex environments (like source search). In this application, we study the feasibility of our user interface in a collaborative exploration

scenario (where multiple intelligent vehicles autonomously explore an indoor environment to achieve maximum coverage).

We designed a prototype crowdsourcing task interface, which also has two control modes for humans, namely the `PRECISE` mode and the `COLLECTIVE` mode. The `PRECISE` mode refers to highly precise means of interaction, which enables workers to directly control the movement of a single vehicle (similar to the FULL control in Application I). The `COLLECTIVE` mode refers to the interaction with the swarm instead of single vehicles, which enables workers to control the overall motion trend of the swarm.

The screenshot of the prototype crowdsourcing task is shown in Fig 1 (b). We are conducting experiments with both experts and non-experts. We will also investigate the potential benefits of learning from humans, meaning the AI algorithm autonomously evolves by adopting human habits and preferences during operations. However, any bias resulting from human intervention must be approached with caution. Therefore, this study is still in progress.

5 Conclusion

In this work, we proposed a design of a user interface to facilitate human-AI collaborations for intelligent vehicles. Based on crowdsourcing approaches, we introduce human intelligence to improve the AI algorithms of vehicles. Our work provides valuable insights into human-AI collaborative system design and web crowdsourcing applications.

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