Research on Intelligent Control Method of Cutter Suction Dredger based on Reinforcement Learning

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ABSTRACT
Aiming at the problems of low degree of automation, large individual differences in manual operation and low average efficiency of dredging vessels, an intelligent control method of cutter suction dredgers based on reinforcement learning is proposed. First, control variables that are closely related to production and can be manually adjusted are screened out. These filtered data are fixed sequences and cannot be directly used for reinforcement learning training. We use the improved KNN method to construct the instantaneous production model of a cutter suction dredger, and use it as input data of the reward function, so as to establish a reinforcement learning environment model including action space, state transition and reward function. Then the agent executes instructions according to the random actions given by the algorithm, and the state information is fed back by the environment model, and the optimal parameters are obtained through interactive learning with the environment. Finally, the control subsystem of the cutter suction dredger controls the dredging process with the optimal construction parameters recommended by the reinforcement learning agent, and realizes the unmanned and intelligent dredging operation process. The simulation results show that the dredger based on reinforcement learning intelligent control has high production, low energy consumption and strong stability, which proves the rationality and effectiveness of this method, and provides a theoretical basis for the application of reinforcement learning method in the control of suction dredger.

KEY WORDS: Cutter suction dredger; reinforcement learning; intelligent control.

INTRODUCTION
The cutter suction dredger is a kind of suction dredger with the most extensive excavation soil type and the largest change in the discharge distance among the dredgers (Hou et al., 2019). The cutter suction dredger adopts the continuous operation mode of digging, transportation and unloading, uses the rotary reamer to cut the underwater soil layer horizontally, and then uses the centrifugal pump to transport the slurry water mixture over long distances, which has a wide range of adaptability and low cost of use, and plays a very important role in channel dredging, port construction and deeper offshore marine development projects (Wang et al., 2022; Wang et al., 2021; Yang et al., 2018). The operation process of the cutter suction dredger is cumbersome, the working principle is complex, and the working environment is diverse. The dynamic characteristics of the actual dredging operation process are very complex, and the main operating parameters of the dredger in the dredging operation process are flexibly determined by the operator according to his own experience, test excavation situation and dredger operation effect. Due to the many influencing factors in the actual construction process and the complex interrelationship, the experience and theoretical level of dredging operators vary greatly, and the actual production of manual work is often lower than the design production. Dredging operations are inefficient, less automated and highly experience-dependent.

In order to reduce labor costs and improve dredging efficiency, Ding (Ding et al., 2020) developed the intelligent unmanned automatic dredger control system software for cutter suction dredger. The software function includes two parts: integrated monitoring function and automatic dredging function, which realizes unmanned control of the dredging operation process, but the system lacks the intelligent autonomous optimization function of dredging parameters. Wei et al. proposed an intelligent optimization control strategy of cutter suction dredger based on reinforcement learning, used the generalization ability of neural network to establish a dynamic model of traverse process, and used the Sarsa algorithm (Wei et al., 2019) and Sarsa-Lambda algorithm (Wei et al., 2019) in reinforcement learning to develop the intelligent decision-making method in the swing process of the cutter suction dredger, and verified that the reinforcement learning method can successfully imitate the dredging behavior of experienced manual operators through simulation. However, both the Sarsa algorithm and the Sarsa-Lambda algorithm are limited by slow convergence speeds, and