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Prioritization of inspection for Infrastructure maintenance considering the information exploration by the Multi-armed bandit algorithm

（多腕バンディットアルゴリズムにより情報獲得の価値を考慮したインフラの点検の優先順位評価）

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Backgrounds & Objectives

This study presents the results of applying Multi-armed bandit problem into the inspection priority policy for infrastructure maintenance problem. Conventional infrastructure inspection strategy has been made either conducting equal inspection policy to all facilities, or giving the inspection priority merely based on the past inspection results. These two methods are being questioned for their efficiency and theoretical rationality, although they have been used extensively in practice for their simplicity and wide generalization. Nowadays with the rapid development of information technology, the significance of utilizing information has been rediscovered. To introduce the information contribution idea to the infrastructure maintenance problem that can make a difference to the conventional maintenance strategy, we will apply the Multi-armed bandit algorithms.

Methodology

For the methodology, we explore the possibility and optimality of applying the Multi-armed bandit problem into inspection priority problem for better maintenance work, which incorporating both the inspection behavior information contribution and traditional inspection results data into the evaluation of facility. We consider three algorithms, the Epsilon-greedy that excludes information contribution, and comparative UCB and UCB-Tuned algorithms that include information contribution in their evaluations for contrast. We apply these strategies in three problems: the influence of value of ϵ on inspection allocation policy, existence of budget limitation and performances under large number of facilities through simulations.

Results & Conclusions

Results of the three algorithms simulation are observed and compared in the simulation. For

Epsilon-greedy, with greater ϵ value, the most dangerous facility shall be found out with more probability since this algorithm will explore more. For the case with budget limitations for different given inspection times, when the inspection times is under certain number, the proportion of the most dangerous facility being inspected will grow steadily. And when it is over the certain number, the proportion will go flat, or fluctuate in a small range that almost can be ignored. It can be referred from this that there is an optimal budget for this maintenance strategy where we can use the least budget for best inspection efficiency in some way. As for the simulation with large facility number, we find that both for the UCB and UCB-Tuned, the facilities in the most dangerous group (DIV level) are being inspected at least two times of the averaged inspection times if we conduct equal inspection strategy for all facilities. and UCB performs better than that of the UCB-Tuned as UCB can inspected the most dangerous much more often than that of UCB-Tuned, while UCB-Tuned can allocate more even and stable inspection resources for all the facilities in relatively dangerous facilities. Instead, the Epsilon-greedy presents unstable and unreliable results. Facilities in the most dangerous group are inspected with results presenting extreme differences. Some of them are inspected substantially, while some inspection times are almost zero. This show that giving priority merely based on mean value only is not reliable and applicable in the theoretical structures. Comparing to that, the UCB family are much more favorable to the infrastructure maintenance strategy.

Conclusions

As a conclusion, the feasibility of applying Multi-armed bandit problem in maintenance strategy has been proved. Comparing to traditional inspection strategy that either conducting equal inspection policy to all facilities, or giving the inspection priority merely based on the past inspection results, Multi-bandit algorithms that considering the information exploration by the Multi-armed bandit algorithm, like the UCB or UCB-Tuned, can provide reliable inspection priority and allocation strategy for maintenance problems. Integrating the information use into the evaluation of facilities is one we can further its applications in the real world and develop more efficient maintenance strategy.

Main references

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