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Integrated optimization of line planning and timetabling on high-speed railway network considering cross-line operation

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ABSTRACT

With the implementation of cross-line operation in high-speed railway system, accessibility of cross-line passengers on the railway network has substantially improved. However, due to limitations of capacity, it is hard to schedule a conflict-free timetable based on a train line plan with many cross-line trains. In order to generate a feasible and optimal transportation plan, a novel methodology is introduced. The approach can simultaneously optimize both the line plans of cross-line trains and train timetable, aiming at having a trade-off between operating profit and direct service. Based on an event-activity network framework, a mixed integer programming model is established. Considering service quality would decline after optimizing line plan and train schedules, the objective of the model is set to minimize deviations from ideal schedules for main-line trains while maximize direct service frequency for cross-line passengers. To solve large-scale scenarios efficiently, an enhanced heuristic genetic algorithm is developed. Two smaller-scale cases are devised to validate the efficiency of the model and approach. Finally, the model and the algorithm are applied to a real-world scenario involving the Beijing-Shanghai High-speed Railway and its connecting lines. Also, comparative experiments, including a scenario without cross-line optimization, are conducted to evaluate the advantage of the proposed approach. The result shows the approach can help to quickly find a feasible solution and have a good balance between operating profit and passenger demand.

ARTICLE INFO

Keywords:
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Izvirni znanstveni članek

Združena optimizacija načrtovanja linij in voznega reda v visokohitrostnem železniškem omrežju z upoštevanjem obratovanja na povezovalnih linijah

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POVZETEK

Z uvedbo obratovanja na povezovalnih linijah v visokohitrostnem železniškem sistemu se je bistveno izboljšala dostopnost železniškega omrežja za potnike, ki potujejo na povezovalnih linijah. Vendar je zaradi omejitev zmogljivosti težko načrtovati vozne rede brez neskladij na podlagi načrta vlakovnih linij z veliko vlaki, ki vozijo na povezovalnih linijah. Za oblikovanje izvedljivega in optimalnega prometnega načrta je uvedena nova metodologija. S tem pristopom je mogoče hkrati optimizirati tako načrte linij vlakov na povezovalnih linijah, kot tudi vozni red vlakov, pri čemer je cilj doseči kompromis med dobičkom iz poslovanja in neposrednimi storitvami. Na podlagi okvira omrežja dogodkov in dejavnosti je vzpostavljen model mešanega celoštevilskega programiranja. Glede na to, da bi se kakovost storitev po optimizaciji načrta linij in voznih redov vlakov zmanjšala, je cilj modela čim bolj zmanjšati odstopanja od idealnih voznih redov za vlake na glavnih linijah in čim bolj povečati pogostost neposrednih storitev za potnike na drugih linijah. Za učinkovito reševanje obsežnih scenarijev je razvit izboljšan hevristični genetski algoritem. Za potrditev učinkovitosti modela in pristopa sta zasnovana dva manjša primera. Na koncu sta model in algoritem uporabljena za dejanski scenarij, ki vključuje visokohitrostno železnico Peking-Šanghaj in njene povezovalne linije. Izvedeni so tudi primerjalni poskusi, vključno s scenarijem brez optimizacije povezovalnih linij, da se oceni prednost predlaganega pristopa. Rezultati kažejo, da lahko pristop pomaga pri hitrem iskanju izvedljive rešitve in dobrem ravnovesju med dobičkom iz poslovanja in potrebami potnikov.

PODATKI O ČLANKU

Ključne besede:
Železniško omrežje;
Optimizacija;
Načrtovanje železniških linij;
Načrtovanje voznega reda;
Obratovanje povezovalnih linij;
Potrebe potnikov;
Pogostost neposredne povezave;
Genetski algoritem

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