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Improving AGV path planning efficiency using Genetic Algorithms with Hamming distance-based initialization

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A B S T R A C T

This paper presents a Genetic Algorithm (GA) framework for warehouse navigation as a Travelling Salesman Problem (TSP) variant for Automated Guided Vehicles (AGVs). The warehouse layout is represented as a graph, where pick-up locations serve as terminal nodes. A distance matrix, computed via Breadth-First Search (BFS) enables efficient route evaluation. To promote diversity in the initial population, a Hamming distance-based vectorized initialization strategy is employed, ensuring that the chromosomes are maximally distinct. The GA balances exploration and exploitation by dynamically adjusting the fitness function. Early generations emphasize diversity, while later ones focus on solution refinement, improving convergence and avoiding premature stagnation. Our key contribution demonstrates that the Hamming distance-based approach achieves comparable or better results with significantly fewer chromosomes. This reduces computational cost and runtime, making the method well-suited for real-time AGV routing in warehouses. The framework is adaptable to structured environments and shows strong potential for integration into real-world logistics and robotics applications. Future work will focus on optimizing the algorithm and integrating it into the ROS 2 environment. The simplified version of the algorithm can be accessed at: *https://github.com/IntoTheVoid-61/Warehouse-Pathfinder*.

A R T I C L E I N F O

Keywords:
Automated guided vehicles (AGV);
Warehouse routing;
Genetic algorithms (GA);
Combinatorial optimization;
Hamming distance initialization;
Robot operating system 2 (ROS 2)

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Izvirni znanstveni članek

Izboljšanje učinkovitosti načrtovanja poti AGV z genetskim algoritmom z inicializacijo na osnovi Hammingove razdalje

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POVZETEK

Prispevek predstavlja pristop, ki temelji na genetskem algoritmu (GA) za navigacijo samodejno vodenega vozila (AGV) v skladišču, obravnavanem kot različica problema trgovskega potnika (TSP). Tloris skladišča je modeliran kot graf, pri čemer prevzemne lokacije predstavljajo terminalna vozlišča. Matrika razdalj, izračunana z algoritmom iskanja v širino (BFS), omogoča učinkovito vrednotenje poti. Za spodbujanje raznolikosti začetne populacije je uporabljena vektorizirana inicializacija na osnovi Hammingove razdalje, ki zagotavlja čim večjo raznolikost kromosomov. Genetski algoritem uravnoveša sposobnost raziskovanja in izkoriščanja z dinamičnim prilagajanjem ciljne funkcije. V zgodnjih generacijah je poudarek na raznolikosti populacije, v kasnejših na izboljševanju rešitev, kar izboljša konvergenco in preprečuje prezgodnjo stagnacijo. Raziskava potrjuje, da pristop z uporabo Hammingove razdalje dosega primerljive ali boljše rezultate z bistveno manjšim številom kromosomov. S tem se zmanjšata računska zahtevnost in čas izvajanja, zaradi česar je metoda primerna za realnočasovno usmerjanje AGV v skladiščih. Predlagani pristop je prilagodljiv strukturiranim okoljem in kaže velik potencial za vključitev v dejanske logistične in robotske aplikacije. Nadaljnje delo bo usmerjeno v optimizacijo algoritma in integracijo v okolje ROS 2. Poenostavljena različica algoritma je dostopna na *https://github.com/IntoTheVoid-61/Warehouse-Pathfinder*.

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Ključne besede:
Samodejno vodena vozila (AGV);
Usmerjanje v skladišču;
Genetski algoritem (GA);
Kombinatorna optimizacija;
Inicializacija na osnovi Hammingove razdalje:
Operacijski sistem za robote 2 (ROS 2)

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