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Priority-Based Genetic Algorithm for Conflict-Free Automated Guided Vehicle Routing

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Abstract

This study presents an algorithm for automated guided vehicle system routing. Priority-based genetic algorithm was used for genetic representation. The objective is minimal path transverse time. Weight mapping crossover (WMX) and insertion mutation was used as genetic operators. Conflict detection and avoidance was incorporated into the system using node and arc occupation time mapping for detection and replacement of the individual with faultless individual from the population for avoidance. Numerical experimentation was conducted to test the effectiveness of the algorithm.

Keywords: Automated guided vehicles (AGVs), Flexible Manufacturing System, Routing, Conflict avoidance, Genetic Algorithm, Priority-based encoding,

1. Introduction

The current usage of Automated Guided Vehicles (AGVs) to transport material between various FMS cells result in bottleneck arising from ineffectiveness of the routing techniques in use[1]. Each request needs generation of optimal route to the dispatched AGV, as a result of serving different request the AGVs travels on the guide path network simultaneously, shortest distance and collision avoidance must be ensured.

Petri Nets (PN) modeling techniques provided a significant contribution to AGV routing literature. PN model the entire problem into P-elements (place, state or conditions), T-element (transitions, actions, and

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change of states) and links (flow relations between P-element and T-element). The main attributes of PN is the transformation of problems into sub-problems. In AGV routing literature places are representing nodes, zones, parking locations, pickup and drop off locations, transitions represent both feasible and infeasible route while links or arcs represent AGVs bidirectional and unidirectional flow path network, token in a place usually represents an AGV.

Petri Nets (PN) based methods in the literature is categorized as Colored Resource Oriented Petri Net (CROPN) based method such as[2–4]), the shortest routes was derived from the guide path layout, routes assign and reassign when necessary to avoid deadlock and blocking of the dispatched AGV. The normal timed Petri Nets(PN) based method such as[5–7]. Time and distance of travel were included to analyze the performance of the system. This was realized by delaying tokens in places for duration proportional to the both loaded and unloaded travel distance. Petri Net based method drawback is incomprehensibility when the system became larger, and complicated to incorporate into existing platform. Furthermore when system dynamics and solutions changes the representation may turn into too complex to be helpful [8].

Other approach to AGV routing includes Integer Programming [9–11] which is mathematical optimization technique, as such heuristic search have a potential of better performance compared with enumerative search. Artificial intelligence approach to solve the problem include knowledge representation [12], genetic algorithm [13], [14], Q-learning[15]. The common problem of all this three artificial intelligence approach is lack of detail routing resource allocation and high probability of deadlock occurrence.

The is need to develop more effective and efficient approach to AGV management [1], [16]. AGVs routing problems is proven to be NP-Complete problem[17], Evolutionary Algorithm (EA) recorded huge success in solving similar NP-Complete combinatorial optimization, such as AGV dispatching problem[14], [15], task scheduling[18]. Priority-based genetic algorithm prove to overcome the problem of legality and feasibility of shortest path problem[19]. This study developed an algorithm for routing and conflict detection and avoidance in AGV system using priority-based genetic algorithm.

1.1 Problem formulation

Let the layout of manufacturing facility be represented by an undirected graph G= (V, A). The set of vertices $V = \{v_1, v_2, v_{3.} \ldots\}$ represent workstations and intersection of paths, while the sets of weighted arcs $A = \{a_1, a_2, a_{3.} \ldots\}$ represent the paths between corresponding vertices. P_r represent current path *Am* represent the graph network adjacency matrix. *E* represents Eligible edge set and *k* representing node Let the weight of the arcs w_{ij} represents the inverse of arc occupation time which is given by the following relation.

$$w_{ij} = \frac{V_c}{d_{ij}} \quad (1)$$

Where d_{ij} is the length of the arc, V_c is the speed of the AGV which is assumed to be constant throughout the transverse time.

Assumptions

AGV travels through the guide path network at constant speed.

Each AGV can only serve one request at a time.

There is sufficient buffer storage capacity to accommodate material at both origin and destination buffers.

AGV travels at constant speed of V_c .