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RESEARCH ARTICLE

ENHANCEDDGG ALGORITHM[1] (PROBLEM OF PUBLICTRANSPORT)

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ABSTRACT

The use of personal cars presents major environmental challenges in terms of climate change, air pollution and noise pollution the government assumed to solve these objections such as pollution and energy consumption, the multi-modal transport as a solution. In fact, the multi-modal transport ten counters several problems as irritants that are related to the distribution, the condenser of researchers classifies it as a NP-hard problem. The aim of this paper is to establish an enhanced distributed as well as guided genetic algorithm in order to solve the multi-modal transport problem, particularly the problem of disturbance. For that, the solution must be accurate in the normal case and absolutely in the degraded mode too. As a consequence, this study intends to refine the quality of services provided to users. Indeed, our approach is based on evolutionary algorithms, and more specifically on the genetic algorithm. So, we apply hybridization in the selection operator and integration of a new template in the mutation operator supporting a multi-criteria method for the itineraries detection.

INTRODUCTION

The mounting car use rate for traveling achieved60% in 2015 is ascribed to the increasing number of travelers to 140 billion in the same period. This leads to an evolution in transport especially the multimodal type. This increase mainly affects energy consumption, and results in more pollution. Statistically, the energy consumption of cars represents 62 % of the total energy consumption in comparison with public transport that presents only 2,4 %. As a solution, the state promotes the multimodal transport that consist to use the diverse public means of transport (subway, bus, TGV, train, streetcar, metro etc…) for the same travel between a departure and a destination.

This solution faces various problems such as how to find the favorable road that fulfills traveler's need and deals with any disturbance perturbing either the route or the different transportation modes. The second part of this work is an overview about the existent works in the literature. In fact, it discusses, on the whole, the diverse problems of multimodal transport. Our approach is widely detailed in Part III. Then, in the fourth section, we list and enumerate the numerical results obtained by our proposal. Conclusively, in the last section we conclude this work with conclusion and the prospect for this approach.

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State of Arts

A disturbance is an accidental incident that emerges in any transport network (Medssia and Khaled Ghédira, 2015). Diverse researchers analyzed this challenge and classified itin accordance with diverse types of categorization, as example transport provider Classification / Users. Such as, Ould Sidi (Ould Sidi, 2006) has arranged the perturbation with reference to its impact on the environment. For that, he has selected the disturbances occurring at the level of vehicles or transport company staff by both internal disturbances and those rising at the network level by the external disturbances (Fayech *et al.*, 2002). Coquio in 2008, has suggested a classification based on the impact level, (Coquio, 2008). He has set three levels where disturbance can take place): 1) at the nodes: insecurity, staffing flux, incoherence; at the level of lines: Damage of a line of train, etc… 3) at the level of the whole network: social events, etc. The last spatiotemporal classification impact type has been proposed by (Melki *et al.*, 2008). Melki has presented a classification depending on analyses of the perturbation influence on the traffic. She, differentiates between the disturbances that involve one or sundry attitudes of the transport actors and those which lead to one or different changes influencing the general characteristic of the traffic (Melki , 2008). Multimodal transport problems are classified into two categories: Controller and passenger sides. Many researchers have proposed decision support systems in order to resolve the problems regulator side (Medssia and Khaled Ghédira, 2015). Concerning the voyager part, the studies intend to provide the common transport customer with all the required information for his journey instead to connect to diverse information systems as he/she is the concurrent user of different operators.

As a result, the aim is to "rescue the traveler from the punishment" as a means to extract information more and more hard to obtain, which triggers a business competitiveness of the information. The achieved works concerning the transport client sector focus on overseeing the passenger from its starting up to its destination by affording diversified and valuable services that are not only associated with routes and transport, but also with offers that can adapt or change his/her journey and even help him/ her during her/ his entertainment and leisure (Kamoun, 2007). ZIDI_K (Zidi, 2006) according to this aime, has created a travel assistance multi- agent system (SMAAD) in both normal and degraded modes using the graphs as well as the multi-agent system (SMA). His purpose is to reduce the waiting time for travelers when there is a problem in the hubs. This system establishes, as far as possible, the persistence displacements in multimodal networks via optimized and distributed the generic information.

In 2007, KAMOUN (Mnasri and Zidi, 2012) has realizeda useful information system of mobility (SICM). The purpose of this work is to convert the search procedure in addition to the routes composition and also to contribute multimodal information by means of system integrator. This approach is based on the theory of multi-agent systems to assimilate and also mediate the diverse information system about the numerous transport operators. ZGAYA (Mguis *et al.,*) has carried out a Multimodal Transport Information system (SITM) in which he respected the possible disturbances to improve as well as develop the various and simultaneous flux management requests users. Actually, SITM should be anticipated by processes of decomposing the simultaneous requests as if independent tasks. The works of ZGAYA admit providing the user with some information concerning their journey instead of their distribution. However, the main objective of kammoun's system is to supply the user with the best route before starting their path in case of knowing disturbance is known earlier. By cons, the SMAAD of ZIDI_K has been adopted to guide or direct the traveler in his route but its costs in terms of time

Contribution

We start our intervention by indicating the complexity of the problem and also the fitness function. After that, we will explain in further our contribution. Firstly, we introduce the guided genetic algorithm. Then, we represent the distributed, guided genetic algorithm.

Problem Complexity

The network of public transport presents a very dense cycle connected by interconnecting nodes. This feature generates an intermodal exchange in these nodes. The latest have a charge (the suspense time, the comfort or cost) that can be improved. The previously mentioned type of travel is identical to the path between multi nodes comprising these nodes once and only once. In literature, this multi-objective issue is relative to the salesman traveling.

Fitness function

The criteria to ameliorate, times (C_1), price (C_2) and comforts (C_3) have not the same intervals of value also not the same types. C_3 is a qualitative criterion and both C_1 and C_2 are quantitative. In fact, there must be a compromise between these values as a means to not affect the fitness function. Accordingly, we adopt the normalization of criteria values between (0, 1). Each aim has its objective function (2), (3) and (4). We obtain three functions to combined them in a single function (1)we are take advantage of an aggregation function (Talbi, 2000) to make the sum of the three objective functions after multiplying each sub objective function with coefficients of penalty.

$$f=\alpha\, g(C1) + \beta g(C2) + \delta\, g(C3) \quad \text{.. (1)}$$

Where α, β et δ are the penalty coefficients calculated dynamically according to the envy of the user.

g(C1), g(C2) and g(C3) are the functions of fitness of each criterion.

And

$$g(C_1) = \sum_{j=1}^{V}(C_1^j / \sum_{i=1}^{N} \sum_{k=1}^{M} C_1^{ik} \quad \text{................................ (2)}$$

Where

- V is the visited node
- N is the total number of node in a zone
-M the mode of transport

$$g(C_2) = \sum_{j=0}^{V} t_j^{m_j} + \sum_{i=0}^{n} t_{Att}^{i} / \sum_{i=1}^{N} \sum_{k=1}^{M} t^{ik} \quad \text{.......... (3)}$$

-$t_j^{m_j}$, is the time taken by the mode m to arrive at the station j

-t_{Att}^{i}Is the waiting time in the node i.

$$g(C_3) = \sum_{\substack{j=1 \\ k\in M}}^{V} C_3^{jk} / \sum_{i=1}^{N} \sum_{k=1}^{M} C_3^{ik} \quad \text{.................................. (4)}$$

Where C_3^{jk} is the comfort cost to arrive at the station j using the mode k.

Distributed, guided, genetic algorithm

Encoding : To demonstrate an individual in our population, we opt the real encoding presented in the following figure;

Departure-node	$Ninter_1$ (T, M)	$Ninter_2$ (T, M)	$Ninter_3$ (T, M)	$Ninter_4$ (T, M)	Arrive-node

Figure 1. Simulation of an individual

With Departure- node: the starting node
Ninter1, Ninter2, Ninter3, Ninter4: intermediate nodes.
T: starting time of this node
M: used mode

Arrived- node: Arrival node

Genetic operators

The selection: For a population with n individual: In Fact, we made hybridization between two selection techniques, the random and the elitist techniques, to take account of the premature convergence phenomenon and evade it as much as possible (Fayech *et al.,*]: Our population contained n/2 the best individuals following theirpositions by objective function and n/2 individuals picked randomly.

Station 1 (L17, 9 :30)	Station 2 (L17, 9 :40)	Station 3 (M1, 9 :10)	Station 4 (L12, 10 :25)	Station 5
		An individual i		
$\delta_{0,0}$	$\delta_{1,0}$	$\delta_{2,3}$	$\delta_{3,1}$	$\delta_{4,0}$
		Template Individual i		

Figure 2. Template Example

Crossover: We have suggested two crossing types based to the shared number of nodes: crossing in two points in the one hand and crossing in one point on the other hand.

Mutation: The following operation in the genetic algorithm is the mutation which means a transformation on one or more genes due to a preset rate, the sons choose in a random way, will undertakes the latter. in our work we have elaborated a guided genetic algorithm. As a matter of fact, the guide is established at this level as we joined "Template" inspired form the work of Bouamma_sadok (Sadok and Khaled Ghédira, 2008) as a new structure.

Each individual has his Template; a pattern which sets up individual's course and also notes the violation returning the path invalidates. $\delta_{i,j}$ J represents the number of violations for an individual in the position i. The latter enables usto depict the individual, more precisely the genes that are going to endure the mutation.

Hence the general structure of a guided genetic algorithm is summarized in Figure 3:

```
Begin
P ←— initial_population
          Evaluate (P)
Update (Template [P])
While (rate <crossover rate) do
Parents ←— Select (P)
Son_pop ←— crossover (Parents)
Update (Template [Son_pop])
Rate ←— rate +1
Mutation (son_pop)
P ←—evolution (P)
End while
End
```

Figure 3. Guided genetic algorithm structure

Distributed Guided Genetic Algorithm

The geographically-distribution of nodes and also the distribution of information are associated with the different modes of transport, nodes, or road traffic. In this context, we have stimulated the notion of the distribution and moreover we have expected to implement the notions of the agents and also the multi- agent system SMA (Zidi *et al.,* 2006) to the guided genetic algorithm. We have selected/settledholonicarchitecture to realize our SMA presented in Figure 4. Each agent in our SMA has its own private unique characteristics and role defined in advance.

- Interface Agent: is the leader agent in our SMA. It checks and verifies every work done by other agents. It also collects the user request and divulges the zone

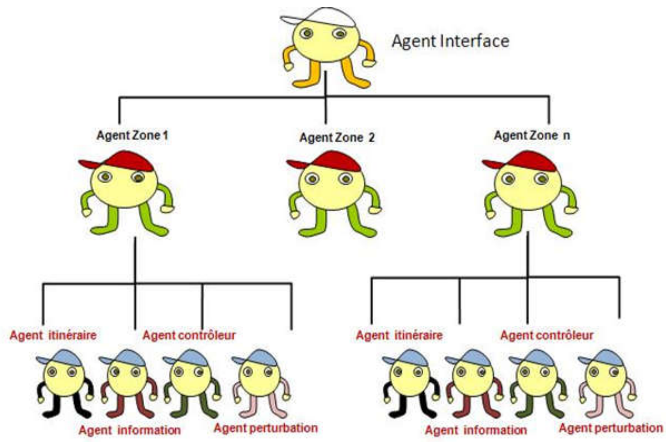


Figure 4. Holonic Architecture

- Zone Agent: Each zone has its responsible agent that calls the itinerary and the controller agents. This agent can communicate with the other agents of the same category as well as the interface agents.
- Itinerary Agent: This agent is responsible for performing the genetic algorithm and finds the optimal path in its zone. This agent creates the information agent which provides him with the information required in order to find the Itinerary.
- Information Agent: is responsible for collecting information concerning the modes of transport and their prices as well as any information modification associated with each mode.
- Control Agent: is an agent whose role is to check/verify or supervise/monitor the road network to declare all disturbance kinds of any specific zone.
- Disturbance Agent: is the agent stated by the control agent throughout disturbances. It informs/notifies the Itinerary agent of not using the zone or the failing mode.

The communication between the agents is made /established via messages transmission for further information or also answering a request.

RESULTS

For a better choice of crossover probability and mutation (P_m and P_C), we have tested/tried out the algorithm with varied/diverse probability values. Moreover, the execution of the algorithm is performed/fulfilled/executed/implemented on an initial population of 15 individuals and for 100 iterations. With reference to the obtained values, our algorithm will be executed as probability of crossing and that of mutation are respectively 0.75 and 0.03 in order to guarantee an optimal run time Table 1. We have tested our algorithm on data concerning/in the matter of the Lille road network. The latter contains 4 common transportation modes. These modes are the metro, the bus, the tram, and finally the regional train. The first three models are insured/ensured by Transpole and the last one by the SNCF. We split/divide the network into three zones. Every zone is illustrated by a graph of n stations and m arc. In our simulations, we use (n=78, m=80) for the first zone, (n=92, m=116) for the second and (n=108, m=134) for the third (14) Table 2.

Table 1. Test of probabilities selection

Pc	0.6			0.65			0.7		
Pm	0.01	0.02	0.03	0.01	0.02	0.03	0.01	0.02	0.03
Fop	18	17.5	17.4	17.5	17.3	16.8	15.6	15.1	15.7
Tex	4.2	4	4.1	4.1	3.9	4	3.7	4.2	3.9
Pc	0.75			0.8			0.85		
Pm	0.01	0.02	0.03	0.01	0.02	0.03	0.01	0.02	0.03
Fop	14.8	14.1	14.4	14.7	15.2	15	15.1	15.6	16
Tex	3.5	3.2	3	3.5	3.7	3.9	4.1	4.6	4.8

Table 2. Example solutions

Solution	Number of station	Mode number	Objective Function	Travel time
1	9	1	16	29 min
2	8	2	15	32 min
3	11	2	18	40 min

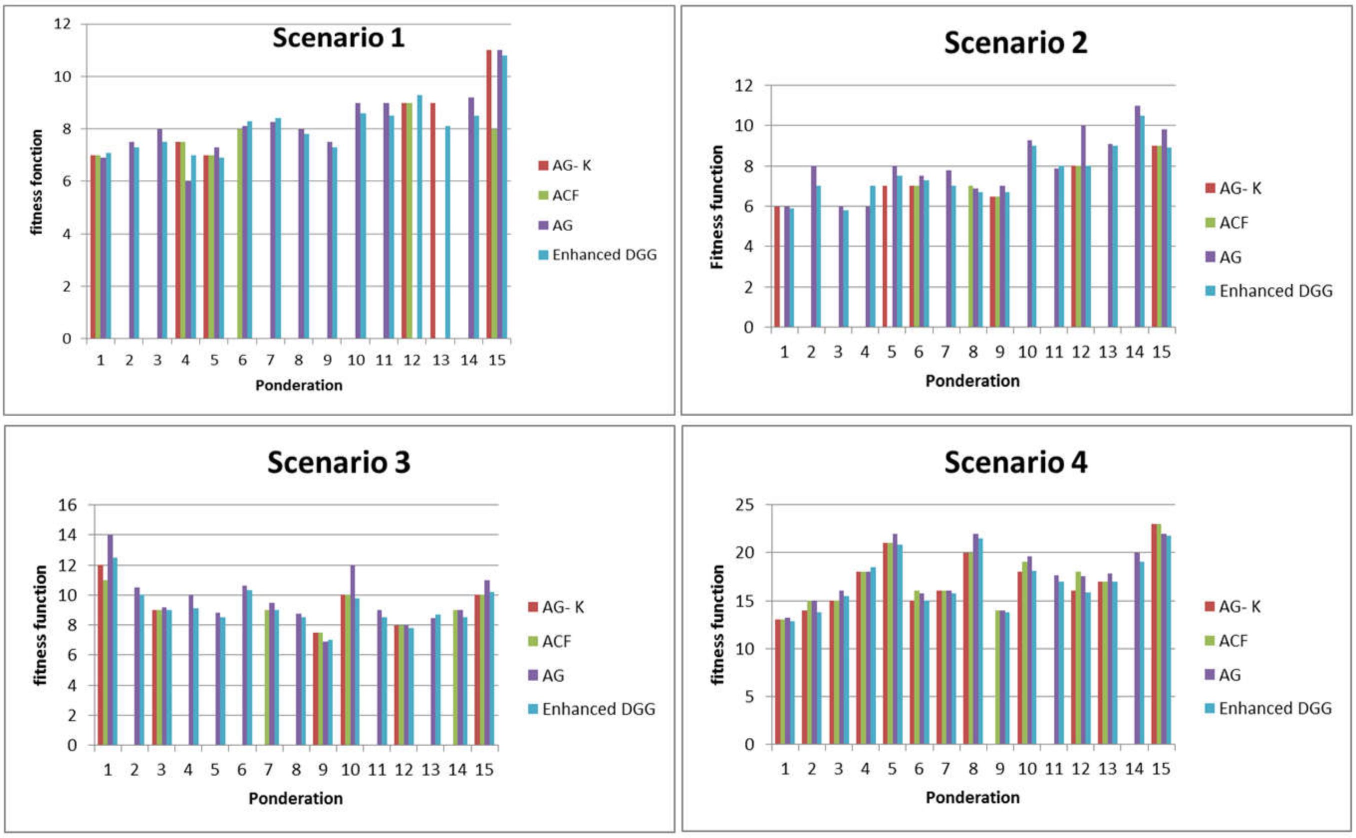
As a means to test the performance/adaptability of the values found by our approach, we have chosen to compare our results with those obtained by Z_KAMEL, Z_SALAH and M_ Najet for the identical usage scenarios with different weightings of the three criteria to be improved/developed.

- Scenario 1: A trouble influencing the services from Catholic Faculty station to station CHR B Calmette.
- scenario2: A disturbance assumed services going of Wazemmes station to Isly station.
- scenario3: A disturbance affecting services from Cormontaigne station at Jaurès station.
- Scénario4: A disturbance affecting services from the station Place of solidarity to the station H Regnault the following Table present our obtained results:

In this article, we have introduced an enhanced distributed, guided genetic algorithm to solve the multimodal transport problems especially in case of disturbance and try to improve the services quality offered to the public transport passenger purpose in the normal case and also in the case of disruption. We have proposed an approach based only on evolutionary algorithms, and more precisely on genetic algorithm. To attain our purpose, we have first applied the guided genetic algorithm.

Then, we have boost certain modifications on the template and on the mutation operator and we did hybridization between random selection and elitism. The hybridization gives us a better exploration of the search space and different diversifying solutions both in in normal cases and disrupted ones. Using the zone concept for transport networks modeling makes us distribute our approach through the use of Multi-Agent System (SMA). The distribution favors us to diminish the time of answering. For each distribution of calculation, each itinerary agent calculates the sub path in its zone. It also undertakes the property and also the reliability of information. We have applied the genetic algorithm developed/acquired/generated on the different executions scenarios. In order to evaluate our approach, we have compared the obtained results with the other ones. Furthermore, this assessment gives us various ideas concerning the improvements that can be done afterwards. In this research, we were adequately able to identify perspectives for future work like diversity improvements (modes and spaces) and distribution of the genetic algorithm itself.

Table 3. Results



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