Generation of customized tourist routes using AI Planning

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Abstract

In this article we consider the problem of generating personalized tourist routes. Considering a set of preferences, a tourist can get a guide of places to visit in a particular tourist spot. These preferences are regarding the time available to make your journey by visiting various points of interest or money that you want and / or can spend. The problem of generating personalized routes can be expressed as a problem of Artificial Intelligence Planning. For this, we designed a model based on the planning domain definition language PDDL 2.1(Fox, 2003). A set of test instances was generated and the planning algorithm LPG-td was used to obtain solutions from the planning model. Considering the results of the experimentation, it is possible to generate these tourist routes according to the preferences established by the user in a reasonable computing time. The resolution of this problem is expected to help tourists to plan their trips.

Planning, Artificial Intelligence, PDDL, Routes, Tourism

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Introduction

In this work an application of the Artificial Intelligence Planning is presented in the design of a personalized tour. To generate these routes, the points of greatest interest or with the highest degree of recommendation for tourists are evaluated. In addition to the above, the preferences of the tourist regarding to the time or money available are considered.

To solve the problem of generating personalized tours, we designed a planning model in the PDDL2.1 planning domain definition language (Fox, 2003). In the instance of the problem capture the public transport network that connects all the tourist points considered, as well as displacement (walking), the transition functions that arise in the generation of the plan, as well as the travel time metrics, visit time and economic costs.

To personalize the route, in addition to offering the tourist points to visit, the tourist is offered to restrict their plan according to the available time and the economic cost destined for their stay. The tourist has as options to minimize the duration of the trip or to minimize the cost.

To solve the developed planning model, the LPG-td planning algorithm was used (Gerevini, 2003).

Justification

At present there is a great mobility of people who visit different places to their place of origin. Some of the reasons are the connectivity and the reduction of the transfer costs. Therefore, the application of this work would help a lot of tourists, to be able to optimize their trips. The plan obtained according to your preferences can serve as a guide to visit the characteristic places of the place you are visiting and know how to move between these places.

In Figure 1 you can see the growing trend of the number of tourists. In this case, represented by the federative entity of the Mexican Republic (SECTUR, DATATUR, 2017).

According to the data presented in the Economist, the country is in eighth place as the most visited country by foreigners worldwide. (SECTUR, 2017).

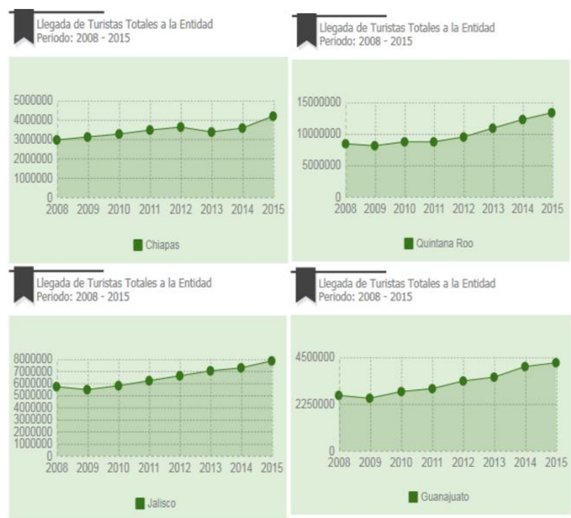

Figure 1 Graphs by federal entity of the Mexican Republic of arrival of foreign tourists, Secretary of Tourism (SECTUR, DATATUR, 2017).

Problem

When a tourist wants to plan his trip to a certain city, the first thing he asks himself is: Which places to visit? In what order to visit the selected places? In addition to the above, you have to consider two important factors: the financial issue and the available time to complete your tour.

What we propose in this article is the use of Artificial Intelligence Planning (AI) models that automatically generate tourist itinerary plans that are personalized to tourists. This personalization is with respect to the factors mentioned before.

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These factors are metrics that can be used as constraints or as variables to optimize when obtaining a plan of the route that can be carried out. The use of public transportation is considered to be able to travel to the different tourist points.

This problem is formally described below.

Problem definition

The network of tourist points consists of a graph where the nodes correspond to locations that may or may not contain a place of interest to visit, the arcs define the transportation means to go from one place to another. These arcs have a cost to be used (transfer time). The problem is to travel from one origin to a set of destinations, considering the use of public transport and a set of preferences that we will call metrics.

This tourism network V is a 6-tuple:

$$RT =< V, E, T, Z, O, A, W >$$

V:It is the total set of network locations.

E: It is the set of arcs that connect two locations of the network. An arc represents a segment of the network where you can go walking or on public transportation.

v: It is the set of tourist sites. Each site $t \in T$ is located at some geographical point $v \in V$. The mapping $r: T \rightarrow V$ defines the location of the touristc place.

z: Set of existing transportation lines in the network.

o: It is the set of transportation means within the network. Each transport action o∈O is described as a 3-tuple or = <z, u, v>, where z∈Z is a transport line and (u, v) ∈V is an arc of the network. Through this representation there are several ways to go from one place to another within the network.

a: Set of actions permissible to the user.

w: Set of metrics of the form w_o: O → R for each transportation in the row, w_a: A → R for each user action a∈A, these can be economic cost and travel time. These includes both the user's movement, as well as entering a site, since some of them usually have an economic cost, and demand a consumption of time.

The planning problem P, is to find a tourist route plan in a public transport network, and is defined as:

$$P =< N, C, i, g >$$

n: It is a public transportation network.

c: It is the set of preferences in the system. These preferences are usually treated as restrictions of the problem that limits the solution found in your search. Currently you have, $C = \{W_{walk}, W_{time}, W_{cost}\}$, where, W_{walk} refers to the maximum time allowed to walk during the journey. For the total travel time we have W_{time}, this is used for when the user has a limited time available and W_{cost} is limiting the economic cost of the plan, this is a cumulative between what was spent for using public transportation and the costs acquired by entering some tourist point.

i: Place of origin of the walk,$i \in V$.

g: Set of objectives to reach is the tourist points to visit, g∈V.

It is worth mentioning that the model allows the user to return to the place where he left.

A solution for an instance of F can be a journey for a day or several, since it is not limited to one day. Plans that use several days may be made.

Then a solution of *P* is a sequence of user actions A and transportation movements of *O* with objective function to minimize a cost without violating any preference.

Hypotesis

Is it possible to generate personalized plans of tourist routes that consider the time and money available to make them?. In addition to the above, using the proposed methodology, which uses planning algorithms to obtain solutions, are the current planning algorithms vast to solve this type of problem?

Objectives

General objective

Apply Artificial Intelligence planning in the development of a model that represents the problem of generating personalized tourist routes. In addition to the above, evaluate the performance of the planning algorithms used to solve the test instances.

Specific objectives

- To determine the topography of the network and what elements make it up.
- Represent the problem in a transition graph.
- Carry out the design of a planning model that represents the problem of generating tourist routes using PDDL2.1 (Fox, 2003).
- Convert the transition graph and the network into a planning domain.
- Perform experimentation to generate the tourist routes considering a proposed site.
- Evaluate the planner used.

Theoretical framework

Planning is the process of searching and articulating a sequence of actions that allow reaching an objective (Russell, 2004). Which is adequate to generate tourist routes, since what is intended is to obtain a set of actions to be carried out that allow me to obtain a plan of the places to visit (objective). The planning uses a language of definition of planning domains called PDDL is a language centered in the actions inspired by the formulations strips of planning problems (Aeronautiques, 1998), this is a standardization of the syntax to express actions using preconditions and post-conditions to describe the applicability and effects of actions (Stuart Jonathan Russell, 2004).

Actions are operators that base their logical descriptions on preconditions and effects, generating complete descriptions of the resulting states after their application. The actions are made up of three parts: name of the action and its list of parameters, preconditions and effects. Preconditions are a conjunction of atoms (positive literals) that says what must be true before the operator can apply; and the effect of an operator is a conjunction of literals (positive or negative) that tells how the situation changes when applying the operator (Stuart Jonathan Russell, 2004).

That is, to be able to apply a certain action it is necessary to comply with a set of preconditions, which are a set of sentences that must be met and, if they are met, the effects of such action will be applied, which are also a set of sentences, which can serve of precondition to other actions. Sentences can be predicates or metrics that form parts of the system. The predicates are those properties of the objects that are of our interest, these are logical statements. The metrics in this planning language are called functions and represent numerical values. It is the relation of an abstract concept to a numerical one.

In order to define the predicates, it is necessary to use objects, which are the elements or particles existing in the model, for example in our problem, tourists and the topography of the network, among others.

A solution in planning is a plan that an agent can execute and guarantees the achievement of the goal. To obtain a solution of the planning models, planning algorithms are used, called planners. A scheduler is a special-purpose algorithm, which uses a formal planning language with well-defined syntax, semantics, and demonstration theory. The theory of the demonstration specifies what can be inferred from the results of the action sequences and, therefore, what the legal plans are. The algorithm allows us to find such plans.

Not all planners use the same solution search method. However, they can be classified with respect to the type of planning models that it solves. For this article we use LPG-td which was the winner in the International Planning Competition and was awarded as the best automated planner in 2003 and later in the IPC 2004.

LPG-td performs local searches greedy randomized. This algorithm has the advantage of obtaining more than one solution found.

Research Methodology

The problem of generating tourist routes is modeled as a problem of Artificial Intelligence Planning. To design the planning model, we use the PDDL2.1 planning domain definition language (Fox, 2003). And then we use the planning algorithms to obtain solutions from these planning models.

Type of Research

This research is an application of Artificial Intelligence, using Planning models for the generation of personalized tours.

Theoretical methods

Modeling of the problem

We have used the planning language to represent the public transportation network of a city, as well as the location of the various points of interest for the tourist. PDDL (Aeronautiques, 1998) is a language centered on actions, for this we have defined a transition diagram for all the actions of the model, with this we aim to facilitate the design of the planning model as well as its translation into the PDDL2.1 language.

This transition diagram describes the conditions necessary to carry out an action, as well as the effects performed once the action has been carried out. This diagram shows the different preferences considered at the time of the calculation of a plan. A similar model can be seen in Elizalde Ramírez, 2017, which was taken as a basis to be used in this problem.

For example to be able to carry out the action Visit, which is the one tells us if to visit a place or not, it is required as previous a condition that the tourist is in the same place that the place to visit. For this, the cost must be less than the defined by the user. In the same way, this is with the total time of the plan at the end of the visit. In this action the economic costs increase and temporary travel, allowing the user to enter the place. This action can be seen in its representation in PDDL in Figure 3.

Actions of the planning model

In the transition model, five actions are shown, which allow the user to generate a travel plan to get from a point of origin to any place of interest, depending on various metrics used, either to optimize or restrict the plan to generate according to available resources, see Figure 2.

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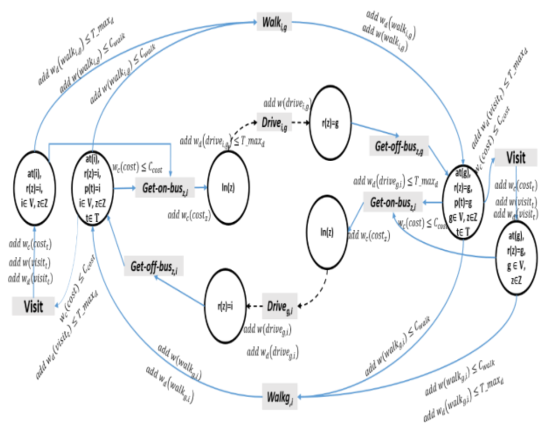

Figure 2 Transition diagram of the tourist routes planning model

```
(:durative-action Visitar
  :parameters(?p - passenger ?l1 - location ?visit - turist)
  :duration(=?duration (time_visit ?visit))
  :condition(and
       (at start(at ?p ?l1))
       (at start(at_visit ?visit ?l1))
       (at start(<(total_cost)(cost_limit)))
       (at end(<=(total_times)(time_travel)))
       )
  :effect(and
       (at end(point_turist ?visit))
       (at end(increase(total_times)(time_visit ?visit)))
       (at end(increase(total_cost)(visit_cost ?visit)))
       (at start(at ?p ?l1))))
)
```

Figure 3 Action Visit in the PDDL2.1 language

In this action, the duration to carry out the action is the necessary time to allocate to the place visited. And to take place, it is required that the user? p and the tourist site? visit be in the same place ?l1 These predicates are expressed as (at ? p ? l) and (at_visit ?visit ?l1).

This ensures that the costs and travel time comply with the rules established by the user. This is reflected in the other two conditions. In the effects of the action it is indicated that a touristic place? visit has already been reached, ((point - tourist ?visit), to prevent it from being visited again. In addition to carrying out an increase in time and in the total cost of the accumulated trip.

The walking action allows the user to move from a source *i* to a destination *g*.

For this, it is required to know the current location of the user and where to move, in addition to no to violate the maximum time limit to walk during the plan established by the user and the available travel time for the entire trip. The generated effect is a change in the geographical position of the user, as well as an increase in the accumulated time traveled. This is represented in PDDL 2.1 in Figure 4.

```
(:durative-action Walk
  :parameters(?p - passenger ?l1 ?l2 - location)
  :duration(=?duration (walking_time ?l1 ?l2))
  :condition(and
      (at start(road ?l1 ?l2))
      (at start(at ?p ?l1))
      (at end(<=(total_walking)(time_limit)))
      (at end(<=(total_times)(time_travel)))
      )
  :effect(and
      (at start(not(at ?p ?l1)))
      (at end(at ?p ?l2))
      (at end(increase(total_walking)(walking_time ?l1 ?l2)))
      (at end(increase(total_times)(walking_time ?l1 ?l2))))
      )
```

Figure 4 Walk action in the PDDL2.1 language

Where (road?l1 ?l2) indicates to which location the user? p can be moved, whose current location is represented by (at? p?l1), the other two conditions are those related to the accumulated time walking and the entire route, which should not violate its limitations. In the effects, it is first indicated that the user is no longer in the same starting location, followed by an update of his current location, after which the temporary metrics already described above are increased.

So far, the modeling of the problem in PDDL only works for a single trip (one day), but this can be extended for several days. Because, when you tend to take a walk, you usually have several days and many places to visit. So the plan is to make tours for days, where each of the objectives is achieved per day, thus giving a better tourist planning.

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In order to extend the model to these instances, the available time per day must be added, and the variables that accumulate the times which now accumulated will be per day must be modified. In the end the plan will snow tours to visit the various sites listed per day. This plan can be seen as in Figure 5 where all the routes leave and return to the same point, this is the place of origin (for example place of lodging), the routes are defined by colors and the nodes are the touristic points.

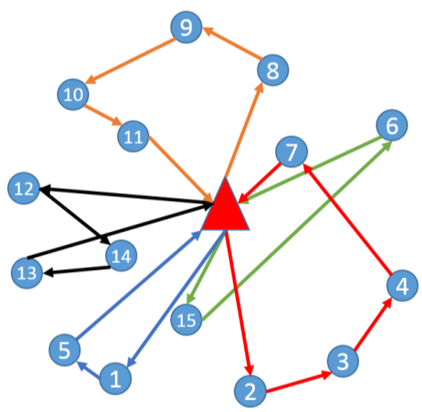

Figure 5 Solution of a tourism problem where several days are considered. Each route is represented by a different color.

As can be seen in Figure 5, the problem considering more than one day to realize the tourist planing has the structure of a typical Vehicle Routing Problem (VRP) (Toth & Vigo, 2014). This entails certain modifications in the model represented in PDDL-2.1, thus affecting the actions described in this article.

```
(:durative-action Walk
   :parameters(?p - passenger ?l1 ?l2 - location)
   :duration(=?duration (walking_time ?l1 ?l2))
   :condition(and
       (at start(road ?l1 ?l2))
       (at start(at ?p ?l1))
       (at end(<=(total_walking ?p)(time_limit ?p)))
       (at end(<=(total_times ?p)(time_travel ?p)))
       )
   :effect(and
       (at start(not(at ?p ?l1)))
       (at end(at ?p ?l2))
       (at end(increase(total_walking ?p)(walking_time ?l1 ?l2)))
       (at end(increase(total_times ?p)(walking_time ?l1 ?l2))))
       )
```

Figure 6 Walk action for a model that makes plans for more than one day.

As you can see in Figure 6, the *Walk* action suffers changes in the functions used for time, either those that accumulate as well as those that limit (restrict). The first ones are modified in the following way: (total-walking?p) and (total-times?p), which unlike what is presented in Figure 4, have been modified so that it is able to find plans where more is required. of a route (one per day) therefore it has been added?p which refers to which day that route belongs, consequently the first function carries the accumulated per day of the plan and the second the available time per day to carry out a tour.

The action "Visitar" also suffers modification in the functions over time, this is seen in Figure 7.

```
(:durative-action Visitar
   :parameters(?p - passenger ?l1 - location ?visit - turist)
   :duration(=?duration (time_visit ?visit))
   :condition(and
       (at start(at ?p ?l1))
       (at start(at_visit ?visit ?l1))
       (at start(<(total_cost)(cost_limit)))
       (at end(<=(total_times ?p)(time_travel ?p)))
       )
   :effect(and
       (at end(point_turist ?visit))
       (at end(increase(total_times ?p)(time_visit ?visit)))
       (at end(increase(total_cost)(visit_cost ?visit)))
       (at start(at ?p ?l1))))
)
```

Figure 7 Action to Visit for more than one day

Software Development Methodology

We translated the network topography to the planning model in PDDL. Defining the actions that are allowed, their preconditions and effects.

We developed a program in ANSI C lenguage to generate automatically the planning models.

A Shell script was used to call the program that generates the planning models, and once having said models, the LPG-td planner (Gerevini, 2003) is called to obtain the solutions. Afterwards, the results are read, that is, the solutions thrown by the planner.

Results

To evaluate our model we have considered the transportation networks of four cities, this information is taken from Google TransitFeed and whose translation to PDDL 2.1 format appears in Elizalde Ramírez, 2017. These networks were randomly included in their locations some points that will serve as sites of interest to the user.

The size of the networks is shown in Table 1. It should be mentioned that not all locations are sites of interest to the user, but can be used as starting points or final destination at the time of finishing visiting the tourist sites.

City	Routes	Locations
Berkshire	7	72
Monroe County	6	285
Berkeley	4	35
IndianReservatio	13	74

Table 1 Copy features of the network.

Between sites, it is possible to arrive walking or using public transportation.

By each city, we tested three diferent configurations that are defined regarding to the number of available touristic points to visit (five, eight and ten).

In addition to these groups, and as has been mentioned, users' preferences are used in this case, the duration of the trip and the permitted walking time, serving as restrictions when wanting to compute a plan. Therefore, there is experimentation only with preference of duration of the plan, another one with the previous preference and the one of time walking, a third group with two days to complete the routes, and finally make the journey in two days and with time Limited duration of the plan and walking.

The duration time of the plan go from ten to twenty hours of availability, and the walking times should not be beyond 50% of the total time of the plan, it is necessary to consider that being a tourist trip, on a considerable part of the routes are walking.

To test our models we use the LPG-td planner (Gerevini, 2003), the results obtained are shown in the Tables [2,3]. The first of them presents the average time for three requests in each of the cases. As you can see the computational time are quite impressive, with the exception of Monroe County limited in both times and with two days of duration of the plan, where no result was obtained, this is due to the large size of the graph, the time available to reach all points of interest.

	Tourist Points	A	B	C	D
Berkshire	5	2.7	2.6	11.7	2.5
Monroe country	8	2.6	6.4	43.7	32.3
Berkeley	10	26.5	36.8	255.0	91.1
Indian Reservation	5	355.6	433.1	30.4	98.7
Berkshire	8	175.5	305.0	20.8	79.1
Monroe country	10	478.3	265.8	671.7	***
Berkeley	5	1.1	10.2	25.7	10.5
Berkshire	8	2.6	14.9	12.6	96.5
	10	1.7	9.6	9.0	72.0
Monroe country	5	426.9	693.3	11.4	298.5
	8	134.1	140.1	45.8	82.7
	10	433.9	172.5	13.6	398.9

Table 2 Processing time to find a plan *.

In the tables shown capital letters are used in the columns, these are interpreted as follows: **A** model without restriction of time walking, **B** model with restriction of time walking, **C** model with two days available, finally **D** model with restriction of time to walk per day, you have two days. For each of the models, the duration of the plan is restricted.

The Table 3 shows the quality in the tourist plan, where the aim is to minimize the duration of the trip (expressed in hours). The obtained results are quite reasonable to realize the tour in each case, except in the case of Monroe Contry.

	Tourist Points	A	B	C	D
Berkshire	5	2.6	2.4	1.5	2.6
Monroe country	8	4.8	3.2	3.2	4.4
Berkeley	10	4.6	3.2	3.7	3.9
Indian Reservation	5	14.4	12.4	12.7	10.3
Berkshire	8	18.4	13.8	21.6	13.7
Monroe country	10	17.7	16.4	21.5	***
Berkeley	5	6.8	5.3	5.5	4.8
Berkshire	8	8.0	5.0	5.4	4.6
	10	7.7	6.5	6.3	4.9
Monroe country	5	10.1	8.1	13.0	7.5
	8	12.3	10.8	8.9	10.9
	10	16.6	63.2	16.2	15.0

Table 3 Travel time, *.

One of the things observed in the experimentation that when touring and considering that much of the time is spent walking, the restriction on this variable is loose, which helps to solve these problems quickly, in addition the algorithm gives priority to make use of this action because it saves number of steps in the generated plan, but this is up to a certain point not so good, since the times are greater than if a means of transport were used, since when to optimize the time we would expect more the use of the action drive, which is the transfer in public transport.

Then, when the action is left open, walking without restriction can lead to the whole walking journey, for this purpose, it is recommended even if the user does not indicate it, to make use of restrictions in the time walking, with an approximate of 50% of the total time of plan travel.

Conclusions

The problem can be modeled satisfactorily using Artificial Intelligence planning techniques.

On the other hand, regarding to the selected planner to obtain solutions, LPG-td, it is observed that it can solve the planning models without problem.

One of the limitations that show the plans thrown by the planner is that it uses the action of walking a lot. This means that tourists will walk a lot on their tourist route. Which could be annoying for some tourists. As future work, you can adjust the parameter that restricts the action of walking in case the user does not enter it directly.

Talking about this action of walking, being a loose restriction in practical cases, it helps to scale between the sizes of the network and in the number of sites of interest. Then we can say that our proposal is applicable to the resolution of this type of problems.

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As part of the future work is to test with larger networks and in certain tourist sites with networks of these real sites. As well as the inclusion of sites such as restaurants, cinemas, etc.

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