Artificial Intelligence Project Proposal
DYNAMIC PATIENT ADMISSION SCHEDULING PROBLEM
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I - Context and Motivations:

a) Description of the problem

The dynamic patient admission scheduling problem is about assigning people arriving to a hospital to the good bed. Indeed, it is a very complex problem to manage the patient in a hospital, they all have different diseases, they needs different treatment, some of them need emergency cares, other have to stay many days, etc... But the hospital has only limited resources, such as rooms, beds, medical equipment, doctors, nurses. So, this problem is about finding the best way of assigning the best resources to the different patients arriving.

b) Motivations for resolving this problem

The motivations are very clear and important, it's very hard to manage a hospital and all its resources, but it's necessary because a lot of lives are engaged in this process. Indeed, sometimes a bad organization in a hospital cans provoke indirectly the death of a lot of people in long term. Moreover, it is a very complex problem that has to be resolve very quickly, and it could be impossible to do it for thousands of patients without using a good algorithm.
We can also think about big natural disaster like the 2004 tsunami, where a lot of hospitals were destroyed, and the number of patients with big surgery needs increased by millions. In that kind of disaster management is the most crucial element to save thousands of lives, and having this powerful algorithm implemented can change everything.
The reason why we want to work on this problem for our project is the fact that actual algorithms are not really adapted. Lots of algorithms were invented, but most of them are slow whereas solving time is an important criterion. Furthermore, a big problem is the fact that they take in consideration only the patients admitted the previous day. Nevertheless, emergency cases that have to be solved in few hours are frequent, especially for natural disaster, so that is a big issue. Another problem is the fact that sometimes there is a big imbalance for the affected resources. For example, with some algorithm it could happen that one doctor has to work 90 hours a week, while another one has to work only 10 hours. The last problem is the fact that some algorithm are not considering all the parameters, for example sometime it's impossible for the patient to choose the day when he want to go to the hospital.

c) Our goal

The goal of our project is to compare the different algorithms that have been implemented, and then try to make a new one that can answer to the problems exposed previously. In fact, we will see what are the advantages and weakness of the different algorithms and try to see what is impacting them. Like this, we will try to make our own algorithm, able to deal with the different issues like the performance, the ability of considering the patient arriving right now, or a better repartition of the use of the resources.

Work Done

1. A work was done by Hans et al. ,wherein he proposed an algorithm which not only assigns elective patients to operating systems,optimizes the operating threatre utilization and minimizes the total time taken by an operation(Though perfection is quite vital as it is a question of life and dead.). Local and constructive heuristics are applied to solve the problem.

2. The work was done is scheduling patients who needs to be treated by a psychotherapist.We maintain certain data structures such as list of psychotherapists,list of patients over a weekend.The algorithm proposed by Oguluta ,selects a patient from the list,and schedules him/her to a day of the week, keeping in mind the priority and duration involved for treatment.They are scheduled in such a manner that the workload of the physiotherapists is equally balanced. Patients' preferences concerning the day of the week for treatment are not taken into consideration. Ogulata et al. solve the problem using themathematical programming tools GAMS and MPL.

3. Another algorithm proposed by Marinagi,looks to maximise the examination time of a patient and the maximum utilization of the hospital's resources.The problem is solved by a combination of agents ,a hierarchical planner which supports the decomposition of complex tests into smaller parts and a scheduler. Subject to the different actions that need to be executed, which is the result obtained by the planner, the scheduler tries to assign the actions to appropriate timeslots.

4. Harper and Shahani [14] describe a simulation model in which bed occupancy and patients' refusals can be calculated, taking into account different what-if scenarios.

5. Akcali et al. describe a network ?ow approach that assists in determining he optimal bed capacity in hospitals. It takes into account the hospital budget and the maximum number of days a patient is on the waiting list before being admitted to the hospital.It is however assumed that all the beds in the hospital are identical.

The Precise Description of the Problem.
-The Precise Project Description.
-Constraints,
-Method.

The Precise Description of the Project.

NOTE: This project description is taken partly from https://cs.uwaterloo.ca/~jchampai/papers/7283770962056173435.pdf

1. Patients are denoted Pi,with i = 1,....P,with P ,the total number of Pateints,There are F Female Pateints and M Male Patients,with P = F+M.Pateints have the following Properties :

- an admission date ADi,with ADi in 1,...,T-1,and a discharge date DDi,with DDi in 2,......,T and ADi < DDi.
- an age Ai and a gender Gi.
- a treatment, which corresponds to a specialism Sl and
- a room preference RPrefw.

2. Nights are denoted Nk , with k varies from 1;...;T, with T the number of nights in the planning period of the time horizon.

3. Departments are denoted as Dm, with m varies from 1;...;D, with D the number of departments. Departments can support one or more specialisms Sl , with l varies 1;...;S, with S the total number of specialisms. A department Dm can enforce that assigned patients have a speci?c age.

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5.The jth room of the hospital is denoted Rj, with j varies from 1;...;R, with Rthe number of rooms in the hospital. A room Rj can have one or more room properties and a gender. According to the specialisms that are supported in the department, rooms can support in some degree different specialisms.

6.The b th bed of room Rj is denoted Bjb, with b varies from 1;...;Bj, with Bj the number of beds in roomRj . The capacity (number of occupied beds) of the room Rj at night Nk is denoted bjk.

7.The transfer of patient Pi from room Rj to another room on timeslot Nk is presented as Ti jk.

The Constraints

NOTE: The constraints are taken partly from https://cs.uwaterloo.ca/~jchampai/papers/7283770962056173435.pdf

There are some constraints we would like to satisfy at any cost so that one could have feasible solution,these are known as Hard Constraints and if this feasible solution satisfies many Soft Constraints ,then the method is better.

Hard Constraints.

- "During the considered planning phase ,The room Rj has to remain free,because pateints has to be assigned the bed." (Taken from http://satt.diegm.uniud.it/uploads/Papers/CeSc11.pdf)

- As opposed to some algorithms ,admission date and discharge date cannot be changed by some model,it could only be adapted by some doctor.

- For each admission of a patient Pi the length-of-stay is contiguous.

- Two patients Pi1 and Pi2 (i1 not equal i2) cannot be assigned to the same bed Bjb in the same time slot Nk.

- Male and female pateints should be assigned different rooms and Pateints Pi should be assigned to departments considering their Ages Ai.

- The medical treatment of a patient Pi may require that he/she is assigned to a room Rj with special equipment. These room properties are mandatory for the treatment.

- " Some patients Pi have to be assigned to a single room Rj for medical reasons".

Soft Constraints.

Here we are not mentioning the soft constraints,because these soft constraints will make the algorithm better,we havn't fixed them as we have to test many such constraints,though some of them can be found from https://cs.uwaterloo.ca~jchampai/papers/7283770962056173435.pdf.

Method.

1. The first step is Integer Programming.The model takes into account the most common case in which the gender of the first patient determines the gender of the room,So,we have no scope for both gender having the same room.But we will incorporate war situation,in which often we have to relax certain constraints,and have to accomdate both.

2. As a matter of fact we will define a function Penalty which shall hold the penalty incurred when a pateint j is assigned to room k.This penalty is based on the number of times we violate the soft constraints.The objective of the algorithm is to decrease the penalty incurred,hence we define a objective function.

3. So if a pateint is staying,he has to have a room assigned to it and that the number of pateints in the room should not be larger than the number of beds.We will check all this by just keeping a variable and compare it with the maximum eachtime a pateint is assigned to a room.
NOTE: However, the integer program did not ?nd a feasible solution within 1 h of calculation.

Hence ,we will look into the TABU method.THis method uses neighbourhood search method to build on a solution.

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```
s = s0
  sBest = s
  tabuList = null
  while (not stoppingCondition())
     candidateList = null
     for(sCandidate in sNeighborhood)
          if(not containsTabuElements(sCandidate, tabuList)
               candidateList = candidateList + sCandidate
          end
     end
     sCandidate = LocateBestCandidate(candidateList)
     if(fitness(sCandidate) > fitness(sBest))
          tabuList = featureDifferences(sCandidate, sBest)
          sBest = sCandidate
          while(size(tabuList) > maxTabuListSize)
               ExpireFeatures(tabuList)
          end
     end
```

NOTE :This algorithm is taken from
http://en.wikipedia.org/wiki/Tabu_search

1. We shall find a suitable representation of the solution.

2. The neighbourhood's which describe the solutions that can be reached from a solution by a single move.

3.The cost function measuring the quality of the solution.

The algorithm stores the store the previous moves that were made from one solution to another.There is this problem of local optima and global optima,we shall prevent local optima using this memory of previously stored moves.
When a better solution is found the tabu list length is decreased, while in the other case the tabu list in increased in order to escape from the local minimum.

NOTE : Tabu search http://en.wikipedia.org/wiki/Tabu_search

"The Tabu Search Algorithm is extended by a token Ring Search.In a token ring search ,neighbourhoods are switched after a certain number of moves,when the solution doesn't get better.. When the maximum number of non-improving moves is reached in the ?nal neighbourhood, the algorithm applies the ?rst neighbourhood again.The algorithm introduces randomness in the search. Small parts of the solution, in this case individual patients are randomly selected and moved. Randomness is furthermore inherently present in the algorithm itself. The quality of a solution may be equal for two possible moves in the same iteration. In this case the tabu search algorithm randomly selects one of the equal moves." (This paragraph is taken from http://satt.diegm.uniud.it/uploads/Papers/CeSc11.pdf)

NOTE: This is algorithm finds an optimal solution keeping in mind the hard constraints.We may have to modify this method to include cases like war , famine when the general working has to be modified and the general notion of optimality is changed because of lots of people to accomodate . The hospitals has to be ready for every kind of situations.

CODE.

Their is a code online : http://satt.diegm.uniud.it/gitweb-public/PASU.git/blob_plain/HEAD:/PASU/validator.cc
Obviously ,this code would have to change to accomodate for our version of Soft constraints.

DATASET.

The Dataset can be found here:
http://allserv.kahosl.be/~peter/pas/

References

1. http://www.sciencedirect.com/science/article/pii/S0933365712001169
2. http://satt.diegm.uniud.it/uploads/Papers/CeSc11.pdf
3. https://cs.uwaterloo.ca/~jchampai/papers/7283770962056173435.pdf