Using machine-generated soft constraints for roster problems

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Abstract. When working the worker follows the roster. It is necessary to make the roster filling the constraint. A peculiar shift pattern to the worker exists from the experience of the past. ILP is convenient to generate the pattern. In this research, the shift pattern is generated from worker's past roster by using ILP. The obtained pattern is applied as soft constraint. The feature of the shift of the office can be extracted by using ILP. Therefore, the shift schedule based on the experience can be made by considering a past shift.

Keywords: roster, shift pattern, soft constraint, constraint logic programming.

1 Introduction

The worker who is working in a certain office follows the roster made by the manager. The method of making the roster uses a special system, and assigns the shift voluntarily without contradiction according to circumstances by manual .Moreover, for the assignment of the shift there is a constraint in worker's working hours, a day of the week, and the ability, etc. It is necessary to assign it as much as possible within the range of the constraint.

In the work shift schedule, a particular shift pattern to worker exists from the experience of the past. For instance if a certain worker always become the shift on Friday and Saturday is a rest, it becomes one shift patterns.

As the method of solving of the roster, there is method like the linear programming, the genetic algorithm, and constraint logic programming, etc. CLP is paid to attention as a technique for solving the shift assignment problem.

Inductive logic programming (ILP) is used in the field of the machine learning to look for the common pattern from a large amount of data, and to lead the rule. In this research, the roster is made by using CLP. ILP can be found based on the induction inference. In that case, the shift pattern is including inferred by using ILP. The shift pattern based on the experience of the past is generated. The shift pattern means the

feature of the shift of the office. Therefore, the feature of the shift of the office can be extracted by using ILP. Section 2 gives constraint logic programming. Section 3 gives proposal method. In Section 4, implement in this research. In Section 5, conclusion and future work in this search are given.

2 Constraint logic programming

Constraint logic programming (CLP) is the programming language that builds the constraint programming to aim at the constraint solution into a logic programming such as Prolog. When it starts solving the problem like the production plan method, the problem can be solved only by the declaring the objective function and the constraint type.

3 Proposal method

3.1 Algorithm of in this research

We need training data to generate the shift pattern using ILP. The roster for training data is made by the algorithm like Figure 1.This is the same as method in a past constraint logic programming. There are two kinds of constraints. The hard constraint is a constraint that should be filled. On the other hand, soft constraint is a constraint that should be filled as much as possible. It searches for the solution to which the soft constraint violation is minimized.

The training data is inferred, and shift pattern is generated. The obtained shift pattern is given as a soft constraint. After shift pattern is made, the roster is executed by algorithm like Figure 2.

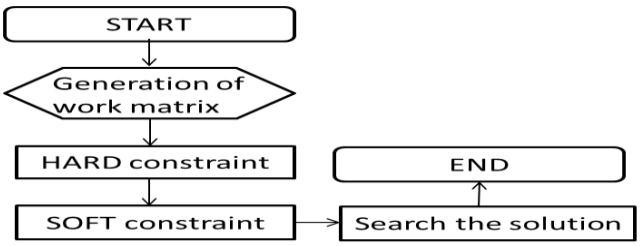

Fig. 1. Algorithm to make roster in the past

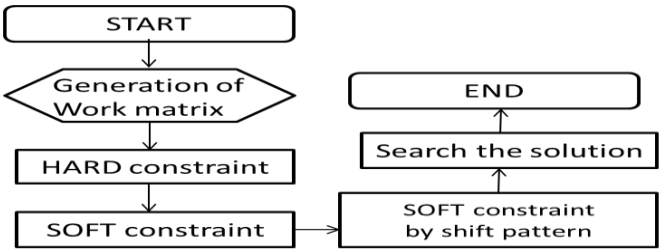

Fig. 2. Algorithm to make roster based on shift pattern

3.2 Generation of shift pattern

The example (positive example and negative example) with a certain shift of one worker at period t1-t10 is shown like Figure 3. Positive example is the whose number of soft constraint violation of a certain shift data at the period is 0, negative example whose the number of soft constraint violation cost is one or more. Moreover, the background knowledge is a shift of each case each week. A part of the background knowledge is presented as shown in Figure 4. Therefore, shift pattern whose the number of constraint violation is 0 is learning by using ILP. For instance, if the shift pattern was obtained like Figure 5,it means the first Friday takes a rest by night shift and the 1st Saturday and Sunday every week is a rest for period A as for a certain worker. This shift pattern is used as soft constraint.

Positive example	Negative example
+ class(t1).	- class(t2).
+ class(t7).	- class(t3).
+ class(t8).	- class(t4).
+ class(t9).	- class(t5).
+ class(t10).	- class(t6).

Fig. 3. Positive example and negative example

```
week1(t1,5,2,2,2,3,1,1),    1: Day-Off
week2(t1,1,3,3,4,2,5,1),    2:Morning
week3(t1,1,5,4,4,2,1,1),    3: Evening
week4(t1,2,3,4,5,2,4,1),    4:Mid-day
week5(t1,1,2,2,3,4,1,1)     5:Jorker
```

Fig. 4. Parts of background knowledge of examples (Period t1)

```
class(A) :-
week1(A,_,_,_,_,3,1,_),    1: Day-Off
week2(A,_,_,_,_,_,_,_),    2:Morning
week3(A,_,_,_,_,_,_,_),    3: Evening
week4(A,_,_,_,_,_,_,_),    4:Mid-day
week5(A,1,_,_,_,_,_,_)     5:Jorker
```

Fig. 5. Shift pattern obtained by ILP

4 Implement

4.1 Outline of implement

The system in this research is implemented using ECLiPSe5.3 [2] of the Prolog base, and GKS [1] is used as the ILP system.

4.2 Contents of roster

The roster is based on the bench mark program [3]. The roster is made only for one worker. Refer to the appendix for a concrete shift, soft constraints, and hard constraints. The period of the roster is five weeks.

4.3 Contents of Implement

When the shift pattern is generated by using ILP, the training data is needed. The training data is generated by the algorithm like Figure 1 in Section 3. The obtained training data is used as background knowledge. A positive example is made a period whose the number of the soft constraint violations is 0. A negative example is made a period whose the number of the soft constraint violations is one or more. The shift pattern is generated from positive examples, negative examples, and the background

knowledge by using ILP. The obtained shift pattern is used as soft constraint. In a word, it means the algorithm like Figure 2. The roster can be made considering the shift pattern that the worker has by using the algorithm. Therefore, the shift schedule based on the experience can be made by considering a past shift.

4.4 An example

If there is a tendency that certain one worker is a night shift on Friday of the first week, and it is a rest on Saturday, and it is a rest on Monday of the fifth week, the shift pattern like Figure 5 is obtained by using ILP. When this shift pattern is applied to a soft restriction, the roster like Figure 6 is composed. It might be shown that the shift pattern is considered.

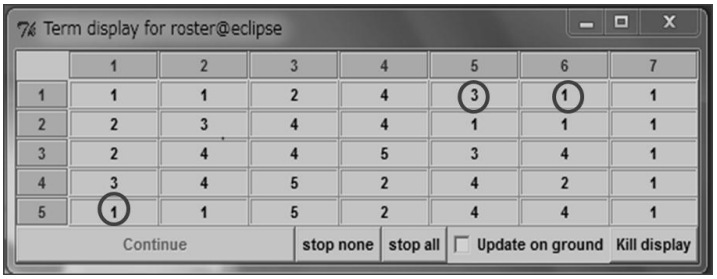

Fig. 6. Roster that considers worker's shift pattern

5 Conclusion and future work

When the roster was made, worker's past shift pattern was inducing inferred by using ILP. The shift based on the experience of the past can be considered by applying the shift pattern to the soft constraint. In addition, the feature of the shift in one worker in the office was able to be found. However, the system in this research has not completed. Because the roster in this research is that only one worker is considered. Therefore, it is necessary to consider the roster composed of multiple workers as a research in the future. If it does so, the particular constraint that the office has without fail can be found. Moreover, the weight putting is done to two or more shift patterns respectively.

References

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Appendix A: The work shift

1. Day-Off. (R)
2. Morning shift. (M)
3. Evening shift. (E)
4. Mid-Day shift. (J)
5. Joker. (K)

Appendix B: The list of hard constraint [4]

1. Each frequency of five shifts is provided each day of weeks, and the total of the frequency is made to become to five.
2. It must be to allocate the rest by at least a day within seven days.
3. Do not put the rest for continuousness four days or more.
4. Do not put the joker for continuousness three days or more.(original constraint)
   It means joker is replenishment for absence.

Appendix C: The list of soft constraint [3] (Initial condition)

1. The Morning shift is not assign as much as possible in the morning after the night shift.
2. The rest can be as continuous as possible. (A continuous the second or three is safe)
3. Joker is not continuously allocated as much as possible on the second.(original constraint)