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## An Improved Happiness-Based Scheduling for Nurse Shifts Planning

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### Abstract

*The nurse shifts scheduling is a multifaceted problem with the extensive number of constraints requirement. There were many researchers addressed and found a high quality scheduling nurse shifts in different aspects and targets, including the lowest cost and the most efficiency. But none of them considered the nurse happiness at all. When the nurses work under unhappy feelings/environment, they are not only distracted from job duties, sometimes they will just quit their jobs and leave. This paper considers the scheduling constraints from both the governmental and hospital policies, and the nurses' feeling in terms of the degree of happiness. A core methodology is developed in this research which consists of the particle swarm optimization (PSO) algorithm to accelerate the generating of the nurses shift schedules and also maximizing the nurse happiness at the same time.*

**Keywords:** Nurses, Shift Scheduling, Happiness, Particle Swarm Optimization

### 1 Introduction

The hospital is a service unit which runs all year-round and 24-hour operation everyday. In addition to the outpatient nurses take care for the sick as the main core duty, they need to take a substantial period of time to get along with patients. The hospital medical management, improved staff morale and productivity have considerable influence on the nurses shift scheduling (Wen, 2008). How to properly manage the nursing manpower arrangement is a major issue. For an adequate manpower supply of services during working hours, the current shift scheduling system as the main arrangement, they should make every certain time interval repeating in a new shift table. A suitable schedules for whether or not the new nurses, on the quality of medical care and other medical services have considerable influence (Lee, 2005). Especially nursing staff is not just a job, but a burden of relating to other people's lives and

safety of nurses not only is the physical exertion, but also the psychological pressure (Liu, 2011). When the accumulation of physical and mental unhappiness and pressure, but can not be properly relieve to cause nurses can not concentrate on work, or even leave. Therefore, the scheduling of the nurses in addition to emphasis on fairness and feasibility, as far as possible to meet the nurses' degree of happiness, construct nurses the highest degree of happiness schedules.

Nurse Scheduling in general hospitals in Taiwan in 24-hour shifts a day divided into three classes eight hours, respectively, for the day shift, evening shift and night shift, some differences in different classes of the nature of work, manpower demand is not the same (Huang et. al., 2009). Must be arranged in accordance with the demand for each shift, to avoid the nurses work excessive burden is too heavy, will have a negative impact on physiological conditions and job preferences (Berrada, Ferland, & Michelon, 1996). Therefore the Nurse Scheduling need to be considered seven factors as fair, reasonable, flexible, humane considerations, etc (Chang and Lee, 1992). And through the unit scheduling, each unit head nurses considering the nurses' personal wishes to schedule. It can improve not only the lack of understanding of the centralized scheduling for nurses demand conditions, and help reduce the self-scheduling to provide high autonomy, easy to increase the difficulty of communication and coordination between the nursing staff, it is both time-consuming and expensive effort.

## 2 Happiness

The word "happiness" of the Chinese people, including the meaning of happy, pleasant, joy, and it symbolizes a person's heart was filled with joy and happy. In the Analects of Confucius, the word "happiness" expresses personal inner pleasant feelings and spiritual enrichment. It's a self-inner feelings (Shan-Hua Bai, 2008). Homer and Herodotus believes that happiness is the human body and mind feel exhilarated. And Allard et al believes that happiness is an emotional joy and happiness, when forward personal emotions than negative emotions will feel happy (Shin & Johnson, 1978).

Happiness is a psychological feeling of self-inner, according to the level of consciousness can be divided into three levels: 1. Competitive happiness: The lowest level of happiness, compared competing with others to get happy, the competitive process is not necessarily happy, even in the final happiness is limited; if the lost, the result is not only unhappy, but pain. It is the worst kind. 2. Conditional happiness: The most common and most easily achieve happiness. People tend to be happy with some of the specific conditions tied together, people will be happy when the conditions are met. 3. Unconditional happiness: True happiness does not come from their own people and things, is derived from the self-bliss, not subject to change due to the interference and influence of external things (Zhou Ye, 2009). Everyone in the pursuit of happiness, in other words the person's life is the target of numerous stacked or chained together (Zhou Ye, 2009). Each person's definition of happiness is different; in this study for the

definition of happiness is a subjective feeling of pleasant personal feelings on their own lives. Freud once said: make up the not enough make people happiness and pleasure (Zi-Fan Ma, 2005). When a person to get what he wants, needs, or goals to achieve satisfactory level, he has sufficient reason that he is happiness. (Simpson, 1975) On the contrary, when the demand cannot be met will feel pain (Zi-Fan Ma, 2005).

Argyle also pointed out that the degree of happiness can be understood as the extent of personal life satisfaction or positive emotional intensity of feelings (Argyle, Jian- Bin Shi, Luo Lu, 1997). Diener also believes that the degree of happiness is a personal assessment of the cognitive experience of own lives (Shan-Hua Bai, 2008). So when the needs and wants of a person's life as much as possible to meet, there will be a happy life (Shin & Johnson, 1978). If a person can do what he wants to do, to get what he needs, he will be glad Therefore, it is a pursuit of happiness behavior, happiness can be obtained through certain events (Dilman, 1982).

Happiness is a feeling. People like a bottle filled with Sense and Sensibility, when put in more rational, emotional lacking something more sensual, so that we have the courage to pursue their full measure of happiness. The ratio to adjust the standard is that our own "three benefits" : Benefit our feeling, benefit our existence, and benefit our lives (Zhou Ye, 2009).。 When beneficial conditions exist, we can feel happy and get happiness. We can through the conditions which would be benefit people are able to do what he wants to do to get what he needs, so that he can be happiness.

### **3 Model construction**

Nurse Scheduling addition to consider the degree of happiness, must also consider the existing restrictions. Nurse Scheduling limits can be classified as administrative law and hospitals, and regulations of the Association, as well as meet particular target or nurses wishes (Berrada, Ferland, & Michelon, 1996). This study refer to the collation Nurse Scheduling restrictions and limitations, and review the limitations of the study. Summarized as follows:

1. In accordance with Article 30 of the Labor Standards Law, the labor daily work can not be more than eight hours, and the bi-weekly work hours should not be more than eighty-four hours.
2. In accordance with Article 34 of the Labor Standards Law, If a rotation system, the work shift should be rotate at least once a week. After the shift has been replaced, should be given appropriate time to rest.
3. In accordance with Article 36 of the Labor Standards Law, Workers should have at least a day as official holiday in every seven days.
4. The minimum limit demand, the number of nurse required to meet the demand of the daily each shift.

5. Continuous scheduling restrictions, each nurse only can arrange one shift, to avoid the night shift followed by the evening shift .
6. Each nurses cannot work continuously for more than six days.
7. The combination of each nurse for three days continuously cannot shift off day, works, off day.
8. Each nurse duty at the night shift cannot take every other day the day shift or evening shift.
9. Each nurse duty at the evening shift cannot take every other day the day shift.
10. Each nurse cannot off day continuously for more than five days.

The purpose of this study is that the maximum degree of happiness pursuit of nurses schedules. Mathematical functions in addition to the inclusion in the above constraints, and joined the nurses measure of the degree of happiness, in the limited solution space to find the optimal solution allows nurses to obtain the maximum degree of happiness.

### 3.1 Parameters

- $i$  index for nurses;  $\forall i = 1, 2, \dots, I$   
 $j$  index for days within the scheduling horizon;  $\forall j = 1, 2, \dots, J$   
 $k$  shift type;  $\forall k = 0, 1, 2, 3$  (off day, day, evening, and night shifts, respectively)  
 $d_{jk}$  demand for nurses of shift type  $k$  on day  $j$   
 $h_{ij}$  happiness for nurse  $i$  on day  $j$

### 3.2 Variables

- nurse  $i$  on day  $j$  for available shift type  $l$  to be assigned  
 $x_{ijk}$   $x_{ijk} = \begin{cases} 1, & \text{if nurse } i \text{ on day } j \text{ for available shift type } k \text{ to be assigned;} \\ 0, & \text{otherwise} \end{cases} \forall k = 0, 1, 2, 3$   
 $A_{ij}$   $A_{ij} = k$ , when  $x_{ijk} = 1 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 2, \dots, J;$   
 $\forall k = 0, 1, 2, 3$   
 $B_{ij}$  the shift type which nurse  $i$  have on the table with happiness on day  $j$ ;  
 $B_{ij} \in 0, 1, 2, 3$  (off day, day, evening, and night shifts, respectively)  
 $L_{ij}$   $L_{ij} = A_{ij} - B_{ij}$   
 $U_{ij}$   $U_{ij} = \begin{cases} 1, & L_{ij} = 0 \\ 0, & L_{ij} \neq 0 \end{cases}$

### 3.3 Mathematical model

The objective of this study is to obtain the greatest happiness of the nurses. The objective function is the sum of all shifts consistent happiness for nurse  $i$  on day  $j$ . That is :

$$\text{Maximize } H = \sum_{i=1}^I \sum_{j=1}^J (U_{ij} \square h_{ij}) \quad (1)$$

s.t

$$\sum_{k=0}^3 x_{ijk} = 1 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 2, \dots, J \quad (2)$$

$$\sum_{i=1}^I \sum_{k=1}^3 x_{ijk} \geq \sum_{k=1}^3 D_{jk} \quad \forall j = 1, 2, \dots, J \quad (3)$$

$$D_{jk} = \sum_{i=1}^I x_{ijk} \quad \forall j = 1, 2, \dots, J; \forall k = 1, 2, 3 \quad (4)$$

$$\sum_j^{j+6} \sum_{k=1}^3 x_{ijk} \leq 6 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 8, 15, 22 \quad (5)$$

$$\sum_j^{j+13} \sum_{k=1}^3 x_{ijk} \leq 10 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 8, 15 \quad (6)$$

$$\sum_j^{j+5} x_{ij0} \leq 5 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 2, \dots, J-5 \quad (7)$$

$$\sum_j^{j+6} \sum_{k=1}^3 x_{ijk} \leq 6 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 2, \dots, J-6 \quad (8)$$

$$x_{ij0} + \sum_{t=1}^3 x_{i(j+1)t} + x_{i(j+2)0} \leq 2 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 2, \dots, J-2 \quad (9)$$

$$x_{ij3} + x_{i(j+1)1} \leq 1 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 2, \dots, J-1 \quad (10)$$

$$x_{ij3} + x_{i(j+1)2} \leq 1 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 2, \dots, J-1 \quad (11)$$

$$x_{ij2} + x_{i(j+1)1} \leq 1 \quad \forall i = 1, 2, \dots, I; \forall j = 1, 2, \dots, J-1 \quad (12)$$

$$x_{ijk}, A_{ij}, B_{ij}, U_{ij} \geq 0; L_{ij} \in Z; x_{ijk}, U_{ij} \in \{0, 1\}; A_{ij}, B_{ij} \in 0, 1, 2, 3 \quad (13)$$

(1) The objective function. (2)~(13)The constraints. (2) The nurses  $i$  only arrange a shifts type  $k$  on day  $j$ . (3) The minimum limit demand, the sum of the nurses arrange shifts type  $k$  on day  $j$  should greater than or equal to the demand. (4) The demand on duty, the sum of the nurses arrange not off day shifts type  $k$  on day  $j$  should greater than or equal to the demand. (5) Minimum weekly days off limit, workers should have at least a day as official holiday in every seven days (6) Minimum bi-weekly days off limit, every two weeks working days must be less than or equal to ten days. (7)Number of consecutive off days shall not exceed five. (8) Consecutive days limit, number of consecutive days shall not exceed six. (9) The combination of each nurse for three days continuously cannot shift off day, works, off day. (10) (11) each nurse duty at the night shift cannot take every other day the day shift or evening shift. (12) Each nurse

duty at the evening shift cannot take every other day the day shift. (13) Description of all variables limit.

### 3.4 Instance validation

In this study mathematical functions use the particle swarm algorithm (PSO) to solve the optimal solution. PSO was published by Kennedy and Eberhart in 1995. By observing nature birds foraging search behavior, they developed the optimized search algorithms. It was applied in various fields for more than ten years. Its biggest advantage is that it only requires a few parameters to adjust, can be used to solve most of the optimization problem. In this algorithm, every possible solution is called particle. Each particle to move in the search space dimension  $D$ , and note the move once the optimal solution here, to convey the message of the particles. Including the location of the particles  $x$  now, acceleration  $v$  and the particles adaptation values, For each generation, each particle updates the acceleration and a new location by using the following equation:

$$v_i(t+1) = w \cdot v_i(t) + c_1 \cdot rand() \cdot [p_i - x_i(t)] + c_2 \cdot rand() \cdot [p_g - x_i(t)] \quad (14)$$

$Rand()$  is a random number between 0-1,  $i$  means the  $i$  particle,  $t$  means the number of iterations,  $w$  means the inertia weight,  $p_i$  means the particle once moved best local solution,  $p_g$  means the particle once moved best global solution,  $c_1$  and  $c_2$  are the learning factors. Calculate the acceleration of a particle, and then update the new location of the particles according to the following formula, and find the optimal solution:

$$x_i(t+1) = x_i(t) + v_i(t+1) \quad (15)$$

PSO step-by-step instructions are as follows:

Step1 : Set parameters.

Step2 : Establish initial solution and randomly generated initialization particle swarm position and speed.

Step3 : Based on the objective function to calculate the fitness values.

Step4 : Compare particles fitness values, if relatively good, updat the location.

Step5 : According to Equation (14), (15), adjustment and update the position and velocity of the particles.

Step6 : Back to the Step3 and calculate the new particle fitness value. Stop searching when the iterations reaches the maximum number of searches.

The goal of this study is to obtain the scheduling with the maximum degree of happiness. Happiness comes from people's own feelings, Through to meet the demand, you can get

pleasure. So through the investigation of nurses demand for the next month, learning how the scheduling arrangement enables nurses to obtain the maximum degree of happiness. For example, the date 4, 5, and 10, 11 for the holidays, No. 2 nurse hope can arrange shift 0 on date 10 and 11. If come true, it can get 90 and 100 degree of happiness.

**Table 1. Happiness table (part).**

No	1	2	3	4	5	6	7	8	9	10	11
				0	0						
1				10	10						
				0	0						
										0	0
2										90	100
3											

Using Table 1 and parameters set into the mathematical functions, and use PSO to find the optimal solution as the following table, nurses can get at least 390 degree of happiness:

**Table 2. Shift table (part).**

NO	1	2	3	4	5	6	7	8	9	10	11
1	0	1	1	0	0	1	1	1	3	3	0
2	3	0	2	2	1	1	1	3	3	0	0
3	0	2	2	0	1	1	1	0	0	2	2

shifts : 0 : off day, 1 : day, 2 : evening, 3 : night.

#### 4. Conclusions

This study constructs a mathematical model to maximize the nurse happiness, and solve it through the PSO. Use computer program to help nurses arrange schedules, solving the maximum degree of happiness schedules. That not only can reduce the time-consuming manual scheduling, but also try to meet the needs of each nurse, to obtain the maximum degree of happiness schedules.

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