Medical Resident Scheduling using Multi-Criteria Optimization Models

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Motivation

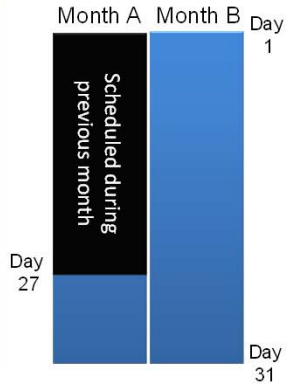
- Every month, the Chief Resident (CR) must determine resident work assignments for the following month.
- These assignments are subject to: 1) Accreditation Council for Graduate Medical Education (ACGME) standards and rules, 2) hospital/program restrictions and 3) resident requests.
- We provide an automated approach to not only validate, but also generate feasible resident schedules using optimization tools.

Background

- The chief resident creates resident schedules, typically by hand.
- Manual scheduling is a laborious process and consumes times that could be spent treating patients.
- The goal of this research is to automatically schedule residents, based on rules/restrictions and evaluating comparable schedules. according to several metrics.

Problem Specific Details

- Residents are scheduled from the 27th of one month to the 31st of the following month. (See diagram to the right)



Resident Types

Type	Pediatrics	Family Practice	Emergency Medicine
Status	Intern & Senior	Intern & Senior	Senior Only

Rules and Restrictions

The ACGME (Accreditation Council for Graduate Medical Education), hospital and the residents themselves impose rules and restrictions on when a particular resident can be scheduled.

1. Intern residents can only work from the 27th of Month A to the 26th of Month B.
2. Senior residents can only work from the 1st of Month B to the last of Month B.
3. A number of shifts are pre-assigned each month to EM Senior staff members.
4. Each resident within that time frame can have a unique start/end day and shift to also recognize transitions to/from the adjacent rotations.
5. Residents may have pre-allocated vacation time and other days-off.
6. Residents may have pre-allocated shifts that must be assigned.
7. Each pediatrics resident has an assigned schedule of continuity clinics (CCs).
8. Interns cannot work the 7am-4pm, 5pm-2am, or 8pm-5am shift.
9. Every shift must have exactly one assigned resident.
10. For the shift pair (7am-4pm and 9am-6pm), (4pm-1am and 5pm-2am) and (8pm-5am and 11pm-8am), at least one resident must be a pediatrics resident.
11. Each resident has a minimum and maximum total number of shifts.
12. No resident can work without a ten hour rest after their most recent shift.

Difficulties in Manual Scheduling

Rules and restrictions interact with each other when scheduling. The following example shows a simple swap between two shifts may cause an infeasible schedule. Thus a feasible schedule is difficult to achieve by hand.

Below is a feasible schedule for two days.

Shift/Day	9-Sep	10-Sep
7a-4p	Br*	JP
9a-6p	AK*	AK*
12p-9p	JP	RG
4p-1a	EMS	BA
5p-2a	Mk	Br
8p-5a	Vad	Vad
11p-8a	San	San

If we only swap two shifts

(*Red indicates PED resident)

It immediately causes two violations.

Shift/Day	9-Sep	10-Sep
7a-4p	Br	JP
9a-6p	AK	AK
12p-9p	Mk	RG
4p-1a	EMS	BA
5p-2a	JP	Br
8p-5a	Vad	Vad
11p-8a	San	San

Violation 1
No PED type resident in this shift pair

Violation 2
Resident JP works without a ten hour rest between shifts

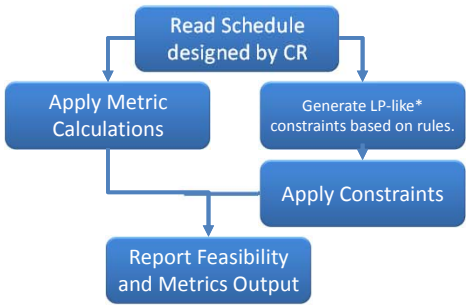
Schedule Metrics

The rules and restrictions often produce several feasible resident assignments. To differentiate such assignments, we employ the following metrics.

- The number of *optional* shifts that are covered.
- The number of potential intern shifts on the 27th of Month B through end of Month B covered and left uncovered.
- The number of shifts per resident, i.e. workload.
- The maximum number of days worked before a day off.
- The number of night shifts that each resident works.

Schedule Validation

We use the following framework to determine schedule validity.



***Constraints in the form**

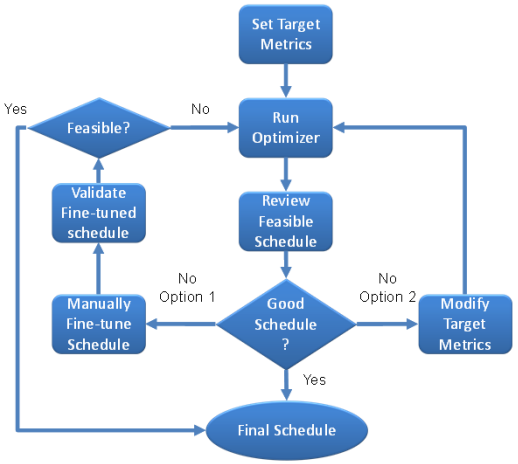
$\sum_{s\in S}\sum_{d\in D} x_{rsd} \geq X \quad \forall r \in R$

$\sum_{s\in S}\sum_{d\in D} x_{rsd} \leq Y \quad \forall r \in R$

Here, s is the set of shifts, *d* the set of days and *r* the set of residents to which this constraint applies, while X and Y are upper and lower bounds.

Schedule Optimization

We implement the following framework to find feasible schedule and provide two options for chief resident to improve the feasible schedule.



To Achieve Better Sleep Pattern

The ten-hour rule only sets up the minimum required rest time for resident physicians. In addition, the sleep pattern is a key metrics to evaluate a schedule. The human body adjusts to certain sleep pattern changes better depending on when the rest takes place. These favorable sleep patterns ensures physicians to have high quality sleep between two shifts and therefore better performance at work and thus better care to patients.

Examples of (Un)desirable Sleep Patterns by Shift Start Time

Gradual shift starting times from morning to evening are undesirable.

Gradual shift starting times from evening to morning are undesirable.

A random pattern is undesirable.

By understanding the desired sleeping patterns, we focus our future work on incorporating such sleep patterns in the optimization framework.

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