Using Linear Programming to Create Monthly Dermatology Resident Schedules
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Question
How can we produce higher-quality schedules in less time while satisfying the various educational and personal requirements of residents?

Problem Statement
Background
The Dermatology Residency Program at the University of Michigan requires each resident to be assigned to two specific activities each weekday, one in the morning and one in the afternoon, within a month-long planning horizon. Each activity must meet staffing requirements, and the residents must adhere to educational requirements.

Traditional Approach
Chief residents typically create monthly schedules by hand. Due to the numerous rules chiefs must abide by, the process of building a feasible schedule typically requires numerous hours to complete, and building a high-quality schedule by hand is nearly impossible.

Feasible Schedule
A valid schedule that meets all of the hard requirements presented by the Dermatology chief residents.

High-Quality Schedule
A schedule requiring a minimal number of undesirable characteristics, such as intra-day travel and shortages of administrative time.

Challenges
• Chief residents spend valuable time creating schedules rather than focusing on patient care.
• Residents are given insufficient administrative time to balance their clinical duties.
• Residents are often required to travel between clinical sites, which wastes time finding parking, and can cause missing lunch.

Research Goals
• Work with chief residents to determine the scheduling rules and quality metrics.
• Formulate a mathematical model, and build a computerized tool which rapidly generates high-quality schedules.

Solution Approach
Formulate mathematical model
Encode in C++ using CPLEX
Load monthly input files
Solve for a high quality schedule
Review schedule and metrics

Decisions
Do we assign resident \( r \) to activity \( a \) on date \( d \) during shift types?

Rules
All of the rules, modeled as constraints, must be satisfied for a schedule to be feasible.

Clinic Staffing Requirements
Resident Assignments
Special Pre-Assignments
Activity Pairing Prohibitions
Resident Prohibitions
Activity Pairing Requirements

Resident Assignments:
\[ \sum_{a \in A} x_{rad} \leq 1 \quad \forall r \in R, d \in D, s \in S \]

Clinic Staffing Requirements:
\[ l(c) - v^c_e \leq \sum_{r \in R} x_{rad}(c)(a)(s) \leq u(c) + v^c_e \quad \forall c \in C \]

Metrics
• After obtaining a feasible schedule, metrics are incorporated to find a high-quality schedule.
• Since optimizing one metric may result in other metrics being suboptimal, chief residents provide input to determine an acceptable balance.

Data Tracking
• The tool enables the chief residents to track metric data on a monthly basis.
• The metric data presented below corresponds to schedules produced for the months of April 2017 through January 2019.

Sample Output
The schedule reports are easier to interpret than the old documentation.

<table>
<thead>
<tr>
<th>Name</th>
<th>Time</th>
<th>3-Sep</th>
<th>4-Sep</th>
<th>5-Sep</th>
<th>6-Sep</th>
<th>7-Sep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resident_0</td>
<td>AM</td>
<td>Holiday</td>
<td>Didactics</td>
<td>Melanoma</td>
<td>Didactics</td>
<td>Continuity</td>
</tr>
<tr>
<td>ME1/ME2</td>
<td>PM</td>
<td>Holiday</td>
<td>Merkel</td>
<td>Continuity</td>
<td>Continuity</td>
<td>Impairment</td>
</tr>
<tr>
<td>Resident_1</td>
<td>AM</td>
<td>Holiday</td>
<td>Didactics</td>
<td>Impairment</td>
<td>Didactics</td>
<td>VA ENT</td>
</tr>
<tr>
<td>VA1/VA1</td>
<td>PM</td>
<td>Holiday</td>
<td>Continuity</td>
<td>VA-PM</td>
<td>TC</td>
<td>VA ENT</td>
</tr>
<tr>
<td>Resident_3</td>
<td>AM</td>
<td>Holiday</td>
<td>Time-Off</td>
<td>Time-Off</td>
<td>Time-Off</td>
<td>Time-Off</td>
</tr>
<tr>
<td>VAST/Clinic</td>
<td>PM</td>
<td>Holiday</td>
<td>Time-Off</td>
<td>Time-Off</td>
<td>Time-Off</td>
<td>Time-Off</td>
</tr>
<tr>
<td>Resident_4</td>
<td>AM</td>
<td>Holiday</td>
<td>Didactics</td>
<td>Continuity</td>
<td>Didactics</td>
<td>TC</td>
</tr>
<tr>
<td>ME2/ME2</td>
<td>PM</td>
<td>Holiday</td>
<td>Merkel</td>
<td>Melanoma</td>
<td>CPU</td>
<td>CPU</td>
</tr>
</tbody>
</table>

Implementation of the computerized tool has allowed for schedules to be produced in significantly less time while satisfying all schedule requirements and improving schedule quality across several metrics.

Discussion
Rapidly-Generated, High-Quality Schedules
Less Time Required By Chief Residents to Create Schedules
Improved Patient Experience

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