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SALSA: Scheduling ALgorithm for Spectroscopic Acquisition

1 Problem modeling

Sets

I	=	set of targets $\{1, \ldots, i_{max}\}$
H	=	Set of time slots to observe $\{1, \ldots, h_{max}\}$
V(i)	=	Set of windows to observe a target $i \in I$ $\{1, \ldots, h_{max} - 2T_i\}$
W(i,v)	=	Set of time slots in window v $\in V$ of target $i \in I$ $\{\text{v}, \ldots, \text{v} + 2T_i - 2\}$

Parameters

a_{ih}	:	Height of target $i \in I$ at time $h \in H$
P_i	:	Priority of observing target $i \in I$
T_i	:	Photometric period of target $i \in I$
sT_i	:	min(5,1/10 of the period of target $i \in I$)

Decision variables

x_{ih} = Observe target $i \in I$ in time slot $h \in H$

Auxiliary variables

$$y_i = \begin{cases} 1 \text{ if target } i \in I \text{ is observed throughout window } v \in V \\ 0 \text{ in any other case} \end{cases}$$

$$z_i = \begin{cases} 1 \text{ if target } i \in I \text{ is observed} \\ 0 \text{ in any other case} \end{cases}$$

Objective function

$$\max \left\{ \sum_{i \in I} \sum_{h \in H} x_{ih}\, a_{ih}\, P_i \right\}$$

Constraints

(1) Observe only one target at a time.

$$\sum_{i \in I} x_{ih} \leqslant 1 \quad \forall\, h \in H$$

(2) Target must be observed when height is above 50 degrees.

$$x_{ih}\,(a_{ih} - 50) \geqslant 0 \quad \forall\, i \in I,\ h \in H$$

(3) Activate observing target (1/2)

$$\sum_{h \in H} x_{ih} \leqslant A\, z_i \quad \forall\, i \in I,\ A \gg 1$$

(4) Activate observing target (2/2)

$$z_i \leqslant \sum_{h \in H} x_{ih} \quad \forall\, i \in I$$

(5) Observe the same target no more than 12 times

$$\sum_{h \in H} x_{ih} \leqslant 12 \quad \forall\, i \in I$$

(6) If a target is observed, it must be throughout a window

$$\sum_{v \in V} y_{iv} \geqslant z_i \quad \forall\, i \in I$$

(7) Observe at least 10 times in the window span

$$\sum_{w \in W(i,v)} x_{iw} \geqslant 10\, y_{iv} \quad \forall\, i \in I,\ v \in V$$

(8) Wait sometime between observations of the same target

$$\sum_{k=h}^{h+sT_i} x_{ik} \leqslant 1 \quad \forall\, i \in I,\ h \in \{1, \ldots, h_{max} - sT_i\}$$

(9) Variable nature

$$x_{ih} \in \{0, 1\} \quad \forall\, i \in I, h \in H$$
$$y_{iv} \in \{0, 1\} \quad \forall\, i \in I, v \in V$$
$$z_i \in \{0, 1\} \quad \forall\, i \in I$$