MATH3202
Assignment 3
Practical Group: P02 (Wednesday 10am)

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Supervisor Report

Stages

Days, $\boldsymbol{t} \in \{0, 1, \ldots, 29\}$

States

The amount of power stored in the battery (MW/h) at the start of day t, $\boldsymbol{s_t}$
The amount of days remaining which can have their chance of high demand reduced, $\boldsymbol{n}$
The demand level of the region on day t, $\mathbf{status_t} \in \{\text{“}Low\text{”}, \text{“}High\text{”}\}$

Action

The amount of power to order on day t, $\boldsymbol{a_t} \in \mathbb{Z}^{\geq 0}$

Data

lowD_t	Normal demand of the remote region on day t for $t = 0, 1, \ldots, 29$ (MWh)
highD_t	High demand of the remote region on day t for $t = 0, 1, \ldots, 29$ (MWh)
batteryCap = 80	Maximum capacity of the battery (MWh)
pHH = 0.5	Probability that on any day, the demand will be high, given the previous day had high demand
pHN = 0.5	Probability that on any day, the demand will be normal, given the previous day had high demand
pNH = 0.2	Probability that on any day, the demand will be high, given the previous day had normal demand
pNN = 0.8	Probability that on any day, the demand will be normal, given the previous day had normal demand
phighL = 0.1	Probability of high demand given that the chance of high demand is reduced on the given day
pnormH= 0.9	Probability of low demand given that the chance of high demand is reduced on the given day

$$cost_{a_t} = \begin{cases} 0 & \text{If the generator is not running on day}\, t \\ 300 + 80 * a_t^{0.9} & \text{If the generator is running on day}\, t \end{cases}$$
Function to return the cost of ordering a_t MWh of power for day t.

$$A_{t,s_t} := \{\max(0, \text{highD}_t - s_t), \text{batteryCap} - s_t + \text{highD}_t\}.$$
Domain of a_t, given s_t, $\forall t \in \{0, \ldots, 29\}$.

Value Function

$V_t(s_t, n, \text{status}_t)$ = The expected minimum total cost of powering the remote region for days $t, \ldots, 29$, given that day t begins the day with s_t power in the battery, the level of demand is given by status_t and there are n days remaining where the chance of high demand can be reduced.

Base cases:

- $V_{30}(s_t, n, \text{status}_t) = 0$

  (We are only interested in costs from June)

- $V_t(s_t, 0, \text{“}Low\text{”}) = \min\limits_{a_t \in A_{t,s_t}} (pNH * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{highD}_t, \text{batteryCap}), n, \text{“}High\text{”})) + pNN * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{lowD}_t, \text{batteryCap}), n, \text{“}Low\text{”})))$

- $V_t(s_t, 0, \text{“}High\text{”}) = \min\limits_{a_t \in A_{t,s_t}} (pHH * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{highD}_t, \text{batteryCap}), n, \text{“}High\text{”})) + pHN * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{lowD}_t, \text{batteryCap}), n, \text{“}Low\text{”})))$

  (When we can no longer request reductions in chance of high demand, we no longer consider the associated probabilities)

We wish to evaluate: $V_0(0,\ 5,\ \text{“}Low\text{”})$

$$V_t(s_t, n, \text{“}High\text{”}) = \min_{a_t \in A_{t,s_t}} \{\min\{X_1, Y_1\}\}$$

Where:

- $X_1 = pHH * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{highD}_t, \text{batteryCap}), n, \text{“}High\text{”})) + pHN * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{lowD}_t, \text{batteryCap}), n, \text{“}Low\text{”}))$

- $Y_1 = \text{phighL} * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{highD}_t, \text{batteryCap}), n-1, \text{“}High\text{”})) + \text{pnormH} * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{lowD}_t, \text{batteryCap}), n-1, \text{“}Low\text{”}))$

$$V_t(s_t, n, \text{“}Low\text{”}) = \min_{a_t \in A_{t,s_t}} (\min(X_2, Y_2))$$

Where:

- $X_2 = pNH * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{highD}_t, \text{batteryCap}), n, \text{“}High\text{”})) + pNN * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{lowD}_t, \text{batteryCap}), n, \text{“}Low\text{”}))$

- $Y_2 = \text{phighL} * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{highD}_t, \text{batteryCap}), n-1, \text{“}High\text{”})) + \text{pnormH} * (cost(a_t) + V_{t+1}(\min(s_t + a_t - \text{lowD}_t, \text{batteryCap}), n-1, \text{“}Low\text{”}))$

Please refer to `ElectrigridSolution.py` for a `Python` implementation of this formulation.