Mandatory Task Approach

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1 Introduction

We approached the mandatory task by using multiple layers of mini models. A moving average is used as the fundamental model.

2 Mini Models

2.1 Moving Average Model

The moving average (MA) model calculates the centered moving average line of the time series. This model takes one parameter n, which is the number of data points back and forth to be considered in the centered moving average. The centered moving average in mathematical terms is,

$$\begin{aligned}\text{CMA}(y_t, n) &= \frac{y_t + \sum_{i=1}^{n} [y_{t-i} + y_{t+1}]}{2n+1} \\ &= \frac{y_t + (y_{t-1} + y_{t-2} + \cdots + y_{t-n}) + (y_{t+1} + y_{t+2} + \cdots + y_{t+n})}{2n+1}\end{aligned}$$

Where y_t represents the spot price at any time t. Hence technically, this average is a $(2n+1)$ simple moving average for y_{t+n}, or the $(2n+1)$ centered moving average for y_t. Since we are using it for time t, this is now a centered moving average.

This moving average model sets the charge period when the price is below the moving average and sets it into discharge period when the price is above the moving average.

2.2 Region Maximisation Model

The region maximisation (RM) model takes a region of consecutive actions and the opening capacity, and returns the most effective way to charge or discharge. We define a 'region of consecutive actions' as time periods where the model recommend consecutive actions.

In the process of filling up market dispatches, we notice that using chronological order to fill dispatches, most of the time, yields inefficient results. This would decrease the total revenue in the final calculation. The RM model solves this by maximising each ROCAs based on their current capacities, action (charge/discharge) and most importantly, the prices. In other words, it allocates the best price points to the most dispatches.

2.3 Loss Removal Model

The loss removal (LR) model looks at transactions between 2 ROCAs and see if there are any matching transactions, where it is actually not profitable to conduct those transactions. This model makes use of the fact that ROCAs are always switching in action by definition. Hence we can compare consecutive ROCAs and find unprofitable transactions.

Due to the MA and RM model, it is almost guaranteed that discharging ROCA's price points are always higher than their proceeding charging ROCA's price points. But due to the efficiency and the Marginal loss factor (MLF) in the revenue calculations, higher alone is not enough.

When charging takes place in a time point t, at C Mwh, the actual increase in capacity is only $D = C \times 0.9$ accounting for efficiency. When dispatching this in the next time point, the maximum possible dispatched amount is $D \times 0.9$ accounting to efficiency. At the end, the revenue from charge C is only obtained from $C \times 0.9^2$. We want to know whether the charging-discharging pairs of points from consecutive ROCAs passes the break-even point or not. If not, we will discard these points.

Let P_c be the charging price, P_d be the discharging price, and R be the revenue. The break-even point is a price combination point, where the revenue will be 0.

$$
\begin{aligned}
R &= DP_d \times 0.991 - CP_c \times \frac{1}{0.991} \\
0 &= 0.9^2 CP_d \times 0.991 - CP_c \times \frac{1}{0.991} \\
0.80271 P_d &= \frac{P_c}{0.991} \\
P_d &= 1.257 P_c
\end{aligned}
$$

Hence to translate this, we want to filter out every charging-discharging pair where the discharging price P_d is less than $1.257P_c$ and keep if otherwise.

2.4 Stationary Maximisation Model

The stationary maximisation (SM) model looks at all the time points where previous models ignores (which we will call stationary points) and ask the question, "Could there be revenue in these time points?". To understand how this model works, we need to know how the revenue calculation works. As stated in 2.2, the revenue becomes $C \times 0.9^2$. Making use of this efficiency fact, let P_c be the theoretical charging price, P_d be the theoretical discharging price and R be the revenue on any time point. If we want to know whether revenue can be obtained from stationary points, we have to calculate the theoretical revenue, given that we know both charge and discharge prices.

$$
\begin{aligned}
R &= DP_d \times 0.991 - CP_c \times \frac{1}{0.991} \\
&= 0.9^2 CP_d \times 0.991 - CP_c \times \frac{1}{0.991} \\
&= (0.80271 P_d - \frac{P_c}{0.991})C
\end{aligned}
$$

Notice that the calculation for revenue is now a scalar multiple of the initial charging dispatch. This means that we can just set $C = 1$ and see if the revenue is positive or not to know whether any other value of $C > 0$ is also profitable. Hence the SM model calculates the theoretical revenue,

$$TR = 0.80271 P_d - \frac{P_c}{0.991}$$

Where $P_c = P_t$ and $P_d = P_{t+1}$, in which t indicates the current time iteration. The model loops for every stationary point t, and assign charging and discharging status respectively at time t and $t + 1$ if the TR at time t is > 0. Because the revenue is a scalar multiple of C, we can maximise the revenue by maximising C, hence the amount of dispatch will be the maximum possible given the current opening capacity at time t.