1. Introduction

- Week-ahead load forecasting: 168 hours for 7 days electrical load forecast after the forecasting point
- Before 2015: not much photovoltaic penetration in South Korea
- Rapid photovoltaic penetration rising since 2016 → different daily load pattern and the change of maximum load occurrence hour due to the weather conditions
- Duck curve phenomenon intensifying → the effect on the base load → the base load generators such as nuclear power plants required to change output power → cannot change generating power within a few hours like daytime
- The importance of week-ahead load forecasting accuracy growing
- A new week-ahead load forecasting method based on CNN proposed → week-ahead load forecasting accuracy improvement

2. Proposed method

- 2-Dimensional Convolutional Neural Network
  - The input data of the 2-dimensional CNN: the plane with respect to a 2-dimensional shape (horizontal, vertical)
  - Each point of the 2-dimensional plane: pixel information of an image
  - Information on the top, bottom, left, and right relationships of the pixel → convolution operation → feature extraction of an image
- 2D CNN and time series data mapping
  - Daily load: closely related to the load of the previous hour and the next hour + similar characteristics to the same day of the previous week → Very similar to each point on the image closely related to the points on the top, bottom, left, and right
  - 3 weeks time-series data → mapped into (168 x 3) 2D CNN structure
- The proposed CNN model
  - 5 channels input layer → Conv2D operation → Flatten layer → Fully connected layer → Output layer (168h electrical load)
  - No pooling ← no low-importance features in time-series data
- Week-ahead load forecasting input and output data structure
  - This structure intended to consider the effect of multiple channels by arranging load, temperature, insolation, predicted temperature, and predicted insolation in different channels
  - Channel 1: the start date information of D-21 and the historic loads of the 3 weeks immediately before
  - Channel 2 to 5: historic temperature, historic insolation, predicted temperature, and predicted insolation data
  - The output values: 168-hour electrical loads
  - The horizontal size is 169, the vertical size is 3 and the kernel size is selected as 2 x 2

3. Performance evaluation

- Input data
  - The actual South Korea load data from KPX (Korea Power eXchange)
  - Meteorological data from KMA (Korea Meteorological Administration)
  - Weighted temperature and insolation by 8 major cities in South Korea
- Temperature and insolation historical data were used instead of temperature and insolation forecasts for performance evaluation
- Performance metric: MAPE (Mean Absolute Percentage Error)

\[
\text{MAPE} = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{\hat{y}_i - y_i}{y_i} \right| \times 100 \%
\]

where, \( n \): number of data, \( y_i \): actual, \( \hat{y}_i \): forecast

2020 week-ahead load forecasting results MAPE

<table>
<thead>
<tr>
<th>Error</th>
<th>D+1</th>
<th>D+2</th>
<th>D+3</th>
<th>D+4</th>
<th>D+5</th>
<th>D+6</th>
<th>D+7</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Load</td>
<td>1.5444</td>
<td>1.7228</td>
<td>1.7799</td>
<td>1.8545</td>
<td>1.9013</td>
<td>1.9738</td>
<td>2.0303</td>
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<td>24th Avg.</td>
<td>1.6986</td>
<td>1.8403</td>
<td>1.9201</td>
<td>2.0031</td>
<td>2.0517</td>
<td>2.1131</td>
<td>2.1980</td>
<td>1.9750</td>
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</table>

2021 week-ahead load forecasting results MAPE

<table>
<thead>
<tr>
<th>Error</th>
<th>D+1</th>
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<th>D+3</th>
<th>D+4</th>
<th>D+5</th>
<th>D+6</th>
<th>D+7</th>
<th>Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Load</td>
<td>1.1798</td>
<td>1.3910</td>
<td>1.5340</td>
<td>1.6083</td>
<td>1.6436</td>
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<tr>
<td>24th Avg.</td>
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<td>1.5525</td>
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<td>1.5841</td>
</tr>
</tbody>
</table>

Week-ahead load forecast results for 2021/11/26-2021/12/02 - the week including weather condition changes (sunny/cloudy/sunny)

- Nov. 30th in D+5 cloudy day: different load pattern from other days
- Dec. 1st in D+6 sunny day: load pattern including the influence of photovoltaic generation unlike D+5 due to clear weather
- Excellent performance even weather condition changes
- The 168-hour MAPE for this period: 1.2477[%]

4. Conclusion

- A week-ahead load forecasting based on 2D CNN is proposed.
- In order to reflect the characteristics of week-ahead load, a new method is proposed by mapping hourly load and weather data to each channel of 2-dimensional CNN structure.
- The effect of photovoltaic generation is appropriately reflected even in the interval between sunny and cloudy weather.
- The proposed week-ahead load forecasting MAPE for 2020 is 1.9750[%], and the MAPE for 2021 is 1.5841[%].

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