AI and cloud computing developments towards integrating renewables

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Graph Neural Networks

Deep learning method designed for inference on graph data.

Neural networks applied directly to graphs for making predictions at nodes, edges, or globally.

GNNs for Electricity Distribution Systems

GNN – Modeling & Deployment

Modeling

Nodes: Voltage by phase + features (incl. 24, 36, 48 hr lags), temperature, solar irradiance

Edges: message passing between (encoded) state vector at neighboring nodes

Endcoding, decoding and message passing implemented as feed forward neural networks.

Deployment

Electricity authority of Cyprus

28 Prosumers

25 feeder heads

15 Substations
Fig. 6. Probabilistic voltage magnitude prediction at one of the prosumers. The shaded area is the 95.4% confidence interval (2 standard deviations) around the predicted mean.

GNN – Results

<table>
<thead>
<tr>
<th>Model</th>
<th># Layers</th>
<th># MP</th>
<th># Params</th>
<th>MAPE</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GNN</td>
<td>2</td>
<td>5</td>
<td>143,464</td>
<td>0.81%</td>
<td>2.42</td>
</tr>
<tr>
<td>GNN</td>
<td>3</td>
<td>5</td>
<td>169,144</td>
<td>0.82%</td>
<td>2.45</td>
</tr>
<tr>
<td>GNN</td>
<td>2</td>
<td>8</td>
<td>142,832</td>
<td>0.80%</td>
<td>2.40</td>
</tr>
<tr>
<td>GNN</td>
<td>3</td>
<td>8</td>
<td>169,144</td>
<td>0.81%</td>
<td>2.41</td>
</tr>
<tr>
<td>MLP</td>
<td>2</td>
<td></td>
<td>1,271,440</td>
<td>0.80%</td>
<td>2.40</td>
</tr>
<tr>
<td>MLP</td>
<td>3</td>
<td></td>
<td>2,118,760</td>
<td>0.73%</td>
<td>2.21</td>
</tr>
<tr>
<td>AE</td>
<td>2</td>
<td></td>
<td>2,407,088</td>
<td>0.72%</td>
<td>2.17</td>
</tr>
<tr>
<td>AE</td>
<td>3</td>
<td></td>
<td>3,796,840</td>
<td>0.70%</td>
<td>2.13</td>
</tr>
</tbody>
</table>

**TABLE I**

Summary test results for GNN, MLP and AE models. Number of layers represent encoding/decoding and edge functions in GNNs and AE. MP denotes message-passing steps in GNNs.

Serverless Computing

Cloud-native development model to build and run applications without managing servers.

Cloud provider handles the routine work of provisioning, maintaining, and scaling the server infrastructure.

Developers package code in containers for deployment.

Serverless apps automatically scale up and down.

When a serverless function is sitting idle, it doesn’t cost anything.
Serverless Computing
For time series forecasting

The system solves the problem of creating and tracking 1000s of value-added time series forecasts.

A value-added forecast combines information from internal and/or external sources.
Business Context of Forecasts

• Entity
  • *where* the observations take place
  • examples: company, business unit, store location, substation, etc

• Signal
  • *What* the time series describes
  • examples: revenue, demand, power, etc
Figure 3: Semantic representation of the IoT data.

Source: B Eck et al. Scalable Deployment of AI Time-series Models for IoT. AI for Internet of Things (AI4IoT) Workshop at 28th International Joint Conference on Artificial Intelligence, August 10-16 2019, Macao, China.
Serverless – Some forecasting Scalability experiments

Forecasting system specs

<table>
<thead>
<tr>
<th>System Task</th>
<th>CPUs</th>
<th>RAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast Model</td>
<td>2</td>
<td>2 GB</td>
</tr>
<tr>
<td>(GAM: wx + lags +calendar)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time series DB</td>
<td>1</td>
<td>4 GB</td>
</tr>
<tr>
<td>Graph DB</td>
<td>1</td>
<td>0.5 GB</td>
</tr>
</tbody>
</table>

Scaling of Forecast Model Task

<table>
<thead>
<tr>
<th>Parallel Jobs</th>
<th># Jobs / hour</th>
<th>Avg. Job Duration [s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>5,600</td>
<td>6.4</td>
</tr>
<tr>
<td>50</td>
<td>18,900</td>
<td>9.5</td>
</tr>
<tr>
<td>100</td>
<td>22,300</td>
<td>16.1</td>
</tr>
<tr>
<td>150</td>
<td>26,900</td>
<td>20.1</td>
</tr>
<tr>
<td>175</td>
<td>27,600</td>
<td>22.8</td>
</tr>
<tr>
<td>200</td>
<td>26,700</td>
<td>27.0</td>
</tr>
</tbody>
</table>

Source: B Eck et al. Scalable Deployment of AI Time-series Models for IoT. AI for Internet of Things (AI4IoT) Workshop at 28th International Joint Conference on Artificial Intelligence, August 10-16 2019, Macao, China.
Integrating Renewables

https://doi.org/10.1145/3538637.3538865

Active prosumers 500
Number of FlexOffers generated 100000
Number of FlexOffers activated 6000
Flexibility offered (MWh) 800
Flexibility activated (MWh) 30
Safe increase in installed capacity with respect to existing renewable capacity 20-59%
Adaptability with respect to peak demand 5-64%

Table 4: Demo sites stats for a typical month.
Current Directions

AI model monitoring for distribution shift and performance changes
- Supply Chain forecasts
- IoT driven forecasts
- Image Classification for manufacturing

Knowledge graphs for scaling and automating AI over 1000s of physical assets
Acknowledgments & References

GNNs
Sanchez-Lengeling, et al., "A Gentle Introduction to Graph Neural Networks", Distill, 2021

Francesco Fusco, Bradley Eck, Robert Gormally, Mark Purcell, and Seshu Tirupathi (2020) Knowledge- and Data-driven Services for Energy Systems using Graph Neural Networks. IEEE Big Data 2020

Serverless

GOFLEX

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IBM Research Europe – Dublin
Open to Collaboration

• Horizon Europe research projects

• Irish research and innovation projects

• Research internships for 2023 are open