Employing Deep Learning for Real-Time Sewage Level Prediction within Smart Cities

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Newcastle upon Tyne as a Smart City

Newcastle named as one of the top smart cities in the UK

Written by Valentino Konusar on 11th December 2017

More in Community:

MP Sharon Hodgson calls for metro link to Washington
15th March 2019

Newcastle is the second fastest growing region for digital and technology employment and has been ranked as one of the top smart cities in the UK.

Commissioned by Huawei UK and conducted by Navigant Consulting, the report is based on evaluations of 20 cities and their strategies, key projects and overall readiness in using
Traffic Observation
Air Quality Monitoring
Real-Time Sewage Level Gauge
Real-Time Data Streaming

- Sampling Interval: 5min
- Format: JSON
- Size: ~5MB
- We need to extract sewage level data
- Periodic model training/re-training (24 hours)

```javascript
> sock = new WebSocket('wss://api.newcastle.urbanobservatory.ac.uk/stream');
> sock.addEventListener('message', (m) => console.log(JSON.parse(m.data).data));
> undefined

{serverTime: 1539881500016}
{brokerage: {...}, entity: {...}, feed: {...}, timeseries: {...}}

brokerage:
  id: "UTMC Open Car Park Feeds"
  meta: {}
    __proto__: Object
  id: "CP_GH_MILLRD"
  meta: {}
    __proto__: Object

tenity:
  meta: {name: "Mill Road", address: "Mill Road"}
  name: "Car park at Mill Road"
    __proto__: Object

feed:
  meta: {totalSpaces: 283}
    metric: "Occupied spaces"
      __proto__: Object

timeseries:
  unit: "Spaces"
  value:
    data: 106
    time: "2018-10-09T10:43:00.000Z"
    timeAccuracy: 20.004
    type: "Integer"
      __proto__: Object
      __proto__: Object
      __proto__: Object
```
Recurrent Neural Network

- Proposed for Natural Language Processing (Mikolov et al., 2010)
- Hidden “memory” ($h_i$) to capture previous information (Lecun et al., 2015)
- Very successful in Time Series Analysis (Graves, 2013)
Long-Short Term Memory (LSTM)

- Using a memory cell (C), an input gate (I), an output gate (O) and a forget gate (F).
- LSTM could handle exploding and vanishing gradient problems that can be encountered when training traditional RNN (Gers et al., 1999)
Experiment Implementation

- Four layers of LSTM (Xingjian et al., 2015)
- Training start from October 2018-January 2019
- Testing with real-time data collected in February and March 2019
- Tensorflow + Keras + Kafka + Apache Storm (Xing and Sieber, 2016)
The Initial Result

Sewage Level Prediction

- Real-Time Sewage Level
- Predicted Sewage Level

Sewage Level mm

Time

0 2500 5000 7500 10000 12500 15000 17500
Integrating Traffic and Weather Data
Encoder + LSTM

- Convolutional Neural Network for High-Order Feature Extraction (Cui et al., 2016)
- Spatial Pyramid Pooling (+) (He et al., 2015)
- Reuse previous LSTM network
The Improvement

Sewage Level Prediction

- Real-Time Sewage Level
- Predicted Sewage Level
Conclusion

- Smart City = IoT + Deep Learning?
- Real-time and Burstiness
- It is still very hard to predict extreme situations
- Integrating various datasets may help, if we have a good understanding of them
- Hyper-Parameter Tuning with geospatial knowledge (Greff et al., 2017)
- More challenging when integrated with imagery data analysis (Zhu et al., 2017)
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Call for Papers: Urban Deep Learning

Special Issue "Deep Learning Approaches for Urban Sensing Data Analytics"

- Special Issue Editors
- Special Issue Information
- Keywords
- Published Papers

A special issue of Remote Sensing (ISSN 2072-4292).

Deadline for manuscript submissions: 31 December 2019

https://www.mdpi.com/journal/remotesensing/special_issues/urban_deeplearning
Topics in Urban Deep Learning

- New deep neural network models for urban scene classification;
- 3D deep learning for urban scene understanding;
- New recurrent neural network algorithms for urban change detection;
- Advanced training and testing of deep learning methods;
- Real-time urban sensing data analytics using deep learning algorithms;
- Generative adversarial network for remote sensing data fusion;
- Innovative reinforcement learning algorithms for transportation management.
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- Emailing us at gisruk2019@newcastle.ac.uk
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- Tweet using the conference hashtag #GISRUK2019
Thank you!

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Call for Papers:
https://www.mdpi.com/journal/remotesensing/special_issues/urban_deeplearning