PREDICTING PERFORMANCE OF GREEN STORMWATER INFRASTRUCTURE USING DEEP NEURAL NETWORK REGRESSION

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OVERVIEW

• Various anthropogenic and climatic processes can introduce long-term effects on the performance indicators of the Green Stormwater infrastructure (GSI), skewing the distribution of the outcomes of numerical models.
• Data-driven predictive models based on deep learning techniques offer an exciting ground to estimate GSI performance accounting for its highly dynamic and constantly evolving nature through leveraging advancements in observational data.
• LSTM (Long Short-Term Memory) neural network is used to predict the GSI performance through Recession Rate of runoff water depth using five years of observational data.
• A comparative study with a numerical model in SWMM (Storm Water Management Model) is performed to show efficiencies of the models.
• Bio-Infiltration Traffic Island (BTI), a raging island situated on the Villanova University Campus is selected as an example GSI. It has been designed to hold and infiltrate incoming runoff from storms smaller than 25 mm.
• The BTI treats over 1.27 acres of stormwater runoff from the west campus in Villanova university.

WORKFLOW

GS! Performance Estimation using Deep Learning Techniques

Model Deployment
- GSI Performance

Model Evaluation
- Error Metrics e.g., RMSE

Model Training
- Train/Test data
- Hyperparameter

Feature Engineering
- Normalization/Standardization
- Data Transformation

Data Collection
- Precipitation
- Temperature
- GSI Parameters

Maintenance and Improvement

EXPLORATORY DATA ANALYSIS

Descriptive Statistics
- Features Distribution
- Impetation

SCHMATIC DIAGRAM

PREDICTIVE MODEL

• Schematic of LSTM Neural Network with all input features. A set of eight features were considered for training the neural network model. All the features and target variables (recession rate) are retrieved from the Villanova Center for Resilient Water System (VCRWS) database from 01/01/2014 to 12/31/2018 (5 years) with 5 mins time interval.

MODEL PERFORMANCE

Continuous Recession Rate

LSTM model performance for increasing lead time. Lead time is the length of a cutout of a time series that is used to predict the output (recession rate) at future time step (e.g., 6 hours).

CONCLUSION

• LSTM algorithm outperformed the SWMM model in estimating recession rate with the full range of observed data as well as specific storm event.
• These findings have the potential to provide insight into the planning and maintenance of GSI with observed data only, ultimately facilitating lower maintenance costs and more sustainable management techniques.
• Learned LSTM model parameters can be transferred to other GSI at similar physiographic locations.
• The application of neural-networks is a crucial stride towards real-time forecasting of GSI performance in a cloud-computing platform and catchment-wide application with multiple GIS.

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References: