SMARTGREENS 2021

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Edge Intelligence with Deep Learning in Greenhouse Management

A methodology to control greenhouse operations based on deep learning working on edge devices

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INTRODUCTION

Increasing greenhouses use in vertical and urban farming.

Anomaly Detection: plant is not growing healthy

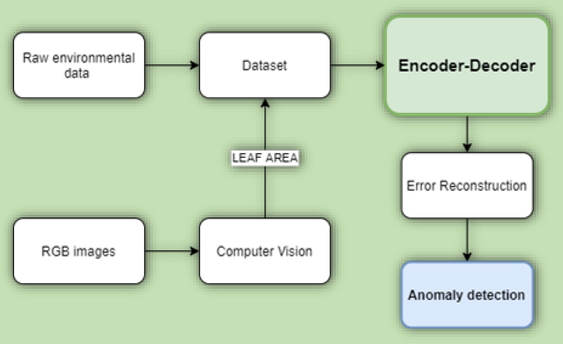
Deep Learning for real world, production level greenhouses

Growing demand for automated and efficient greenhouse management

Exploiting data with Edge Intelligence

Anomaly detection with Autoencoders

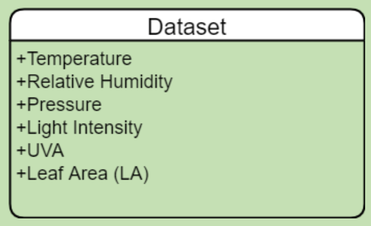
METHODS



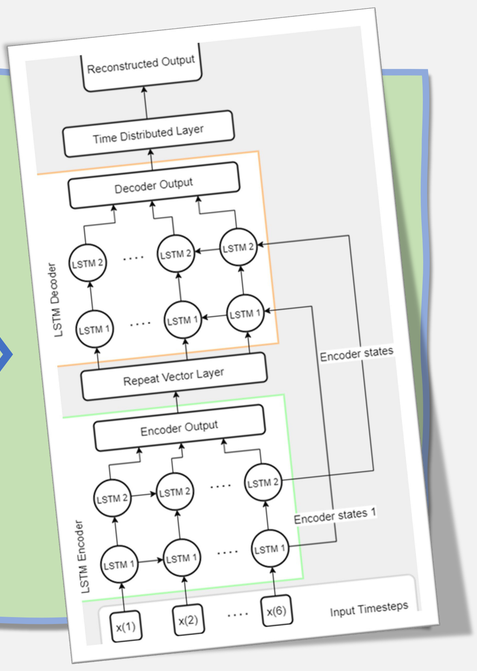
Anomaly Detection WorkFlow

- 2m^2 greenhouse.
- Environmental sensors with Arduino MKR.
- Full-HD RGB camera.
- LED lamp managed through Arduino Uno.
- Computational devices tested for Edge Intelligence: Raspberry Pi 4 Model B, NVIDIA Jetson Nano.
- Easy Leaf Area (ELA) algorithm for Leaf Area (LA) calculation **[Easlon and Bloom, 2014]**

Experimental setup



LSTM Autoencoder



RESULTS

Rate of successful leaf identification	
Plant 1: Cichorium Endivia 	94%
Plant 2: Apium Graveolens 	97%
Plant 3: Lactuca Sativa (Young) 	94%
Plant 4: Lactuca Sativa (Adult) 	86%

LSTM autoencoder training time on edge devices

NVIDIA

128 LSTM units, 2 layers 8.32 ms/sample

256 LSTM units, 2 layers NA due to an internal error

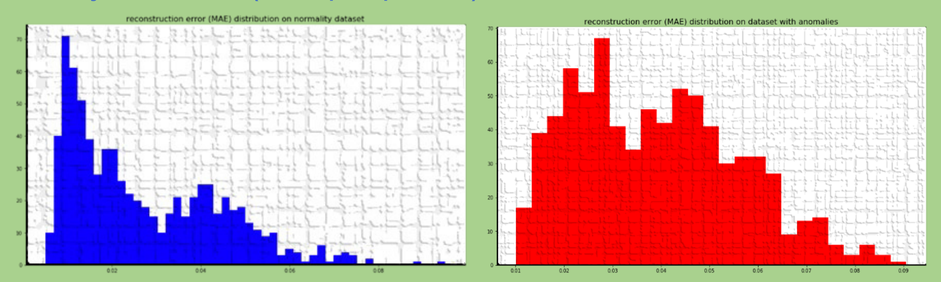
128 LSTM units, 2 layers 11.6 ms/sample

256 LSTM units, 2 layers 30.84 ms/sample

Baseline: Local Outlier Factor (LOF) algorithm

Best LOF F1 score: 0.233

Reconstruction error (MAE) on «normality» dataset and on whole dataset for anomaly threshold (example: plant 4)



Grid search optimization: normality-anomaly threshold through F1 score maximing. (example: plant 4)

Stacked layers	LSTM units per layer	Optimized F1	Threshold
1	32	0.370	0.104
1	64	0.473	0.063
1	128	0.374	0.062
1	256	0.330	0.055
2	32	0.292	0.102
2	64	0.319	0.070
2	128	0.344	0.064
2	256	0.267	0.062

CONCLUSIONS

- ELA requires too much calibration for Edge automated use
- Edge Intelligence of level 4 (Cloud-edge co-training) is a good compromise between anomaly detection model complexity and local factors (variable conditions, privacy, network issues)
- Deep Learning algorithms are essential for real-world, production level greenhouse.
- Need for a Deep Learning LA algorithm

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