RUHR-UNIVERSITÄT BOCHUM

INSTITUT FÜR NEUROINFORMATIK

RUB

# A Simulated Car-Park Environment for the Evaluation of Video-Based On-Site Parking Guidance Systems

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(a) Sunny day (b) Foggy afternoon (c) Rainy afternoon (d) Afternoon snowfall

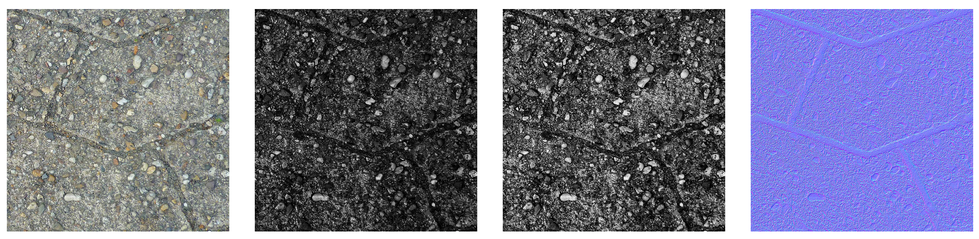
## Motivation

- Development of image-processing algorithms requires huge amount of data
- Internet offers numerous tagged images for training and evaluation of classifiers for a number of standard problems
- But: For a more distinct problem it is extremely difficult to find representative images

→ Simulated environment can overcome these problems by creating video data reproducing natural scenes

## Simulated Environment

- Based on next-gen graphics engine Unreal Engine 4
- Replica of existing car park for direct comparison to real-world
- Goal: Real-time classification of vacant/occupied parking spaces
- Extraction of ground truth data on the fly
- PBR approach for highly realistic materials
- Implementation of 5 different weather/lighting conditions: sunny, cloudy, foggy, rain, and snow



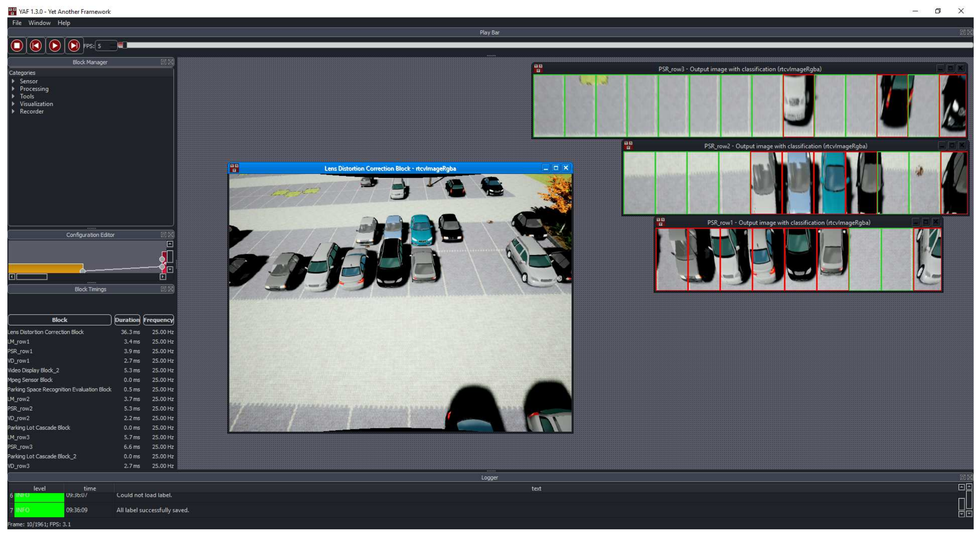
Material layers used in PBR approach

## Artificial Camera

- Generation of highly realistic camera images
- Translation of physical restrictions to virtual camera, such as depth of field, image noise, and motion blur
- Camera model modifies image generation process in UE4
- Model based on parameters of real-world modern camera systems
- Implemented parameters: focal length, aperture opening, film speed, exposure time, and focal distance

## Experiments

- Evaluation of classifier previously trained on real-world samples of sunny and cloudy weather images
- Reproduction of real-world video material in simulated environment for direct comparison of classifier performance
- Evaluation of classifier on sequences of different weather and lighting conditions to test its robustness




Softwareframework YAF; used for image processing. *Left:* (Artificial camera image with lens undistortion applied, *Right:* Visualization of classification results

## Results

- Comparable results for real-world video data and reconstruction
- Difficulties with untrained weather conditions due to underfitting
- Precipitation is challenging task
- Overall good performace on different weather conditions

| | reconstruction | | real world | |
|---|---|---|---|---|
| | color | gray | color | gray |
| **row 1** | 93.68 % | 99.53 % | 96.68 % | 99.96 % |
| **row 2** | 72.73 % | 82.78 % | 98.95 % | 96.99 % |
| **row 3** | 100.00 % | 100.00 % | 91.83 % | 92.33 % |

## Outlook

- Train a classifier on a mixture of real-world and artificial video data, or purely on artificial images
- Use the resulting classifier in real-world scenarios

→ Enabling more topics for image-processing algorithms

| | sunny | | cloudy | | foggy | | rain | | snow | |
|---|---|---|---|---|---|---|---|---|---|---|
| | color | gray | color | gray | color | gray | color | gray | color | gray |
| **row 1** | 99.72 % | 99.78 % | 98.25 % | 99.77 % | 80.31 % | 99.70 % | 93.04 % | 99.83 % | 72.40 % | 71.41 % |
| **row 2** | 98.48 % | 93.17 % | 77.20 % | 88.74 % | 56.42 % | 97.18 % | 62.90 % | 82.77 % | 40.94 % | 52.11 % |
| **row 3** | 92.28 % | 99.82 % | 98.77 % | 99.27 % | 4.35 % | 58.44 % | 65.01 % | 43.11 % | 25.02 % | 25.75 % |