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Methods for Objective Video Quality Assessment in Recognition Tasks

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Outline

- Introduction
- Preparation of required experimental set-up and research plan
- Acquisition of existing Source Reference Circuits (SRC)
- Preparation of Hypothetical Reference Circuits (HRC)
- Preparation of Processed Video Sequences (PVS)
- Recognition experiment
- Quality experiment
- Development of new objective video quality assessment model
- Conclusions

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Introduction

Introduction (1/2)

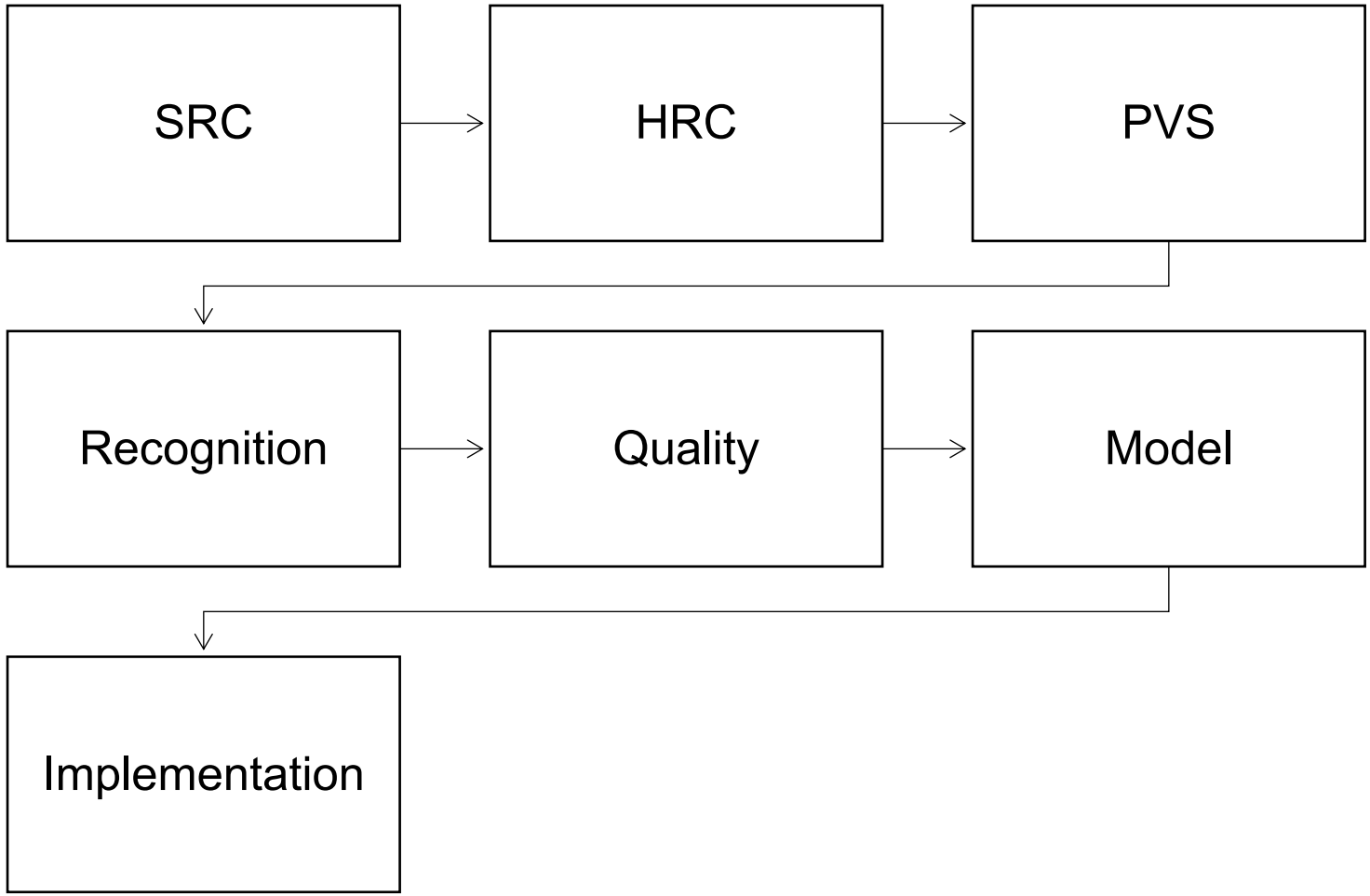
- Metrics for overall Quality of Experience (QoE) successfully used for video processing systems quality evaluation:
  - Full-Reference (FR) ones
  - No-Reference (NR) ones
- However, not appropriate for recognition tasks analytic in Target Recognition Video (TRV)
- Estimation of video processing pipeline performance still posing research challenge in Computer Vision (CV) tasks
- Need for an objective video quality assessment method for recognition tasks

Introduction (2/2)

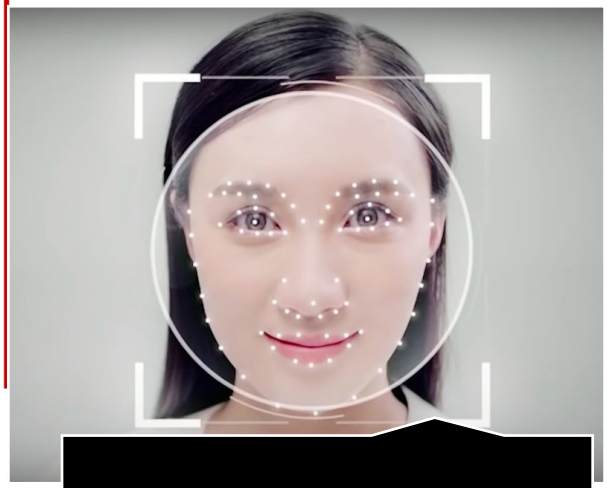
- Here showing possibility to deliver objective video quality assessment method for TRV
- Implemented as prototype software being a proof/demonstration
- Method trained and tested on representative set of video sequences
- Describing new innovative approach proposal used by software

Preparation of Required Experimental Set-up and Research Plan

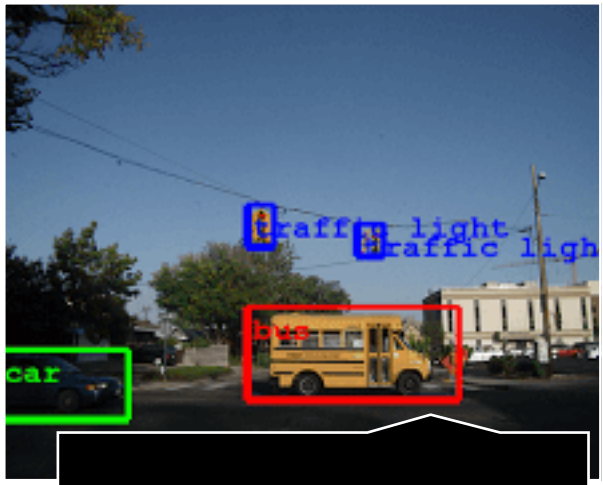
Research Plan



Scenarios



Facial Recognition (FR)



Object Recognition (OR)

Automatic License-Plate Recognition (ALPR)

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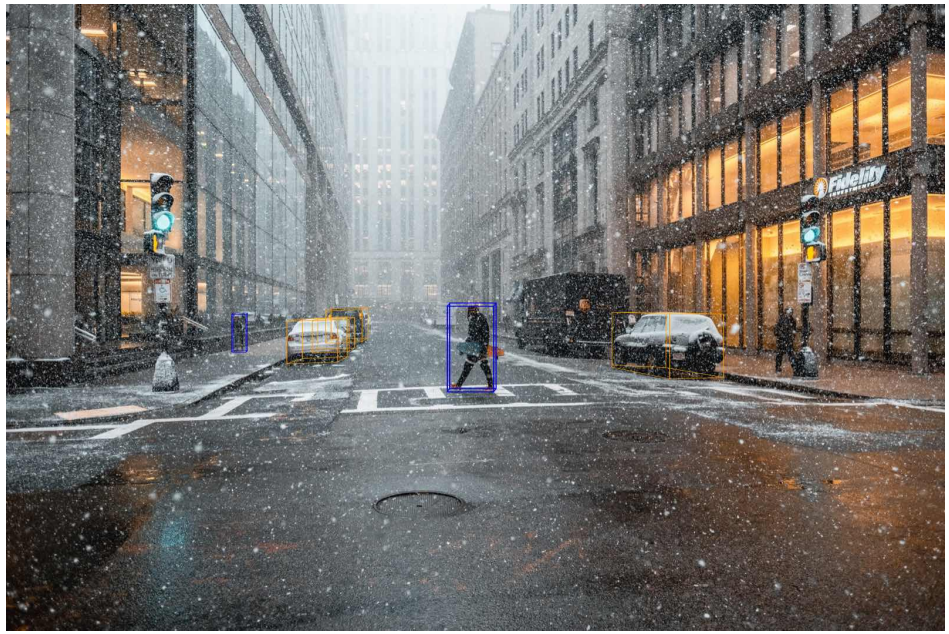
Acquisition of Existing Source Reference Circuits (SRC)

FR Scenario: LFW Face Database

- **Resolution**: 250 ✖ 250
- **Count**:
  - 13,233 images of 5,749 different people
  - 1,680 people with 2 or more images

OR Scenario:
Aptiv Mobility nuScenes Dataset

- **Resolution**: 1600✕900 (HD+)
- **Count**:
  - v1.0-mini-CAM_FRONT sweeps images
  - 1,938 frames in total:
    - 4 Boston scenes
    - 4 Singapore scenes

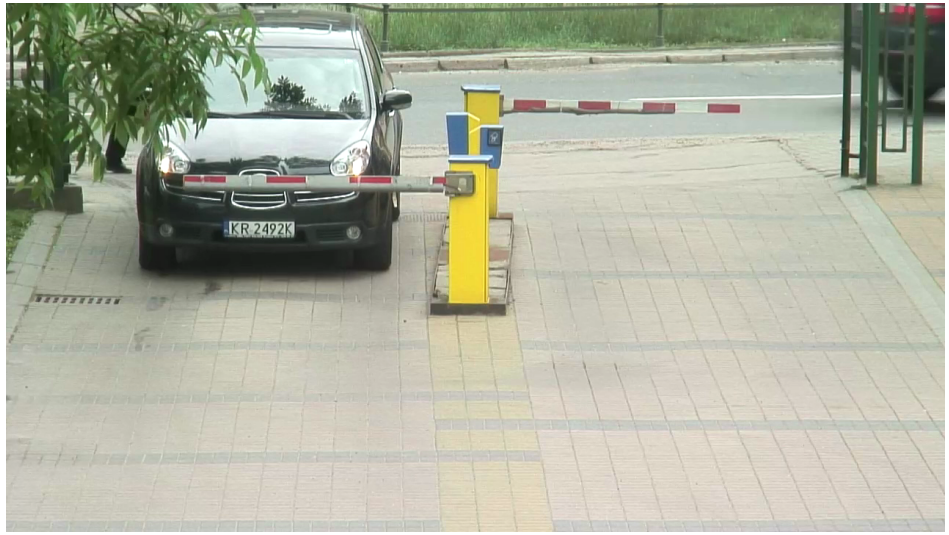


OR Scenario: KITTI Vision Benchmark Suite

- **Resolution**: 1242×375
- **Count**:
  - 3 categories:
    - “City” – 18 sequences
    - “Residential” – 13 sequences, and
    - “Road” – 7 sequences
  - Duration:
    - From 28 frames (00:02 minutes)
    - To 809 frames (01:20 minutes)
  - Synced + rectified image_02 data (7,480 frames in total)

ALPR Scenario:
AGH Parking Database Video Library

- **Resolution**: 1280✖720 (HD)
- **Count**:
  - 31 video sequences
  - Each one containing approximately 500 frames
  - Approximately 15,500 frames in total



Selected SRC as Glance

Scenario	Database	#SRC (training, validation, test)	≈#Objects/#SRC
FR	LFW	120	1
OR	nuScenes KITTY	60 60	4.14 3.85
ALPR	AGH	120	1

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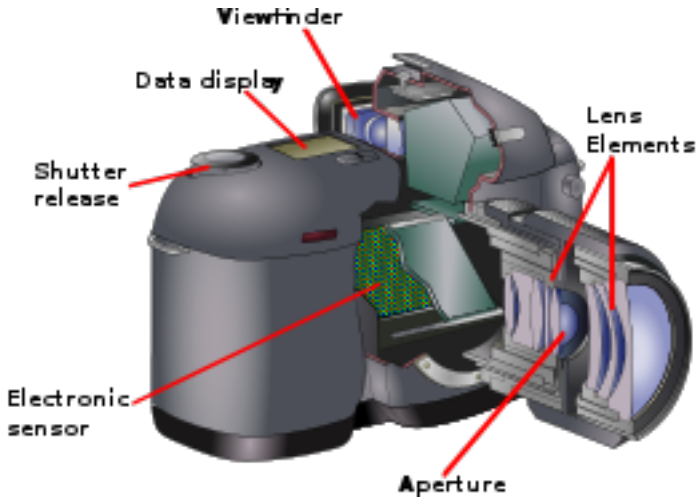
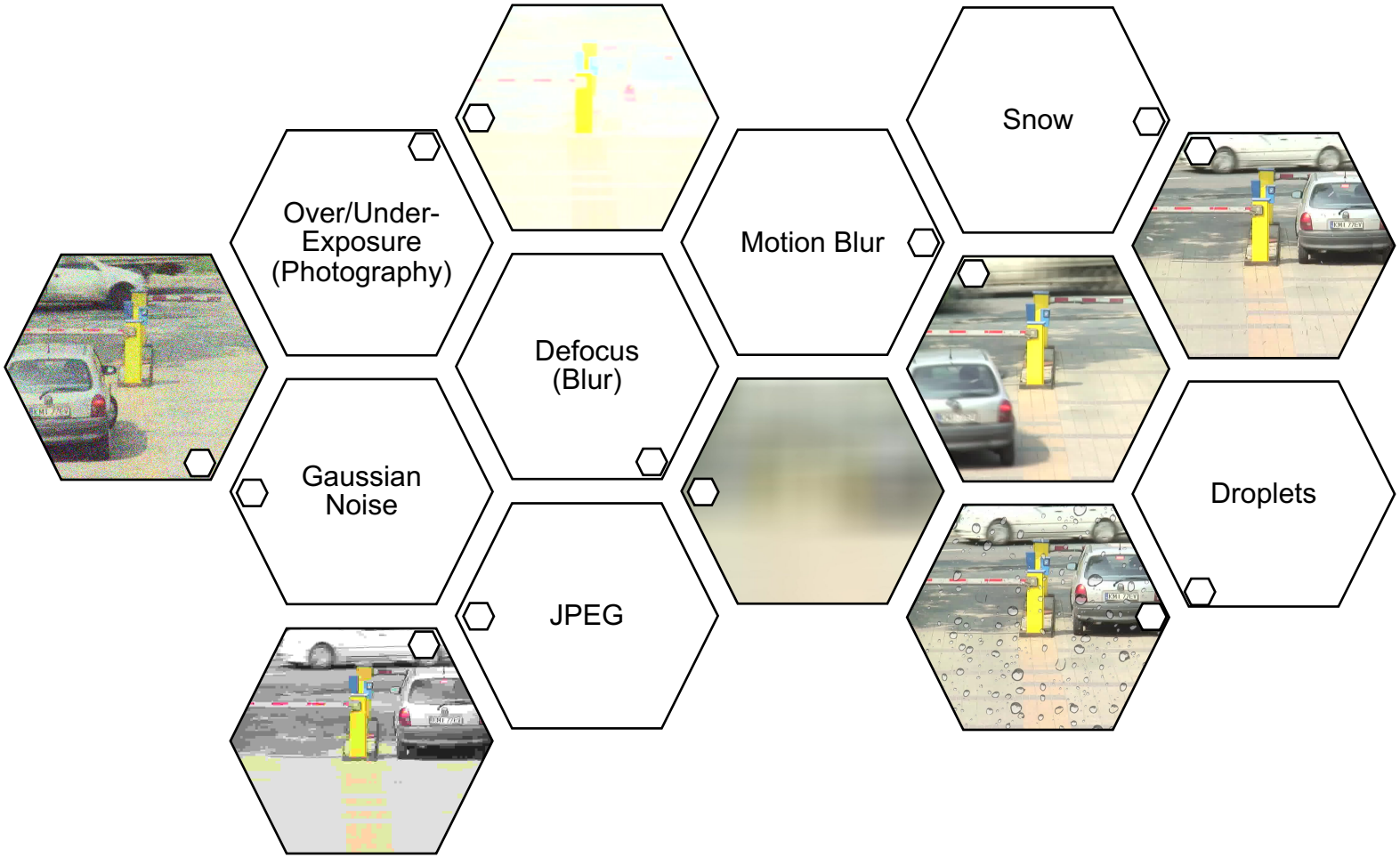
Preparation of Hypothetical Reference Circuits (HRC)

Distortion Model



- Illuminance
- Weather conditions
- Optics (e.g., aperture defocus)
- Sampling
- Sensor (noise)

HRC


Over/Under-
Exposure
(Photography)
Motion Blur
Snow
Defocus
(Blur)
Gaussian
Noise
JPEG
Droplets

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Preparation of Processed Video Sequences (PVS)

Which Distortions Go to Which Scenario?

HRC	#HRC	FR	OR	ALPR
Gaussian Noise	6	✓	✓	✓
Defocus (Blur)	6	✓	✓	✓
Over/Under-Exposure (Photography)	12	✓	✓	✓
Motion Blur	6	✓	✓	✓
Snow	2	✗	✓	✓
Droplets	1	✗	✓	✓
Motion Blur vs. Gaussian Noise	5	✓	✓	✓
Over-Exposure vs. Gaussian Noise	5	✓	✓	✓
Under-Exposure vs. Motion Blur	5	✓	✓	✓
JPEG	19	✓	✓	✓
#PVS		6720	7080	7080

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Recognition Experiment

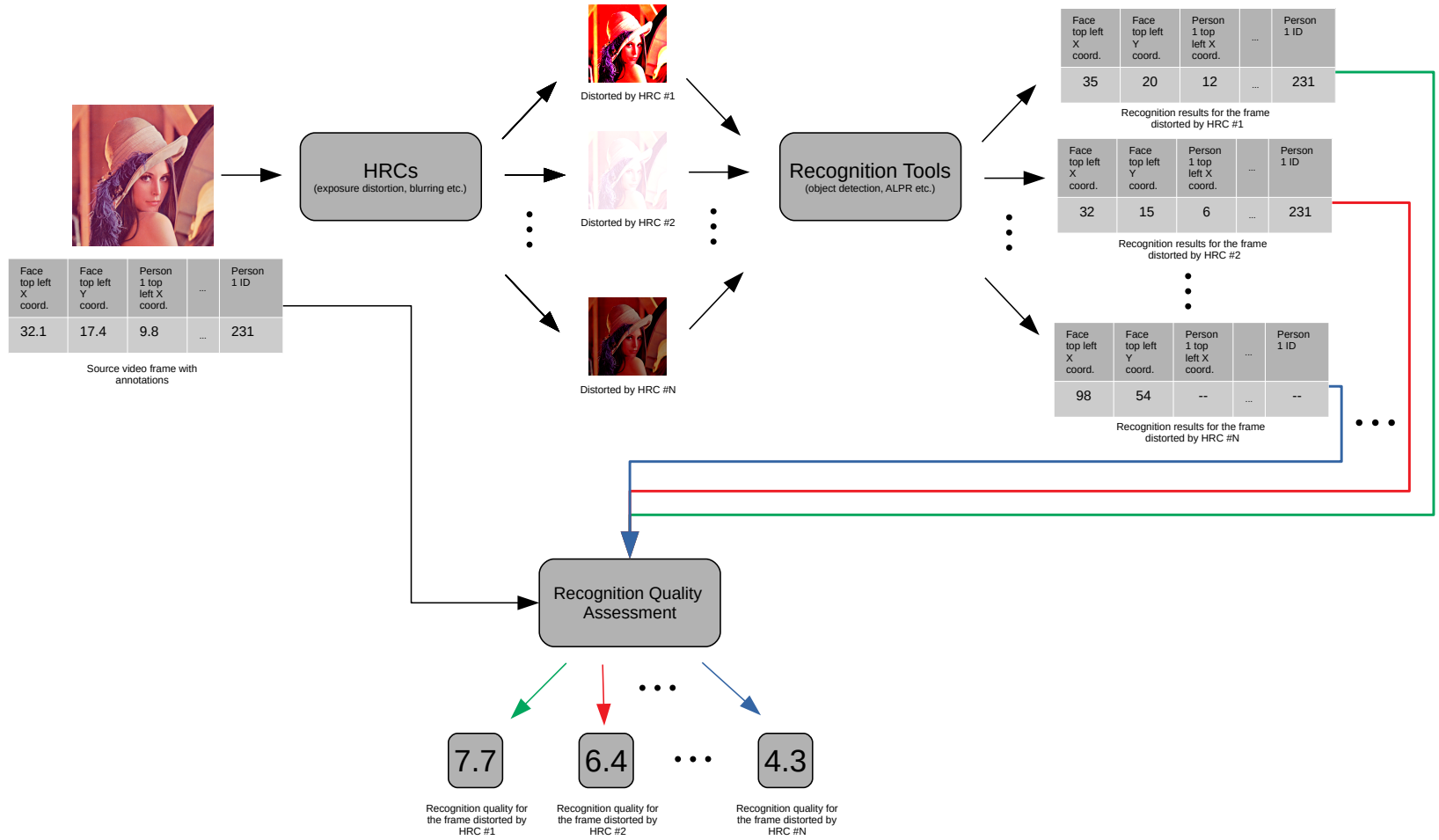
Recognition Tools

Facial Recognition (FR)

Object Recognition (OR)

Automatic License-Plate Recognition (ALPR)

Flowchart Presenting Processing Pipeline of Recognition Experiment



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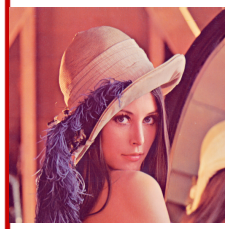
Quality Experiment

Quality Indications

Authors	Algorithm Name(s)	Language	Time [s]
VQ AGH VQIs	Commercial Black, Blockiness, Block Loss, Blur, Contrast, Exposure, Interlacing, Noise, Slicing, Spatial Activity, Temporal Activity	C/C++	0.12
LIVE	BIQI	MATLAB	1.60
LIVE	BRISQUE	MATLAB	1.67
LIVE	NIQE	MATLAB	3.92
LIVE	OG-IQA	MATLAB	5.72
LIVE	FRIQUEE	MATLAB	40.79
LIVE	IL-NIQE	MATLAB	10.70
UMIACS	CORNIA	MATLAB	7.71
BUPR	HOSA	MATLAB	0.43
Total			**72.66**

Flowchart Presenting Processing Pipeline in Quality Experiment



Source video frame

HRCs
(exposure distortion, blurring etc.)

Distorted by HRC #1

Distorted by HRC #2

Distorted by HRC #N

Quality Indicators
(Blur VQI, BRISQUE etc.)

49.2	23.2	10.2	...	79.2

A vector of results for the frame distorted by HRC #1

32.1	17.4	9.8	...	23.1

A vector of results for the frame distorted by HRC #2

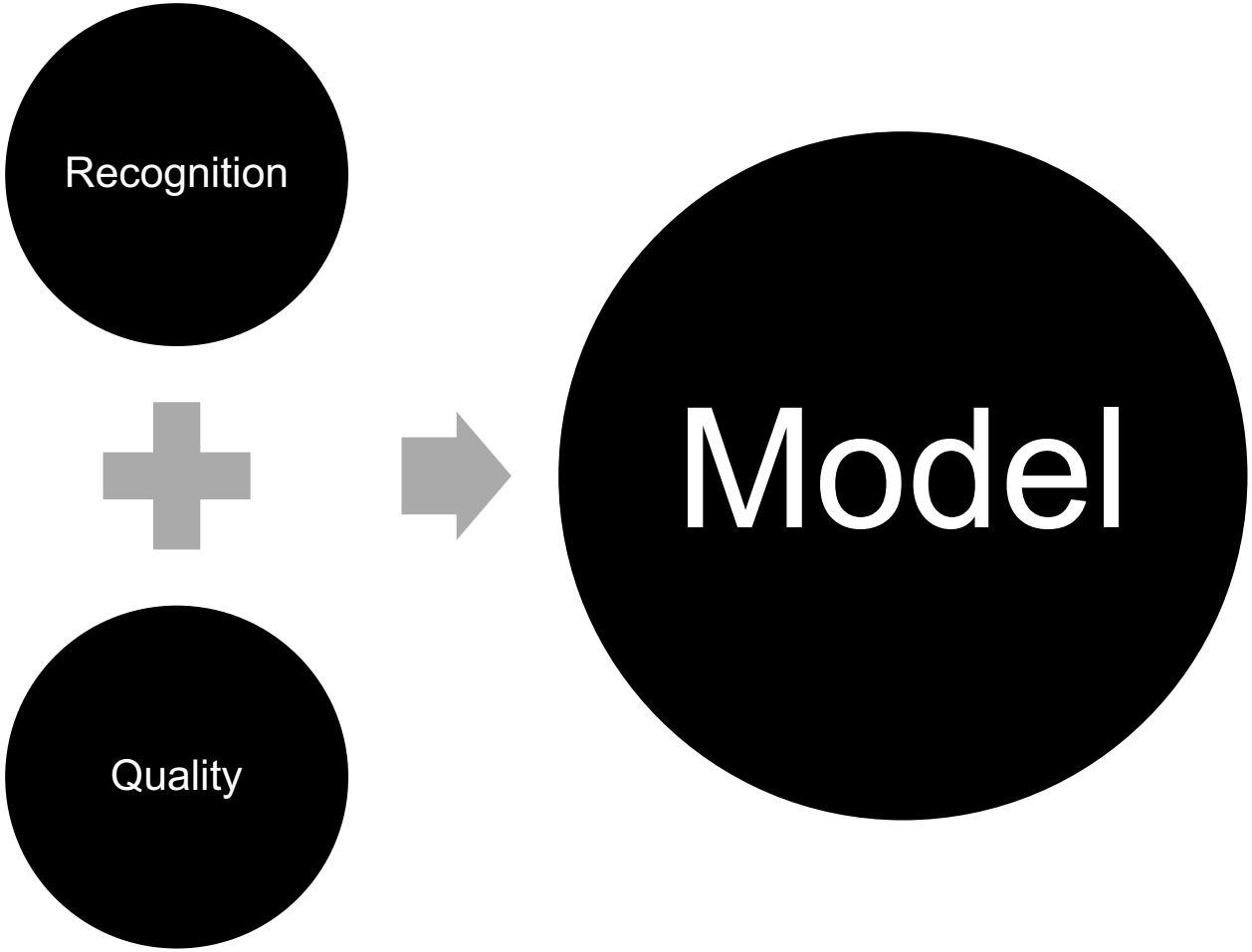
91.5	34.6	55.8	...	61.2

A vector of results for the frame distorted by HRC #N

Development of New Objective Video Quality Assessment Model…

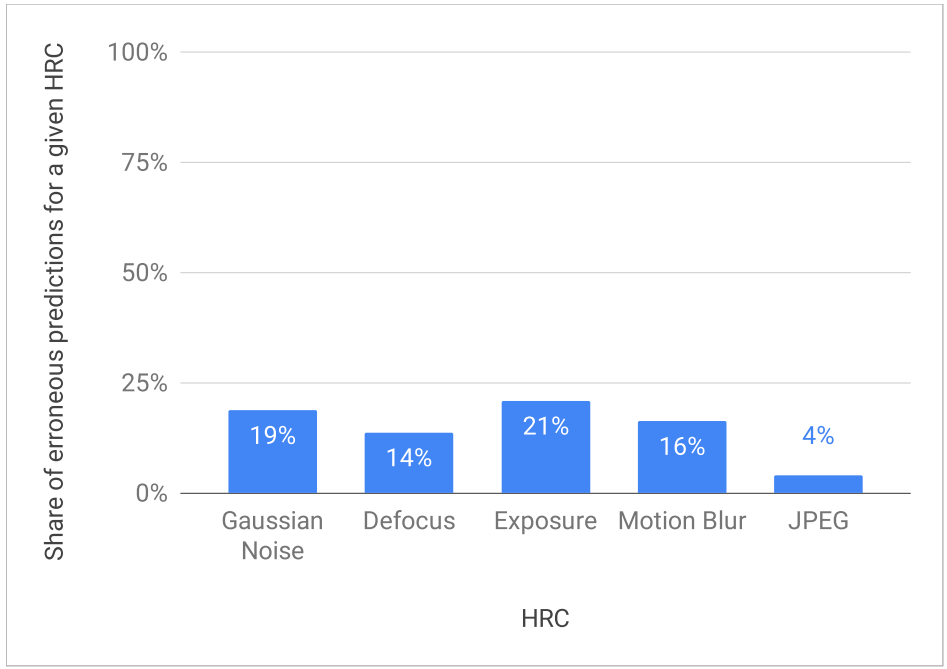
…For Recognition Tasks

Development of New Objective Video Quality Assessment Model



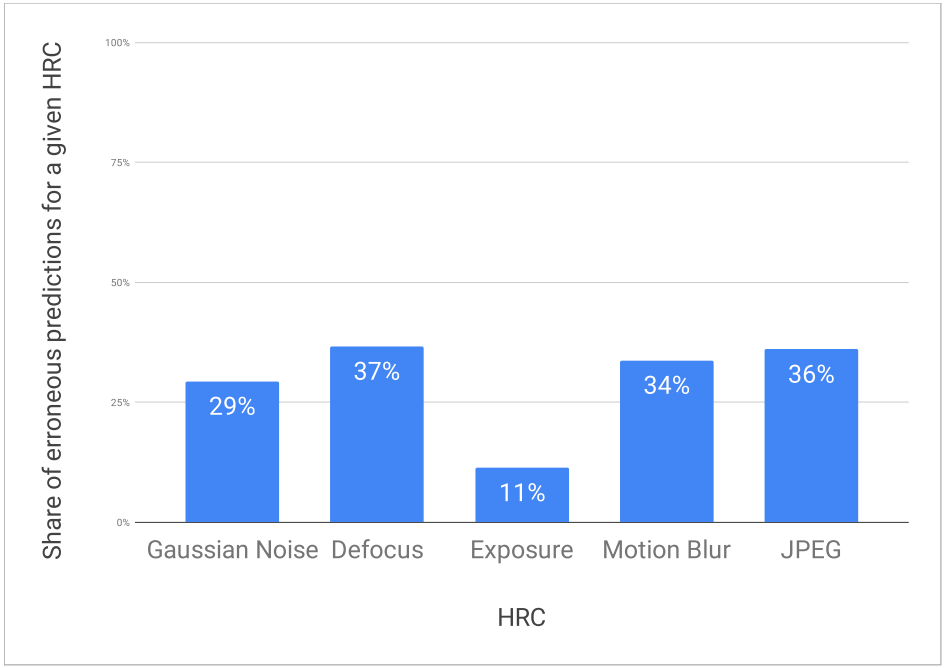
General Results Received for FR

	Precision	Recall	F-Measure
All Indicators	0.893	0.846	0.869
AGH Indicators	0.870	0.791	0.829



General Results Received for ALPR

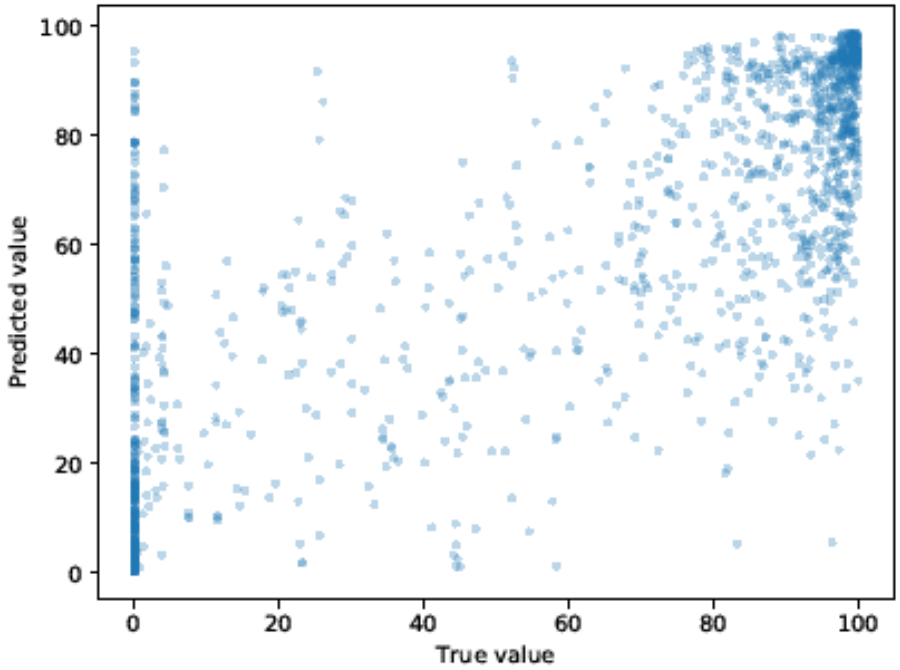
	Precision	Recall	F-Measure
All Indicators	0.779	0.776	0.777
AGH Indicators	0.768	0.759	0.764



General Results Received for OR

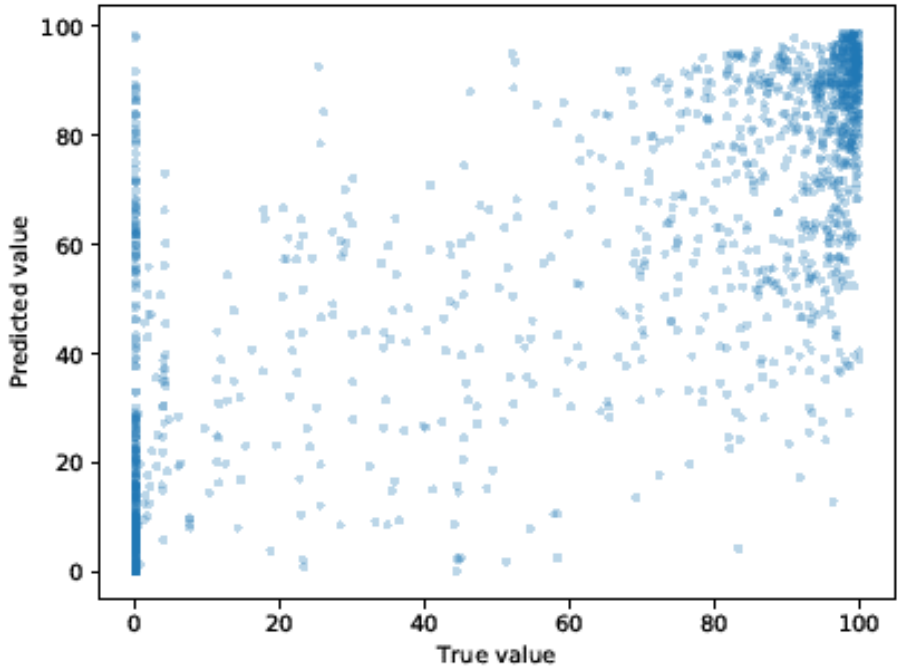
All Indicators:

$MSE = 672.4, PCC = 0.77$



AGH Indicators:

$MSE = 722.1, PCC = 0.75$



Conclusions

Conclusions

- Conventionally using metrics for general QoE, both FR ones and NR ones in video processing systems for video quality evaluation
- Unfortunately, these metrics not appropriate for recognition tasks in video analytics (TRV)
- Therefore, correct estimation of video processing pipeline performance – still significant research challenge in CV tasks
- As response to this need, goal of research: method trained and tested on representative set of video sequences
- Prototype software: proof/demonstration of new proposal concept of objective video quality assessment method for recognition tasks
- Further plans: Just Noticeable Degradation (JND) for Computer Vision (CV) performance