Augmented Reality Simulation for Testing Advanced Driver Assistance Systems in Future Automotive Vehicles

IARIA

SIMUL 2022

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Agenda

- **Research Team**
- **Introduction**
- **Advanced Driver Assistance Systems**
- **Augmented Reality in ADAS**
- **Conclusion and Outlook**

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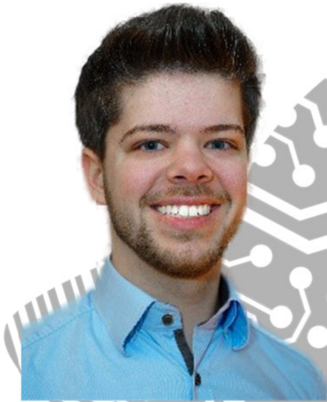

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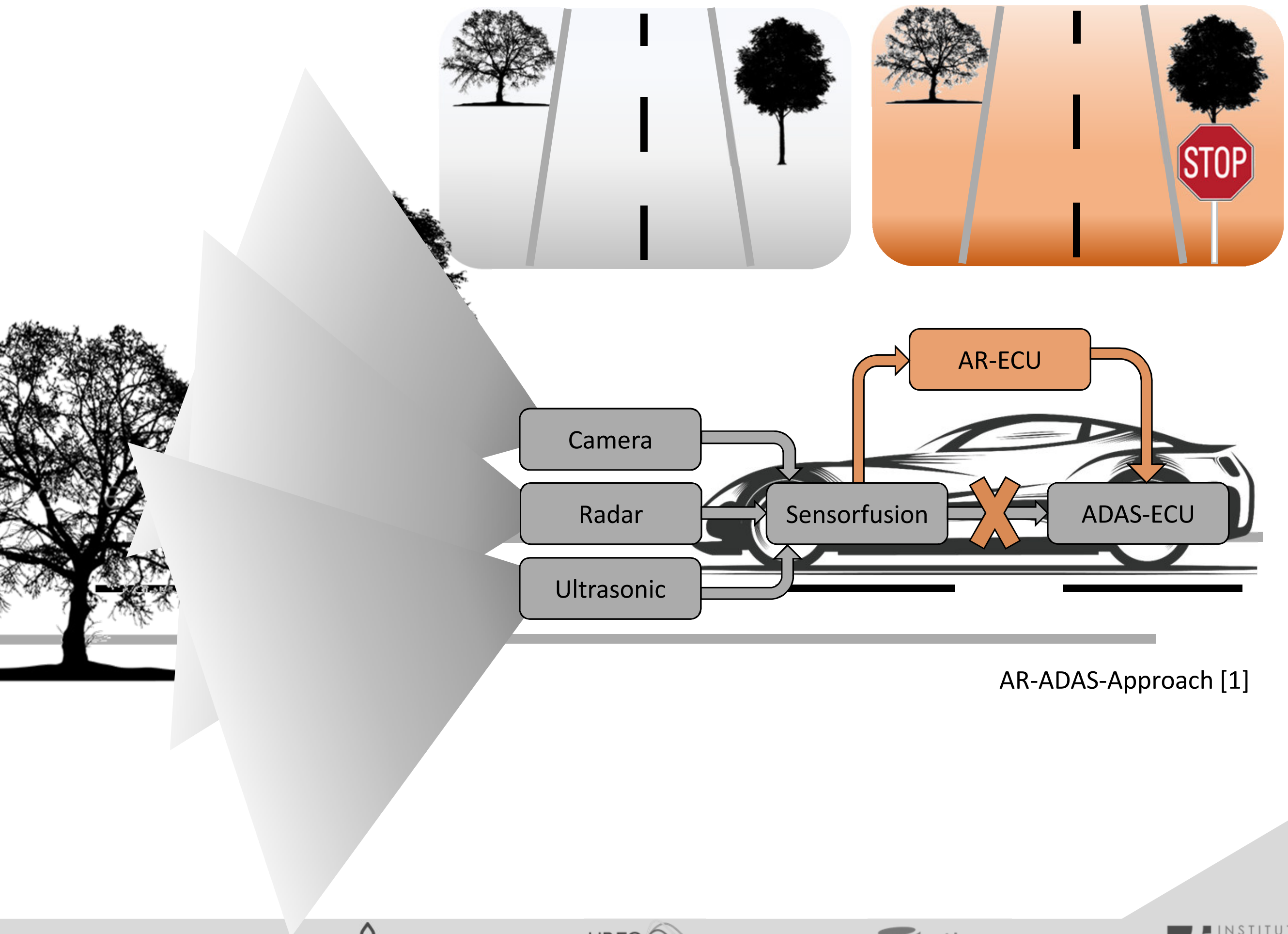
Introduction



AR-ADAS-Approach [1]

Today's Test Methods for ADAS

- **Simulation (Virtual Reality)**
- **Reality**

Tests of ADAS using Simulation

Test of ADAS in HIL-Simulation [2]

Test of ADAS using Simulation [3]

Advantages of using Simulation

+ Reproducibility
+ Flexibility
+ Low costs
+ Early in the development phase

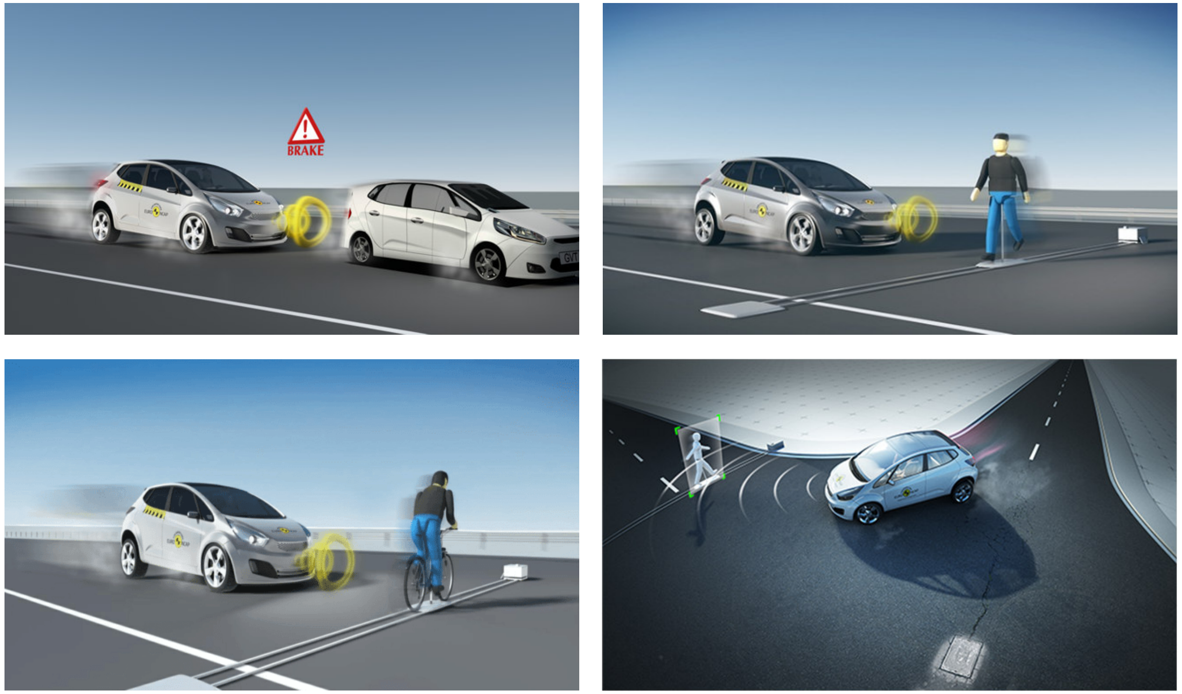
Tests of ADAS in Reality

NCAP [4]

Advantages of using Reality

+ Complexity of reality
+ Real disruptive influences

Test of ADAS in Reality [4]

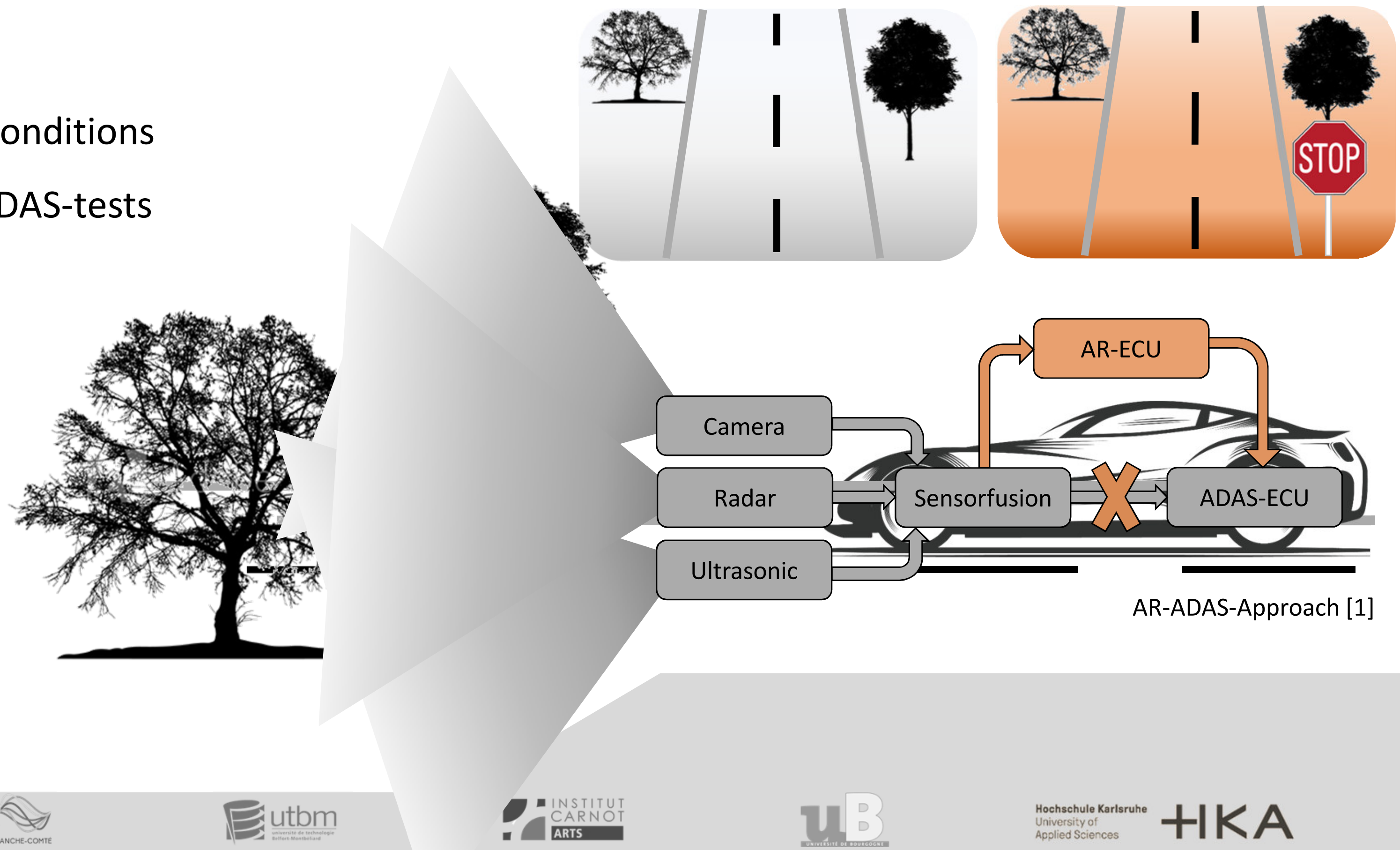


Different Test Scenarios in Reality [5]

Tests of ADAS using Augmented Reality

Advantages of our Approach

+ Reproducibility under real test conditions
+ Flexibility in conditions to the ADAS-tests



AR-ADAS-Approach [1]

Characteristics of Smartphone-Apps for Augmented Reality

Pokémon Go on a Smartphone [6]

AR-App on a Smartphone [7]

Characteristics of Smartphone-Apps

- Application up to walking speed
- Slight change in the scenario
- Access to the sensors of the smartphone
- No precise placement of AR-objects necessary

Characteristics of Augmented Reality

AR-Algorithm

- Image Analysis
- 3D Modelling
- Augmentation

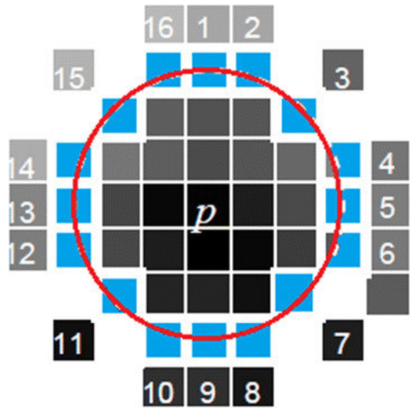
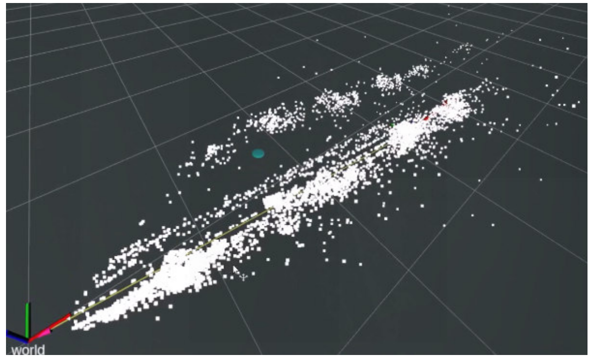
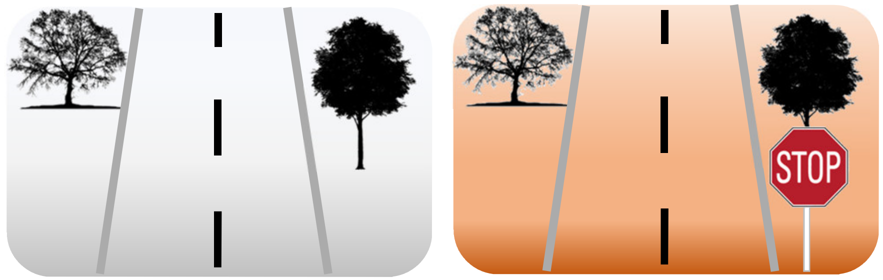


Image Analysis [8]



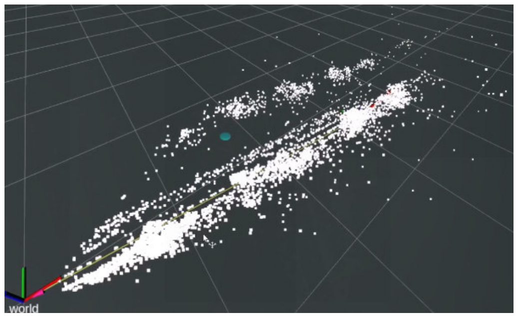
3D Modelling [9]



Augmentation [10]

AR-ADAS-Approach

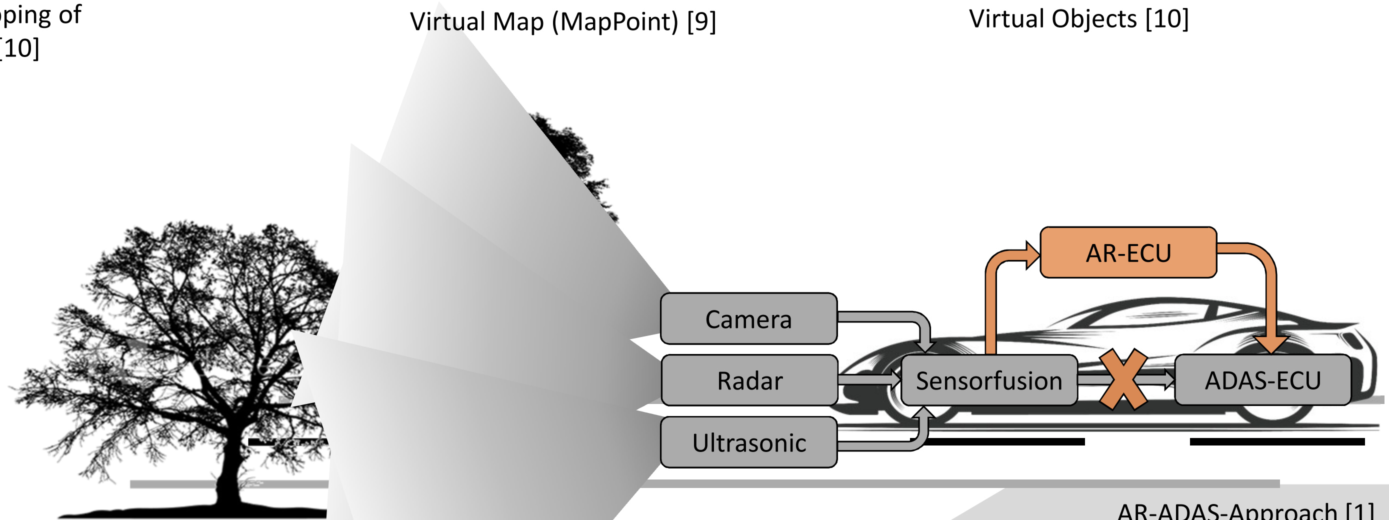
Tracking and Mapping of Environment [10]



Virtual Map (MapPoint) [9]

Virtual Objects [10]

Augmentation [10]



AR-ADAS-Approach [1]

Visual Odometry and SLAM

	SLAM or VO	Pixels used	Data association	Estimation	Relocali-zation	Loop closing	Multi Maps	Mono	Stereo	Mono IMU	Stereo IMU	Fisheye	Accuracy	Robustness	Open source
Mono-SLAM [13], [14]	SLAM	Shi Tomasi	Correlation	EKF	-	-	-	✓	-	-	-	-	Fair	Fair	[15][1]
PTAM [16]–[18]	SLAM	FAST	Pyramid SSD	BA	Thumbnail	-	-	✓	-	-	-	-	Very Good	Fair	[19]
LSD-SLAM [20], [21]	SLAM	Edgelets	Direct	PG	-	FABMAP PG	-	✓	✓	-	-	-	Good	Fair	[22]
SVO [23], [24]	VO	FAST+ Hi.grad.	Direct	Local BA	-	-	-	✓	✓	-	-	✓	Very Good	Very Good	[25][2]
ORB-SLAM2 [2], [3]	SLAM	ORB	Descriptor	Local BA	DBoW2	DBoW2 PG+BA	-	✓	✓	-	-	-	Exc.	Very Good	[26]
DSO [27]–[29]	VO	High grad.	Direct	Local BA	-	-	-	✓	✓	-	-	✓	Fair	Very Good	[30]
DSM [31]	SLAM	High grad.	Direct	Local BA	-	-	-	✓	-	-	-	-	Very Good	Very Good	[32]
MSCKF [33]–[36]	VO	Shi Tomasi	Cross correlation	EKF	-	-	-	✓	-	✓	✓	-	Fair	Very Good	[37][3]
OKVIS [38], [39]	VO	BRISK	Descriptor	Local BA	-	-	-	-	-	✓	✓	✓	Good	Very Good	[40]
ROVIO [41], [42]	VO	Shi Tomasi	Direct	EKF	-	-	-	-	-	✓	✓	✓	Good	Very Good	[43]
ORBSLAM-VI [4]	SLAM	ORB	Descriptor	Local BA	DBoW2	DBoW2 PG+BA	-	✓	-	✓	-	-	Very Good	Very Good	-
VINS-Fusion [7], [44]	VO	Shi Tomasi	KLT	Local BA	DBoW2	DBoW2 PG	✓	-	✓	✓	✓	✓	Good	Exc.	[45]
VI-DSO [46]	VO	High grad.	Direct	Local BA	-	-	-	-	-	✓	-	-	Very Good	Exc.	-
BASALT [47]	VO	FAST	KLT (LSSD)	Local BA	-	ORB BA	-	-	-	-	✓	✓	Very Good	Exc.	[48]
Kimera [8]	VO	Shi Tomasi	KLT	Local BA	-	DBoW2 PG	-	-	-	-	✓	-	Good	Exc.	[49]
ORB-SLAM3 (ours)	SLAM	ORB	Descriptor	Local BA	DBoW2	DBoW2 PG+BA	✓	✓	✓	✓	✓	✓	Exc.	Exc.	[5]

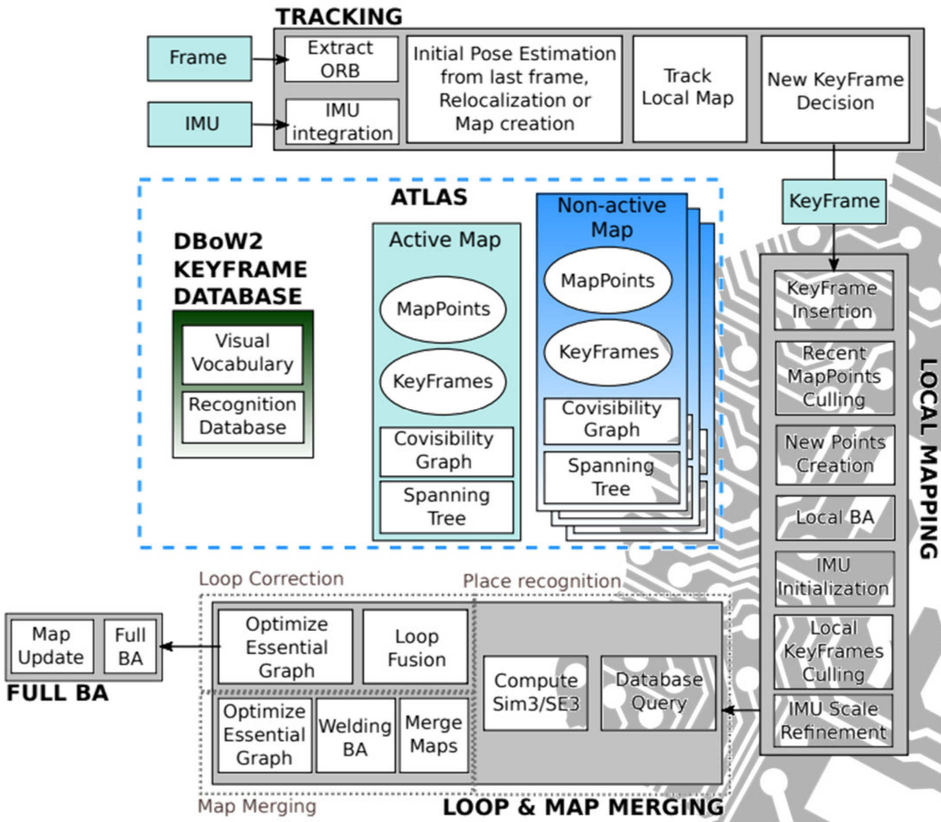
Benchmarking VO and SLAM [11]

Basic Modules

- Initialisation
- Tracking
- Mapping

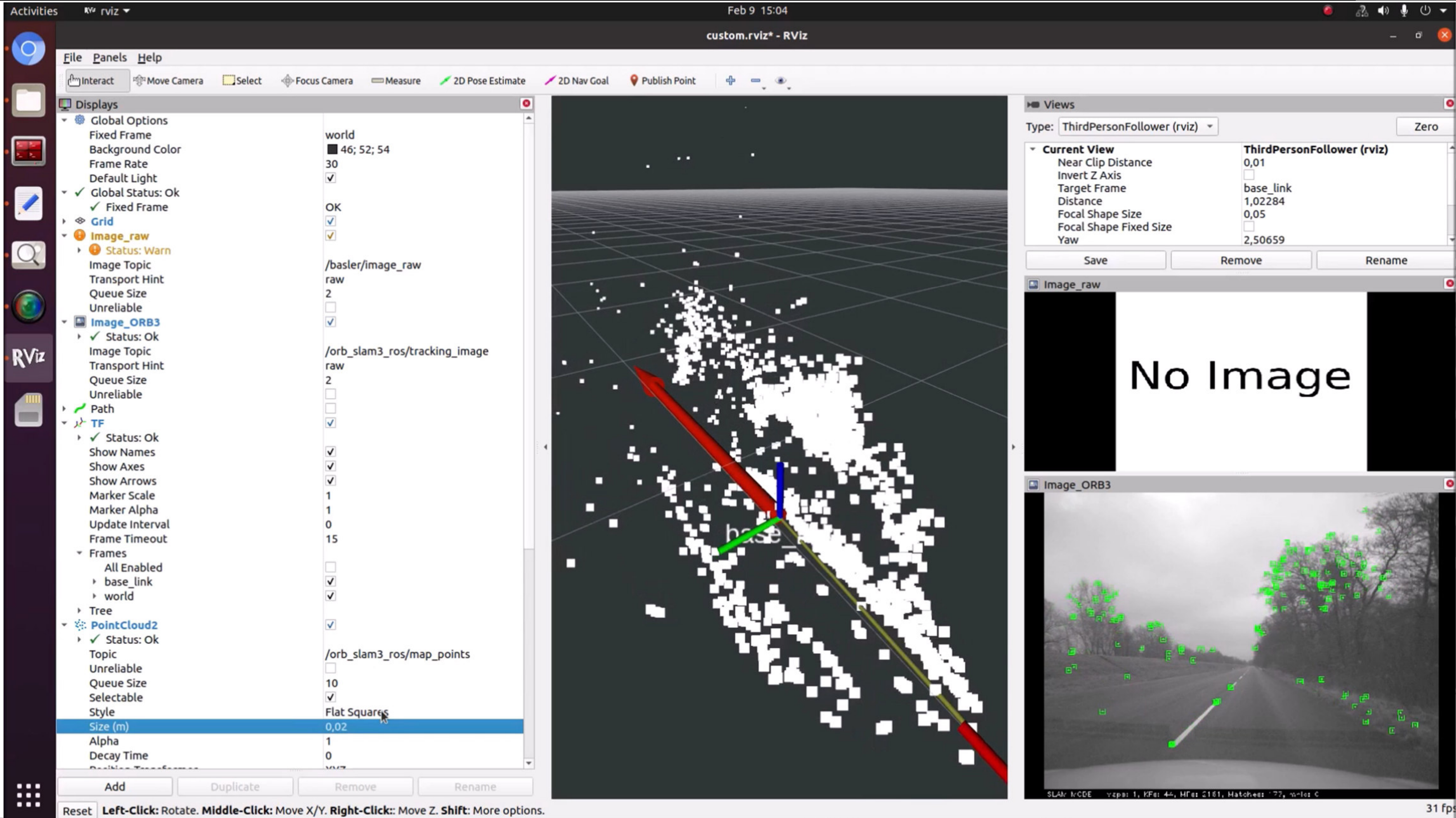
Additional Modules

- Relocalisation
- Glob Map Optimization (Loop Closing)


TRACKING
Frame
IMU
Extract ORB
IMU integration
Initial Pose Estimation from last frame, Relocalization or Map creation
Track Local Map
New KeyFrame Decision
KeyFrame
ATLAS
DBoW2 KEYFRAME DATABASE
Visual Vocabulary
Recognition Database
Active Map
MapPoints
KeyFrames
Covisibility Graph
Spanning Tree
Non-active Map
MapPoints
KeyFrames
Covisibility Graph
Spanning Tree
LOCAL MAPPING
KeyFrame Insertion
Recent MapPoints Culling
New Points Creation
Local BA
IMU Initialization
Local KeyFrames Culling
IMU Scale Refinement
Loop Correction
Place recognition
Optimize Essential Graph
Loop Fusion
Compute Sim3/SE3
Database Query
Optimize Essential Graph
Welding BA
Merge Maps
Map Merging
LOOP & MAP MERGING
Map Update
Full BA
FULL BA

ORB-SLAM 3 [12]

Testresults so far



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Challenges

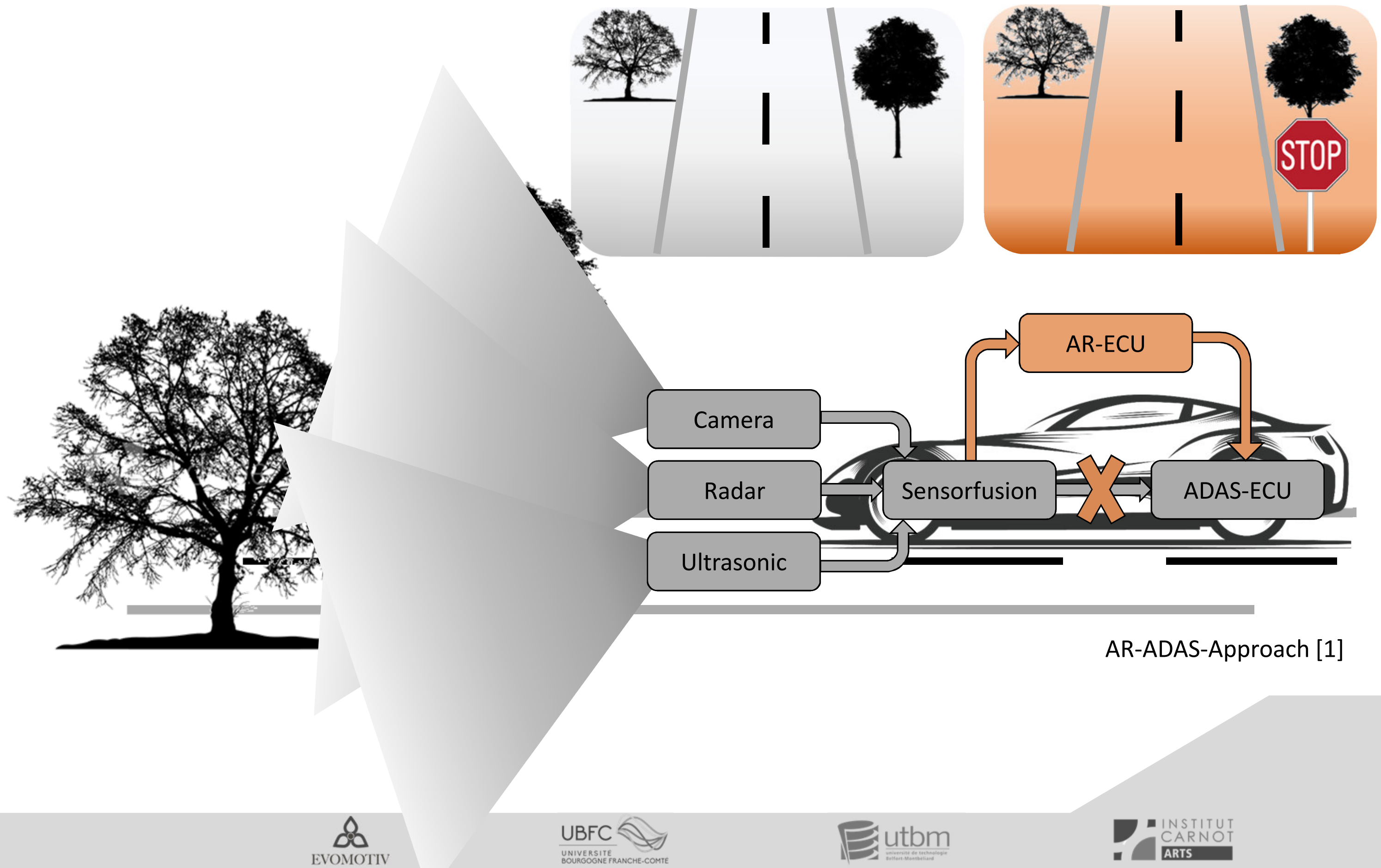
Vehicle Dynamics

$$(1) \qquad d = \frac{v_{Vehicle}\,[\frac{m}{s}]}{Framerate[\frac{frames}{s}]}$$

$$(2) \qquad d = \frac{36.111\,[\frac{m}{s}]}{30\,[\frac{frames}{s}]} = 1.204\,\frac{m}{frame}$$

NCAP Test Scenarios [4]

Further Thoughts



AR-ADAS-Approach [1]

Image Segmentation with
Neuronal Networks [10]

Conclusion and Outlook

Conclusion

- New Approach to combine the advantages of Simulation and Reality
- Urban Environment for testing AR-ADAS

Outlook

- Further Sensors like Lidar, Radar, Ultrasonics
- Increase overall Performance
- Combining of Image Segmentation and vSLAM

Sources

[1] Source: Created by ourself

[2] https://www.vector.com/de/de/produkte/produkte-a-z/hardware/vt-system/adas-hil-system/ (Online: 14.10.2022)

[3] https://www.avsimulation.com/pack-ad-adas/ (Online: 14.10.2022)

[4] https://www.oxts.com/de/products/rt-range-adas// (Online: 14.10.2022)

[5] https://www.euroncap.com/en/vehicle-safety/the-ratings-explained/vulnerable-road-user-vru-protection/aeb-pedestrian/ (Online: 14.10.2022)

[6] https://www.pokemon.com/de/pokemon-videospiele/pokemon-go/ (Online: 14.10.2022)

[7] Source: Created by ourself

[8] https://www.andreasjakl.com/basics-of-ar-anchors-keypoints-feature-detection/ (Online: 14.10.2022)

[9] Source: Created by ourself

[10] Source: Created by ourself

[11] T. Taketomi, H. Uchiyama, and S. Ikeda, "Visual Slam Algorithms: a Survey from 2010 to 2016." In: IPSJ Transactions on Computer Vision and Applications, Article number: 16, 2017.

[12] C. Campos, R. Elvira, J.J.G. Rodŕıguez, M. Montie, and D. Tard́os, "Orb-slam3: An Accurate Open-Source Library for Visual, Visual–Inertial and Multimap Slam." In: IEEE Transactions on Robotics, pp. 1–17, July 2020, doi: 10.1109/TRO.2021.2075644

Thank you for your Attention

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