3D Vision –
An enabling Technology for Advanced Driver Assistance and Autonomous Offroad Driving

AIT Austrian Institute of Technology
Safety & Security Department

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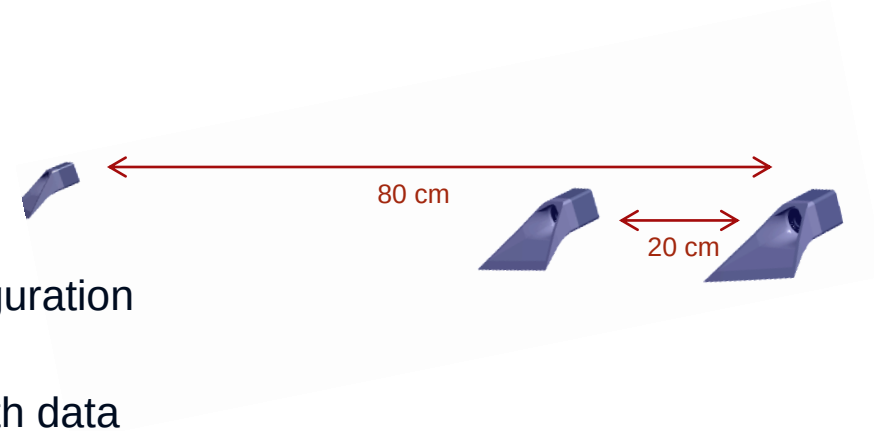
Safe and Autonomous Systems

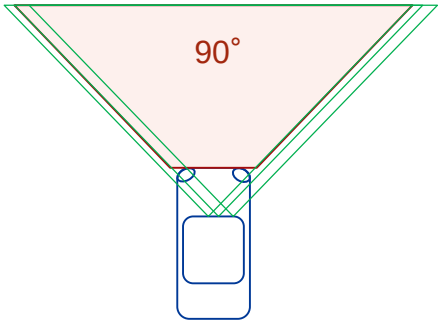
Assistance and Autonomous Systems – Application Areas

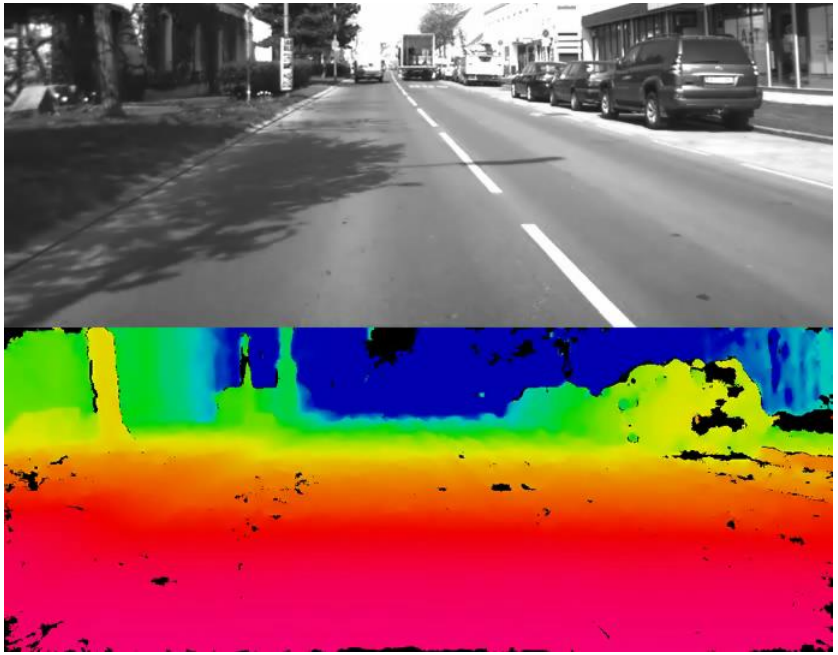
- Traffic
- Transport
- Production
- Agriculture
- Construction
- Surveillance
- Leisure industry
- Crisis & Disaster Management

AIT 3D Vision - Real Time Stereo

- Standard high volume cameras
- AIT stereo matching engine
- Resolution up to 1920 x 1200 (Sony low noise sensor)
- Large baseline and trinocular camera configuration
- Long distance 3D data (>100m)
- Efficient computation of high resolution depth data
- Windshield integration without connecting structure enabled by online calibration refinement
- Large horizontal field of view

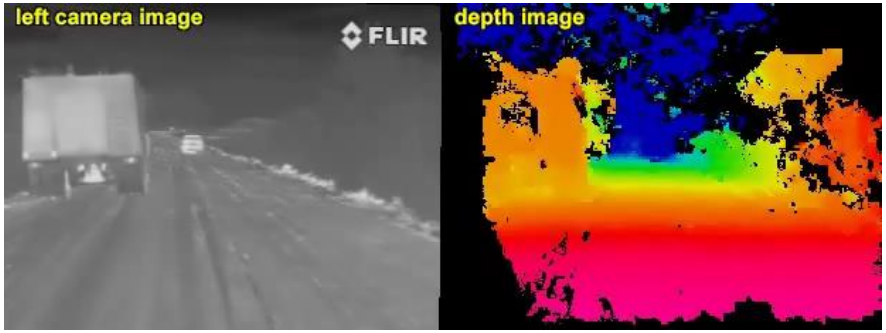




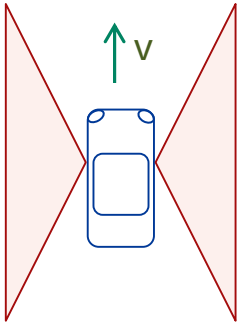


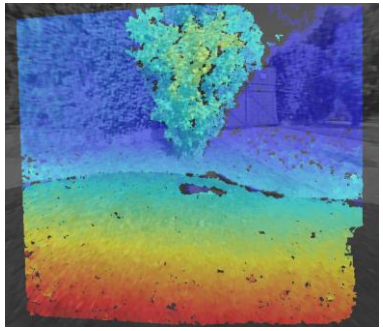
Other Visual Depth Sensor Modalities

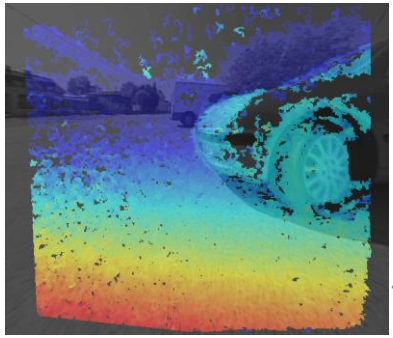
- Night vision stereo
  - Thermal infrared imaging
  - Bolometer array sensors
  - Dense 3D data despite noisy + low resolution images



- AIT dense motion stereo
  - Structure-from-motion in real-time with moving mono camera
  - Side-viewing single camera with wide angle optics
  - Consecutive images build up stereo pairs
  - Depth image computation with modified stereo matching engine

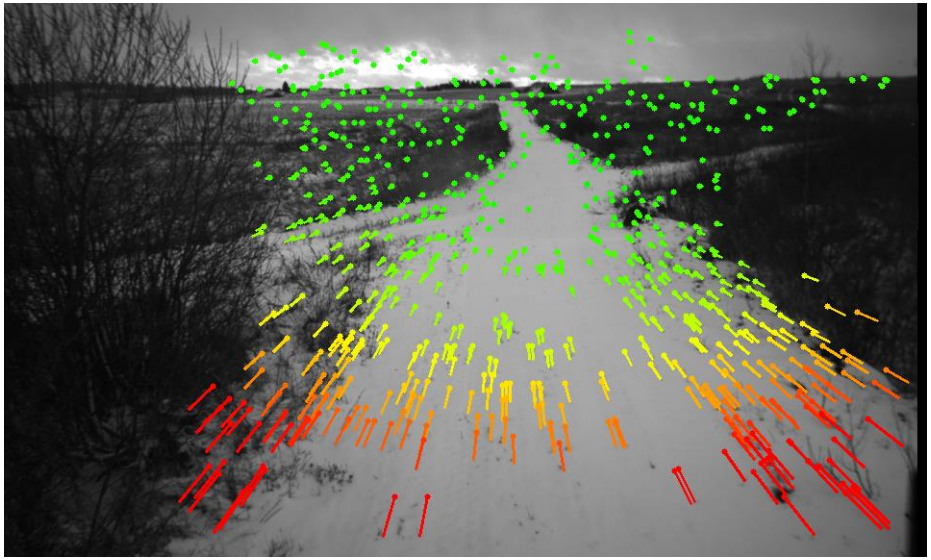


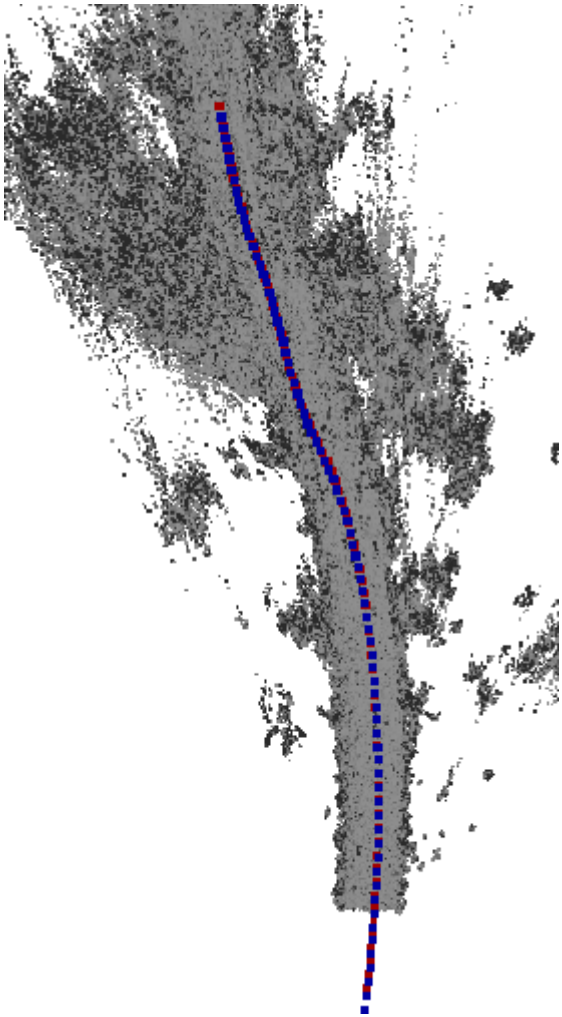




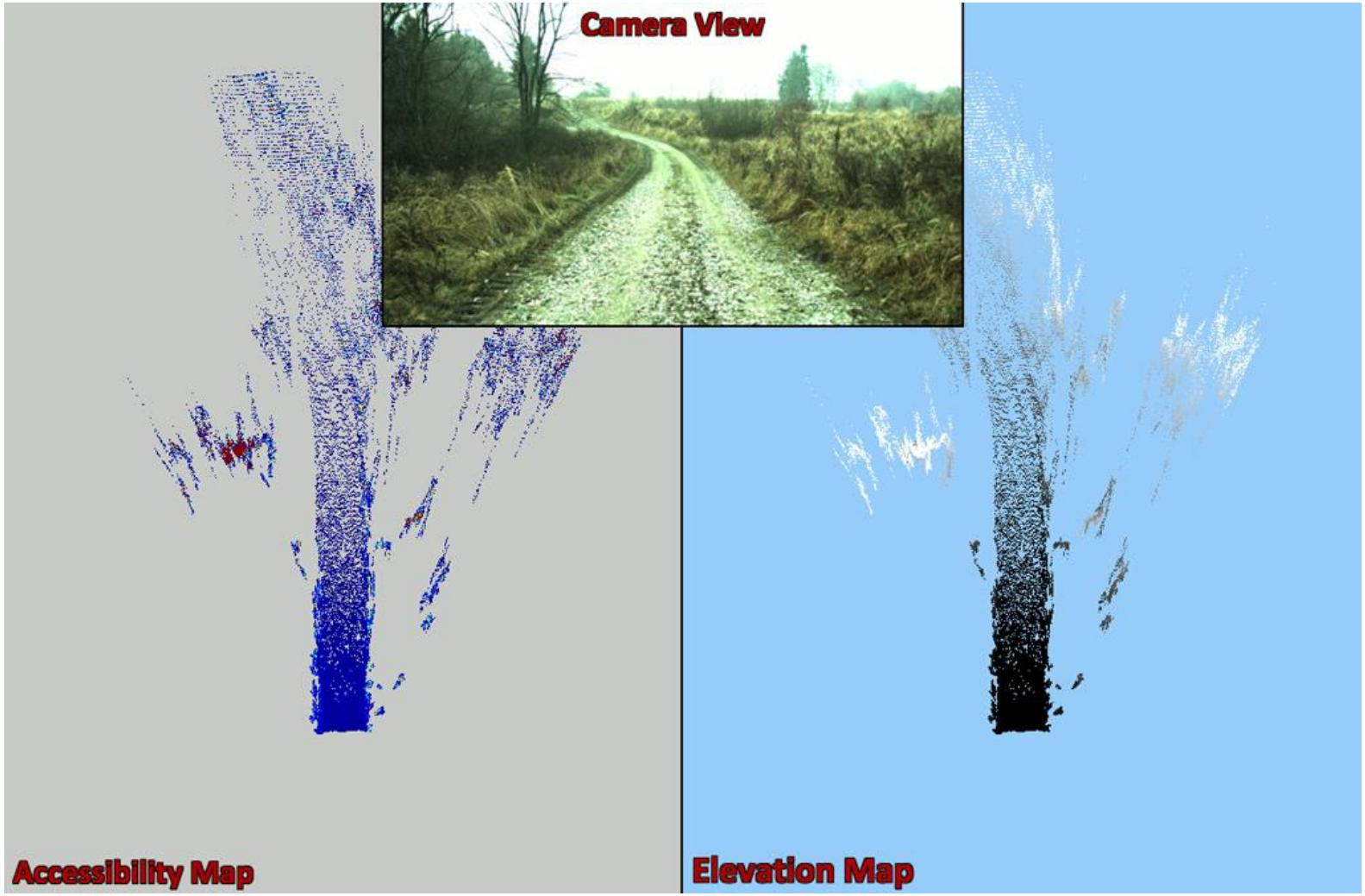
Visual Odometry

- Recognition and tracking of image features
- Reconstruction of the relative vehicle movement based on the displacement of image elements
- Tracks 6 degrees of freedom (location and pose)
- Drift rate <1% when using stereo cameras
- Stabilizes self-localization (e.g. during GPS dropouts)



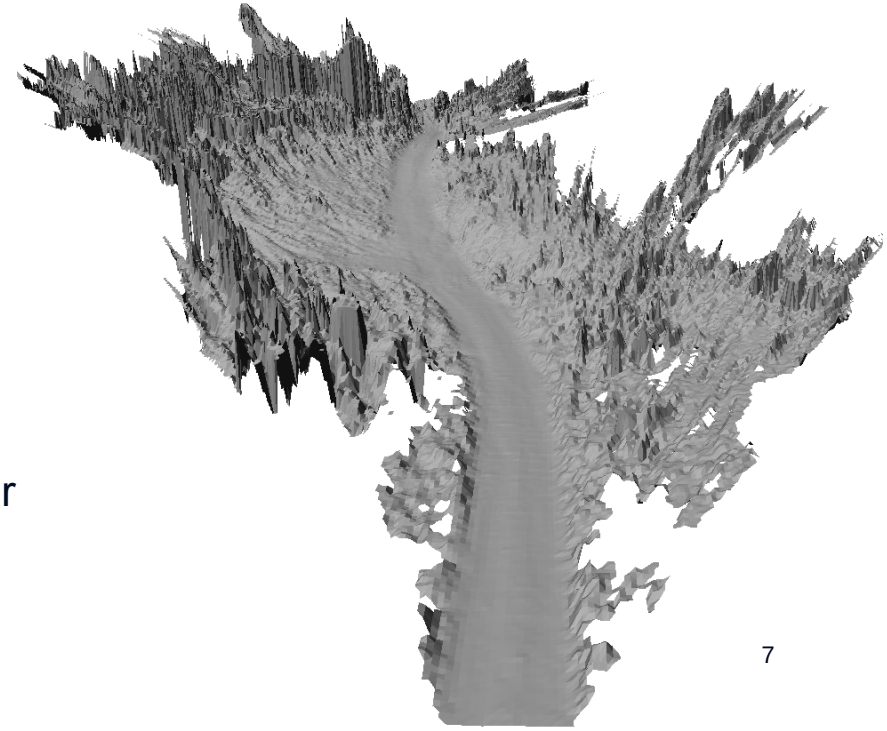


AIT Mapping Module – live Map Creation from Stereo Vision



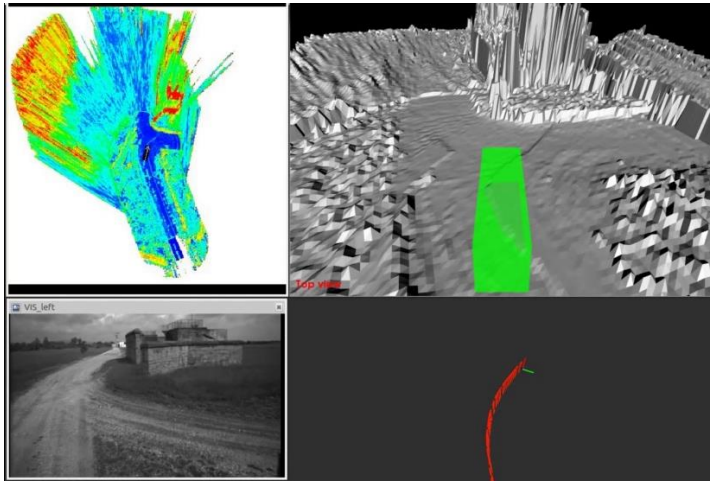
AIT Mapping Module – 3D Environment Model

- Online-creation of geo-referenced map from sensor data
- Map stores various data modalities / attributes
  - elevation
  - texture
  - terrain roughness
  - visual cues
- Methods for visual self localization of a vehicle within a pre-recorded map
- Key to GPS-independent navigation
- „Living“ map: each ride generates new sensor data for map update



Autonomous off-road Vehicle

- Driverless operation in „unregulated/unstructured“ Environment
- Missions in crisis & disaster management
- Visual mapping and self-localization
  - Towards GPS independent navigation
  - 3D-Vision based obstacle avoidance and terrain modelling
  - Solely camera based mode of operation (no need for laser scanners)



Autonomous off-road Vehicle

Technology components

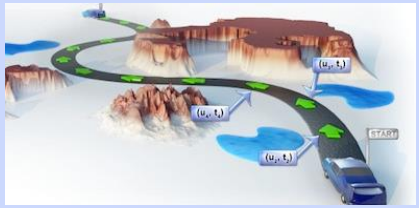
Actuators
- Steering
- Throttle
- Braking
- …

Autopilot & Cruise control

Tracking

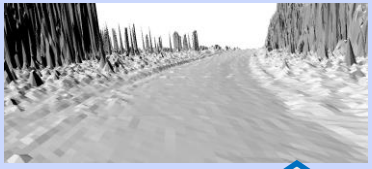
Processing Hardware

Path planning



Mission planning / Route definition

Mapping



3D - Sensors
- Night vision Stereo camera
- Daylight Stereo camera
- Laser scanner

Odometry / Localisation
- Inertial sensor
- Magnetometer
- Wheel speed
- GPS Receiver
- Visual Odometry
- Trajectory filter

Advanced Driver Assistance System for Trams

- Cooperation between

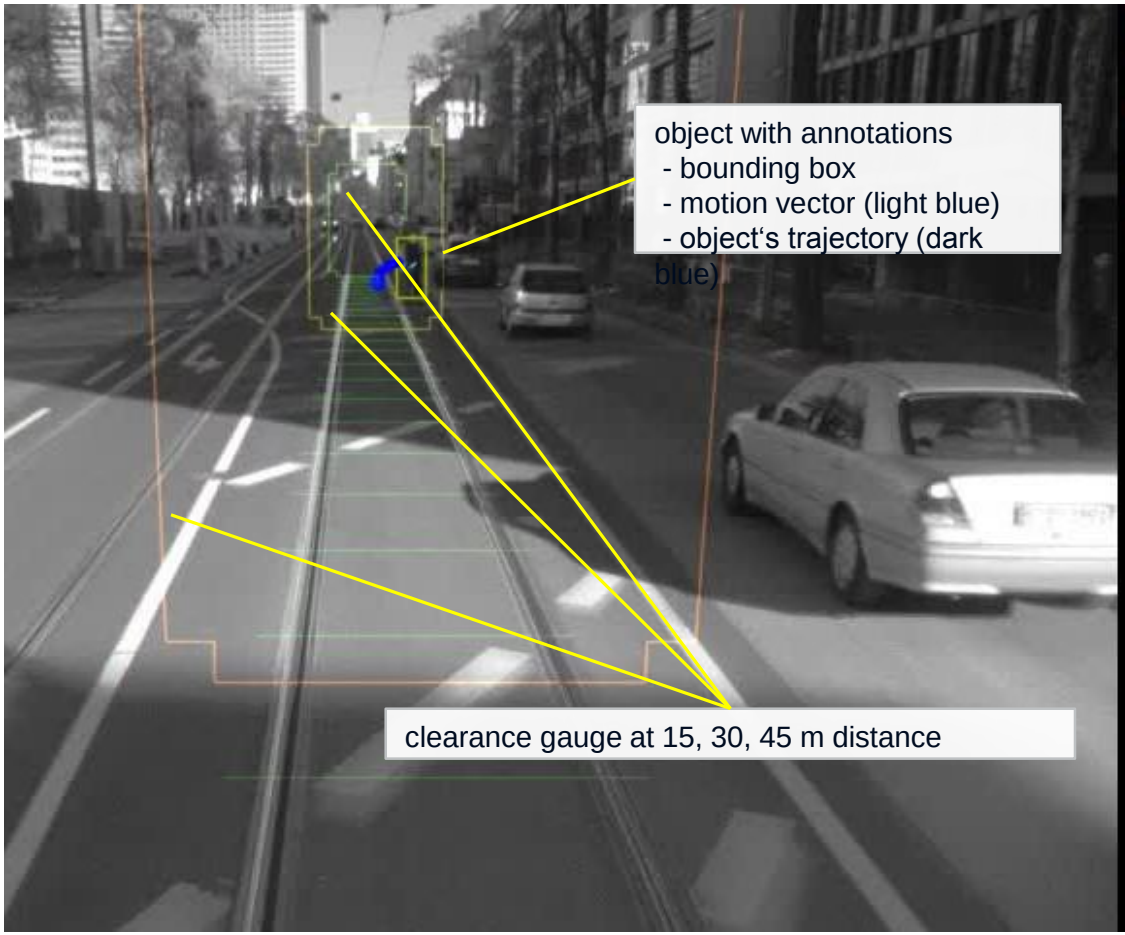
  AIT AUSTRIAN INSTITUTE OF TECHNOLOGY and BOMBARDIER the evolution of mobility

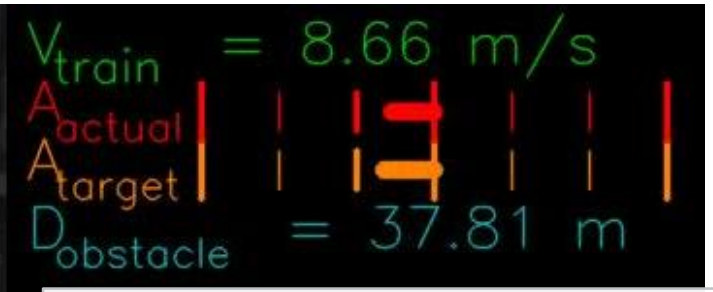
- Collision avoidance for light rail vehicles
- Observation of vehicle envelope in front of the vehicle
- Stereo vision sensor
- Detect and track obstacles
- Identify collision risks
- Issue warnings or trigger brakes

Staatspreis Mobilität 2013

TÜV AUSTRIA Wissenschaftspreis 2014

Advanced Driver Assistance System for Trams





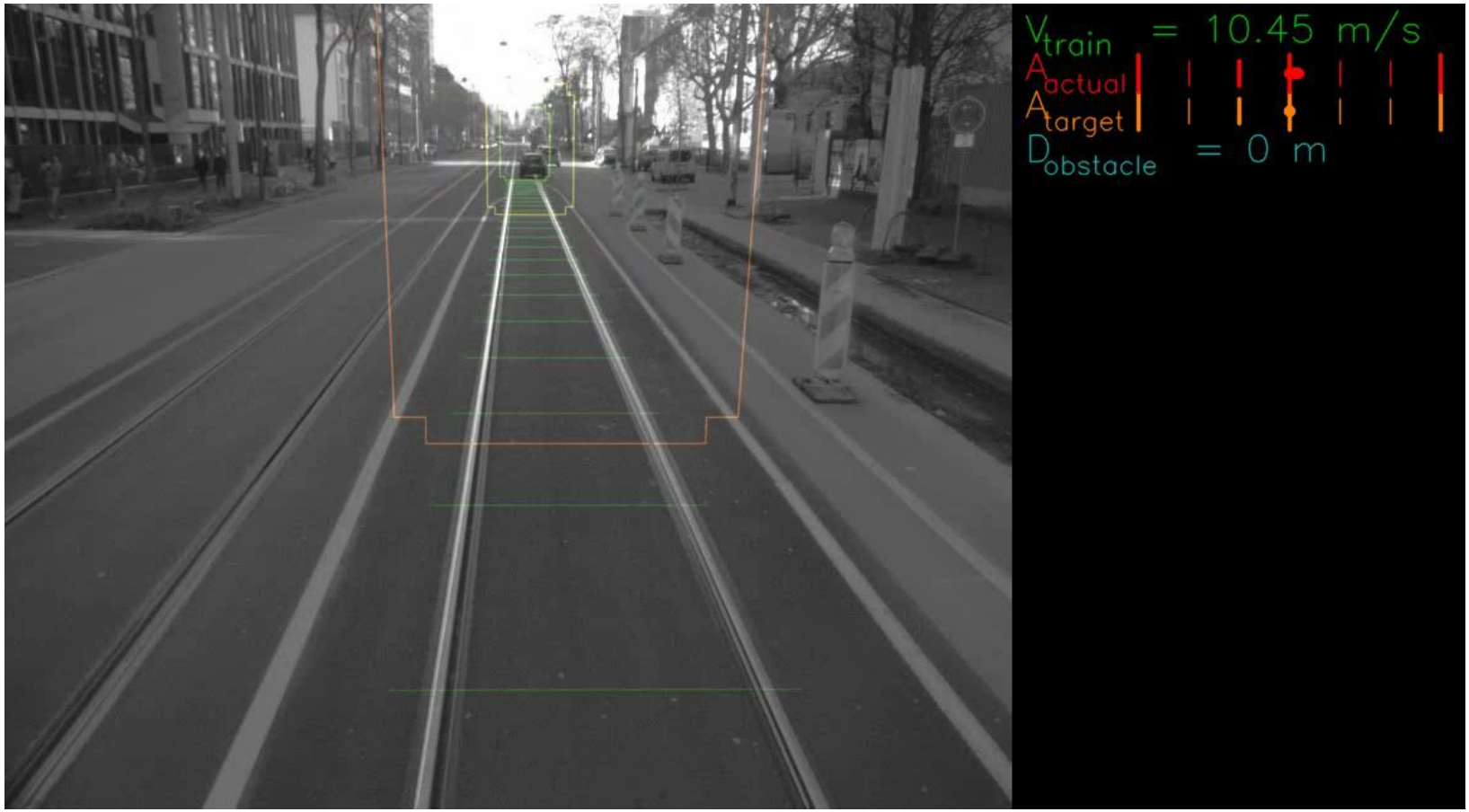
V_{train}…vehicle speed estimated from visual odometry

A_{actual}…vehicle acceleration / deceleration

A_{target}…required braking deceleration

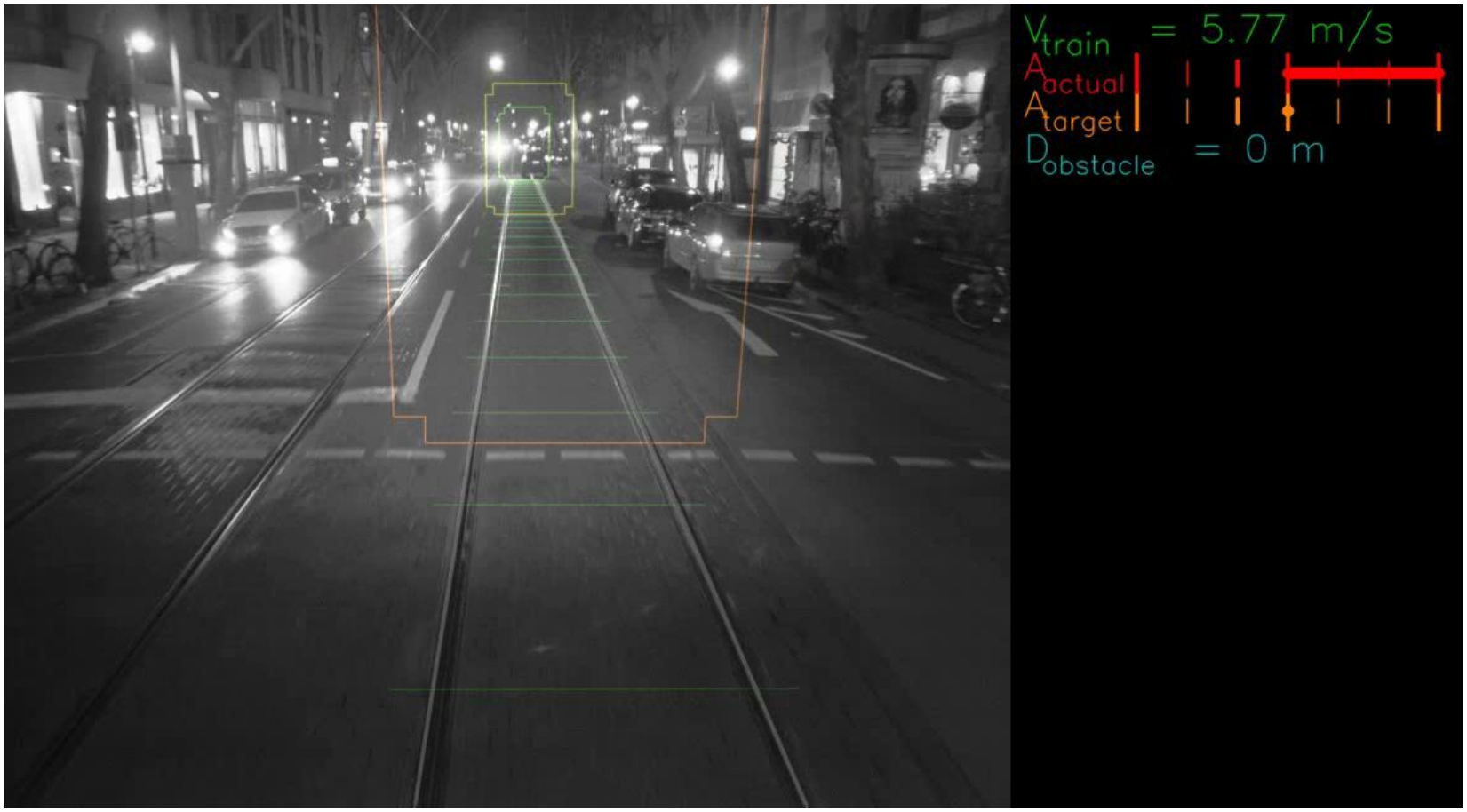
$D_{obstacle}$…distance to closest obstaclet

Tramway Assistance System
Example Daylight & Night Sequences



Tramway Assistance System

Example Daylight & Night Sequences



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