

Concretization of Abstract Traffic Scene Specifications

Using Multi-objective Optimization



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Autonomous Vehicles (AVs) have safety issues



Uber in fatal crash had safety flaws say US investigators

6 November 2019

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Tesla accident in Sichuan kills 2, raises concerns over safety

Source: Global Times Published: 2020/9/6 22:03:40

[social icons] 10

Tesla driver charged with vehicular manslaughter over fatal Autopilot crash

2 Killed in Driverless Tesla Car Crash, Officials Say

"No one was driving the vehicle" when the car crashed and burst into flames, killing two men, a constable said.

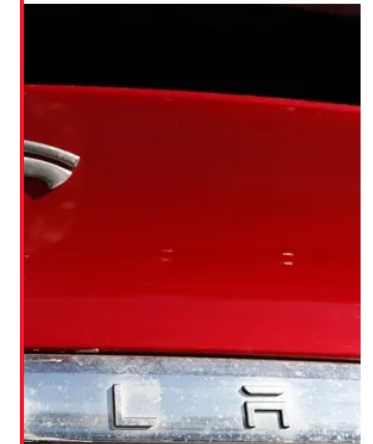
[social icons]



The men killed in the crash said just before they left that they wanted to go for a drive and were talking about the vehicle's driverless features, an official said. KTRK-TV - ABC13

By Bryan Pietsch
Published April 18, 2021 Updated Nov. 10, 2021

er, speed and
two federal agencies

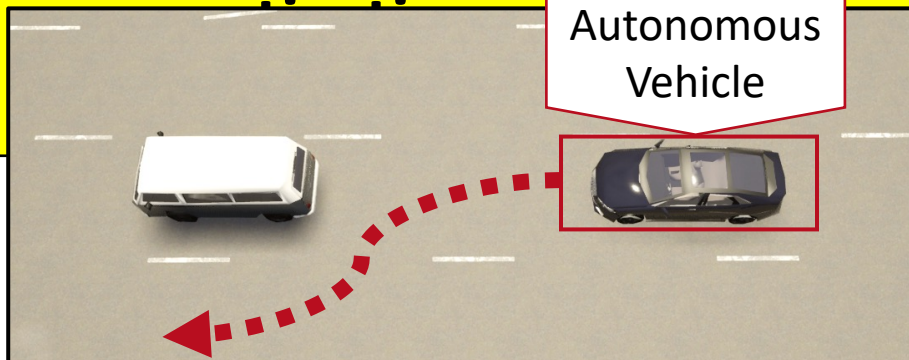


not guilty. Riad, a limousine service driver, is
vid Zalubowski/AP

Scenario-based safety assurance approaches

Often represented at
an abstract level
(i.e. in safety standards)

We need a **scene**



Lane Change Scenario

**Current (*scenario-based*)
safety assurance approaches:**

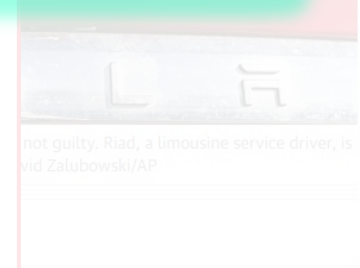
- (1) Obtain challenging *traffic scenarios* for AVs
- (2) *Simulate the scenarios* and evaluate AV safety

Uber in fatal crash had safety flaws say
US investigators



The men killed in the crash said just before they left that they wanted to go for a drive and were talking about the vehicle's driverless features, an official said. [KXAN-TV/ABC7](#)

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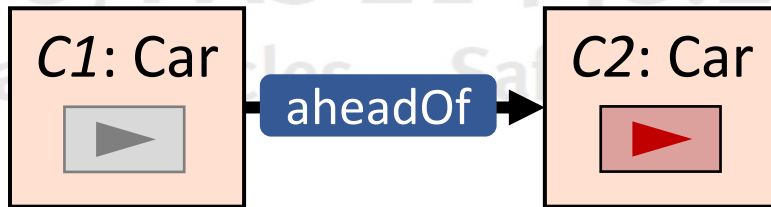
Contributions at the functional (abstract) level

Abstract Repr.

Functional Scene

uses

Qualitative abstractions



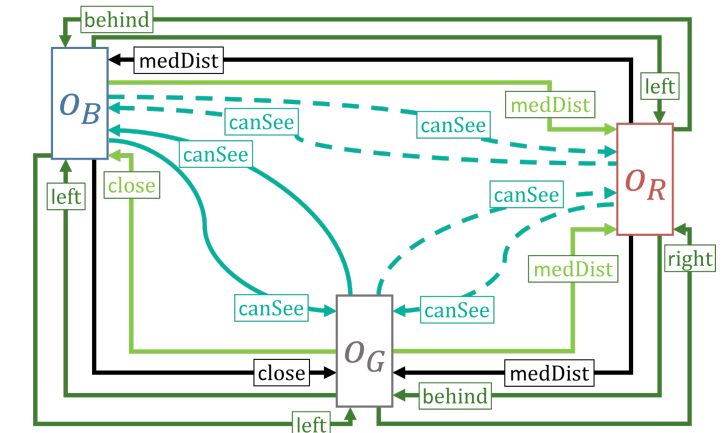
Abstract relations to represent arbitrary scene

- **Distance:**
 - close, medDist, far
- **Visibility:**
 - canSee
- **Positional:**
 - left, right, ahead, behind
- ...

Partial model semantics

Natively handles **4 truth values:**

- *True, False, Unknown, Error*



[Menzel, *et al.*; IVS 2016]

Contributions at the logical level

Abstract Repr.

Simulation-ready

Functional Scene

Logical Scene

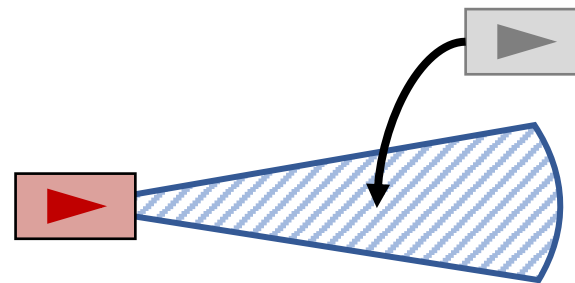
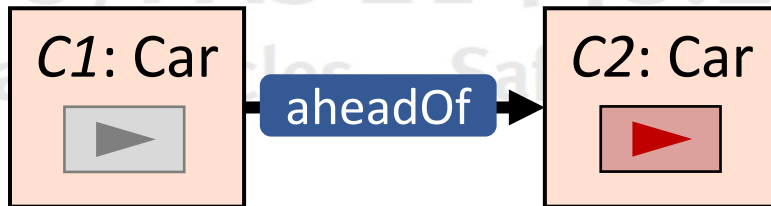
Concrete Scene

uses

uses

Qualitative abstractions

Intervals and regions



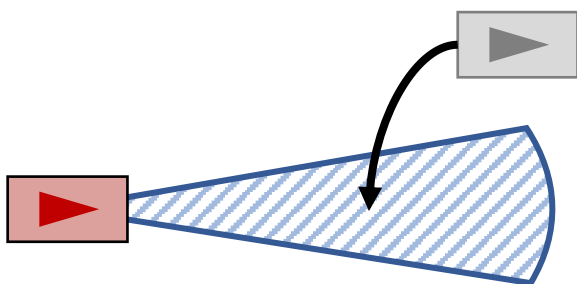
Contributions at the logical level

Abstract Repr.

Logical Scene

uses

Intervals and regions



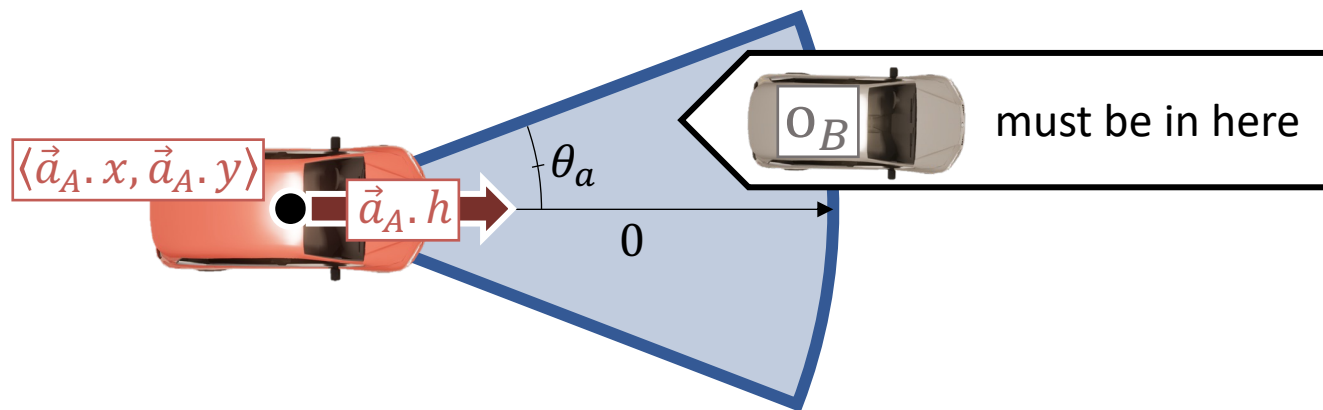
A road-map-independent
abstract-to-numeric constraint mapping

Functional relations

$\text{aheadOf}(o_B, o_A)$

Numeric constraint

$$\exists r_a \geq 0, \vec{a}_A \cdot h - \theta_l \leq \alpha_a \leq \vec{a}_A \cdot h + \theta_l:$$
$$\vec{a}_B \cdot x = \vec{a}_A \cdot x + r_a \cos \alpha_a \wedge \vec{a}_B \cdot y = \vec{a}_A \cdot y + r_a \sin \alpha_a$$



Contributions at the concrete (numeric) level

Abstract Repr.

Simulation-ready

Functional Scene

Logical Scene

Concrete Scene

uses

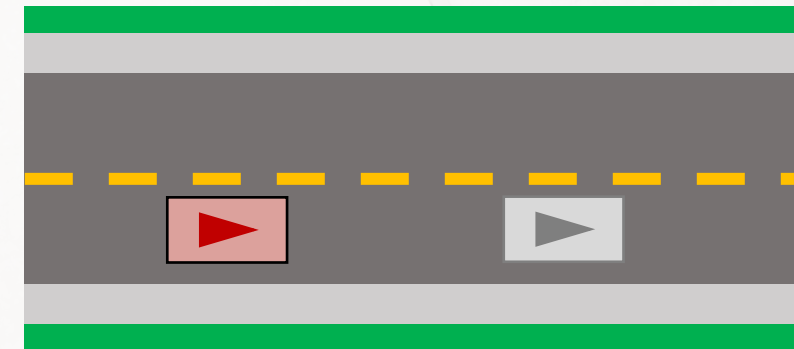
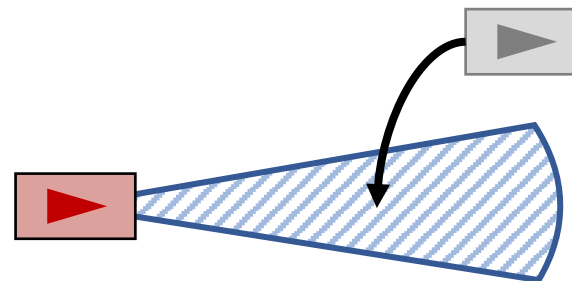
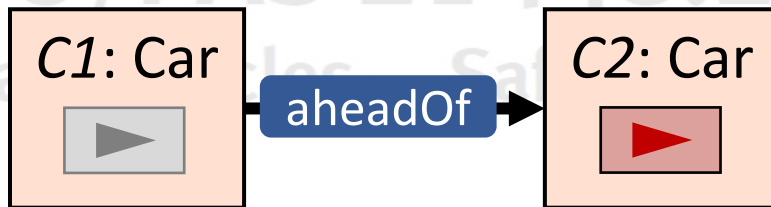
uses

uses

Qualitative abstractions

Intervals and regions

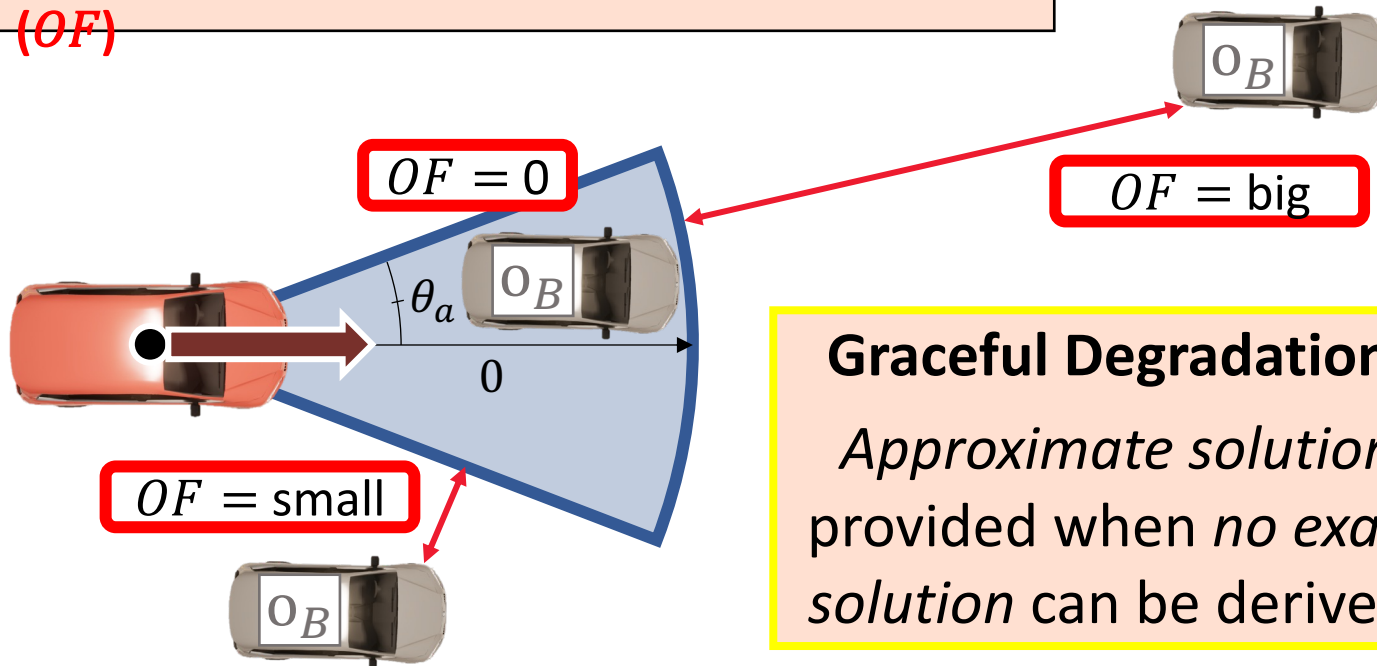
Exact numeric values



Contributions at the concrete (numeric) level

Derived through Multi-objective optimization

We define **custom optimization functions** (OF)

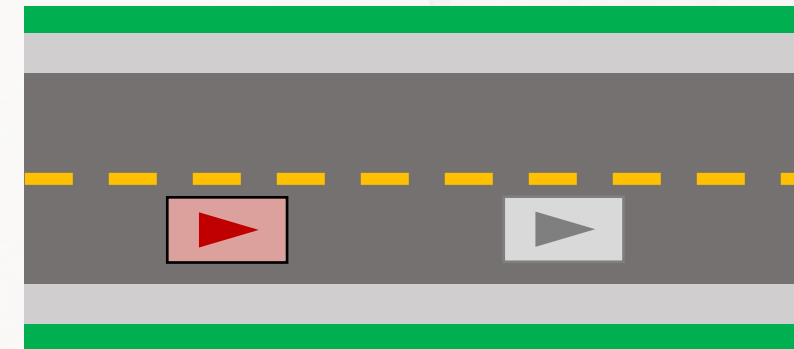


→ Simulation-ready

Concrete Scene

uses

Exact numeric values



Towards safety assurance of AVs

Current (*scenario-based*) safety assurance approaches:

- (1) Obtain challenging traffic scenarios for AVs
- (2) Simulate the scenarios and evaluate AV safety

What makes scenarios *challenging*?

How to *evaluate* safety of an AV?

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Share

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Global Times Publish

Official

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f @

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David Zalubowski/AP

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Autonomoose