Parallel Multi-Hypothesis Algorithm for Criticality Estimation in Traffic and Collision Avoidance

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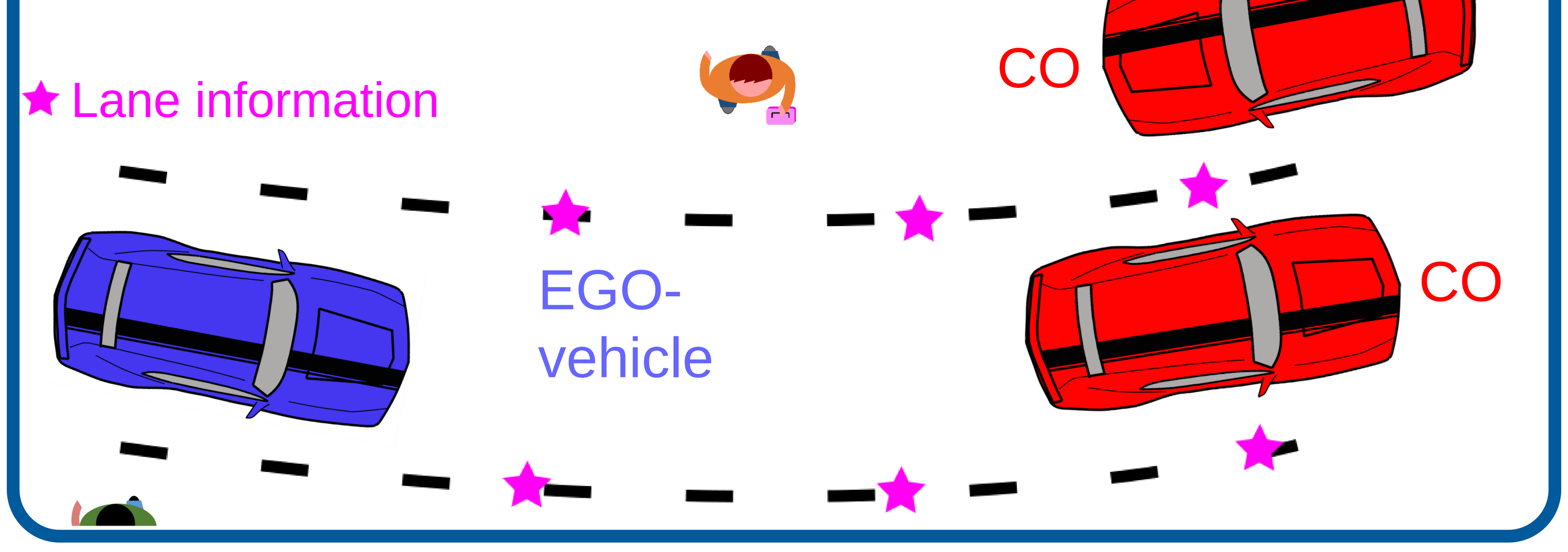
1. Overview

- Prediction of the collision probability of a traffic situation termed as “Criticality”
- Generation of traffic situations based on vehicle sensor information
- A model-based prediction of possible vehicle and pedestrian trajectories
- Detection of possible collisions between traffic participants
- Approximation of conditional probabilities of the possible collisions
- Implementation on multi-core processor
- Output of the algorithm: safe trajectories

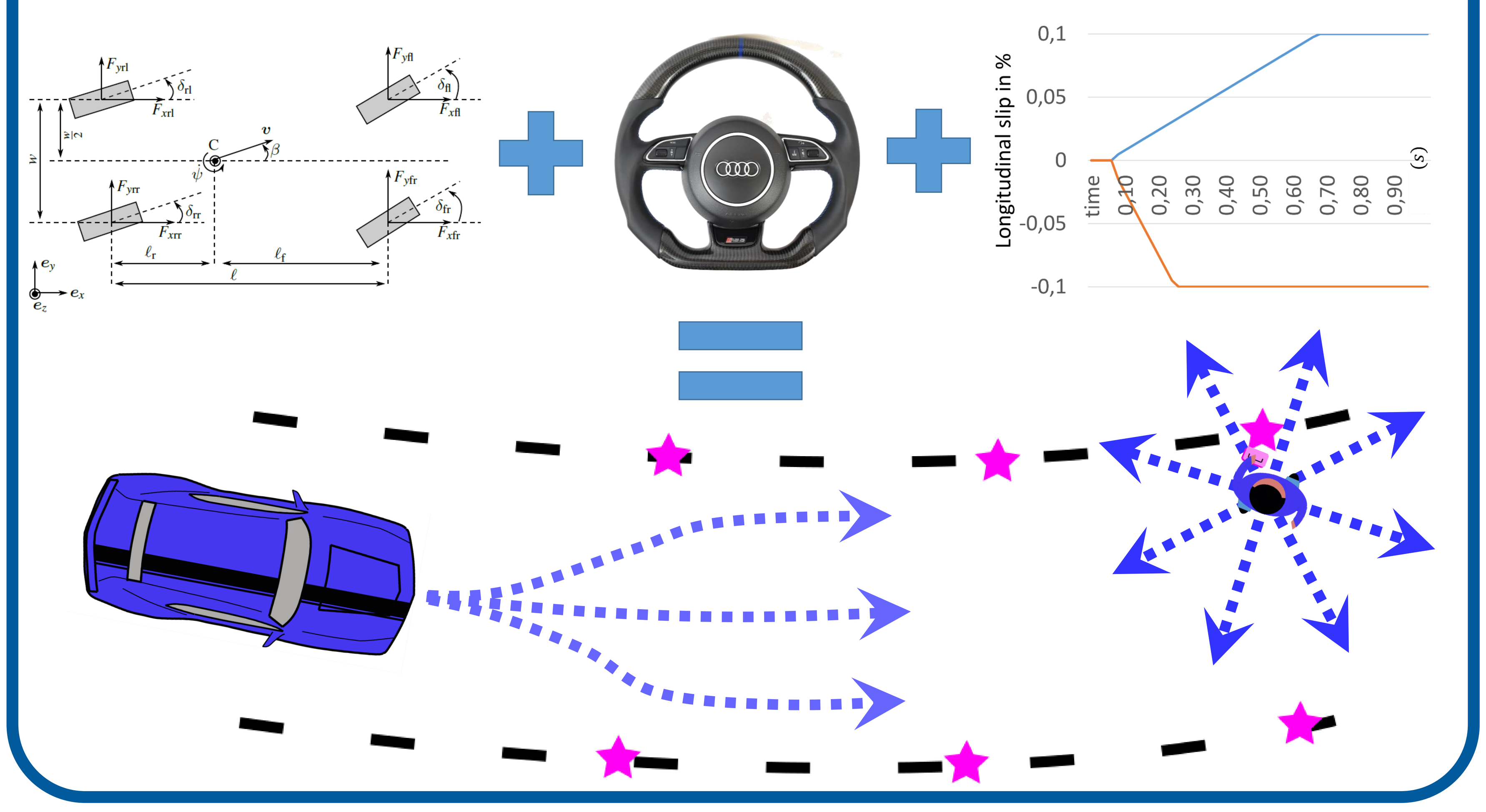
2. Traffic Situation Data Processing

- Sensors deliver information from the traffic situation:
  - Road infrastructure (lanes)
  - State of own (EGO-) vehicle
  - State of collision objects (CO)
    - Other vehicles
    - Pedestrians



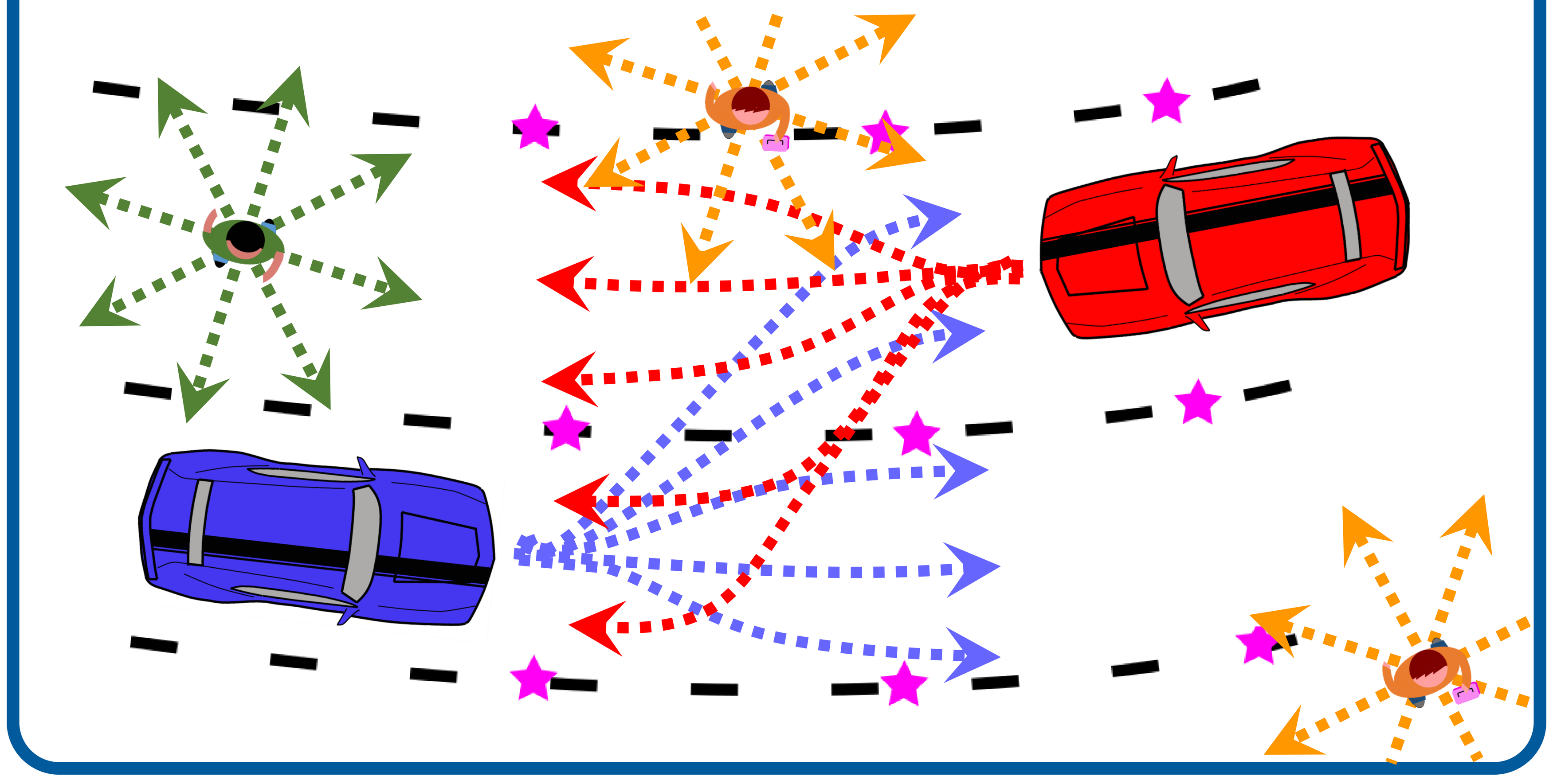
3. Trajectory Generation

- Generation of thousands of realistic trajectories for all vehicles by combining
  - Motion models
  - Controllers for lateral dynamics
  - Acceleration profiles
- Pedestrians are not bound to the road infrastructure



4. Collision Recognition

- Comparison between millions of pose combinations (EGO+CO)
- Detection of possible collisions between objects



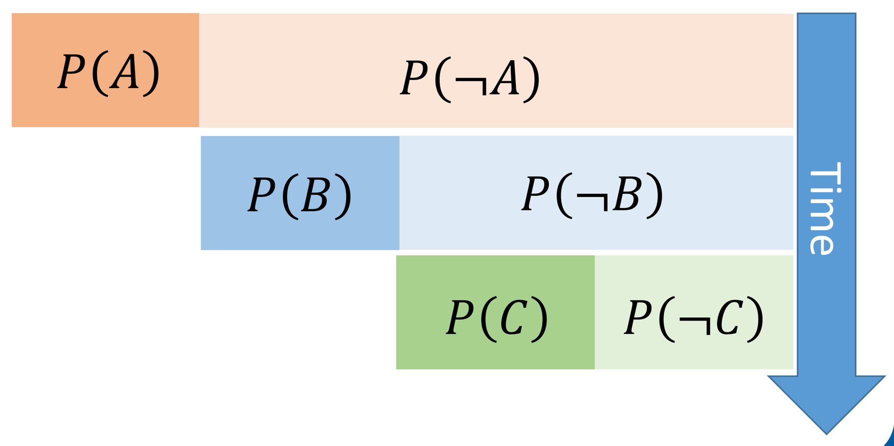
5. Risk Assessment

- Considering two objects**:** joint probability of two objects driving trajectories that lead to a collision
- Extension to more objects**:** taking into account the order in which the collisions can occur

$P(A)$

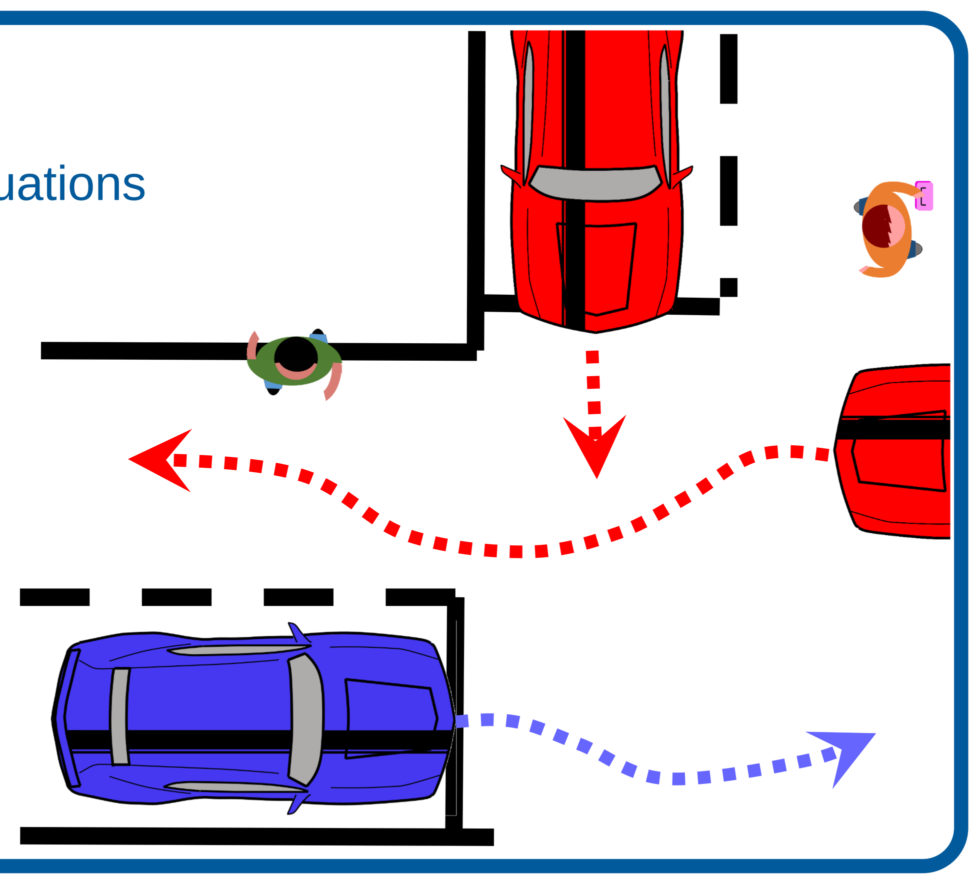
$P(B \cap \neg A) \approx P(\neg A) \cdot P(B)$

$P(C \cap \neg B \cap \neg A) \approx P(\neg A) \cdot P(\neg B) \cdot P(C)$



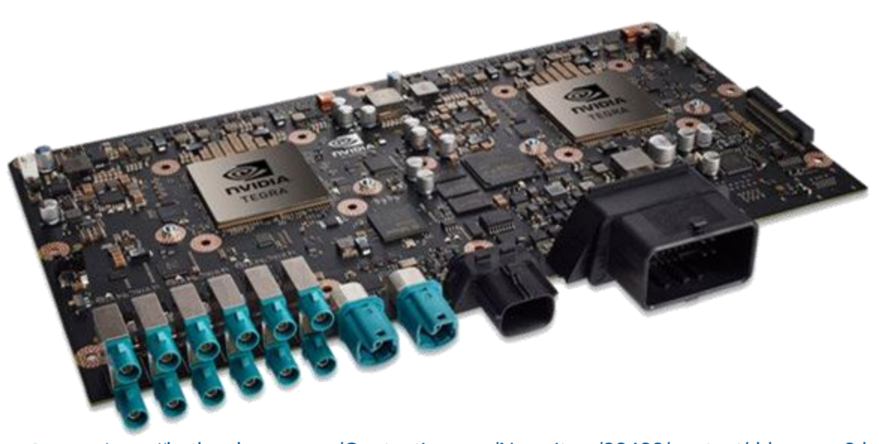
6. Evaluation

- 20 generic, designed traffic situations
- 547 real-life traffic situations



7. Algorithm Mapping to Embedded Systems

- Possibility of parallel execution of thousands of threads
- Exploit hardware specific features: module mapping to the GPU, extensive use of intrinsics (sine, cosine, tangent), no data-transfers between CPU and GPU
- AnyDSL used to avoid tying the implementation to a specific platform
- Thrift used to retrieve input data from the vehicle and to return the algorithm outputs



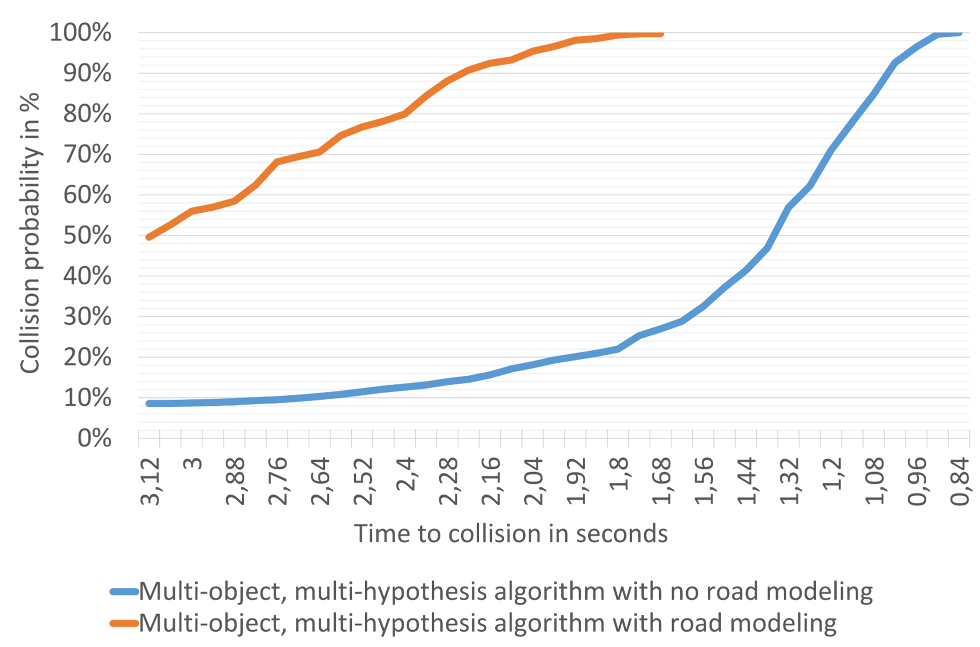
Source: https://hothardware.com/ContentImages/NewsItem/38428/content/drive_px_2.jpg

Runtime performance on a Drive PX 2

# of CO	# of pose combinations	CPU ARM Cortex A57	Pascal GPU GP106 - 1280 cores	Tegra X2 GPU GP10B - 256 cores
3	25.93 million	1800 ms	10 ms	15 ms
	18.00 million	1600 ms	8 ms	11 ms
10	86.44 million	11600 ms	21 ms	49 ms
	60.01 million	9600 ms	14 ms	35 ms

8. Results

- Smooth, gradual changes in the predicted criticality
- Enough anticipation time for activating passive safety systems (cross-traffic) and active safety systems (longitudinal traffic)



9. Conclusion

- Prediction of safe trajectories
- A fully model-based, multi-modal, parallelizable algorithm is presented.
- The criticality of the current traffic situation is predicted
- Further inclusion of road infrastructure elements is possible
- Implementation on vehicle-compatible hardware proves prototypically possibility of use in series-production vehicles