#CAM2019 @LCV_Event

connected automated mobility cenex

The MuCCA Project: Cooperative Collision Avoidance using Desired Versus Planned Trajectory Concept, Implemented on IDAPT Real-Time CAV Platform

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CAM Seminar Hall Sponsor

ZENZIC

SELF-DRIVING REVOLUTION

Multi-Car Collision Avoidance: Theory and Practice

LCV 04Sep2019

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Applus+ IDIADA

MuCCA

- Project supported by CCAV/Innovate UK

Applus IDIADA

WESTFIELD

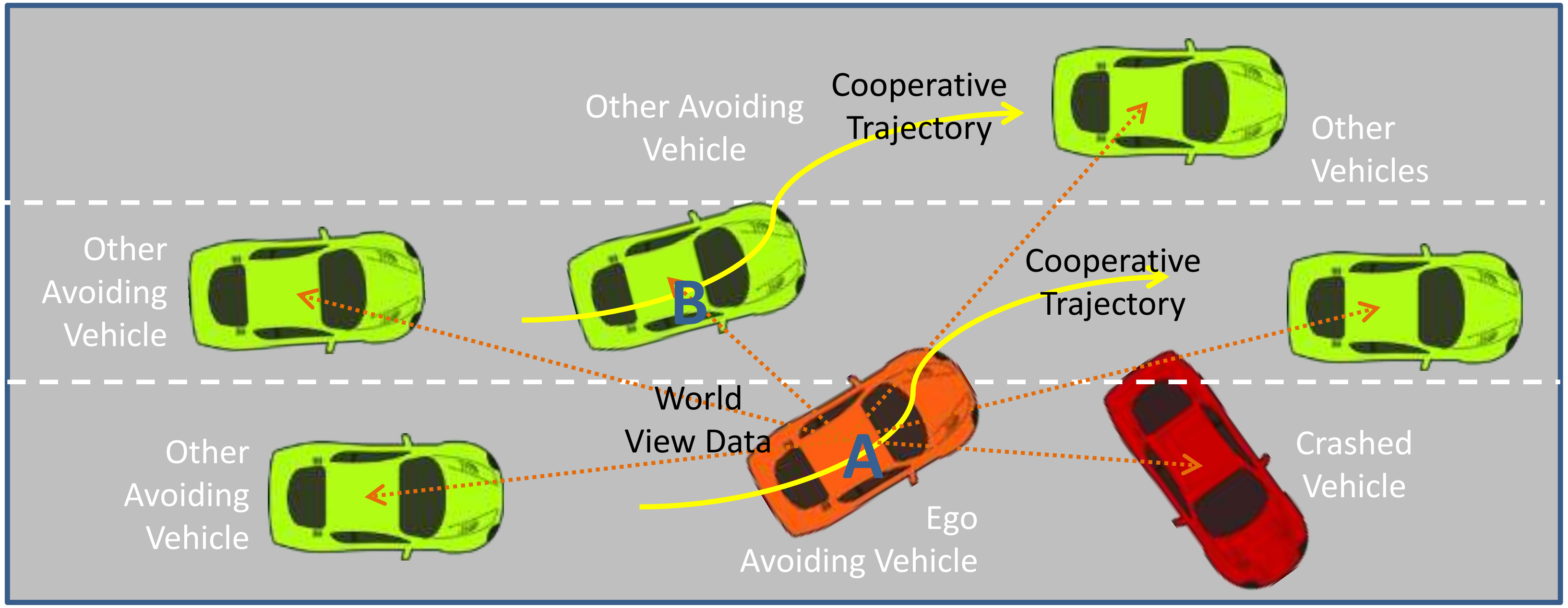
SBD

CATAPULT Connected Places

Cranfield University

COSWORTH

- Real-time V2V data sharing and avoidance coordinated between MuCCA vehicles:
  - "world view" (local dynamic map) enhanced with objects not visible to each car's own sensors
  - Trajectory plans shared between vehicles; each one knows where the others intend to go
  - Co-operative trajectory planning
    - e.g. vehicle B pre-emptively swerves out to give space to vehicle A to swerve past obstacle



- Human driver model
  - Non-MuCCA vehicles likely to be involved too
  - MuCCA vehicles run human behaviour model to estimate likely trajectories
  - Even a single MuCCA vehicle has superlative collision avoidance (by anticipating other vehicle paths)

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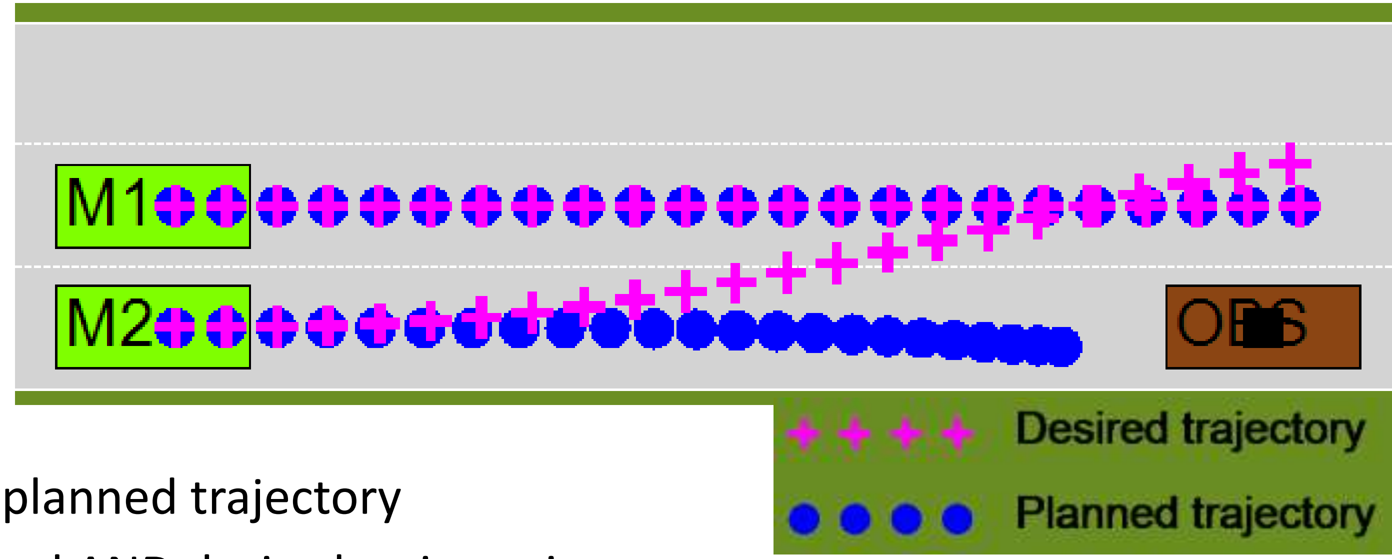
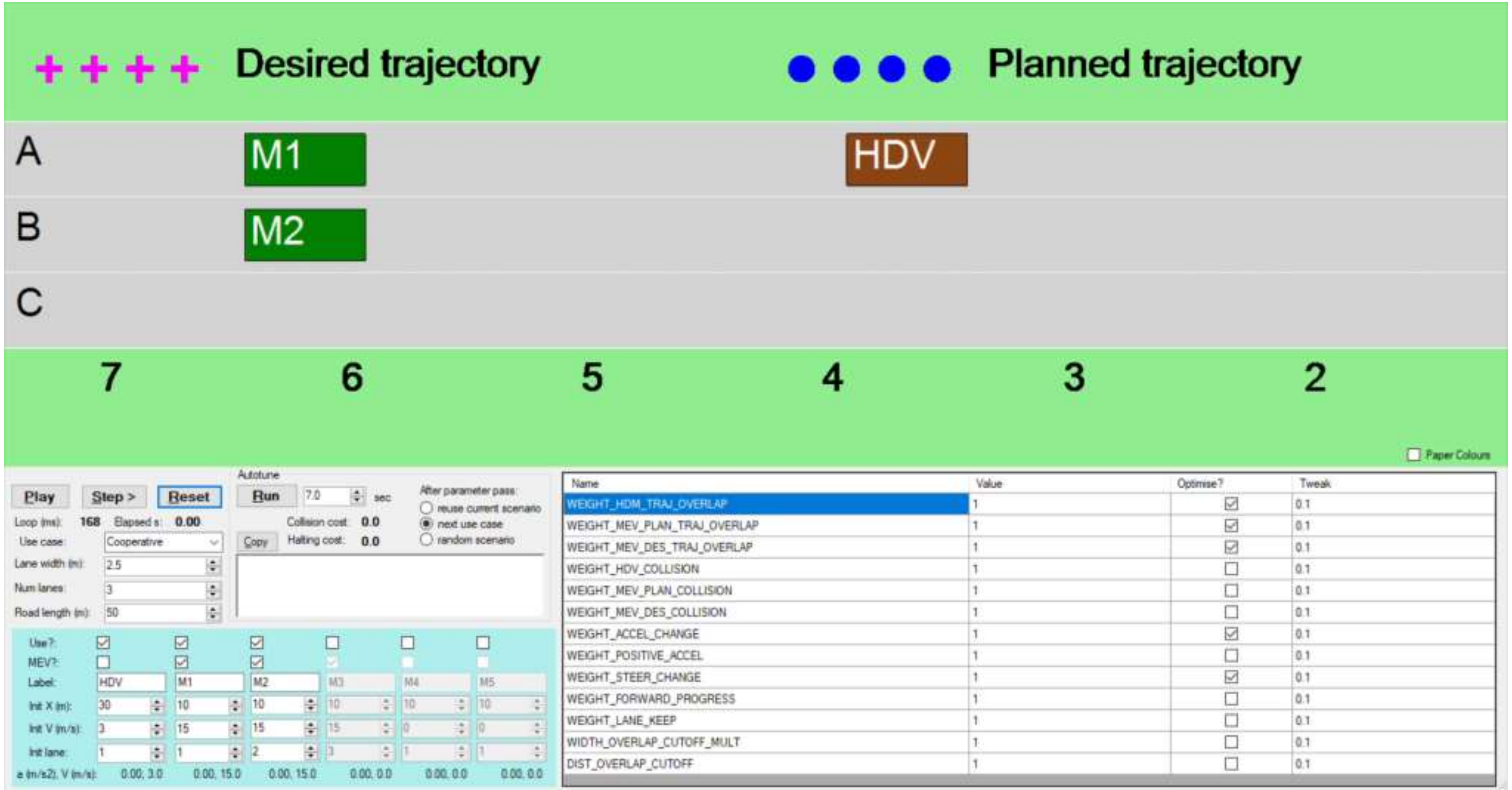
MuCCA



- Video on next slide shows this working
- No leader, each vehicle follows safest immediate planned trajectory
- Each vehicle calculates and V2V-broadcasts planned AND desired trajectories
- Cost function solved using most recent D&P trajectories from all cooperating vehicles
- Other-vehicle desired trajectories avoided if safe to do so
- No predefined reference trajectory; weakly prefers to stay in whichever lane it finds itself
- Cooperative behaviour emerges from these basic rules, as desired trajectories influence other vehicles

- DVP approach (e.g. for cooperative lane changes) from TransAID project, also: B. Lehmann, H. J. Günther and L. Wolf, "A Generic Approach towards Maneuver Coordination for Automated Vehicles," *Proc. IEEE 21st International Conference on Intelligent Transportation Systems (ITSC)*, Maui, Hawaii, USA, 2018, pp. 3333-3339.



Desired trajectory
Planned trajectory
A
B
C
M1
M2
HDV
7
6
5
4
3
2
Paper Colours
Play
Step >
Reset
Loop (ms): 168
Elapsed s: 0.00
Use case: Cooperative
Lane width (m): 2.5
Num lanes: 3
Road length (m): 50
Autotune
Run
7.0
sec
Copy
Collision cost: 0.0
Halting cost: 0.0
After parameter pass:
reuse current scenario
next use case
random scenario
Use?:
MEV?:
Label: HDV M1 M2 M3 M4 M5
Init X (m): 30 10 10 10 10 10
Init V (m/s): 3 15 15 15 0 0
Init lane: 1 1 2 3 1 1
a (m/s2), V (m/s): 0.00; 3.0 0.00, 15.0 0.00, 15.0 0.00, 0.0 0.00, 0.0 0.00, 0.0
Name
Value
Optimise?
Tweak
WEIGHT_HDM_TRAJ_OVERLAP 1 0.1
WEIGHT_MEV_PLAN_TRAJ_OVERLAP 1 0.1
WEIGHT_MEV_DES_TRAJ_OVERLAP 1 0.1
WEIGHT_HDV_COLLISION 1 0.1
WEIGHT_MEV_PLAN_COLLISION 1 0.1
WEIGHT_MEV_DES_COLLISION 1 0.1
WEIGHT_ACCEL_CHANGE 1 0.1
WEIGHT_POSITIVE_ACCEL 1 0.1
WEIGHT_STEER_CHANGE 1 0.1
WEIGHT_FORWARD_PROGRESS 1 0.1
WEIGHT_LANE_KEEP 1 0.1
WIDTH_OVERLAP_CUTOFF_MULT 1 0.1
DIST_OVERLAP_CUTOFF 1 0.1

- Demonstration scope:
  - Straight motorway, no junctions, good weather, daytime, no non-car actors
  - Operational safety measures (trained drivers intervene if necessary)
  - Human drives into scenario before making manual transition to auto driving
  - Only aiming to solve cooperative collision avoidance – that is hard enough!

- Vehicles: 2x Kia Niro with CAN control of actuators, dead man's handle, touchscreen, spoken audio warnings
- Main controller: our own IDIADA IDAPT with:
  - NVIDIA Jetson TX2, safety micro, differential GNSS
  - IMU, cellular modem, 802.11p V2X radio, real I/O
  - Fits in spare wheel well
  - R&D CAV with room for luggage!
- Sensing:
  - Single Cosworth PDR camera working now
  - 4-camera rig + LiDAR augmentation in progress
- Software:
  - C++ application implementing DVP over V2V

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- Initially, virtual (preprogrammed) obstacles at certain GPS coordinates, marked by cones
- Fake GPS offset: allows "side by side" testing when vehicles safely separated
- Lanes pre-mapped so not depending on camera detection of lines
- Robot control geofenced to marked road area

Marking "obstacle" location with cones

Checking preplotted lane lines against real end of track

Applus IDIADA

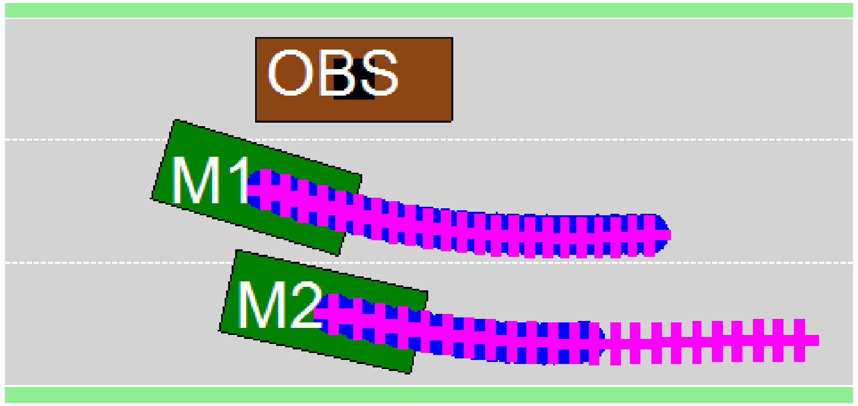
MuCCA

First MuCCA Track Tests

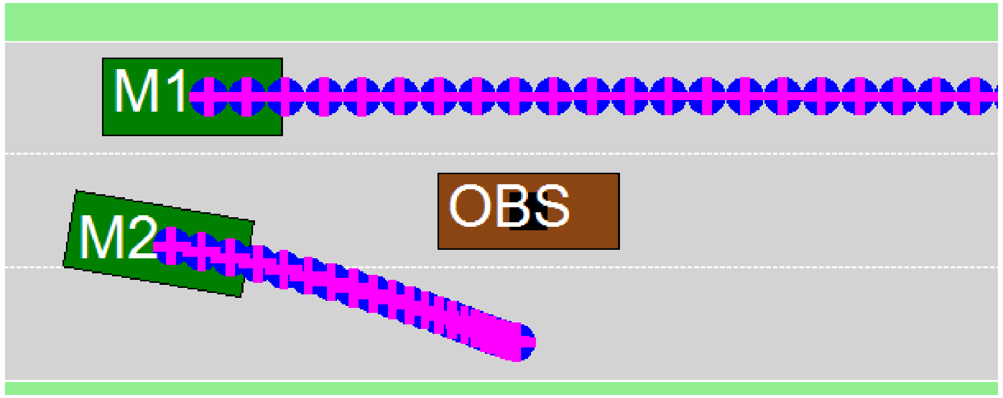
Bruntingthorpe Proving Ground July 2019

- Single car swerved round or braked for obstacle, depending on cost function weights
- Live fully automated cooperative behaviour demonstrated using DVP protocol and V2V communications
  - Scenario 1: pre-emptive cooperative swerve
  - Scenario 2: swerve avoiding both obstacle and other vehicle
- Both using fake GPS offset, so both cars "think" right hand one starts in lane 2, actually in lane 3:

Scenario 1



Scenario 2



- Distributed, leaderless Desired Versus Planned algorithm flexible, simple and robust for 'n' vehicles cooperating over V2V
- First (?) real-time automatic cooperative collision avoidance seen in full-sized robot cars in early track tests
- Much work remains for quantitative reproducible results
- Author: charlie.wartnaby@idiada.com
- Desired versus planned concept/simulation paper: https://arxiv.org/abs/1904.07053
- **Work supported by CCAV/Innovate UK**

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