Predictive gearshift strategy

Challenges and solutions:

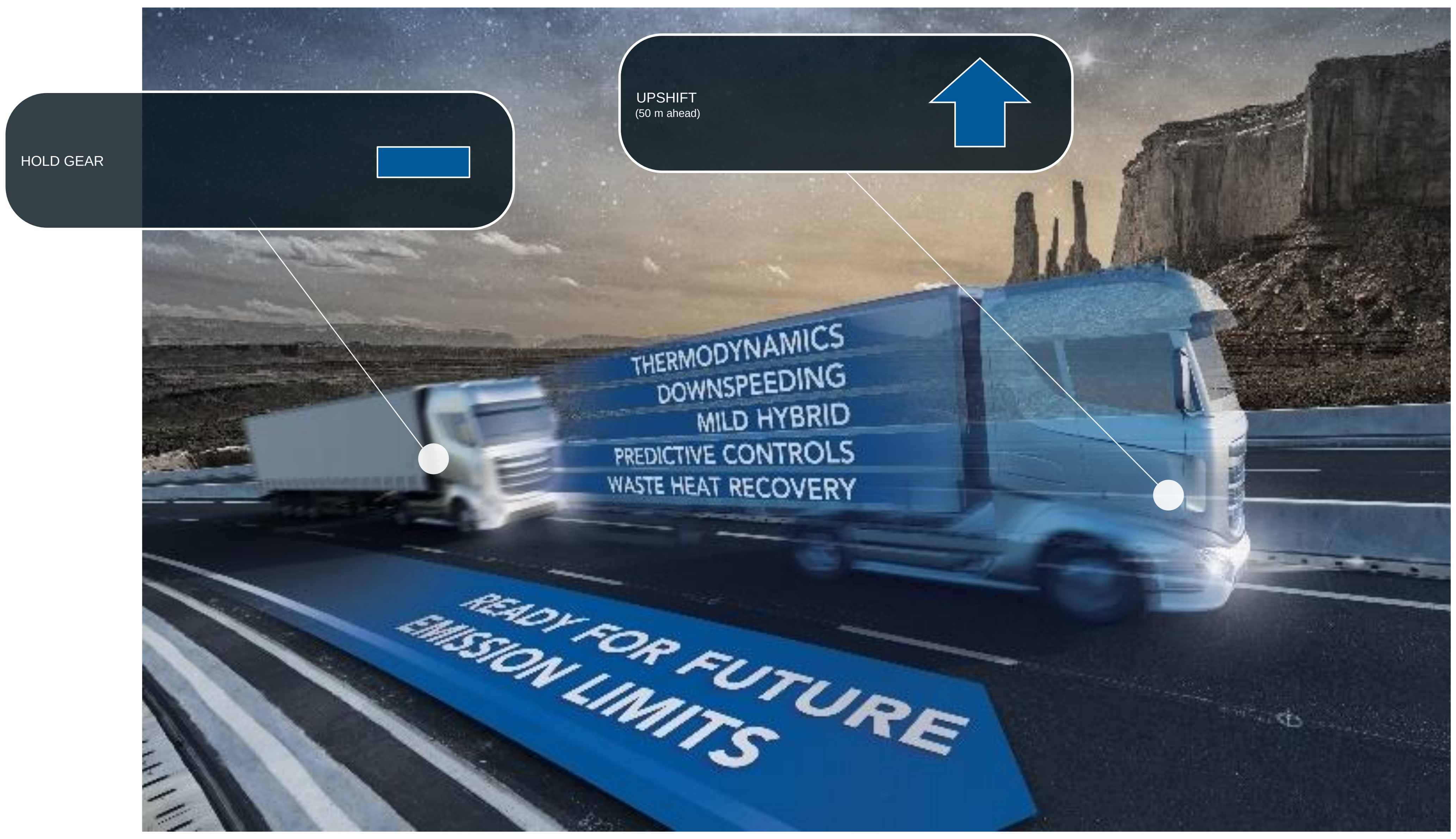
Modern powertrains are designed for lowest fuel consumption at cruising speeds (highest gear for the lowest losses in the transmission) and therefore run at fairly low engine speeds. The power however at that engine speed is limited (despite high torque engines) and therefore in order to be able to get the full engine power a gear shift has to be made to keep the cruising speed going uphill. When that shift is made when the vehicle speeds starts to drop, then even time is lost during the gearshift (due to the power interrupt). Also fuel is saved by reducing shifts due to reduction of is revving up events of the engine.
The time that is gained by avoiding uphill downshifts can be used for instance on lower speed just before approaching the top of the hill (knowing that shortly after going downhill the vehicle speed will increase again) and avoiding another gear shift just before the crest (with another power interrupt that is causing delays). With the road data in the shifting algorithms uphill shifting can be reduced and time gained can be used in other parts of the cycle for further reduction of fuel consumption.

IMPERIUM's contributions:

The main target of the preview shift algorithm is to calculate an optimized gear shift strategy for a defined horizon to gain a fuel consumption benefit compared to a conventional shifting strategy. The required preview information about the road ahead is provided by an eHorizon system, which sends predictive static and dynamic data according to the vehicle position and most probable driving route.
Conventional non-predictive gear shift strategy usually operates with predefined and adaptive shift up- and down shifting thresholds. Multi-shifts are depending on heuristic rules which are imitating a trained driver's behavior. Modern predictive shift strategies also consider predictive driver behavior, e.g. shifting back before an uphill maneuver starts to avoid shifting at high drivetrain loads.
The proposed method uses predictive information and optimizes the fuel consumption. The predictive road data is available from an eHorizon system and heuristic models are avoided if mathematical fuel cost models are available.
The predictive gear selection (PGS) algorithm optimizes the sequence of possible gears to minimize a mathematical cost function. This cost function corresponds to the required fuel for the predictive drivetrain command.
An online dynamic programming approach was applied (DP) to provide gear sequences and their fuel costs in addition. The optimization core considers the drivetrain and the vehicle dynamics with its losses (air, rolling, rear axle losses, and transmission losses).

Impact / what's next:

For a first functional verification of the dynamic programming algorithm a more detailed evaluation of the cost grid calculation was performed.
Testing of the algorithm was performed, to ensure that the functional requirements are met. The advantage of "seeing" an upcoming hill can be translated into a fuel consumption reduction, if the non-predictive gear selection is forced to shift down driving already uphill. In this use case the loss of kinetic energy can be avoided with optimizing the shifting point using the predictive information. Another use case that can be identified is shifting earlier into higher gears, if the prediction shows a low power demand in the upcoming section.
The potential of this strategy is reduced somewhat by faster shifting in the latest generation gearboxes (reduced time of power interrupt), however still interesting and part of measures to be considered for achieving future goals in CO_2-reduction of trucks. With partners (coming to a reliable standard) in future projects need to come to better road data availability.



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