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DETERMINATION AND OPTIMIZATION OF THE TRAFFIC FOOTPRINT

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Technical task:
Safety systems are known that warn a motorist and/or automatically initiate a braking process as soon as the distance to an object in front is rapidly reduced and an accident is therefore imminent. Systems are also known that keep a vehicle at an approximate distance from a vehicle ahead (Adaptive Cruise Control (ACC)).

Initial situation:
It is also known that traffic jams occasionally arise "out of nowhere" (phantom jams) due to the fact that individual vehicles brake strongly and this continues. The reason for this is usually too little distance to the front vehicle and/or braking too late (and correspondingly faster). Other reasons for suboptimal traffic flow are overtaking too slowly and disregarding the right-hand drive requirement.
Drivers are often not aware of their negative influence on traffic flow. For example, (co-)generated phantom traffic jams are not visible to the driver because the traffic jam behind him is created.

Solution:
For a vehicle or a driver, a "traffic footprint" is determined by a computing unit. This footprint describes the negative influence on the overall traffic flow, i.e. for example the sum of travel time that all road users would need less if this road user did not participate in the traffic events. Example: If a road user causes a traffic jam that affects 100 vehicles arriving 10 minutes later, then this event contributes 1000 minutes to the Footprint. As an alternative or in addition to this "temporal footprint", an "energetic footprint" can also be calculated because the 100 vehicles consume energy by braking and accelerating (which is not otherwise necessary) (measurement of the "destroyed" kinetic energy or a quantity of fuel or electricity that can either be estimated or even reported by the vehicles concerned). It is also possible to calculate an extended "CO2 footprint" which takes into account the additional CO2 emissions of other road users.
In order to calculate the footprint, as much traffic information as possible must be processed, which can be obtained from data sources such as vehicle sensors, traffic monitoring cameras, ground loops, movement data of other vehicles, etc. The data can also be used to calculate the CO2 footprint of other road users. For example, at a traffic light it can be calculated how many more vehicles could have passed the traffic light if a certain driver had not "overslept the start". (Incidentally, optimum behaviour at a traffic light can also produce a negative footprint if following vehicles have to stop - instead of the vehicle, one of the following vehicles could have passed and thus wait less).
Depending on the desired accuracy of the result, simulations can be used to determine the footprint: For example, in a phantom jam, simulation can be used to determine how the traffic would have behaved if a particular driver had not been involved in the traffic situation. It could be, for example, that a traffic jam would not have occurred, or that a traffic jam would have occurred anyway. It would even be possible that a traffic jam would be mitigated by particularly skillful driving behaviour (smooth driving with large safety distances), which would have a positive effect on the footprint. Such simulations are possible with the state of the art, but require the above-mentioned information on the traffic situation, the course of the road, etc.
If a large amount of information is to be processed over a larger area, it is advantageous that the calculation of the footprint does not take place in the vehicle, but on a computing unit to which this information may already be available, e.g. a traffic light control system or a modern traffic control system for motorways. In this case, appropriate equipment must be provided to determine the respective vehicles. A description such as "the blue car which was at GPS position X at 14:21:12:244 hrs" is sufficient if this can then be assigned by other control devices (for example, the own car would know these values and could then assign itself to the given footprint).

Advantages:
The driver becomes aware of the consequences of his actions. He will (hopefully) show a more conscious driving style. He can also be rewarded for good behaviour.

Possible applications:
The traffic footprint (temporal/energetic/environmental) is then communicated to the driver and, if necessary, related to the footprints of other drivers. The advantage is that the footprint is transmitted by radio to a vehicle control unit, which then controls a display device. If, for example, the driver has produced a relatively bad/large footprint, this could be indicated to him. Tips can also be displayed. In particular, situations that had a particularly large influence on the footprint can also be displayed/evaluated and a behaviour recommended that would have been better in these situations. If, for example, the driver has been at the mercy of a traffic jam, he can be shown in concrete terms how this was done and how he could have acted better in the situation.
In a further version, particularly "critical" situations are recognised promptly and the driver is informed in advance of an advantageous course of action, for example not to oversleep the start at a traffic light or not to block the left lane on the motorway. Historical data can also be included, e.g. it can be known that phantom traffic jams often occur at certain times on a certain section of motorway and that therefore particularly careful driving behaviour is recommended there.
In another variant, the calculated footprints or potential footprints are incorporated into the planning process of an automatic control unit. For example, an ACC can then prefer a particularly steady driving speed for motorway sections at risk of traffic jams.

In another variant, the footprint is stored in a database. This knowledge can then be used, for example, to reward particularly careful drivers. In this way an incentive for better behaviour can be created.