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STOP AND GO CRUISE CONTROL

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ABSTRACT–This paper will address the basic requirements for realizing a stop and go cruise control system. Issues discussed comprise: functional, sensor and basic HMI requirements, primary characterization of naturalistic stop & go driving, and the basic approach of the transformation of situational knowledge in an elementary controller.

KEY WORDS : Driver assistance systems, ACC, Cruise control, Stop and go

1. INTRODUCTION

The concept of assisting the driver in the task of longitudinal vehicle control has been a major focal point of research at many companies and institutes in the past decade. Automotive companies like BMW have already marketed first products (Prestl, 2000) and several others are close to the market introduction of assistance systems such as Active Cruise Control (ACC). These systems are characterized by a moderately low level of throttle and brake authority. They are predominantly designed for highway applications characterized by a rather homogeneous traffic behavior with some substantial geometry constraint and a rather low level of dynamic driver-vehicle interaction. Currently, second generation longitudinal assistance systems are being developed that can handle more complex traffic scenarios and consequently can be operated at lower speeds and on roads with less geometrical constraints found, for example, in urban areas.

Active Cruise Control for metropolitan areas can significantly enhance the benefits of a first generation ACC in terms of comfort, safety, traffic flow, noise and emissions. Such a system may be operated in a very complex environment consisting of a variety of road users (such as cars and cyclists) using a much more complex infrastructure creating numerous traffic situations. However, due to this complexity, it will be virtually impossible to create a system that can handle all the possible situations and, therefore, one particular case is of special interest: stop and go driving.

Stop and go cruise control, relative to an ACC system with a low level of deceleration, must take into consideration a much broader view of the driving environment. The traditional approach of following the vehicle immediately in front of the equipped vehicle may no longer apply, as stop and go is no longer limited to the simple task of following. It requires extensive knowledge about driver and traffic behavior. New sensor concepts for detecting the driving environment will need to be developed and the acquired information needs to be transformed into an assessment of the traffic situation.

Models are necessary in order to identify the traffic state and determination of the appropriate actions for each situation needs to be established. The basis for the design of a stop and go cruise control system lies in empirically studying naturalistic driving, involving driving measurements, data processing, model development, model evaluation and model-based analyses.

2. OBJECTIVE

Stop and go cruise control can be seen as a typical evolution of the current ACC system. The main objective is to offer the customer longitudinal support on a vehicle guidance level at low vehicle speeds all the way down to zero velocity. This support is offered to alleviate the driver from strenuous tasks and the strain of routine processes such as accelerating, decelerating and stopping while maintaining proper spacing with the surrounding vehicles in an environment characterized by a congested traffic flow with the following properties:

- all lanes occupied by vehicles
- no possibility to choose speed of travel
- little or no speed variations inside and outside the driving lane
- maximum velocity < 30 km/h
- minimum velocity 0 km/h
- longer time periods of stopped traffic

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- frequent stops followed by intermittent starts
- relatively long duration

Longitudinal support on a vehicle guidance level has the potential to harmonize the traffic flow which will lead to an increase in traffic safety. Its operation might even lead to a mitigation of the congestion level if a large enough market penetration can be achieved.

BMW's philosophy is to actively support the driver by keeping him/her in the loop. The support system ensures that the driver has the ability to override the assistance offered at any given moment. For that, it will need to provide sufficient feedback and explain its mode of operation such that the driver is able to understand clearly why the support system behaves in a particular manner. Furthermore, it is required that the support offered behaves consistently, transparently and predictably.

3. FUNCTIONAL REQUIREMENTS

The stop and go cruise control system comprises at least the following functions (Motiv ACC-Konsortium, 1999):

- remain safe distance from preceding vehicle(s)
- slow down behind decelerating vehicle, eventually make a full stop
- slow down and stop behind stopped vehicles
- autonomous "go" when stopped behind vehicle
- "go" when initiated by driver in case no preceding vehicles are present
- control vehicle speed (up to set speed) when no preceding vehicles are present
- manage standstill condition even on slopes
- manage near cut-ins from adjacent lanes comfortably
- recognize and manage lane changes initiated by the driver
- harmonize perturbed traffic flows
- inform driver when system limits are reached
- switch off when brake pedal is activated
- limit vehicle speed when set-speed has been reached
- adjust headway according to driver preference

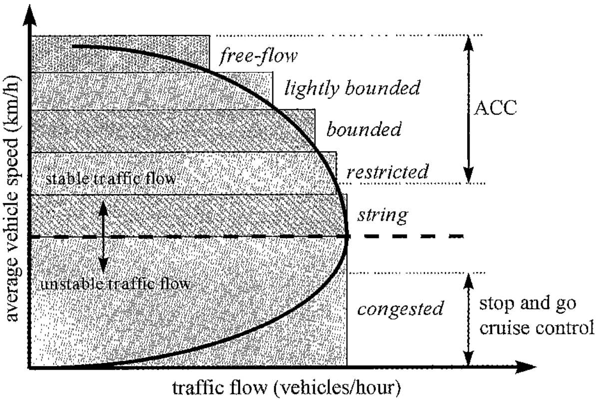

Figure 1. Fundamental diagram (Keller, 1987).

Additional functions could be realized when a stop and go cruise control system is integrated with, for example, a vehicle navigation system (Venhovens *et al.*, 1999):

- adjust headway and vehicle speed according to road class, road attributes (such as prevailing speed limits) and roadway curvature

Functions that a first generation stop and go cruise control system will not be able to cope with are:

- react to cross traffic from side streets
- react to traffic signals and signs
- avoid a collision under every circumstance

4. AREA OF OPERATION

Stop and go cruise control will typically be operated in congested traffic on highways and possibly in urban areas. Its area of operation can be illustrated using the so called fundamental diagram (Figure 1) often used by traffic engineers.

The level of compatibility or distinction between regular ACC and stop and go cruise control needs to be determined. There is a clear delimitation between the two systems with respect to stationary targets. The philosophy behind a typical current ACC system is that it will be operated on well structured roads (mainly highways) with a fairly orderly traffic flow driving at speeds of at least 40 km/h. Stationary targets are, therefore, disregarded which also reduces the sensory and computational requirements. However, the stop and go cruise control system should very well be able to deal with stationary targets because within its area of operation the system will encounter such objects quite frequently. Consequently, a seamless transition between regular ACC and stop and go cruise control is questionable from the point of view of the driver because of the different manner by which the system reacts on stationary targets. In order to avoid confusing the driver, it is recommended to activate the stop and go function separately from the standard ACC function.

The functional requirements combined with the area of operation form the base for defining the prerequisites with respect to sensors, actuators, controllers and the human-machine interface.

5. SENSORY REQUIREMENTS

The information derived from the vehicle environment detection is the most important kernel on which a stop and go assistant will base the level of support for the driver. Stop and go traffic can behave quite chaotically and is characterized by a medium to high level of driving dynamics (acceleration/deceleration) and frequent and sudden lane changes. Therefore, the sensory requirements regarding coverage, dynamics and robustness are higher than for a conventional ACC range sensor. Most likely stop and go cruise control systems will incorporate multiple sensors that are connected to a bus-type of hardware architecture for easy data access. The sensory system should also have the ability to track multiple targets. Under every circumstance the sensory system must be able to capture passenger vehicles, trucks, motor cyclists and cyclists. Pedestrians can also be seen as relevant targets. However, a reliable detection method still does not exist. For aesthetic reasons a concealed installation/ mounting should be considered as well as multiple utilization of sensors for different functions (such as parking aid, ACC, traffic sign recognition, etc.).

For object detection the following variables need to be measured: range, relative velocity and azimuth (or lateral position). Important, but hard to acquire, are the extents of the objects sensed. The object width becomes quite relevant if their position is close to the equipped vehicle, especially in adjacent lanes where they could pose a possible threat.

5.1. Sensor Geometry

Unlike standard ACC, the sensory requirement for the driving environment detection is much more extended for a stop and go cruise control system. Especially, in the mid and short range a wider field of view is necessary in order to detect vehicles in adjacent lanes and track targets in curves with a rather small radius. A possible starting point for setting up the sensor geometry requirements is based on the determination of the space required to maneuver a vehicle driven by an average driver as a function of the vehicle speed. According to Figure 2, the average driver uses a much larger level of lateral acceleration while cornering at lower speeds than at higher speeds.

Combining the knowledge from Figure 2 with the space required to stop a vehicle given a maximum deceleration (combined with a signal processing delay time) leads to the determination of the maneuverability space (Figure 3). The curve radius R of a possible trajectory as a function of the lateral acceleration a_y and vehicle speed v is given by

$$R=\frac{v^2}{a_y} \tag{1}$$

The stopping distance d_s as a function of the longitudinal acceleration a_x, initial speed v_{ego} and processing time t_d is given by

$$d_s=-\frac{1}{2}\cdot\frac{v_{ego}^2}{a_x}+t_d v_{ego} \tag{2}$$

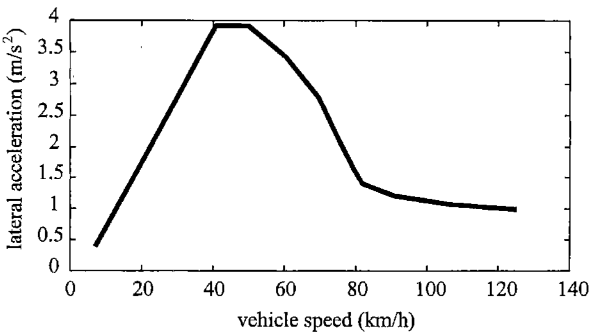

Figure 2. Relationship between lateral acceleration and vehicle speed (Krebs and Damianoff, 1983).

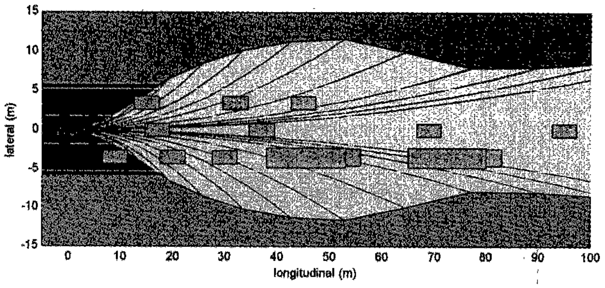

Figure 3. Space of maneuverability based on Figure 2, 4 m/s^2 brake deceleration and 0.5 sec processing time.

The assumption was made that the maximum deceleration available a_x is 4 m/s^2 and the signal processing delay between data collection and brake activation t_d amounts to 0.5 sec. The level of maximum brake deceleration is a point for discussion and depends on the level of confidence in the assessment of the driving environment detection. The more detailed and reliable the assessment of the driving situation is, the more authority an assistance system can be given to support the driver in that particular situation.

In Figure 3 the space of maneuverability has been augmented with a three lane road (lane width is 3.5 m) and other vehicles.

The lines originating from the leftmost vehicle indicate the trajectories of that particular vehicle at a given initial speed. The circumference of the shaded area represents the final position of the vehicle after applying the brakes and coming to a full stop. It is obvious that due to the motion of the other traffic participants a wider azimuth might be required than outlined in Figure 3. Nevertheless, practical experience demonstrates the usefulness of the proposed assumption.

Based on Figure 3, various sensor configurations can be put together such that the space of maneuverability is covered as much as possible. As a starting point the radar

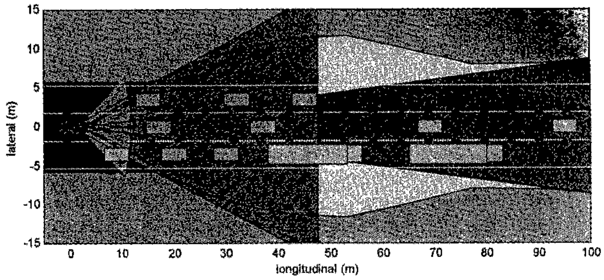

Figure 4. Possible sensor configuration for low-speed ACC: long-range radar (± 5 deg azimuth, 150 m range); mid-range vision system (1/2" camera chip, 14 mm lens, 50 m range), 3 short-range radars (± 20 deg azimuth, 10 m range).

sensor of a typical first generation ACC system is added to the plot. This sensor is characterized by an azimuth between ± 5 deg and a maximum range of detection of 150 m (Figure 4). For the short range, radar-based parking-aid sensors could be used which typically have a range of less than 10 m and come in various extents of azimuth and angular resolution. These sensors could be used by the stop and go cruise control as well as a parking-aid system. The gap between long range and short-range is filled in with a vision-based sensor which should capture obstacles up to about 50 meters in front of the vehicle and also could be used for capturing road geometry information (lane tracking).

Figure 5 shows another possible configuration. The long-range ACC radar (now with ± 10 deg azimuth and 150 m range) is supported by one near-field laser range sensor (azimuth ± 25 deg, 35 m range). This configuration contains less sensors but also misses the option to use the sensor suite for multiple applications (such as a parking aid or lane-tracking).

Low speed driving also comprises driving through turns. Unlike highways, the curve radii that occur in urban areas are much smaller. This has a considerable influence on the sensory requirements. Figure 6 displays the configuration of Figure 5 in a curve with a radius of 100 m. The vehicle and the adjacent lanes are still visible while driving in the center lane.

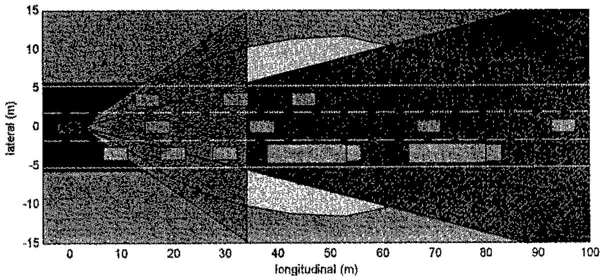

Figure 5. Possible sensor configuration for low-speed ACC: long-range radar (± 10 deg azimuth, 150 m range), short-range lidar (± 25 deg azimuth, 35 m range).

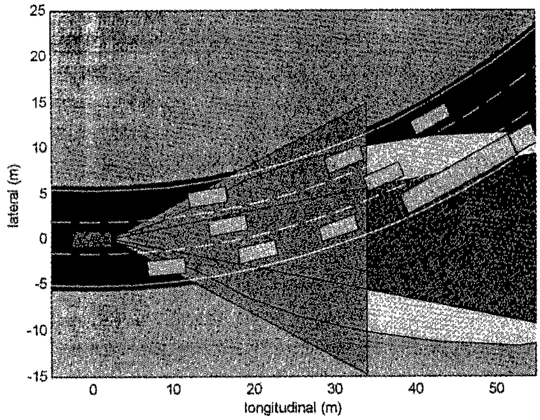

Figure 6. The configuration of Figure 5 in a curve with a radius of 100 m.

5.2. Sensor Options

Currently, four means of object detection are technically feasible and applicable in a vehicle environment: radar, laser, vision and ultrasonic. Each of the principles has its own technical and economical advantages and disadvantages.

Most of the current ACC systems available in Europe are based on 77 GHz radar sensors. The radar-based systems have the great advantage that the relative velocity can be measured directly and that the performance doesnt deteriorate under adverse weather conditions (such as heavy rain, road spray). Creating a sufficiently large enough angular reach with correspondingly good angular resolution is one of the key issues with radar-based sensors. Mechanically-scanned systems will offer a better angular resolution but are most likely more expensive than fixed-beam radars. Currently, several manufacturers are working on 24 GHz radar sensors as an alternative for ultrasonic parking-aid sensors. With a sufficiently large range and good enough angular resolution, these sensors might become valuable for a stop and go cruise control system.

In Japan the first generation ACC systems were based on laser range sensors. The laser-based systems are more sensitive to adverse weather conditions (reducing the maximum detection range in rainy conditions, creating "ghost" objects due to road spray) but have the potential for a larger angular reach and a better angular resolution (especially with a scanning principle) than radar-based systems. From the cost perspective laser-based systems are cheaper than radar-based system. Scanning laser sensors have a potential to become viable for stop and go cruise control systems because of their good angular resolution. The range of interest for a stop and go assistant (30-40 m) and the speeds of travel are small enough, such that sensor deterioration due to adverse weather conditions becomes less significant.

Computer vision systems have not yet gained a large enough acceptance in automotive applications. The fact that computer vision is based on a passive sensory principle creates detection difficulties in conditions with adverse lighting or in bad weather situations. The amount of information available from an image is very large. Isolating the features of interest and extracting the necessary information is not straightforward. The high costs coupled with a computer vision system might only be justified if additional functions could be realized with this type of sensor. Possible examples are: lane (marker) detection which will enable lane keeping support.

Lane detection might be a feature that could become a necessary prerequisite in future ACC generations because it enables the possibility to locate (radar/lidar sensed) objects relative to the roadway geometry. This will improve the assessment of the traffic constellation which results in a more reliable selection of the appropriate support actions.

Ultrasonic-based sensors currently used for parking aid systems will most likely become obsolete if, for example, in the near future radar-based parking-aid sensors become available. The range and (angular) resolution of ultrasonic-based sensors will not be adequate enough to be of use for a stop and go cruise control system.

5.3. Multi-sensor Fusion

A stop and go cruise control system will most likely be based on a "multiple sensors" approach (possibly using different detection principles) with conceivable overlap in detection ranges. Therefore, a concept for sensor fusion is required.

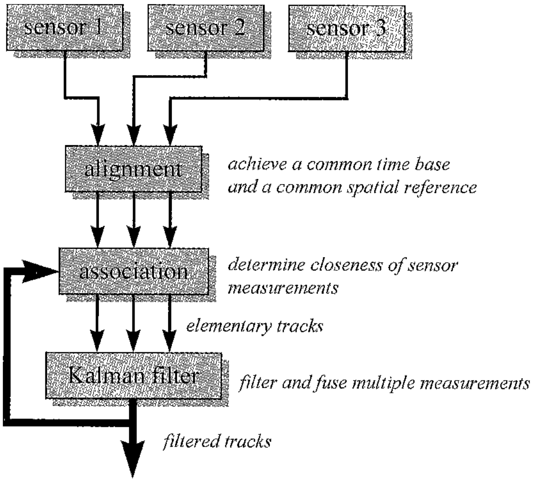

Figure 7. Multiple-target tracking and sensor fusion concept.

Fusion not only enables and stabilizes fast-object information through redundant information and models, but also inhomogene and un-synchronized data can be dealt with. Furthermore, a mechanism for detecting sensor malfunctioning is available. A multiple-target tracking module forms the framework of the sensor fusion module (Figure 7). It generates continuous object trajectories from individual measurements and maintains tracking even if sensor signals drop out for a short duration of time. The core of the tracking module is a Kalman filter (Venhovens and Naab, 1998). This filter is a prerequisite for continuous tracking and fusion of redundant sensor information and contains a model that describes the object dynamics (trajectories) through differential equations.

6. ARTIFICIAL COGNITION

Sensory systems, as discussed above, more or less provide merely raw information such as relative object location/velocity and thus are by far inferior to the ability of human beings to perceive, recognize and interpret traffic situations (human cognition). Consequently, in a driver assistance system, the missing information regarding the context of a traffic scene must be established artificially through model based know-how. Artificial cognition describes the human ability to interpret, assess, recognize and reason in mathematical formulations.

The interpretation of the captured driving environment data will become more significant with future generations of longitudinal support systems due to the amount and diversity of the collected (raw) data. Constellations of objects have to be organized such that a meaningful representation of the traffic situation is formed based on hypotheses and information collect over time. Unlike with first generation ACC systems, the amount of possible traffic situations during stop and go driving is considerably larger. Furthermore, the duration of each situation is relatively short and consequently transitions between situations occur quite frequently.

A good starting point for the acquisition of know-how on human cognition during stop and go driving is studying naturalistic driving. It is important to systematically find out the following aspects of the driving process:

- identify occurring traffic situations
- analyze the relative importance of these situations (duration, frequency)
- identify and classify situations that are relevant for a stop and go assistant
- characterize each of the relevant situations using, for

example, empirical measurements (speed, headway, etc.) collected under naturalistic driving conditions

- identify what information acquired by drivers is relevant in the driving task for each of the selected situations
- investigate how drivers detect this information
- analyze how drivers respond naturally in each of the situations, revealing essential elements of manual speed and headway control

With all the acquired information, a model must be created that explains as much of the manual control task as possible. This does not imply that the stop and go assistance system should almost completely reproduce human driving behavior. Due to severe sensory limitations this will be virtually impossible. Moreover, certain human deficiencies should not be represented in an artificial assistant (as long as the alternative solution is acceptable for the driver). Nevertheless, the human driver should be offered assistance that reflects most of his/her own behavior and augments actions, if needed.

In the real-time implementation of the stop and go assistant the following sequence of tasks will take place:

- identify the traffic situation based on sensory data and model hypothesis
- classify targets
- propagate the traffic situation into the future
- generate alternative actions to assist the driver
- analyze and value each alternative action
- make one selection out of the alternatives
- transform selected action into appropriate vehicle dynamics (brake & throttle control)

The generation of alternative actions is built on the situational assessment. Unlike regular ACC driving, the interaction between traffic participants is quite large during stop and go situations, and thus the appropriate support is to a large extent affected by multiple participants. The rather simple headway-based policies used in standard ACC systems now needs to be extended with a more in-depth "threat" analysis of elements that are in a bounded zone that includes all elements (even traffic signs and traffic lights) a driver takes into consideration at any given moment of the driving task. The extent of the "threat zone" depends very much on the driving scenario and maneuver but also on the drivers motivation, perception and expectations that are based on learned behavior.

7. CONTROLLER

The main task of the controller is to translate the desired behavior resulting from the situation and threat assessment into appropriate actions (through throttle and brake system activation) such that the required headway and vehicle speed meet the preferences of the driver.

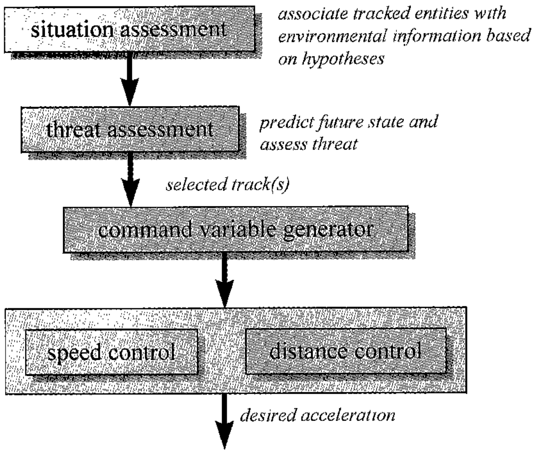

Figure 8. Controller concept.

Controlling headway and velocity at low driving speeds (such as required for stop and go cruise control) is quite a challenge. Coming reliably to a full stop should occur safely and comfortably without jerks. Stop and go situations can be very dynamic (especially with the frequent occurrence of lane changes) and combined with the given fact that stationary targets are present, it makes it very hard for the controls engineer to build a comfortable support function that is safe and that behaves consistently, transparently and predictably in all situations.

Depending on the actual traffic situation two types of controllers will need to be available: speed control or distance control (Figure 8). In case there are no targets of influence close enough to the equipped vehicle, conventional cruise control will be responsible for following the velocity set by the driver. In case this is not possible because of slower traffic participants in front of the equipped vehicle, the distance control is responsible for maintaining a safe distance to the preceding vehicle(s) of interest. Often a control action is preceded by a determination of the so called command variables. These variables describe a desired trajectory (expressed in terms of acceleration, speed and headway) for the equipped vehicle as a function of time.

As already discussed in the sections above the stop and go controller has to cope with a variety of different traffic situations. It is significant to get the distance error down to zero. This process should be completed in a limited time span because drivers will not accept lengthy stabilizing procedures. Furthermore, a stop and go controller should be able to stop the vehicle. In doing so, it is less important to stop behind a preceding object with cm-accuracy since the human being is not capable of estimating a range with such accuracy. Nevertheless, the vehicle

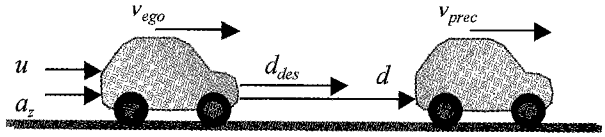

Figure 9. Vehicle following situation.

must stop at a distance within the human tolerance boundary.

A suitable controller which meets many of the requirements mentioned above is proposed in (Naab, 1999):

$$u=k_v\Delta v+k_vk_d\Delta d-a_z+\bar{u} \tag{3}$$

where u is the desired vehicle acceleration [m/s^2], is the difference between the velocity of the preceding and the equipped vehicle (Figure 9), often denoted by the range rate [m/s]

$$\Delta v=v_{prec}-v_{ego}\,, \tag{4}$$

and Δd represents the headway error or range [m]

$$\Delta d=d-d_{des}\,, \tag{5}$$

with d_{des} being the desired headway.

Parameters k_v and k_d represent damping and stiffness terms respectively, and a_z is the disturbance acceleration caused by e.g. road slopes, wind, uncertainties of parameters or, in case of low driving velocities, by the engine idling controller. $\bar{u}$ is an additional term which is explained later in this paragraph.

Often a linear relationship between the desired headway and the vehicle speed is used according to:

$$d_{des}=d_{min}+v_{ego}t_{dist} \tag{6}$$

with t_{dist} being the headway time [s] and d_{min} the minimum vehicle spacing [m] at zero speed. The acceleration of the stop and go vehicle reads

$$\dot{v}_{ego}=u+a_z \tag{7}$$

By combining Equation (7) and (3) the distance error Δd can be derived according to:

$$\Delta\ddot{d}+k_v\Delta\dot{d}+k_vk_d\Delta d=\dot{v}_{prec}-k_v\dot{d}_{des}-\ddot{d}_{des}-\bar{u}\,. \tag{8}$$

In case of a steady-state situation

$$\Delta\ddot{d}=\Delta\dot{d}=\dot{v}_{prec}=\dot{d}_{des}=\ddot{d}_{des}=0 \tag{9}$$

and assuming that $\bar{u}$=0, the distance error Δd will become zero. By substituting headway law (6) in Equation (8) it can be shown that the achieved behavior is still dependent on the motion of the preceding vehicle:

$$\Delta\ddot{d}+k_v(1+k_dt_{dist})\Delta\dot{d}+k_vk_d\Delta d=(1-k_dt_{dist})\dot{v}_0 \tag{10}$$

Merely by choosing

$$k_v=\frac{1}{t_{dist}} \tag{11}$$

it will be possible to avoid the dependency on the target vehicle.

In order to avoid unnecessary limitation in the choice to select control parameters, this dependency can also be eliminated by setting:

$$\bar{u}=\dot{v}_{prec}-k_v\dot{d}_{des}-\ddot{d}_{des} \tag{12}$$

Consequently, the differential equation for u is given by:

$$\frac{t_{dist}}{1+k_vt_{dist}}\dot{u}+u=\frac{1}{1+k_vt_{dist}}[k_v\Delta v+k_vk_d\Delta d+\dot{v}_{prec}]-a_z \tag{13}$$

This choice of controller structure has the advantage that all the quantities on the right side of this equation are fed through a first-order filter (Figure 10) and therefore system operation will be more smooth and thus comfortable.

The proposed controller structure is suitable for many different traffic situations and can be adapted by choosing the parameters k_v and k_d in the appropriate manner. In some situations it is useful to switch to alternative controller structures because a different control action is

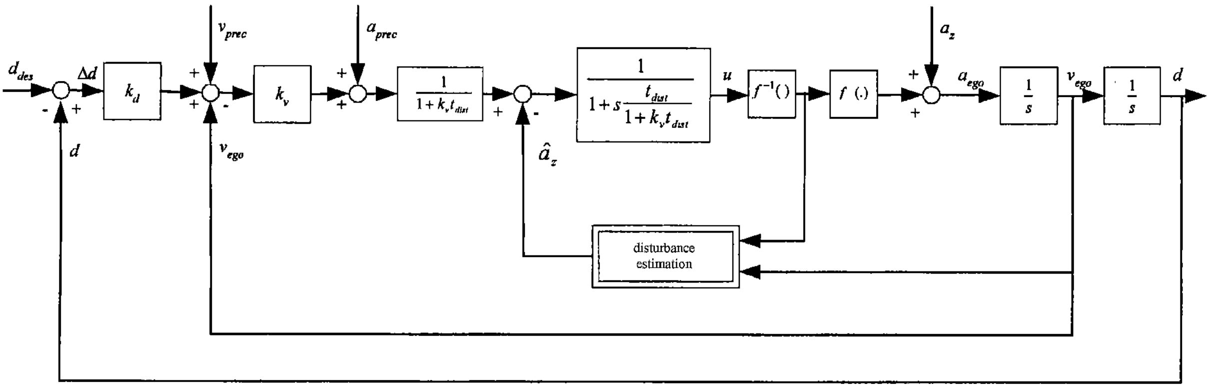

Figure 10. Basic layout of a distance control-loop with non-linearities of the drive train and disturbance estimation.

required, e.g. stopping within a certain distance behind a stationary vehicle without overshooting.

8. ACTUATION

Actuators used for ACC of the 1st generation are also suitable for stop and go cruise control. Throttle and brake control will remain the main source of authority to influence the dynamics of the vehicle. The level of acceleration and deceleration must be altered such that the assistant system can cope with dynamic stop and go traffic situation. Deceleration levels up to 5 m/s^2 will be necessary (2.5 m/s^2 for the 1st generation ACC) for coming to a full stop. Especially the stopped state needs special attention because it might occur on slopes.

9. HUMAN-MACHINE INTERFACE

As described in section 3, the ACC functionality on highways differs from the aspired stop and go functionality with the fact that the stop and go cruise control will regard stationary targets as control objects. A clear distinction should be made between both functions and it is therefore necessary to regard the stop and go functionality as an independent mode engaged separately from an ACC function. A separate stop and go activation combined with an indicator telling the driver in which ACC mode he/she is supported, provides the driver with a clear understanding what situations the system will handle.

Stop and go cruise control should only be active up to a certain maximum vehicle speed (e.g. 30-40 km/h). The driver always has the ability to override the system by using the brake and accelerator pedal. The system should be automatically deactivated once the vehicle has exceeded the operational speed limits. The ACC system will remain on, but the driver has to set a new set speed in order to engage the ACC system or could re-activate the stop and go function again after coming to a complete stop.

The stop and go cruise control will allow the user to set the desired headway analog to the current versions of ACC systems.

The status of the road surface, i.e. the friction between tire and road, is an important piece of information that determines the limits of the vehicles dynamics. It therefore is a viable information for the selection of the vehicle speed and vehicle spacing especially because stop and go cruise control involves greater deceleration than ACC systems do. This is due to the small spacing present particularly when coming to a full stop behind an object. Integration of the road friction information in a next generation ACC system becomes self-evident, once friction monitoring sensors become available at reasonable costs.

10. CONCLUSIONS

Stop and go cruise control is an extension of active cruise control and aims to offer longitudinal support to the driver in an environment characterized by a congested traffic flow on highways and well structured (sub)urban roads at speeds lower than 30-40 km/h. The support function comprises: remaining at a safe distance from preceding vehicles according to the drivers preferences, automatically slowing down and coming to a full stop behind preceding vehicles, and (driver initiated) “go”. This function has been evaluated as very efficient and commonly desired by customers (Motiv ACC-Konsortium, 1999).

The sensory requirements for the vehicle environment detection calls for a wide field of view in the near to mid range (at least ± 25 deg azimuth and at least 35 m range), combined with a conventional ACC range sensor with an azimuth of ± 10 deg and a range of 150 m. A reliable detection of stationary targets is a prerequisite for the “stop” function. The concept of multi-sensor fusion will enable dependable target tracking through redundant sensor information in combination with model based state estimation.

The sensory information combined with vehicle state and driver intention assessment must be combined such that the context of the traffic scene can be established through artificial cognition based on multiple model hypothesis. The stop and go support algorithms are based on a propagation of the compiled traffic state, followed by a generation of alternative actions. The final selection out of the alternatives strategies is to a large extent based on a threat analyses assessing the potential hazard of elements that are in a bounded zone surrounding the equipped vehicle.

The control function will translate the action chosen into appropriate throttle and brake actuation. A suitable controller has been proposed that ensures a comfortable behavior under various dynamic traffic situations.

Stop and go cruise control requires a higher level of brake authority than conventional ACC. A clear distinction must be made between both longitudinal support functions with respect to the human-machine interface because of the difference in behavior of ACC and stop and go cruise control regarding stationary targets. Road friction monitoring might become a necessary pre-requisite for the selection of the vehicle speed and vehicle spacing especially because stop and go cruise control involves higher dynamics.

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