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METHOD FOR THE AUTOMATED SEARCH FOR THE OPTIMAL SENSOR POSITION IN A VEHICLE

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Technical task:
The invention is a software for automated and optimal determination of the position of a sensor in a motor vehicle.

Initial situation:
Radar, lidar and camera sensors must be optimally positioned and integrated in the vehicle to achieve their full effect. Each type of sensor (radar, lidar, camera, ultrasound, etc.) has specific characteristics and capabilities as well as tolerance fields that must be taken into account during integration. The basic conditions are described in a so-called installation guideline or Customer Integration Guideline from the respective sensor supplier. This includes minimum heights above base or maximum heights for the sensor function as well as angles of attack, tolerance bands and distances to surrounding components, etc.

To date, each supplier and each component used has its own installation guideline. Therefore, at the beginning of an integration work to find the installation space in the vehicle, an in-depth study of the installation guideline is carried out by the integrator. This costs valuable time, as there is a struggle for installation space in the early design phase of a vehicle. Those who are already placed enjoy priority. Other components then inevitably have to be moved or a lengthy discussion about a compromise begins. There is currently no procedure or methodical approach to automatically search for the best position of each sensor and to position it accordingly in the best possible way and also to be able to place it quickly. The task is therefore to find a methodical procedure for automatically and optimally positioning and aligning sensors in the vehicle according to their specific properties and boundary conditions in accordance with the installation guideline, so that the installation space can be occupied quickly and maximum performance can be achieved.

Solution:
According to the invention, the method is intended to automatically carry out the positioning and alignment of sensors in the motor vehicle and then ensure optimum performance by optimization in a pre-selected area.

First, the basic conditions of the installation guidelines are entered into a database. The limits of the lower and upper installation height above ground, the pitch and twist angles as well as the clearance areas and tolerance values are to be entered. In a favourable design, further information such as distance to surrounding components, also classified according to other electronic components from an EMC point of view with a different distance than to mechanical mountings, is conceivable. Furthermore, visual and clearance cones of the sensor's effective field can be stored. The use of a database is helpful in order to carry out such a parameterization only once for each sensor and supplier. If necessary, the variant of a sensor can be created by inheritance of the properties. From the given frame conditions a cube can be created in CAD. This is determined by its height, width and depth from the specifications of position, height above ground with maximum installation height above ground. This cube forms the limited search space for the position search. Outside the cube, the supplier's installation guidelines for the sensor would be violated. If no position can be found after the next steps have been carried out, a possible position can be searched for by expanding the search space. This also allows you to quickly recognize when it is worth discussing with the supplier, for example, if you would only find an installation space with good performance outside the installation guideline. In a further step, the vehicle is trimmed with the cube so that only the search space remains. The amount of data is now massively reduced and is suitable for normal CAD computers or laptops without special requirements for computing power or memory expansion. Since most installation guidelines also specify a maximum and minimum curvature of the outer skin, e.g. curvature of the windscreen in the case of a camera, the curvature analysis is now carried out on the outer skin in the further course of the project. This can be carried out automatically in a favourable form by means of a script in CATIA or other CAD programs and immediately represent a colouring of the curvature surfaces, so that e.g. green = within the very good performance expectation, yellow = sub-optimal and red = borderline to the installation tolerances, so that the effect of a repositioning is immediately apparent.
In most cases, the optimal range will be further restricted, so that the number of iterations for a search for the optimal position will be very much reduced here as well. The next step is to search only in the green area and to try to achieve an optimum of performance. If this does not lead to the desired result, the search area can also be extended into the yellow or red area. For this purpose, the boundary parameters from the installation guideline are used, which specify the cone of vision, twisting and tilting as well as maximum damping of the outer skin. Pure CAD checks of the sections allow collisions with other components, truncations of the field of view and thickness of the materials to be penetrated to be determined. If a limit value, e.g. a maximum material thickness of 3.5 mm in front of a radar sensor, is assigned to these cuttings and thickness checks, a weighting of the installation position can be carried out and evaluated by means of factoring. In a favorable design, an inverse factor of the trim will automatically lead to a devaluation of the performance expectation, so that in the end only the best 3 positions with the highest normalized performances have to be selected.

Furthermore, an automatic distance measurement to surrounding components can be carried out, so that an automatic centering of the component within the distance limits is also conceivable here. Since all automation steps are transparently traceable, the user can also intervene during or after automated searches. Furthermore, it is possible to change the parameters, which will lead to slightly different results, so that compromises are also possible. At the end of the optimization and positioning run, the three best positions for the sensor are output or visually marked in the CAD, so that feedback to other designers and integrators in other departments can be seen for the allocation of the installation space. In a favorable execution of the workflow, other designers can also see the three available sensor positions, so that an analysis for a possible compromise position can be carried out independently without having to call long meetings. The automatic run can be performed iteratively for all sensors to be positioned.

Current implementation status:
A VBA application has been programmed in which the sensor properties are recorded in a mask, the vehicle is defined with the geometries and possible positioning spaces and all this together is automatically transferred to CATIA V5. One can visualize here the sensors with their native view cones in three-dimensional space, rotate, tilt, cut, overlap etc. and examine them in all views.
In the extension the cubes of the sensors and the cutting of the search space are programmed in VBA code. The demoulding analysis is already automated. Furthermore, the trimming analysis of the view and clearance areas is currently in progress.

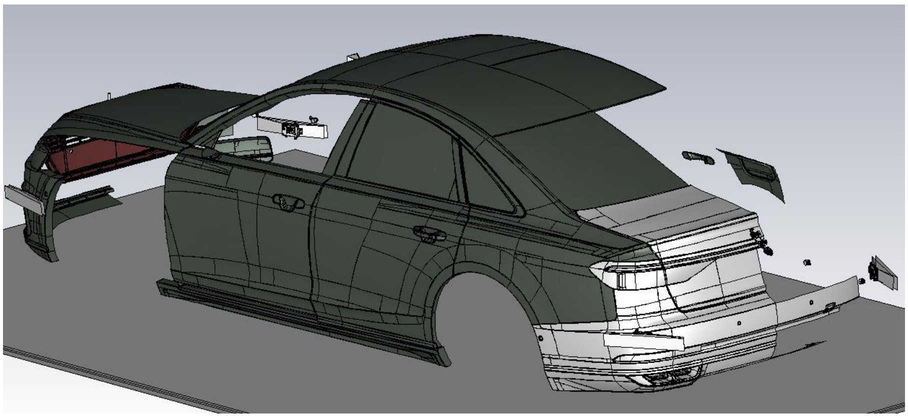
2.2.2 Alignment of the sensors

To ensure the function of the system, the sensors must be installed at defined angles. For this purpose, two angles or two orientations must be specified:

Alignment of the sensors to the X-Z plane is 22°-25° (installation tolerance +/- 0.5°)
Alignment of the sensors to the X-Y plane is 0°-3° (installation tolerance +/- 0.5°)

A different angle shall be assessed on the bumper. The reason for the variable alignment to the X-Z plane is that the geometry of the outer skin can have an influence on the antenna characteristics and thus on the sensor performance. For this reason, it is recommended that the performance of the sensors be determined and evaluated simulatively at an early stage at the intended installation location with the real closing part and the outer skin and then the final position should be determined.

Figure 1: Extract from an installation guideline



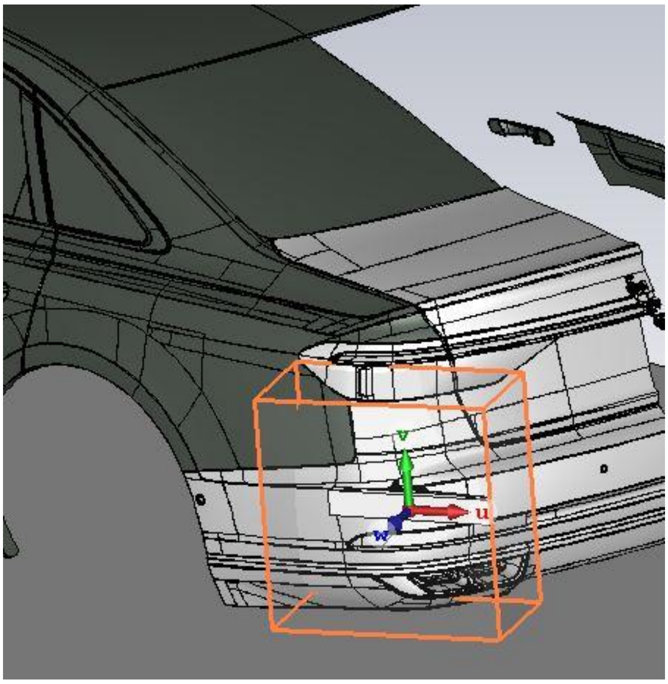


Figure 2: Determined cube and remaining trim to determine the curvature

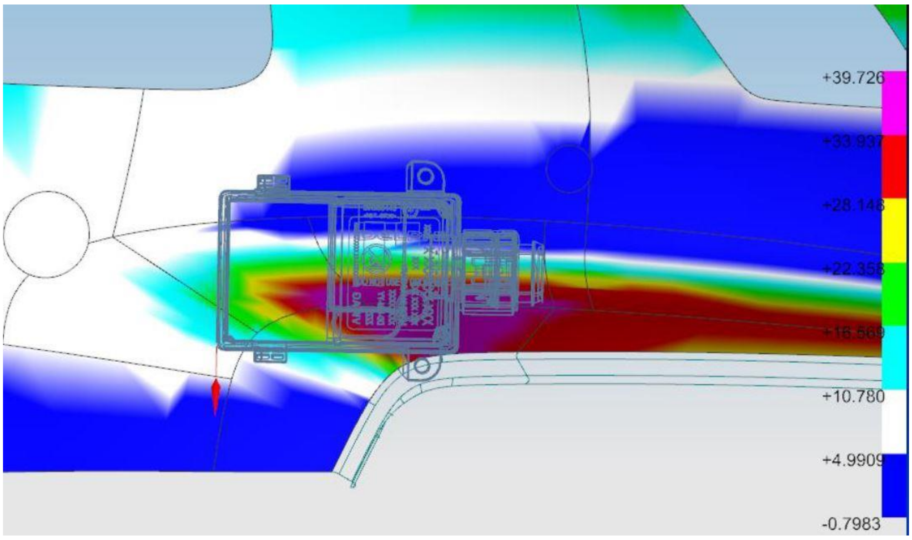


Figure 3: Search for the optimum installation position only within the favourable curvature range

Advantages:

As a favourable design and extension, a variation of different sensor manufacturers with their sensor characteristics is possible. From the combinatorics of different manufacturers, different models of the product range and different positioning within the target vehicle, it is also possible to make reliable statements about the supplier selection and model selection with the described new evaluation method, so that here an argumentation aid for or against a supplier selection would be created. The fact that three or more alternative positions can be determined means that alternatives can be quickly identified and their impact determined. A current run for one sensor takes about 1 minute with a simple laptop.