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Measurement of Tractor Cab with a 3D-Laserscanner

The cab is the most recent assembly group of the agricultural basis machine tractor [1]. It minimized on the one hand the exposure of the driver to external influences. On the other hand, it represents the central interface between humans and machine. It has two important tasks so that a continuous further development for improving the efficiency of the man-machine unit is of great importance. In an experiment, tractor cabs were scanned with a 3D-Laserscanner. Based on these data, an objective evaluation of the cabs is guaranteed, to gain approaches for improvements and advancements.

A big problem with the evaluation of tractor cabs is the fact that many capability characteristics can only be evaluated subjectively. While there is a firm unit (decibel) e.g. for the acoustic pressure in the cab, the all-round visibility or operability can only conditionally be quantified. Here one falls back primarily to the evaluation results of owners and testers [2].

Material and method

To arrange the evaluation the efficiency of the modern tractor cabs more transparent, the employment one of laser scanner offers itself to.. Within the framework of a first test by means of a 3D-laserscanner of the company „FARO“,various cabs were measured by a laserscanner. The laserscanner was set up in each case in several positions in and beside the tractor cab. During the scanning procedure, the vicinity is scanned with a laser beam.. The horizontal field of view amounts to 360° and the vertical field of view to 320°. Per second 120,000 measuring and/or scan points are produced. Depending upon dissolution, a scan lasts about one til five minutes. Each scan point corresponds to a xyz space coordinate. With the provided software „FARO Scene “a point cloud is generated from, which is presented on the computer [3]. In first applications the entire unity Scan procedure of a cab lasted inclusive up- and dismantling as well as the intermediate positioning of the laser scanner for about one hour. It was operated with a dissolution of approximately 17 million scan points and four to five scan positions were used.

As primary positions for the laser scanner the driver's seat was established. This position can be used for the reference scan, since most ranges can be seized in the cab by the laser beam. For the secondary scans, the positions offer themselves on the right of and left outside of the opened doors as well as by the opened front and back window. A further appropriate, however hard to realize position is from above through the roof hatch. It can be used likewise very well as primary CAN.

A problem with the scan procedure is that measurements through the panes are not possible, since they lead to inaccurate results. Therefore, the panes should be masked with tape or sprayed accordingly. Or these ranges should not be analysed or left out.

Beside the three-dimensional representation as point cloud, also a two-dimensional representation is possible, which resembles a black-and-white photo (*Fig. 1*). It has the advantage that it ensures a good overview,

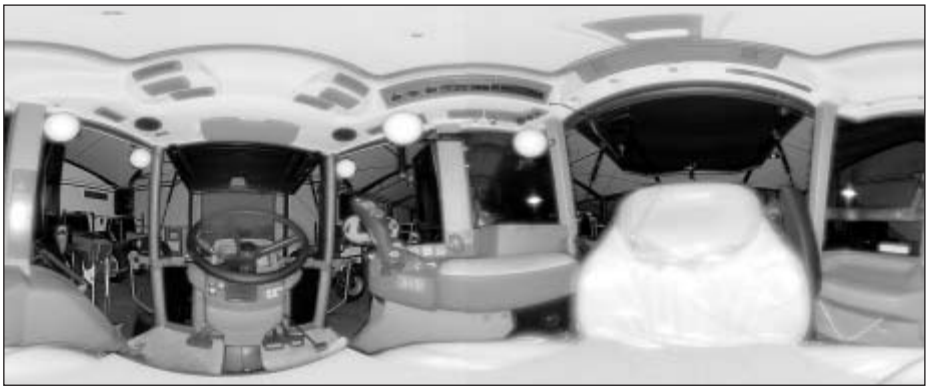

Fig. 1: Two-dimensional illustration of the primary scan from the driver seat view

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which is of advantage with imple measurements, e.g. distances. Thus, measurements can already be made without having the previous images already processed.

The challenge is the processing of the scanned data by the computer. The more carefully the unnecessary scan points can be eliminated, the more effective become the following measurements. Apart from manual cutting out manually unnecessary ranges, the employment of special filter tools helps in removing outliers In order to achieve an optimum quality and only to remove the redundant scan points, a certain eagerness to experiment is necessary during the input of the filter parameters.

By fixed points, which were already defined before the scan procedure in the form of attached balls, the individual point clouds can be put one above the other afterwards. Primary CAN serves as reference CAN, to which the secondary scans is adapted. an optimum quality The more different scans are produced and put one above the other, the less scan shadow remains. However thereby also the data sets, which can be processed, rises. The result of this first step is a point cloud, arranged from several single scans, which shows a tractor cab (*Fig. 2*).

Processing and analysis of the data already gained

In this stage it is already very efficiently possible, to determine distances, surfaces and volumes and to attain conclusions on some capability characteristics in such a way. The pane and the cross-beam surfaces of the cab can be measured by simply marking at the computer, in order to receive data for the evaluation of the all-round visibility. The size of the control elements and its distances to each other and to the driver can be included in such a way and be used as valuation criterion for operability.

In order to be able to accomplish further investigations, a surface feedback of the point cloud is necessary. The FARO Scene's own tool was used for the surface feedback, which produces a meshed network from the point cloud. With the following import into a CAD program, e.g. Catia or ProE, the data can be processed. For data exchange, the wrl format was used.

The largest problem exists in the "hissing". It occurs when the individual scan points of a body or of a surface were not measured accurately on one height to the scanner. The higher the deviations are, the more strongly are the hissing. From too strong hissing result during the surface feedback no smooth, but crumpled surfaces. Resuming analyses are made more difficult. An exact digital image, compared to a generated

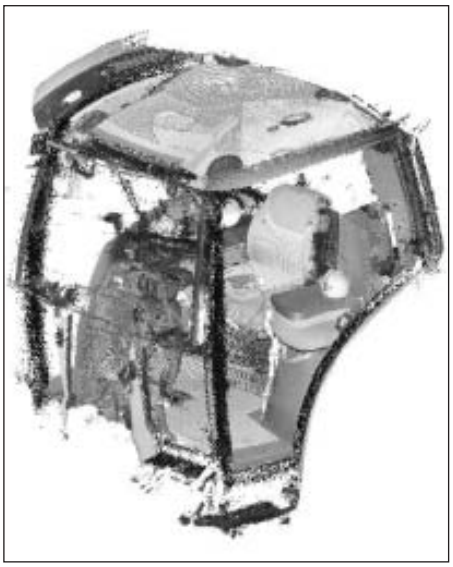

Fig. 2: Scatter-plot of a tractor cab out of four single scans

CAD file, could not be established yet and is worked on an optimization in this direction.

In order to keep the degree of hissing as small as possible, the scanning must be done very carefully. So the tractor cab must be as dust free as possible. An external source of light, particularly sunlight, is to be avoided during the scan procedure as far as possible, too. A surface feedback with other programs will lead in the future to further improvements.

For complex elements, as for instance the control console, a hand-guided scanner is suitable, in order to seize the difficult structures accurately from all sides, too. Thus not only the hissing is minimized, but likewise the emergence of scan shadows in this range avoided.

Benefits

The goal during the collection of tractor cabs by means of 3D-laserscanner is the production of a qualitatively high-quality digital image, which can be represented and examined with assistance of the CAE technology. This offers the possibility of both temporally and to spatially independent measuring method for the collection of reproducible test results.

A high potential of analysis possibilities promises the employment of virtual test persons. Courses of motion and work can be seized and examined by, which permit objective conclusions on the comfort of the cabs.

The comparison of tractor cabs among themselves becomes thus more transparent. The counting of control steps makes the determination of the time requirement possible, with performing standardized operational sequences, e.g. for loading work with the front loader. Data can additionally be determined regarding the accessibility of control elements or for physical continuous stress for the driver. The results are available afterwards as reference value. The customer has an extended data basis, which can help him during the purchase decision. The industry has objective valuation criteria, those strengths and the weaknesses of the own tractor cabs regarding the ergonomics, which comfort and the control-friendliness can be uncovered and be consulted thus for the purposeful improvement.

Result

Apart from the subjective evaluation, the measurement of tractor cabs with a 3D-laserscanner is a valuable addition to evaluate the efficiency of tractor cabs. Particularly for ergonomics more objective data than hitherto can be collected.. Since the measurable parameters of this method are limited, the subjective evaluation of the tractor cab will not be replaced by it.

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