Correction of 3-D coordinates using consistence check

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Fig. 2c:
brake drum: photo of the object

Motivation – problem description

Optical 3-D measurement methods often lack on the fact that some faulty measurement points within the 3-D points cloud appear, so called "scattered points", which can strongly influence the quality of the 3-D data. Normally available 3-D-shape measurement systems then use filtering or complex mask operations to reduce these faulty points.
The problem is, that by these methods neighbourhood relations between the different measurement points are used yielding to an averaging and at the end a "bending" of the data points.
We have developed a new method using only information's on a single point and not on their surroundings for a detection and automatic masking of these faulty points which utilised a consistence check method.

Method of solution

The basis of this method is that the 3-D coordinates in the developed 3-D-measurement systems /1, 2, 3/ are calculated from an overestimated equation system, i.e. that more than 3 phase values can be used to calculate the 3-D coordinates of a single measurement point. The developed check consists on the following procedure: At the first the 3-D coordinates are calculated using all phase values. The next step is a backward calculation of so-called theoretical phases based on these coordinates. The difference of the measured phase values and these theoretical phases giving a phase error for each measurement. Then the complete set of all phase errors is normalized. In the consistence test phase values whose normalized phase error is over a given limit are cancelled, i.e. they do not fit this consistence check and are not considered in further calculations. This procedure is repeated iteratively until the single-phase errors are in a given limit.
So faulty measurement points are removed, especially values near the surface of the measured object which are not detected by usual filters.

Result

In the example we are showing on two different objects the effect of these algorithm. In both cases the checked point clouds contain a reduced number of inconsistent points and can be analysed more easily. Looking at the parameters of the consistence check, the minimum number of valid phase measurements is 3 in theory, but in practice, a suitable number of this parameter is 4 to 5 phase-values.
The normalized relative phase error should by between 2.5 up to 4 in maximum.
With the method "Consistence Check of 3-D coordinates" one reduces the total number of measured points by about 10 to 20%. In addition, the program offers the possibility to calculate quality parameters (accuracy as a scalar value for one point) for each data point and its coordinate components (x, y, z) separately (accuracy of the 3 coordinates).

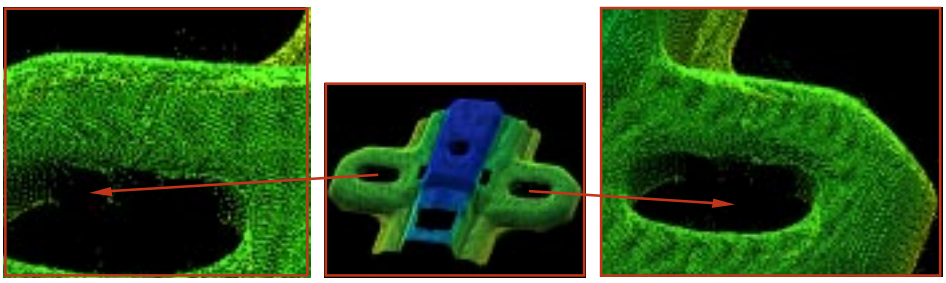

Fig. 1a:
metal fitting: without consistence check – faulty data points

Geometry parameters like angles and distances of objects can be estimated automatically on the resulting point cloud.

References

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"Theory and arrangements of self-calibrating whole-body 3-dimentional systems using fringe projection technique"
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/2/ Kowarschik R., Kuehmstedt P., Gerber J., Schreiber W., Notni G.
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Selfcalibrating 360-deg shape-measurement systems within this Annual Report

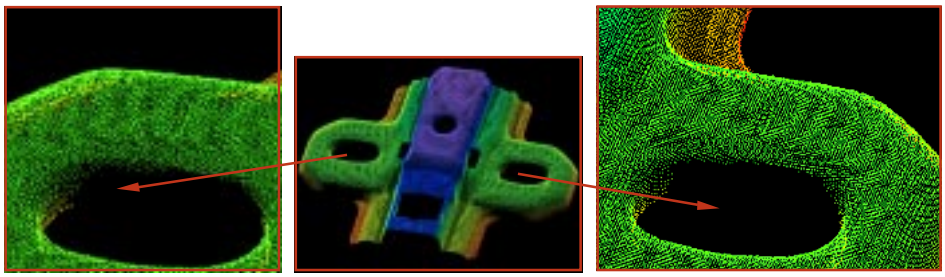

Fig. 1b:
metal fitting: with consistence check – reduced point cloud, no faulty data points

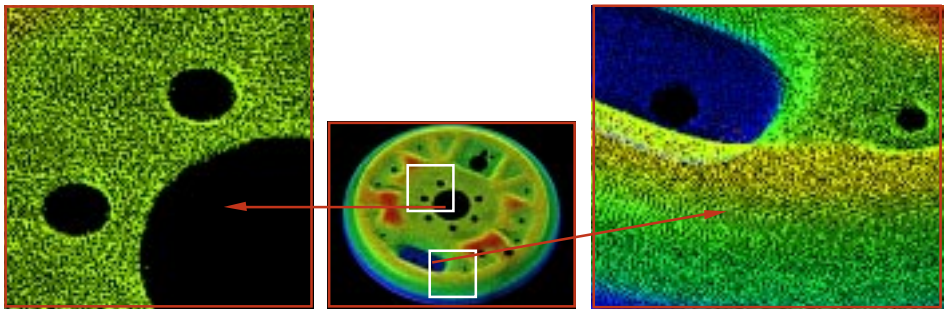

Fig. 2a:
brake drum: without consistence check – faulty data points

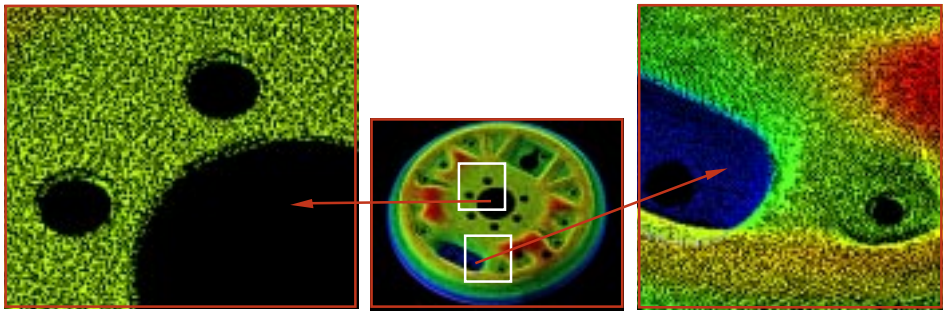

Fig. 2b:
brake drum: with consistence check – reduced point cloud, no faulty data points;
463442 à 408639 points equal 12% reduction