GEOMETRIC INSPECTION USING LINE SCANNING

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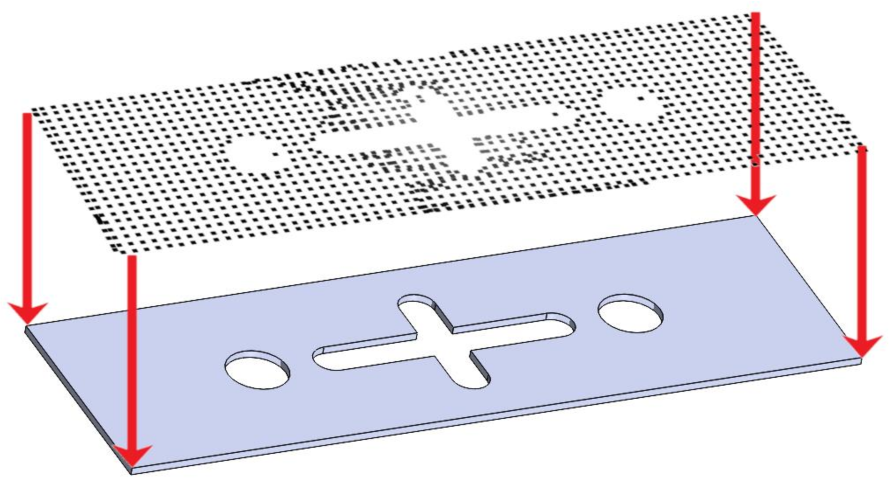
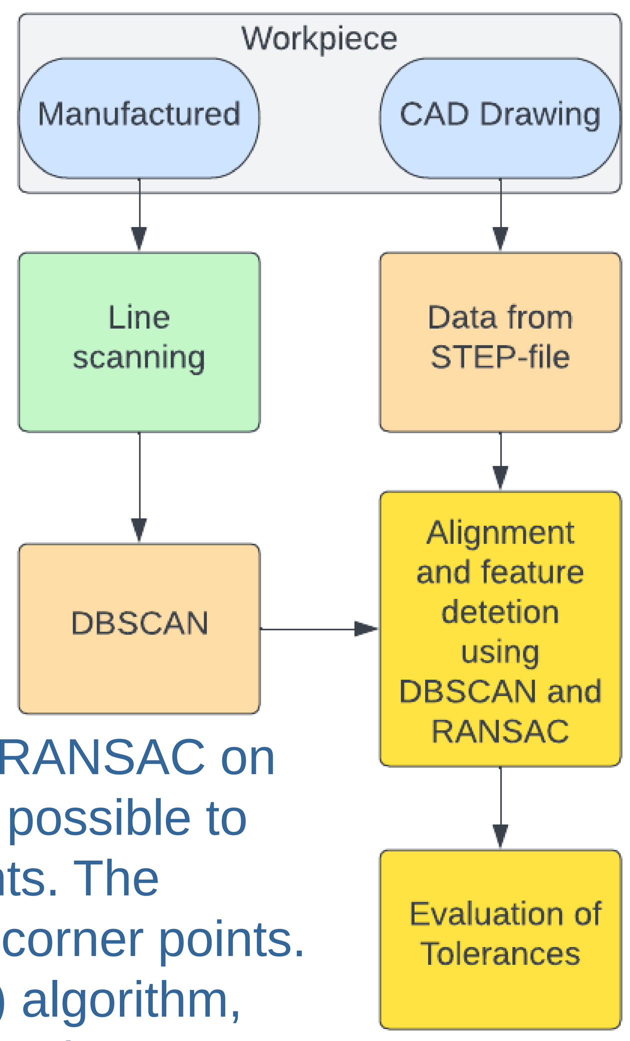
1. Alignment of point clouds

Implementing geometric inspection as part of quality control is prevalent in the transformation from Industry 4.0. By aligning point clouds from line scanned manufactured items to points from a CAD reference model, it is possible to evaluate tolerances based on the positional error of the features. While methods already exists for this purpose, application of fails when the point cloud from the scan are planar, symmetric and has a non-uniform point density distribution. This paper proposes an assumption that allows methodology using the existing methods on point clouds that exhibit the previously mentioned attributes.



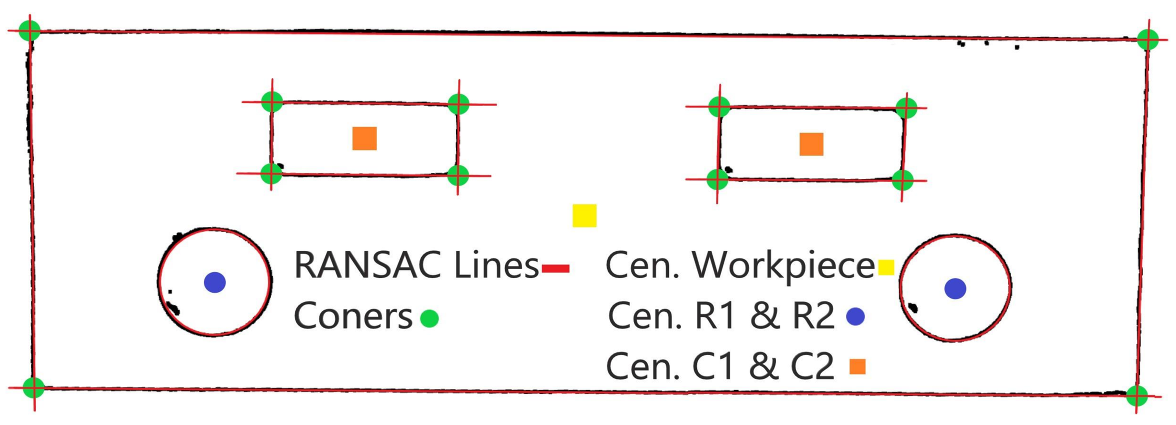
2. Methodology

The general procedure for the geometric inspection of a manufactured workpiece is to scan it, filter the scan and remove noise. The geometry and features is then compared with geometric data stemming from a CAD reference model. By using the assumption that the general position and orientation of the scanned workpiece being known when scanning, it is possible to used established methods. This includes Density-Based Spatial Clustering of Applications with Noise (DBSCAN) and Random Sample Consensus (RANSAC) for both aligning the point cloud to the geometric data from a Standard for the Exchange of Product model data (STEP)-file, and for detection of manufacturing features.



By using DBSCAN to separate the workpiece from the environment in the scan, and using RANSAC for plane segmentation, it is possible to align the workpiece to a plane in the global coordinate system. This utilises the planarity of the workpiece for reducing the dimensionality of the problem.

DBSCAN is additionally used for separating points that lie on a physical edge into a separate point cloud. Using RANSAC on the point cloud containing the edge, it is possible to identify the lines that have the most points. The intersection of these lines represent the corner points. By using an Iterative Closest Point (ICP) algorithm, these identified corner points is aligned to the CAD-model's corner points. A similar approach is done for the feature detection of the manufacturing features.



3. Results of validation

To evaluate the influence of the procedure and deviancy from the assumption, multiple scans are made. The results are made from multiple scans of the same workpiece without any change, scans where a translational deviancy is introduced, and scans with orientational deviancy.

Tolerance [x, y]	Standard deviation
Corners	[0.32, 0.55]
Circle1 centrum	[0.10, 0.17]
Circle2 centrum	[0.04, 0.17]
Rectangle1 centrum	[0.09, 0.16]
Rectangle2 centrum	[0.05, 0.16]

The standard deviation of the Euclidean distance of the workpiece's corners and the centres of the detected manufacturing features is used to evaluate the methodology's own influence on the resulting tolerance evaluation. The standard deviation of these results show that the methodology's influence is significant, as the workpiece was manufactured in a CNC milling machine using a geometric tolerance of 0.1 mm.

The paper presents the results from all transformations applied to the workpiece. These give the indication that the primary influence on the results stem from the procedure itself if the transformations are not too large. A significant change occurs when rotating the workpiece more than 10° in either direction, as the ICP algorithm is no longer limited in identifying the correct corner point pairs. Essentially, multiple corner points is paired to the same CAD-drawing corner, which cause the transformation matrix that is applied to the detected manufacturing features to be ill-suited for alignment purposes.

4. Conclusions

The objective of the project was to evaluate whether existing methods could be used for geometric inspection of a workpiece, which creates a planar, symmetric and non-uniformly distributed point cloud. Following from the results of validating the methodology of achieving this objective, the methodology itself cause error factors, which is presented in the form of standard deviation in the paper. While specific identification of the error factors was not made, it is speculated that both the line scanner parameters, such as line and point distance, plays a role, as presented in the paper. Additionally, the inherent randomness associated with the RANSAC method is assumed to cause a similar influence on the results.

The work demonstrates the feasibility of using line scanning for tolerance evaluation of manufactured workpieces, though further work is necessary, before a real-world implementation is possible. This work should be experimentation of modifying the parameters of the line scanner, and identifying alternative implementations of RANSAC, or a different method entirely.

Acknowledgement

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