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Problem 4. The 2D/3D Best-Fit Problem

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Company's overview. Sirma Group Holding JSC is one of the largest software groups in Southeast Europe, with a proven track record since 1992. The group employs more than 300 experienced software professionals who have implemented hundreds of successful projects worldwide.

Sirma has gained substantial expertise in some of the most innovative areas of ICT: semantic technologies, mobile applications, ERP (Enterprise Resource Planning), BI (Business Intelligence), financial, banking and payment services, e-government and others. Our successful projects laid the foundation of the long-term customer relationships. Following its visionary mission, our company has focused on the creation of new knowledge enterprises. A few of Sima subsidiaries are among the world leaders in their verticals.

The Group traditionally launches innovative businesses; it founded its own business incubator for technology startups a few years ago. Our companies have won many international and national awards. For instance, Sirma Solutions JSC was awarded the Forbes Business Awards 2012 in "Business Development" category; Ontotext won the Innovation Enterprise Award 2014 in the category "Innovation Visionary", the prize of the 3rd NewsHack2014 contest on the BBC. Sirma Mobile JSC was honoured with the prestigious prize for mobile security SIMagine 2011. Sirma Business Consulting JSC was distinguished twice for the Best ICT employer for 2014 and 2012. EngView Systems Jsc, our subsidiary company for CAD/CAM software, was awarded with the European Information Technology Prize.

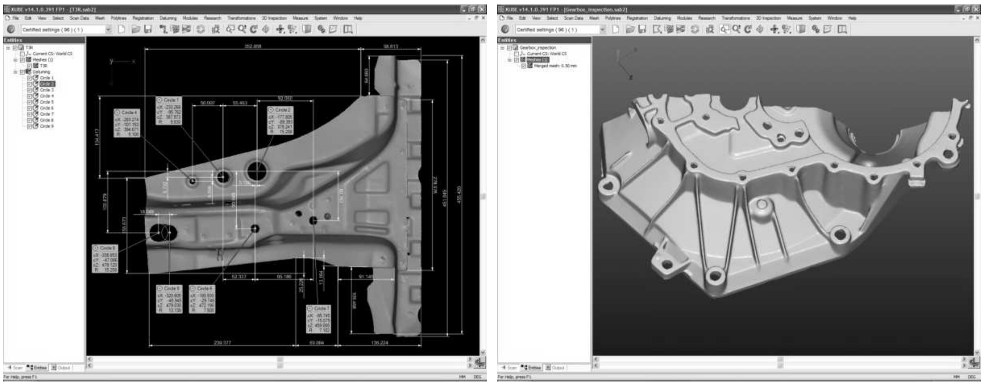
Problem description. In computer systems, the best-fit problem can be described as a search for the best transformation matrix to transform input measured points from their coordinate system into a CAD model coordinate system using a criteria function for optimization. For example, if the criterion is Minimum Sum of Deviations, we search for a transformation matrix M that minimizes the sum of all distances from an matrix-transformed measure points to a CAD model.

The formula that describes this process is as follows:

$\sum_{i=1}^{n} dist(Pi.M, CADsurface) \to 0$, where n is the number of points and $Pi.M$ is the matrix-transformed measured input point.

The case. The standard case where the problem takes place is quality control of part production. The process is as follows:

1. Engineers create a part as a CAD model in the coordinate system A (Pic 1).



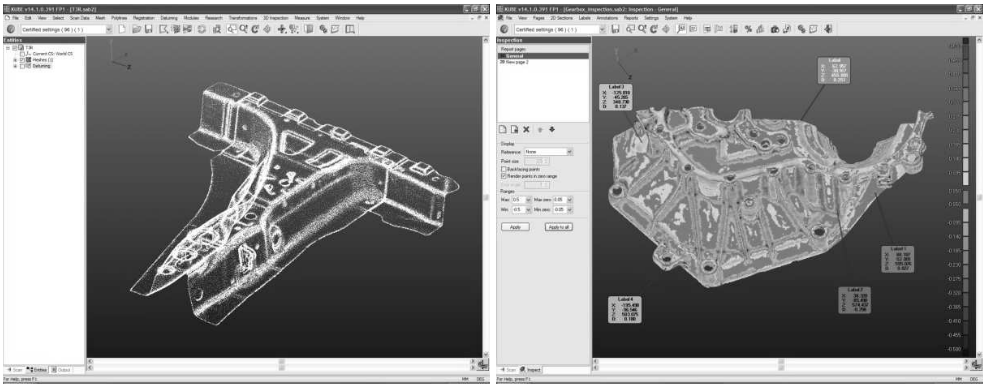
Pic 1. The CAD model is in the coordinate system A

2. The part is produced and is measured as a real-point cloud in the coordinate system B (Pic 2).

Pic 2. The physical part is scanned in the coordinate system B as a points cloud or as a triangular mesh

3. The best-fit matrix allows the direct comparison of the produced part surface relative to the wanted design. After the produced part has been compared with the designer project, it either:

– Passes quality inspection and becomes part of a product, or
– Does not pass quality control, and as a result is discarded.



Pic 3. We search for the best transformation that will transform points from coordinate system B to coordinate system A

The solution. The best algorithmic solution should include the following features:

1. Partial fit (only part of the object is scanned).
2. Different parts (these could also be measure points) can have their own individual weights.
3. Only some of the three rotations and three translations can be applicable.
4. The algorithm can be applied on 2D or 3D data.
5. Preliminary assessment can be made if there are points that constitute noise. If such points are detected, they should be filtered out.
6. In the ideal case, the algorithm's input data – these are the data in the two coordinate systems – can appear as points, as a mesh, or as a CAD model.
7. Optimization can take place by different optimization criteria: least squares, minimum sum of deviations, mini-max, uniform deviations, minimum standard deviation, tolerance envelope, tolerance envelope mini-max.
8. The fit process should be able to accept also partially deformed parts. Even if there are discrepancies between the CAD model and the input data, the algorithm must be able to process them.
9. The computation needs to be fast and efficient.

10. An option could exist for multi-core, parallel computation.

2D example: