# Depth Correction for Depth Cameras From Planarity


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Depth cameras open new possibilities in fields such as 3D reconstruction, Augmented Reality and video-surveillance since they provide depth information at high frame-rates. However, like any sensor, they have limitations related to their technology. One of them is depth distortion. In this article we present a new method for the correction of depth distortion.

The methods presented in literature require an accurate ground-truth for each depth-pixel. However, acquiring these reference depth is extremely difficult for several reasons. In fact, an additional system is required, *i.e.* high accuracy track line as in [3, 6] or a calibrated color camera as in [1, 7, 8] (see Figure 1). In contrast, the proposed method is more easy to use, since it does not need a large set of accurate ground truth. It is based on two steps:

**Non-planarity correction (NPC):** estimates a correction function: $F : \psi \to \mathbb{R}, \psi \subset \mathbb{R}^3$ such that, $F(\mathbf{Q}) = C_Z$ where $\psi$ is a subset of $\mathbb{R}^3$ and $C_Z$ is a scalar that represents the $Z$ correction. NPC is based on training $F$: collecting a massive set of different views (different orientations and different distances) of a plan that intersect to cover all the 3D calibrated space (see Figure 2(a)), which is easy to set up. The 3D points of each view are not coplanar. This is caused by the depth distortion. The NPC principle is to train $F$ such that the corrected points of each view tend toward coplanar points. This will constraint $F$ up to a global 3D affine transformation A.

**Affine correction (AC):** estimates an affine transformation A. Any affine transformation of the corrected space will keep the planarity constraints. Estimating A (12 parameters) requires to collect a small set of ground truth measurements. AC will end up as linear least squares constraints and can be easily solved. The depth correction steps are shown in Figure 2. An iterative process is adopted to resolve the NPC step and a 3D smoothing spline, known as a 3D Thin-Plate-Spline is chosen to model $F$. Initially (iteration number $k = 0$), the point-to-plane distance is large (Figure 2(c)), it decreases at the next iteration (Figure 2(d)) and become very small in the last iteration (Figure 2(e)). After NPC step, the points are coplanar but not aligned with ground truth Figure 2(g). The AC step is then performed. It is shown in Figure 2(h) that after AC the obtained data are very close to the ground truth.

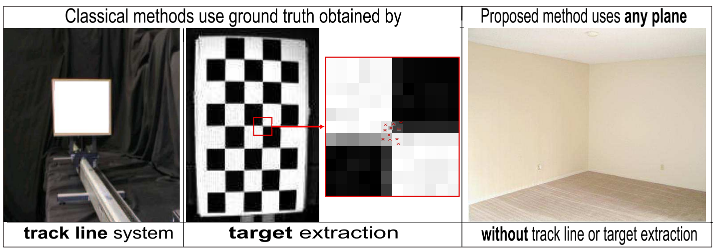
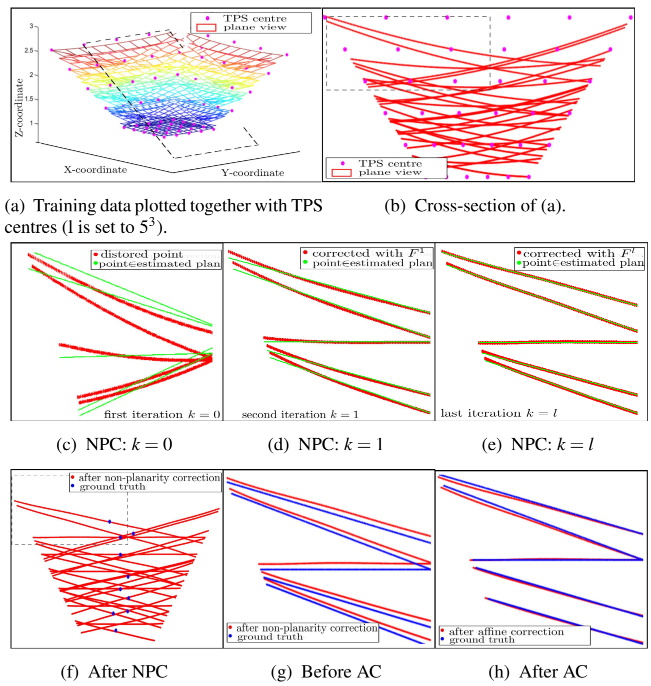



Figure 1: Classical approaches require a set of accurate ground truth that are obtained by track line system or target extraction approach. The first system is expensive. The second approach does not provide accurate ground truth: it is not feasible to extract accurate point due to the camera's low resolution (lack of accuracy at transition area): the red crosses represent the different possibilities of a corner localization. Our approach uses planar views and does not need a large number of ground truth.




(a) Training data plotted together with TPS centres (l is set to $5^3$). (b) Cross-section of (a).

(c) NPC: $k = 0$ (d) NPC: $k = 1$ (e) NPC: $k = l$

(f) After NPC (g) Before AC (h) After AC

Figure 2: Simulated data results during depth correction process. (a)A part of calibrated space ranged from 1m to 2.5m. A part of (b) is considered to show obtained results at (c) first iteration, (d) second one and (e) last one of NPC. (f)A small set of reference data used to compute A plotted together with the corresponding section of training data obtained after NPC. Comparison of results (g) before and (h) after AC.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