Evaluating Guided KLT Tracking for Next Best View Planning in 3D Reconstruction

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This report considers the task of 3d reconstruction within a Next Best View (NBV) planning approach. Particular attention is given to the possibilities of extending the well-known Kanade-Lucas-Tomasi (KLT) tracker [1] for the application within a controlled planning framework. The benefit of the tracker's extensions to the planning procedure is evaluated quantitatively.

In relation to general structure-from-motion approaches with passive illumination, a controlled planning setup for 3d reconstruction provides additional knowledge about sensor parameters and may adjust sensor parameters in an active manner. The adjustment of sensor parameters refers to the set of planning goals.

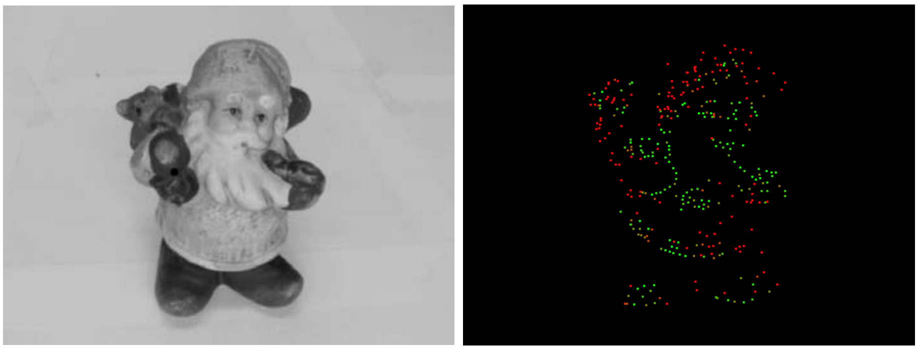

Fig. 1. Santa Claus figurine and 3d reconstruction with uncertainty estimation, continuous colors from green (uncertainty low) to red (uncertainty high)

Additional knowledge about sensor parameters is valuable information to be considered in each step of 3d reconstruction. Nonetheless, uncertainty of the given parameters must be regarded explicitly.

The first step of 3d reconstruction without active illumination consists of establishing point correspondences. Feature tracking using the KLT tracker yields a solution to this problem. The work [2] shows a way to incorporate knowledge about sensor parameters into the KLT tracking model, while regarding uncertainty of the given data. This first version of *Guided KLT (GKLT) tracking* alters the translational part of the feature warping function with respect to the corresponding epipolar line. Later versions of GKLT, that wait for getting published,

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include combined estimation of warping and uncertainty parameters as well as 3d point estimation. This allows for rating the quality of a current 3d point reconstruction, see Figure 1. The experimental comparison of the GKLT versions revealed different performances in the tracking duration and the accuracy of a resulting 3d reconstruction [3].

The planning method chosen for evaluation is the information theoretic approach from [4]. This planning procedure uses point trails from feature tracking, performs 3d reconstruction by an extended Kalman filter, runs visibility analysis and, finally, selects optimal camera parameters to minimize the uncertainty of the 3d estimation.

For experimental evaluation, the planning procedure uses the tracking trails produced by the standard KLT and the different extension stages of GKLT.

Planning the next best view for an initial reconstruction based on the standard KLT tracker is possible for only one further position. Due to the minor image quality within the sequence used the tracker is not capable of tracking the features to the first NBV. The mean 3d reconstruction error reduces marginally from $3.03mm$ to $3.01mm$.

The same deficit in the tracking duration holds for the GKLT extensions that do not incorporate 3d estimation of tracked points, resulting in only one planned view. Even so, the mean 3d reconstruction errors yielded are smaller than the ones from standard KLT.

Using *GKLT3D*, i.e. GKLT tracking combined with continuous 3d estimation, lost features are potentially found again during the tracking process by their back-projections to the current image. This feature retrieval increases dramatically the feature's mean trail length and, thus, allows up to four planned views. Additionally, the quality of the tracked feature is measured by the uncertainty of the corresponding 3d estimation. By these means, the GKLT3D affords longer tracking and better control of the result. The mean 3d reconstruction error for a subset of all points can be reduced from $1.36mm$ to $0.88mm$.

References

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