Incremental self-calibrated reconstruction from video

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Abstract

The aim of this thesis is the implementation of new algorithms for recovering the three dimensional information of a scene from a video sequence using an un-calibrated camera. Two important processes in the self- calibrated reconstruction pipeline are the matching correspondences and the projective reconstruction stages. Preliminary results are presented on these topics to illustrate the performance of two novel algorithms.

1. Introduction

The problem of shape from motion is to recover the structure of the scene and camera motion at the same time using feature point correspondences from multiple views. In the last years different methods to obtain 3D models from an image sequence have been developed [1, 2].

In particular we are interested in the investigation of self calibrated 3D reconstruction methods where some open issues are not covered on current research.

2. Main Objective

Develop an incremental self-calibrated 3D reconstruction algorithm where for each additional frame an estimate of camera pose and the structure of the scene is computed.

2.1. Particular Objetives

- Develop an incremental self-calibrated 3D reconstruction algorithm based on the factorization method [1].

- Propose modifications to the matching correspondence and projective reconstruction algorithms to incorporate metric information from the self calibrated stage.

3. Current Work

A new algorithm for projective reconstruction has been proposed in [5] The original algorithm proposed by Mahamud et al in [1] is extended to achieve incremental projective reconstruction. The main contribution of the new algorithm is the development of an online domain reduction step. Analyzing the contribution of previous frames on the projective reconstruction process a subset of frames is selected by using the fifth eigenvalue as a measure of contribution in the reconstruction quality.

The robust detection and tracking of a set of points is computed integrating appearance and distance properties between putative match candidates. In [6] we show how to integrate SIFT [3] and ICP [4] methods to overcome one of the intrinsic limitation of each algorithm. Adding spatial information in the matching stage of SIFT and providing a good initial set of correspondences to initialize ICP algorithm. Our motivation is to increase the number of feature correspondences on images containing repetitive patterns and to eliminate false match pairs.

4. Preliminary Results

4.1 Real Image Sequence experiments

In this section we evaluate the structure of the scene recovered by the proposed incremental projective factorization method on three real image sequences (see figure 1).

Figure 2 shows that the proposed factorization method can efficiently recover the shape and motion from the corresponding image sequences. This is appreciated from the identifiable geometrical components recovered by our method. See Figure 6: Top, reconstructed 3D models from the video sequences. Bottom, measured reprojection error for the original BPF and the proposed IPF algorithms. Left: 6 and 7 frames are considered for the IPF algorithm. Right: 9 and 13 frames are automatically considered for the cube sequences using IPF algorithm.

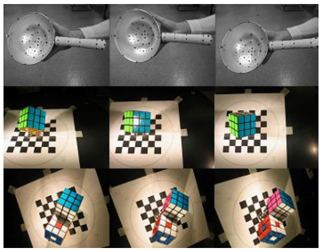

Figure 1. Three frames of real video sequences.

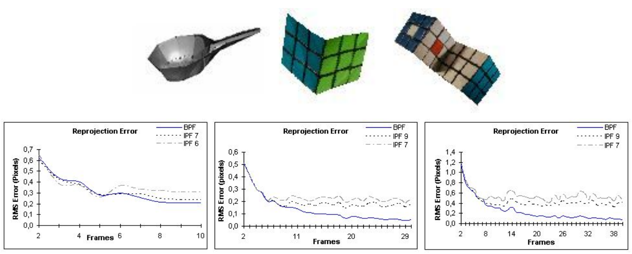

Figure 2. Reconstructed 3D models .

4.2 Processing Time

Figure 3 shows the comparison of processing time for the original and proposed method. The structure and motion is computed along a sequence of 10 frames. Notice how the proposed incremental reconstruction algorithm requires constant processing time (0.32 ms) when the number of previous frames to be considered on the reconstruction pipeline has been reached (4 in the current example).

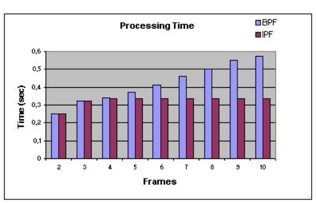

Figure 3. The processing time for BPF algorithm vs IPF Algorithm.

The reduction of processing time can appear marginal for the last example but having in mind that real image sequences could have hundreds of frames the advantage of our approach is evident. For example 10 seconds of video is composed of 300 frames then, computing the 300th with a full measurement matrix would take minutes compared to less than a second when the proposed algorithm is used.

4.3. Detection and Matching

This section shows the comparative results of the proposed IC-SIFT Algorithm against the original SIFT and ICP algorithms. The performance of each matching algorithm is measured considering the number of correct matching features and the number of false positives matches i. e. incorrect matches between non corresponding feature points. In addition the RMS registration error is measured.

Table 1. Matching results for cube sequence

Matching Method	Initial Features	Correct Matches	False Matches	RMS Error
IC-SIFT	200	110	3	1.91
SIFT	200	96	26	2.51
ICP	200	92	15	4.08

The results show that the proposed algorithm increase the number of correct feature correspondences and at the same time reduce significantly matching errors when compared to the original SIFT and ICP algorithms.

5. Conclusions

In this paper two algorithms for incremental projective reconstruction has been presented. We have shown that adding an online selection criterion to keep or reject frames incremental projective factorization can achieve similar results compared to the original algorithm while reducing the computing time. In addition a robust feature matching algorithm has been proposed to increase the robustness of a 3D reconstruction algorithm.

References

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