DENSE OPTICAL FLOW FOR THE RECONSTRUCTION OF WEAKLY TEXTURED AND STRUCTURED SURFACES: APPLICATION TO ENDOSCOPY

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Scientific challenges
- Few textures and structures,
- Illumination changes, few contrast,
- Small field of view, camera close to object surface,
- Artifacts (reflections, saturations, etc.).

Contributions
1. Adaption of Structure from Motion (SfM)-based methods to the surface reconstruction of hollow organs seen in endoscopic video sequences.
2. Proposal of an effective Dense Optical Flow (DOF)-based SfM approach.
3. Accuracy evaluation of the proposed method using phantom data and robustness assessment on real medical data (gastroscopy).

Surface reconstruction pipeline

2D sequence of undistorted images Structure from Motion (SIM) Mesh generation Surface texturing
This work focuses on the determination of homologous points in SfM.

Principle of our SfM pipeline

2D images → Determination of homologous points groups (HP-groups) (homologous points between 2D images) → Determination of camera poses and dense 3D point clouds

Experimental results

2. Subjective evaluation

A gastroscopic video and three images selected among the 101 images of the sequence.

Video of the reconstructed surface and images of the pyloric antrum under two viewpoints.

1. Objective evaluation

Determination of HP-groups

Observation:
If \( A_0, A_1, \ldots, A_j \) is a HP-group, then set \( \{ A_0, A_1, \ldots, A_j \} \) belongs to an overlapping (common) image region showing a same scene part.

Our idea:
1. Determination for each \( I \), of its set of overlapped images.
2. Determination of reference images with Algorithm 1 (paper).
3. Generation of HP-groups.

References


[Image of four viewpoints among the 111 images acquired for the phantom. (b) Snapshot of the reconstructed surface. (c) Surface reconstructed by the proposed method: \( D_B = 3.945 \).]

(a) Determination of pairs of overlapped images
\[
\begin{align*}
\mathbf{v}_{i+j} = & \mathbf{v}_{i+j} - \mathbf{v}_{i+j+1} = \mathbf{OF}_{i+j}, \\
n_{i+j} = & \sum_{t=i+j}^{i+j+1} \mathbf{v}_{t+1} + \mathbf{v}_{t+1}^2 ,
\end{align*}
\]
where \( \mathbf{OF} \) is the image flow computed by \( \mathbf{I} \).

Image \( I \) is called \( t \)-overlapped with image \( I_j \) if the area of \( I \cap I_j \) is greater than \( \tau \) pixels.

Experimental results

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