

Doctorant: Tan-Binh Phan¹

Directeur de thèse : Christian Daul¹

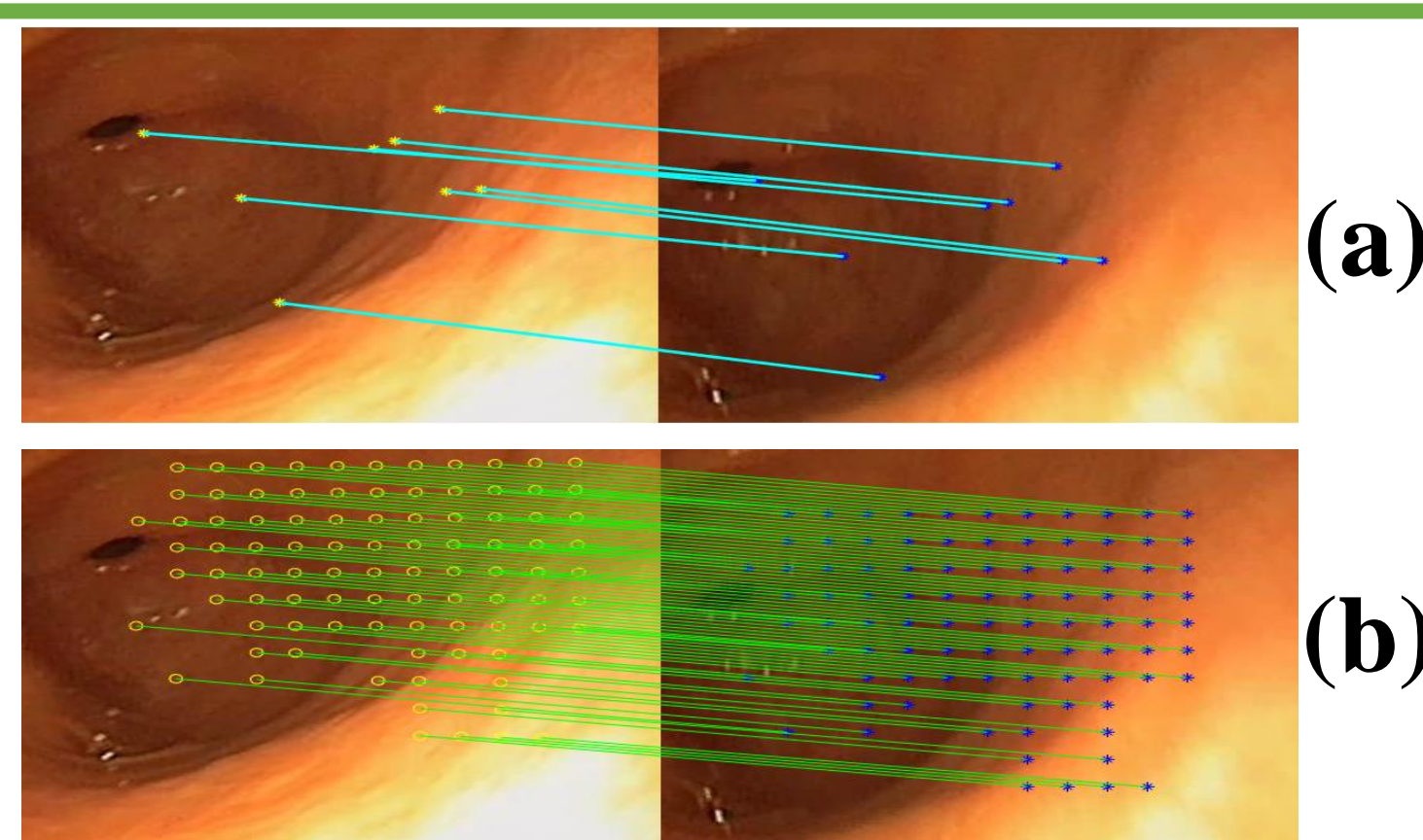
Co-directeur de thèse : Didier Wolf¹

Co-encadrement de thèse : Dinh-Hoan Trinh¹

¹CRAN, UMR 7039, Université de Lorraine, 2 avenue de la Forêt de Haye, 54518 Vandœuvre-lès-Nancy

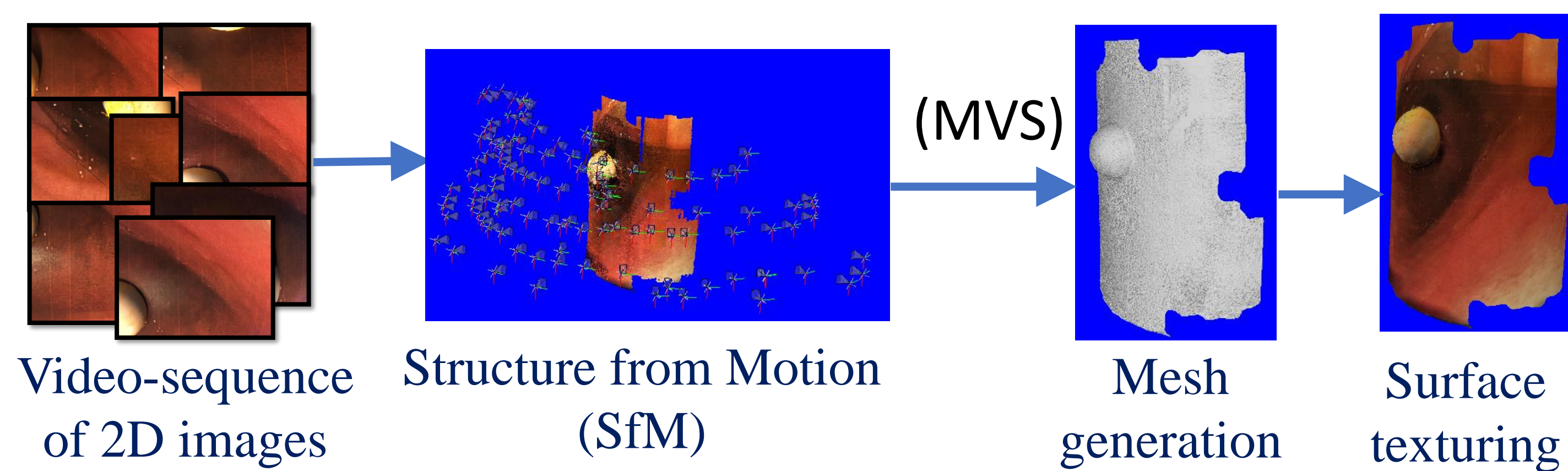
Scientific challenges

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



(a) SIFT matches (b) Optical flow

Surface reconstruction pipeline

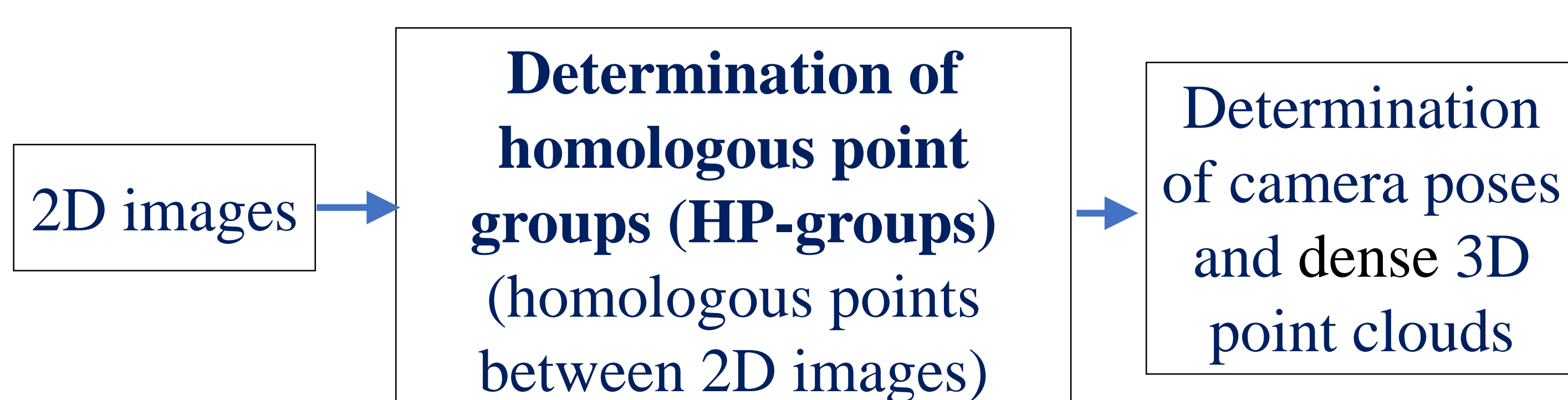


This work focuses on the determination of homologous points in SfM

Contributions

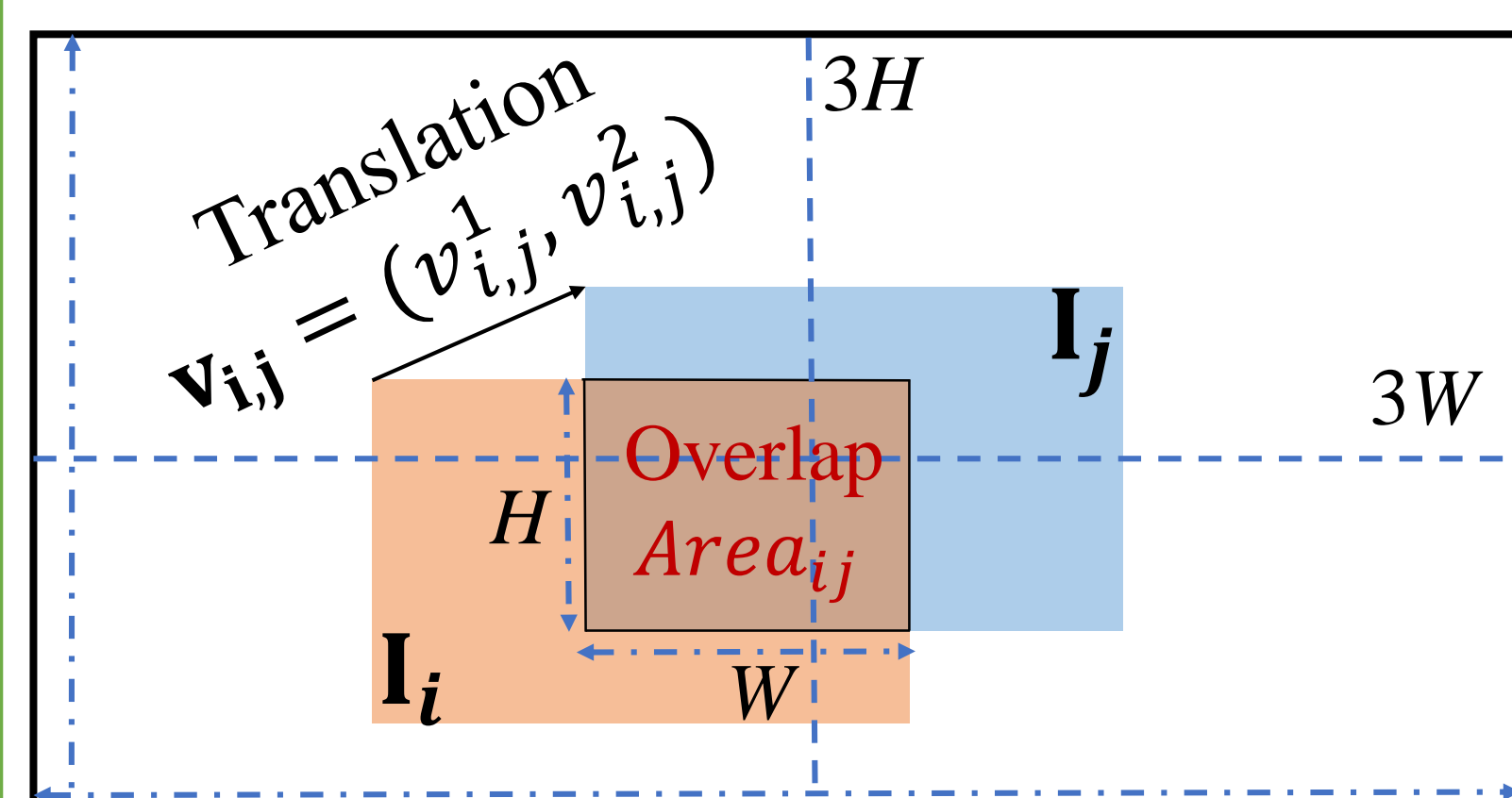
1. Novel optical flow-based Structure-from-Motion (SfM) for scenes with few textures.
2. High accuracy optical flow estimation using a new illumination-invariant descriptor.
3. Proposal of an effective Dense Optical Flow (DOF)-based SfM approach. Determination of large homologous point groups using dense optical flow.
4. Robust surface reconstruction for different medical scenes and image modalities.

Principle of our SfM pipeline



Proposed DOF-based SfM method

Determination of pairs of overlapped images

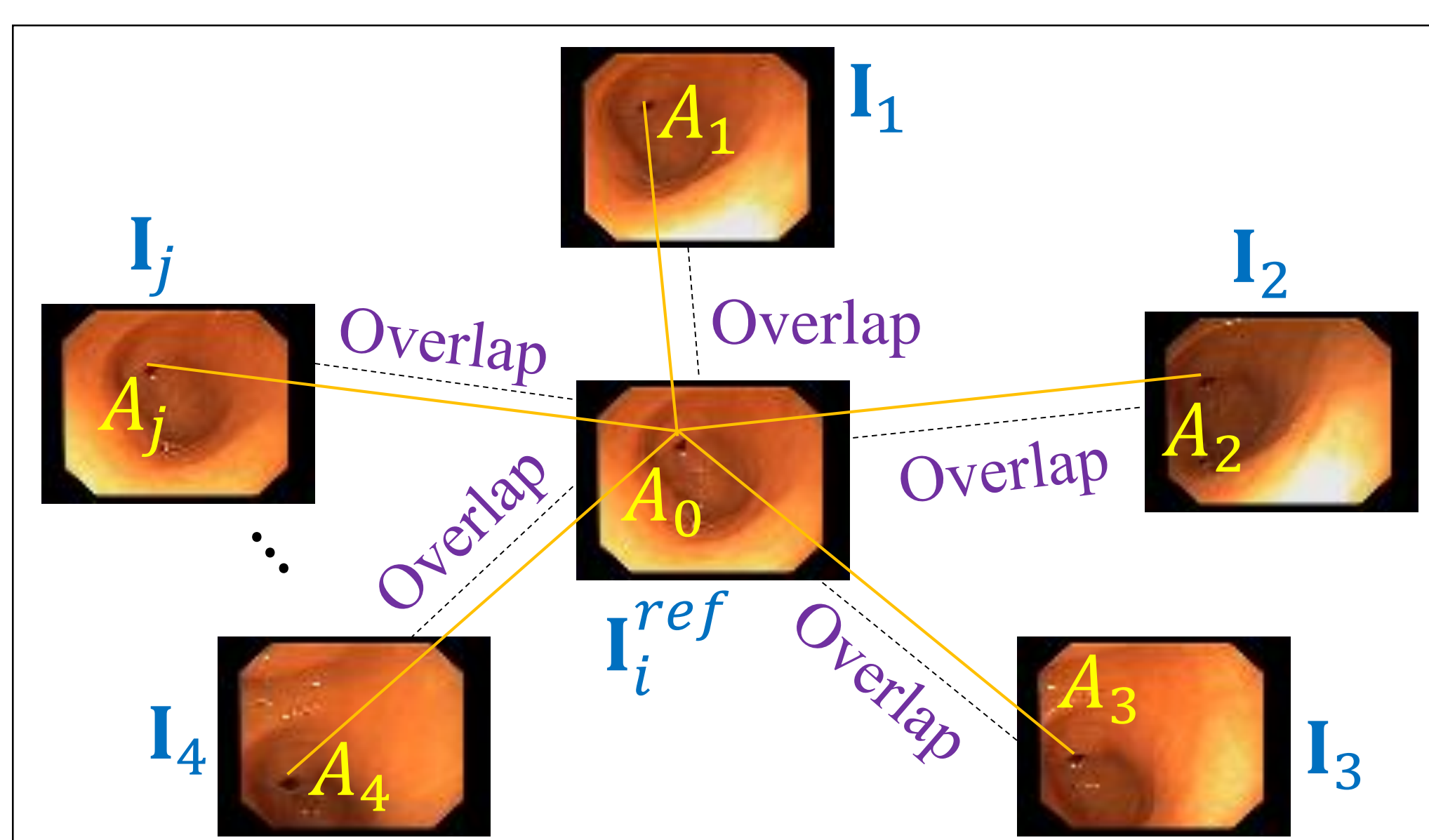


- $\mathbf{v}_{i,i+1}(v_{i,i+1}^1, v_{i,i+1}^2) = \mathbf{OF}_{i,i+1}(\mathbf{c})$, where $\mathbf{c}(W/2, H/2)$ is the image center point and \mathbf{OF} is the optical flow computed with [3].
- $\mathbf{v}_{i,j} = \sum_{t=i_0}^{j_0-1} \mathbf{v}_{t,t+1}(v_{t,t+1}^1, v_{t,t+1}^2)$, where $i_0 = \min(i, j)$, $j_0 = \max(i, j)$, $|i - j| > 1$.

- Image \mathbf{I}_i is called τ -overlapped with image \mathbf{I}_j if the area of $\mathbf{I}_i \cap \mathbf{I}_j$ is greater than τ pixels.

$$\left\{ \begin{array}{l} Area_{ij} = (W - |v_{i,j}^1|)(H - |v_{i,j}^2|) > \tau, \\ -W < v_{i,j}^1 < W, \\ -H < v_{i,j}^2 < H \end{array} \right.$$

Determination of HP -groups



Observation:

If (A_0, A_1, \dots, A_j) is a HP-group, then set (A_0, A_1, \dots, A_j) belongs to a common region of overlapped images showing a same scene part.

Our idea:

1. Determination for each \mathbf{I}_i of its set of overlapped images.
2. Determination of reference images with Algorithm 1 in [1].
3. Generation of HP-groups.

HP-group definition:

- If
- A_0 is a point in a reference image \mathbf{I}_i^{ref} and
 - A_1, \dots, A_j are homologous points of A_0 , then (A_0, A_1, \dots, A_j) is defined as a HP-group.

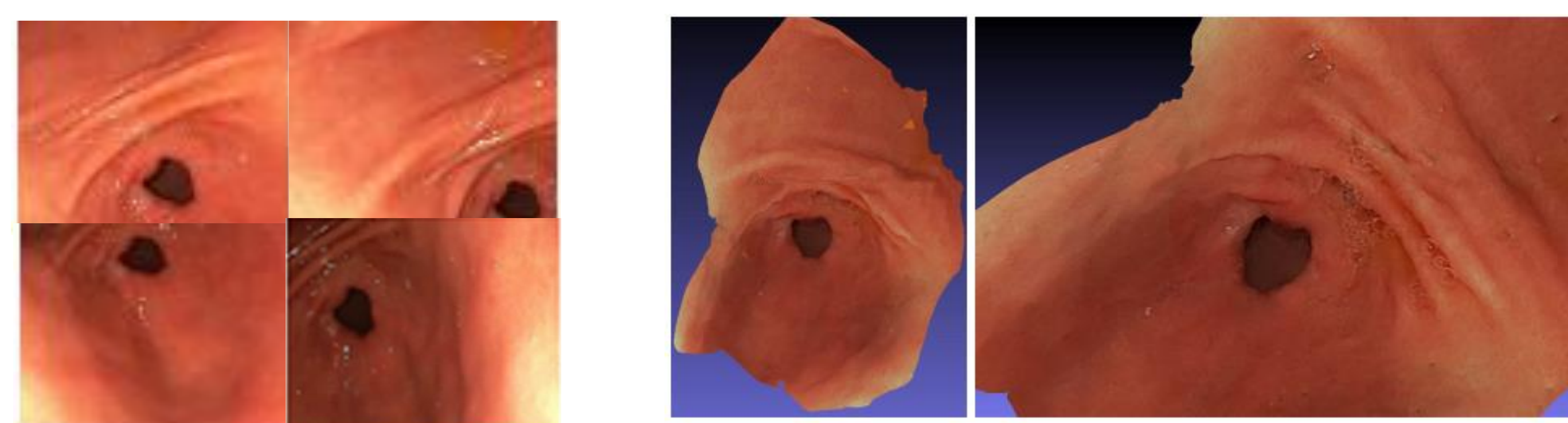
Experimental results

1. Objective evaluation

The accuracy of the proposed method was published in [1].

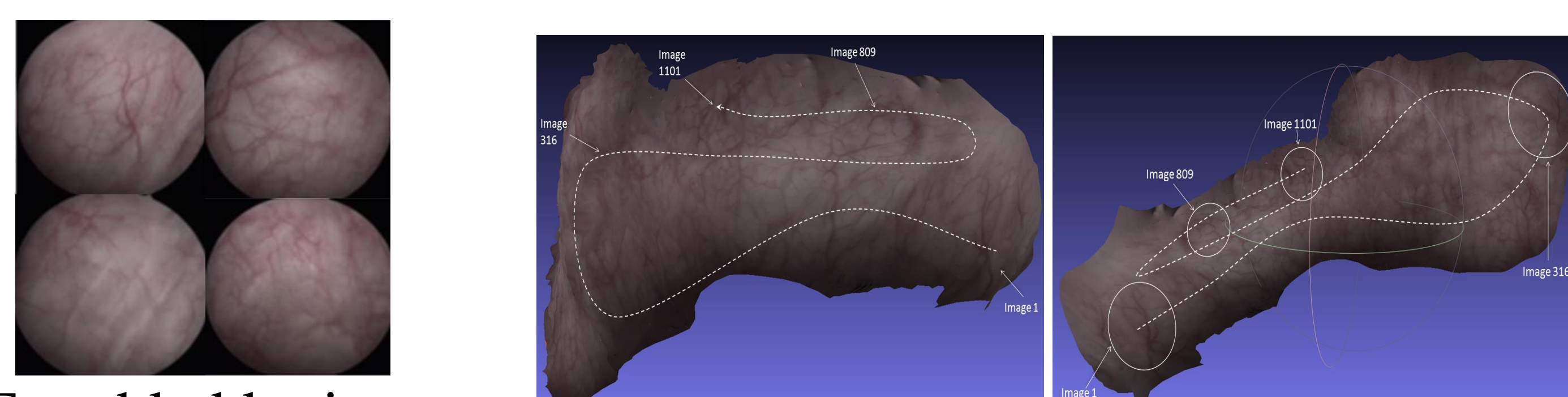
2. Subjective evaluation

Surface example in gastroscopy



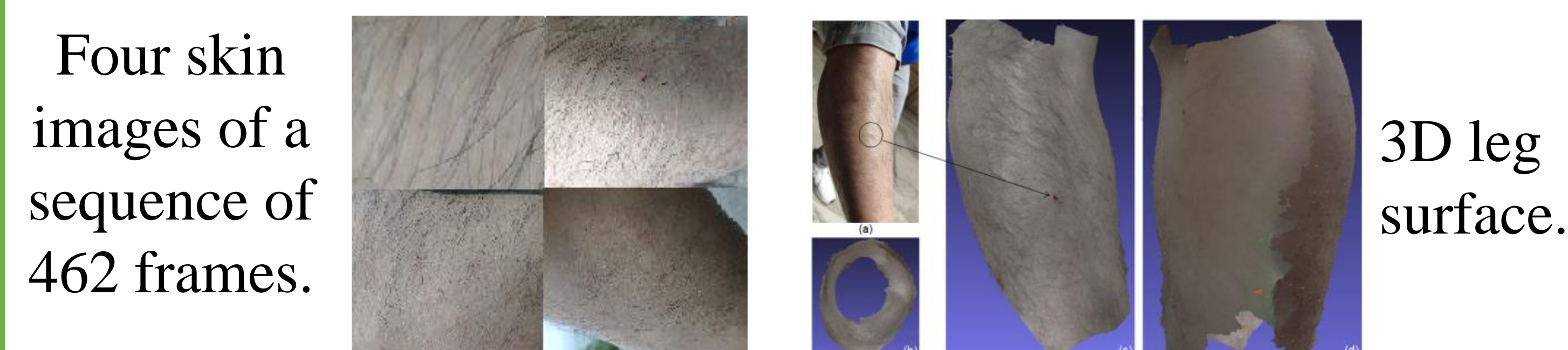
Four color images taken from a sequence of 191 frames. 3D surface of the pyloric antrum region under two viewpoints.

Surface example in cystoscopy



Four bladder images among a sequence of 1101 frames. 3D mosaic: bladder wall under the two viewpoints.

Surface example in dermatology



Four skin images of a sequence of 462 frames.

3D leg surface.

Publications

1. T.-B. Phan, D.-H. Trinh, D. Lamarque, D. Wolf, C. Daul, "Dense Optical Flow for the Reconstruction of Weakly Textured and Structured Surfaces: Application to Endoscopy", IEEE Int. Conf. on Image Processing (ICIP 2019), 310-314.
2. T.-B. Phan, D.-H. Trinh, D. Lamarque, D. Wolf, C. Daul, "3D Surface Reconstruction using Dense Optical Flow combined to Feature Matching: Application to Endoscopy", GRETSI, 2019.
3. T.-B. Phan, D.-H. Trinh, D. Wolf, C. Daul, "Optical Flow-based Structure-from-Motion for the Reconstruction of Epithelial Surfaces" Pattern Recognition, under review.