Introduction

- Treatment of twin-to-twin transfusion syndrome (TTTS) can be hindered by a limited fetoscopic field-of-view, a challenge that can be addressed through image stitching.
- A state-of-the-art framework incorporates U-Net based segmentation of placental vessels for more consistent frame-to-frame image registration [1].
- While accurate, this method has not demonstrated real-time capabilities [2] where images can be stitched at 10 Hz.

Objectives

- Achieve faster image stitching through a feature-based (SIFT) homography estimation from the segmented placental vessel maps.
- Implement a simple loop closure-based map correction procedure to help mitigate the drifting error.

Methodology

Vessel Segmentation:

- Training data: Six in vivo endoscopic videos and the corresponding annotations [1], and custom data obtained from a phantom placenta and annotated manually.

Field-of-view Expansion:

- Homography Estimation: Features obtained from the segmented frames (SIFT), an optical flow is calculated (Lucas-Kanade), and outliers are removed (RANSAC).
- Image Stitching: Circular masks are applied to the rectangular frames to enhance lighting consistency.

Addressing Drifting Errors:

- Loop Closure Detection: A histogram is generated for each frame by clustering its SIFT descriptors. A loop is detected when the Wasserstein distance between a given and initial histogram falls below a threshold.
- Map Correction: Once a loop closure is detected, the overlapping initial and final frames of the loop are restitched and all other homographies are adjusted.

Results

Frame-to-frame estimation times across various feature extractors and a featureless iterative registration method:

- SIFT is the most reliable among the feature extractors while upholding real-time performance.
- Reliability analysis involved error measurements across scaling, translation, and rotation of the camera frame.

Qualitative stitching and map correction results on a submerged phantom placenta:

Conclusion and Discussion

Deep segmentation of placental vessels can increase image stitching accuracy, improving TTTS treatment [1]. Our proposed framework builds upon this concept with:

- Feature-based homography estimation to enable real-time image stitching of at least 10 Hz.
- Incorporating a simple loop closure-based map correction procedure for the speed-accuracy trade-off.

Future Work: To help overcome limitations of the proposed framework, future work could explore:

- An optimization-based map correction procedure to enhance accuracy in more elaborate closed loops.

References