HAAG Week 13 Report -Lizard Jaw Segmentation

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Time-Log

What did I do this week?

- I consulted the computational advisor on the next steps for the non-rigid registration and why it didn't work.
- I am looking into providing mathematical explanation and hypothesis and using specific parameters for RANSAC registration for the registration method of working properly or not
- I received registration-based literature to read up on to provide greater understanding of image registration and optimization
- As the webpage manager and meeting leader of my group, I updated the webpage of the Stroud group with a subpage for the Lizard Jaw Segmentation group's weekly reports and group meeting recording link.

- What I will do next week
  - I will provide the mathematical explanations and hypothesis testing results suggested by the computational advisor for the registration process code currently.
- Blockers, things I want to flag, problems, etc.
  - The ability to provide a functional non-rigid registration method to increase data may not be possible by the end of the semester and will need to be continued into the summer semester.

Abstract:

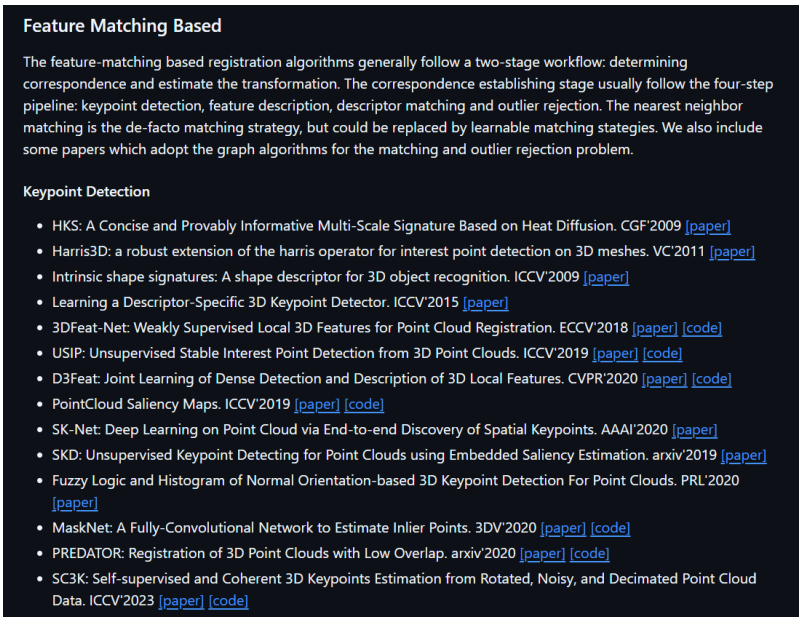
Numerous imaging techniques are available for observing and interrogating biological samples, and several of them can be used consecutively to enable correlative analysis of different image modalities with varying resolutions and the inclusion of structural or molecular information. Achieving accurate registration of multimodal images is essential for the correlative analysis process, but it remains a challenging computer vision task with no widely accepted solution. Moreover, supervised registration methods require annotated data produced by experts, which is limited. To address this challenge, we propose a general unsupervised pipeline for multimodal image registration using deep learning. We provide a comprehensive evaluation of the proposed pipeline versus the current state-of-the-art image registration and style transfer methods on four types of biological problems utilizing different microscopy modalities. We found that style transfer of modality domains paired with fully unsupervised training leads to comparable image registration accuracy to supervised methods and, most importantly, does not require human intervention.

Link: https://academic.oup.com/bib/article/25/2/bbae029/7628265?

General summary: The paper proposes SuperCUT, a fully unsupervised deep learning pipeline that accurately registers multimodal microscopy images without the need for manual annotations. The method combines Contrastive Unpaired Translation (CUT) for style transfer and SuperPoint for feature matching to align images from different modalities. SuperCUT is benchmarked against both supervised and unsupervised registration methods across four diverse microscopy datasets and achieves performance comparable to the best supervised methods, including U-Net with SuperPoint. The pipeline is especially useful for high-throughput applications like single-cell microdissection and localization microscopy, significantly reducing manual effort in precise image alignment tasks.

What did you do and prove it

1. Below are list of literature resources found to be reviewed:
   GitHub - XuyangBai/awesome-point-cloud-registration: A curated list of point cloud registration.



Feature Matching Based

The feature-matching based registration algorithms generally follow a two-stage workflow: determining correspondence and estimate the transformation. The correspondence establishing stage usually follow the four-step pipeline: keypoint detection, feature description, descriptor matching and outlier rejection. The nearest neighbor matching is the de-facto matching strategy, but could be replaced by learnable matching stategies. We also include some papers which adopt the graph algorithms for the matching and outlier rejection problem.

Keypoint Detection

- HKS: A Concise and Provably Informative Multi-Scale Signature Based on Heat Diffusion. CGF'2009 [paper]
- Harris3D: a robust extension of the harris operator for interest point detection on 3D meshes. VC'2011 [paper]
- Intrinsic shape signatures: A shape descriptor for 3D object recognition. ICCV'2009 [paper]
- Learning a Descriptor-Specific 3D Keypoint Detector. ICCV'2015 [paper]
- 3DFeat-Net: Weakly Supervised Local 3D Features for Point Cloud Registration. ECCV'2018 [paper] [code]
- USIP: Unsupervised Stable Interest Point Detection from 3D Point Clouds. ICCV'2019 [paper] [code]
- D3Feat: Joint Learning of Dense Detection and Description of 3D Local Features. CVPR'2020 [paper] [code]
- PointCloud Saliency Maps. ICCV'2019 [paper] [code]
- SK-Net: Deep Learning on Point Cloud via End-to-end Discovery of Spatial Keypoints. AAAI'2020 [paper]
- SKD: Unsupervised Keypoint Detecting for Point Clouds using Embedded Saliency Estimation. arxiv'2019 [paper]
- Fuzzy Logic and Histogram of Normal Orientation-based 3D Keypoint Detection For Point Clouds. PRL'2020 [paper]
- MaskNet: A Fully-Convolutional Network to Estimate Inlier Points. 3DV'2020 [paper] [code]
- PREDATOR: Registration of 3D Point Clouds with Low Overlap. arxiv'2020 [paper] [code]
- SC3K: Self-supervised and Coherent 3D Keypoints Estimation from Rotated, Noisy, and Decimated Point Cloud Data. ICCV'2023 [paper] [code]

Outlier Rejection

> We also include the algorithms designed for finding matching between keypoints given descriptors (which replaces nearest-neighbor-searching) in this section.

- RANSAC: Random Sample Consensus: A Paradigm for Model Fitting with Applications to Image Analysis and Automated Cartography. 1981 [paper]
- Locally Optimized RANSAC. 2003 [paper]
- Graph-cut RANSAC. CVPR'2018 [paper] [code]
- MAGSAC: Marginalizing Sample Consensus. CVPR'2019 [paper] [code]
- VFC: A Robust Method for Vector Field Learning with Application To Mismatch Removing. CVPR'2011 [paper]
- In Search of Inliers: 3D Correspondence by Local and Global Voting. CVPR'2014 [paper]
- FGR: Fast Global Registration. ECCV'2016 [paper] [code]
- Ranking 3D Feature Correspondences Via Consistency Voting. PRL'2019 [paper]
- An Accurate and Efficient Voting Scheme for a Maximally All-Inlier 3D Correspondence Set. TPAMI'2020 [paper]
- GORE: Guaranteed Outlier Removal for Point Cloud Registration with Correspondences. TPAMI'2018 [paper] [code]
- A Polynomial-time Solution for Robust Registration with Extreme Outlier Rates. RSS'2019 [paper]
- Graduated Non-Convexity for Robust Spatial Perception: From Non-Minimal Solvers to Global Outlier Rejection. ICRA'2020 [paper]
- TEASER: Fast and Certifiable Point Cloud Registration. T-RO'2020 [paper] [code]
- One Ring to Rule Them All: Certifiably Robust Geometric Perception with Outliers. NeurIPS'2020 [paper]
- SDRSAC: Semidefinite-Based Randomized Approach for Robust Point Cloud Registration without Correspondences. CVPR'2019 [paper] [code]
- Robust Low-Overlap 3D Point Cloud Registration for Outlier Rejection. ICRA'2019 [paper]
- ICOS: Efficient and Highly Robust Rotation Search and Point Cloud Registration with Correspondences. arxiv'2021 [paper]

Additionally, I updated the Stroud lab webpage with my group's relevant information up to week 12 of this semester (see images below).

Lizard Jaw Segmentation Group Meetings and Recordings

Updated On April 4, 2025

Spring 2025 Week 13 Computational Advisor Meeting Recording

Computational Advisor Meeting_ Lizard Jaw Segmentation-20250402_170010-Meeting Recording.mp4

Spring 2025 Week 12 – No meeting this week as other team members were not available

Spring 2025 Week 11 Computational Advisor/Group Meeting Recording

https://gtvault-my.sharepoint.com/personal/stian40_gatech_edu/Documents/Recordings/Computational%20Advisor%20Meeting_%20Lizard%20Jaw%20Segmentation-20250319_170154-Meeting%20Recording.mp4?web=1&referrer=Teams.TEAMS-ELECTRON&referrerScenario=RecapOpenInStreamButton.view.2b8a23c1-2849-409b-8a09-0935ed879990

Spring 2025 Week 10 Group Meeting – No meetings this week due to scheduling conflicts

Spring 2025 Week 9 Computational Advisor/Group Meeting Recording

https://sites.gatech.edu/haagstroudprojects/wp-admin/user-new.php

Spring 2025 Week 8 Meeting Recording

Weekly Lizard Jaw Meeting-20250226_170110-Meeting Recording.mp4

Spring 2025 Week 7 Computational Advisor/Group Meeting Recording

Weekly Lizard Jaw Meeting-20250219_170647-Meeting Recording.mp4

Spring 2025 Week 6 Meeting Recording

Weekly Lizard Jaw Meeting-20250212_170746-Meeting Recording.mp4

Spring 2025 Week 5 Computational Advisor Meeting Recording

Lizard Jaw Segmentation_ Student Researcher _ Computational Advisor Meet-20250206_171303-Meeting Recording.mp4

Spring 2025 Week 4 Meeting Recording

Weekly Lizard Jaw Meeting-20250129_150624-Meeting Recording.mp4

Spring 2025 Week 3 Meeting Recording

Weekly Lizard Jaw Meeting-20250122_150152-Meeting Recording.mp4

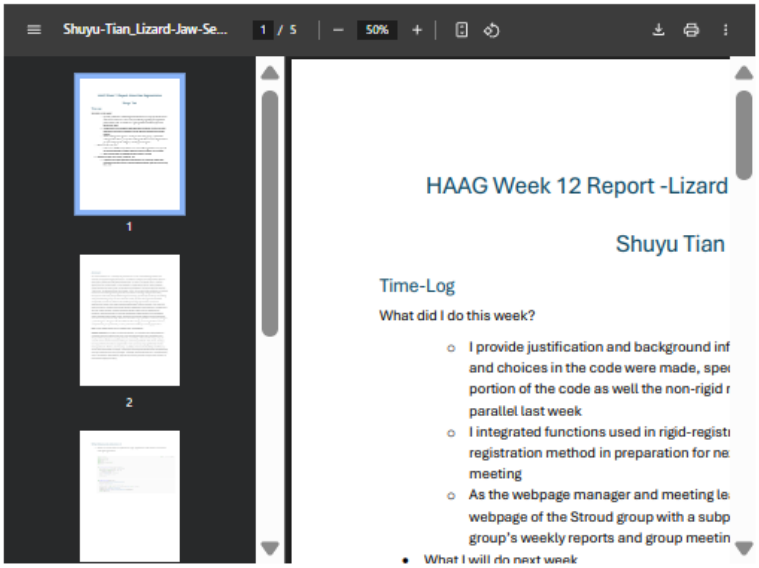
Spring 2025 Week 3 Computational Advisor Meeting Recording

Lizard Jaw Segmentation_ Student Reasearcher _ Computational Advisor Meet-20250120_150433-Meeting Recording.mp4

Lizard Jaw Segmentation Weekly Submissions

Updated On April 4, 2025

Week 12 Weekly Report



Shuyu Tian_Lizard Jaw Segmentation_Week 12

DOWNLOAD