Location Recognition in Laparoscopic Surgery
Recap: Project Requirements

- **COMPASS system**: Online construction of an anatomical map, based on stereo-endoscope images and IMU-sensor data using **SLAM**

- **Drift correction** by finding loop-closures (already visited locations) → **Visual Bag of Words (BoW)**

- Project requirements:
  1. Build BoW-dictionary for given dataset
  2. Integrate BoW-algorithm into existing pipeline
  3. Integrate additional consistency checks based on e.g. IMU-data

GANTT Project Plan

- **Project Start**: Oct 18
- **Requirements Presentation**: Nov 8
- **Intermediate Presentation**: Dec 14
- **Final Presentation**: Feb 7

**2021**

- Oct 18 - Oct 31: Reimplementation of Bag of Words (BoW) Algorithm
- Nov 1 - Nov 21: Extraction of new BoW Vocabulary
  - Feature extraction for all images
  - K-means Clustering
  - Export of BoW Vocabulary
- Nov 22 – Dec 12: Testing 1
- Dec 12 – Dec 23: Integration of BoW Algorithm in Existing Pipeline
  - Use of pre-implemented BoW algorithm
- Dec 24 - Jan 9: Christmas Holidays
- Jan 10 - Jan 23: Integration of additional Consistency Checks
  - Based on IMU-data etc.
- Jan 23 – Feb 7: Testing 2

**2022**

- Oct
- Nov
- Dec
- Jan
- Feb

Today

February 7, 2022 Slide 3
Further Evaluation of BoW-Dictionaries
Further Evaluation BoW-Dictionaries

1. Evaluation of BoW-vector distances for different Dictionary parameters:

- K: 10, L: 4
- K: 15, L: 4
- K: 30, L: 2
Further Evaluation BoW-Dictionaries

2. Choice of suitable matching threshold:

$\rightarrow$ Improved matching precision from 0.64 to 0.74

$\text{Precision} = \frac{TP}{TP + FP}$
Integration into current workflow
Current Workflow

1. Detection of stereo-matches (landmarks) and triangulation for 3D position:

Frame A, Cam 1

Frame A, Cam 2
1. Detection of stereo-matches (landmarks) and triangulation for 3D position:

- **Landmark_1**: \{A_1, 3\}; \{A_2, 2\}
- **Landmark_2**: \{A_1, 5\}; \{A_2, 3\}
Current Workflow

2. Tracking Landmarks and adding observation:

**Frame A, Cam 1**

- Landmark_1: \{A_1, 3\}; \{A_2, 2\}; \{B_1, 2\}

**Frame B, Cam 1**

- Landmark_2: \{A_1, 5\}; \{A_2, 3\}
Integration of BoW

For all query matches find features that match landmarks:

Frame A, Cam 1

Frame Y, Cam 2

Landmark_2: \{A_1, 5\}; \{A_2, 3\}; \{Y_2, 4\}

Landmark_31: \{Y_1, 2\}; \{Y_2, 1\}; \{A_1, 1\}
Motivation Consistency Checks

Problem:

Frame A, Cam 1

Landmark_2: \{\{A_1, 5\}; \{A_2, 3\}; \{Y_2, 4\}\}

Frame Y, Cam 2

Landmark_31: \{\{Y_1, 2\}; \{Y_2, 1\}; \{A_1, 4\}\}
Consistency Checks
Consistency Checks

Solution: Find outliers using **RANSAC**

- find **camera pose** given a number of **2D-3D correspondences** (2D – features, 3D – landmarks)
- Try to find camera pose such that **maximum amount of correspondences** fit the transformation
- Only **inliers** get considered as observations

Source: https://laurentkneip.github.io/opengv/page_how_to_use.html#sec_threshold
Consistency Checks

Additional consistency check using Gyro-data:

- Check if rotation $R_{\text{RANSAC}}$ corresponds to measured rotation $R_{\text{gyro}}$ of IMU sensor
- If close enough, add observations

$\rightarrow$ Consistency check of found inliers
Testing
Results Testing

**Project matched landmarks** into current frame and **calculate** distance in 2D image coordinates

→ For **841** frames and **3923 observations**: **average error** of **1.93 pixel**
Open Problems
Open Problems To Solve

1. Find a suiting **threshold** for **gyro-consistency** → **Compensate** for eventual **gyro-drift** over time
2. Use **more data** to extract **BoW-Dictionary**
3. Use **more data** for **testing**
4. Evaluate **online performance**
Thanks for your attention!