

# Activity Classification with Persistent Homology Barcodes

Project Management and Software Development  
for Medical Applications

## General Info

Project Title: Activity Classification with Persistent Homology Barcodes

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## Project Abstract

Using topological data analysis, the goal of this project is to classify different medical maneuvers tracked by an optical tracking system. For a series of hand movements with medical instruments such as performing an ultrasound scan, poses are collected and the maneuvers are compared using persistent homology barcodes.

## Background and Motivation

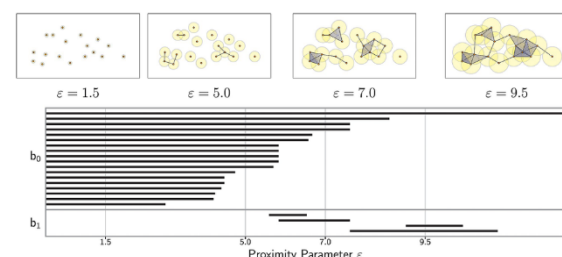
Action recognition has a wide field of applications within the medical domain. To treat chronic diseases such as epilepsy, understanding the incident of an epileptic seizure from data plays an important role in analyzing their causes and to adjust medication accordingly. On the other side, a specific reaction in a cooperative robotic surgery scenario is based on an automatic understanding of the performed action by the physician.

To pave the way towards automatic scene understanding and action classification many learning based approaches have already been investigated for different scenarios based on video data or other sensor modalities. However, especially the more recent deep learning

approaches often need a tremendous amount of training data and elaborate data augmentation procedures. In clinical applications, this data can often not be collected easily.

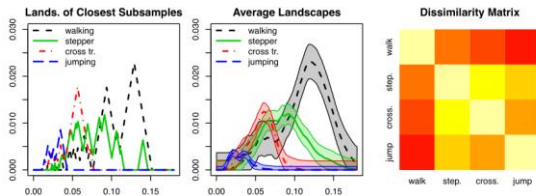
The goal of this project is to automatically separate different actions based on the data gathered from an optical tracking system using topological data analysis which is per se insensitive to orientation changes and thus does not suffer from these extensive augmentation needs. For this, a series of hand movements with different medical instruments such as needling, ultrasound scanning and sewing is investigated.

Persistence homology is one way to think about the structure of a space (our action representation) at different spatial resolutions. If one thinks about the data arising from the pose of the tracking system as points in the feature space of actions and slowly grows balls around these points while keeping track of the connecting structures created in this process, a barcode can be generated. Each bar represents the lifetime of an individual connected component and long (persistent) bars indicate the more important topological features.



[C. Topaz](#): Persistence Homology Barcode.

There are elaborate ways (and existing libraries) to calculate such barcodes and to compare different ones. The image below shows a topology-based analysis of different magnetometer measurement series for the actions listed.



#### *Activity Classification with Magnetometer Data.*

The project aims to give a first trial of the recent progress in persistence homology for medical application and evaluates how well a topological consideration of the different medical activities can be used to classify these tasks.

### Student's Tasks Description

After an initial investigation of the common methods used in persistence homology, the first target for the student is to get familiar with one of the commonly used libraries to calculate persistent homology barcodes and the distance metrics used for comparison.

The method proposed in Chazal et al. (Example 14) is then implemented and tested on a dataset generated within the scope of the project using the FRAMOS Optical Tracking System (OTS).

Adjacently, the classification is evaluated and documented for different tasks with several users.

After this project, the student can work with the FRAMOS software framework and gained some experience in topological data analysis which can be used for a variety of other problems. Also, some experience with real-time optical tracking and pose estimation has been achieved. Moreover, the constant coordination with FRAMOS gives some insight into the working procedures in the industry.

### Technical Prerequisites

- Basic knowledge of MATLAB / C++

Optional requirements that can also be learned during the project are:

- Basic skills in Topological Data Analysis

- Ability to work with versioning tools such as GIT

### References

F. Chazal et al. "Subsampling Methods for Persistent Homology". ICML 2015.

J. Reininghaus et al. "A stable multi-scale kernel for topological machine learning". CVPR 2015.