Title of research:

Research Capacity in Topology based Object Tracking (TOT)

Objectives:

- To identify key insights gained by Topological Data Analysis (TDA) in the object tracking area, and its application to real world use case.
- Developing a knowledge base in TDA in BMW.
- Developing a Python based library for TDA tasks.

Please give a brief justification of your proposed research project:

In the past few decades, many researchers have explored the area of intelligent vehicles and tried to make vehicles perceive and analyze their surrounding environment in order to enhance on-road safety. However until now, reliable detection and tracking of on-road obstacles remains one of the most complex tasks for driver assistance and autonomous navigation systems. This issue is challenging due to variable illumination conditions, changing weather conditions, and highly dynamic background.

In this paper, we focus on the identification of moving and stationary obstacles on the road, and the robust tracking of mobile agents using LIDAR point cloud data or Images by applying a segmentation method based on topological persistence.

Domains of application that can benefit:

• Tracking of objects in a sequence of Lidar space (in Autonomous Driving)

The hope of this research project would be:

- To develop a Library (in Python preferably) which BMW data scientist can use out of the box to apply 3D point-clouds object tracking.
- To apply TDA based on 3D point-clouds object tracking to autonomous driving related Lidar space and/or Video Images.

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   Available from: https://www.nature.com/articles/s41598-018-23488-y

   [Accessed 3 June 2018]

2) Somrita Chattopadhyay, Qian Ge, Chunpeng Wei, Edgar Lobaton (2017) Robust Multi-Target Tracking in Outdoor Traffic Scenarios via Persistence Topology based Robust Motion Segmentation

   Available from: https://research.ece.ncsu.edu/aros/wp-content/uploads/2016/01/GlobalSIP2015_RobustTracking.pdf

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3) Paul Bendich, Sang Chin, Jesse Clarke, Jonathan deSena, John Harer, Elizabeth Munch, Andrew Newman, David Porter, David Rouse, Nate Strawn, Adam Watkins (2018) Topological and Statistical Behavior Classifiers for Tracking Applications

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4) Herbert Edelsbrunner and John Harer, "*Computational Topology – an Introduction*", AMS 2010.

5) Julien Tierny, Guillaume Favelier, Joshua Aaron Levine, Charles Gueunet, Michael Michaux, "The Topology ToolKit", IEEE Transactions on Visualization and Computer Graphics (Proc. Of IEEE VIS 2017). http://topology-tool-kit.github.io

6) Peer-Timo Bremer, Gunther Weber, Julien Tierny, Valerio Pascucci, Marcus Day and John Bell, « *Interactive exploration and analysis of large scale simulations using topology-based data segmentation »* IEEE Transactions on Visualization and Computer Graphics 2010.

7) Herbert Edelsbrunner, John Harer, Ajith Mascarenhas, Valerio Pascucci, Jack Snoeyink, *« Time-varying Reeb graphs for continuous space-time data »*. Comput. Geom. 41(3): 149-166 (2008)