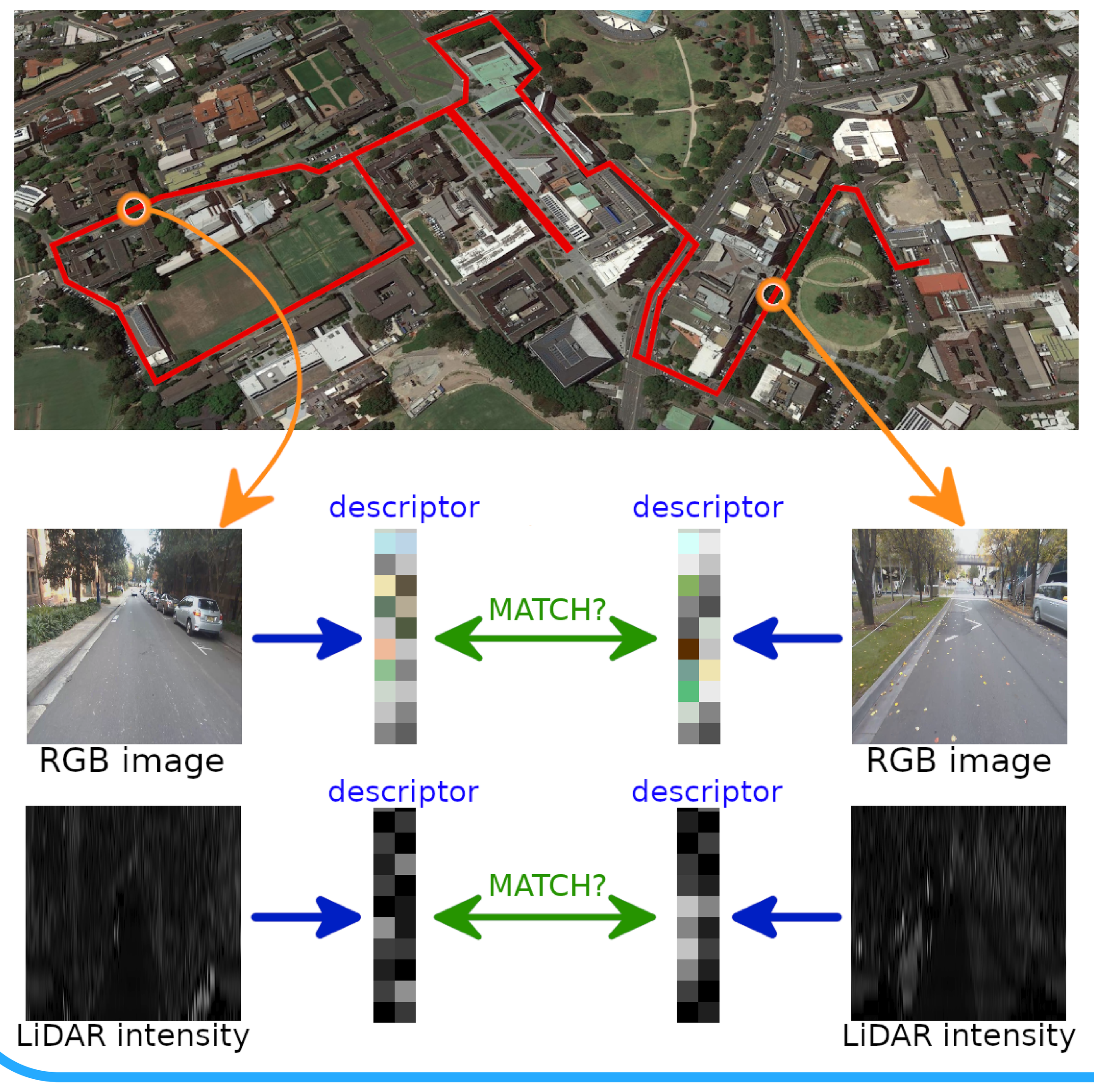
Camera-based and 3D LiDAR-based Place Recognition Across Weather Conditions

Kamil Żywanowski, Adam Banaszczyk, Michał Nowicki

Institute of Robotics and Machine Intelligence, Poznań University of Technology

Introduction

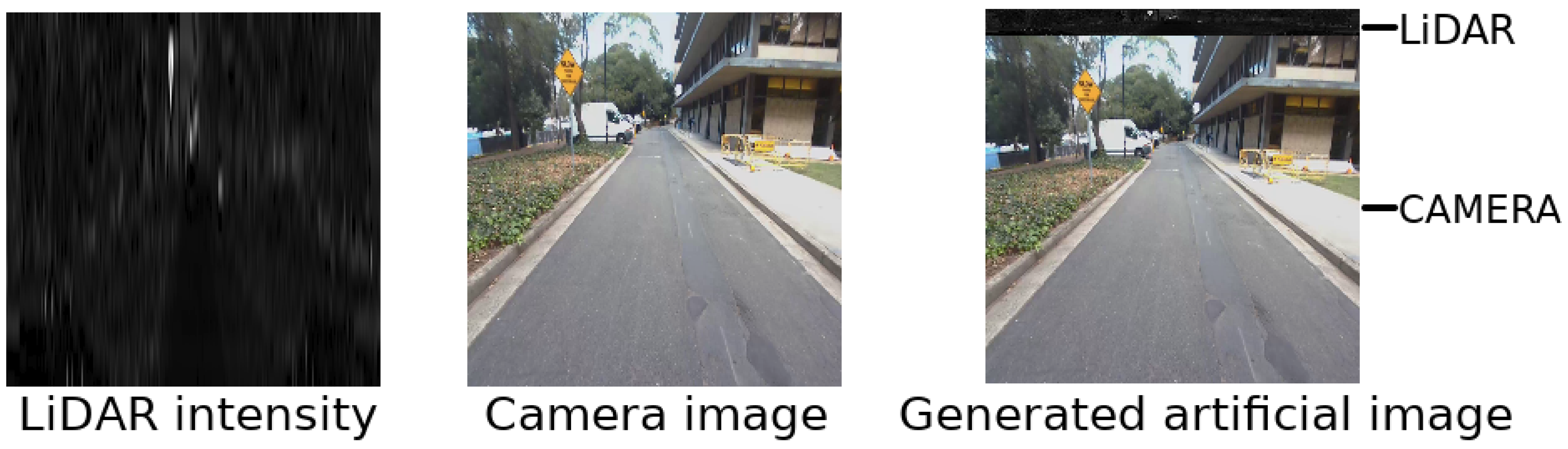


This research focuses on a place recognition task - checking if the data received from the sensor corresponds to a known location, to reduce drift and provide global localization. Known flaws of camera-based solutions and increasing LiDAR popularity lead to the following questions:

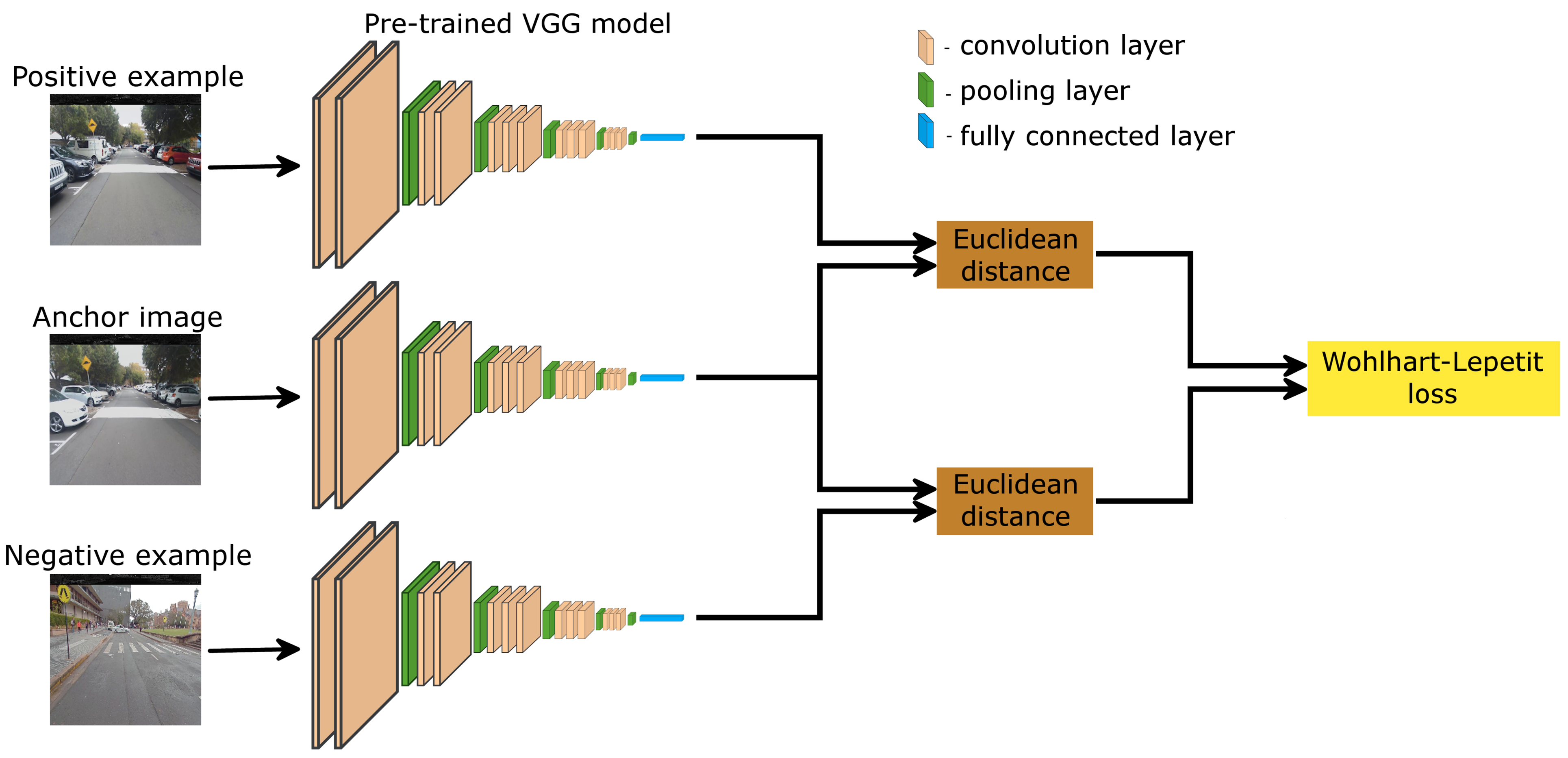
- Is camera reliable enough for place recognition across different weather conditions?
- Can 3D LiDAR data be used for place recognition task?
- Is the information acquired by LiDAR sensors complementary or redundant to camera images in case of place recognition?
- How to process point cloud data by a neural network?

A triplet VGG-16 neural network architecture serves as descriptor extractor for all locations. RGB camera images, Velodyne VLP-16 LiDAR readings and GPS data from The USyd Campus Dataset are used to train and validate the network. The dataset consist of multiple runs on the same trajectory, in various weather conditions.

Processing pipeline and artificial image



- Three different input configurations were tested – camera-based, LiDAR-based, camera-LiDAR-based.
- The joint camera-LiDAR artificial image is created by scaling the RGB image and stacking the LiDAR intensity data onto it.

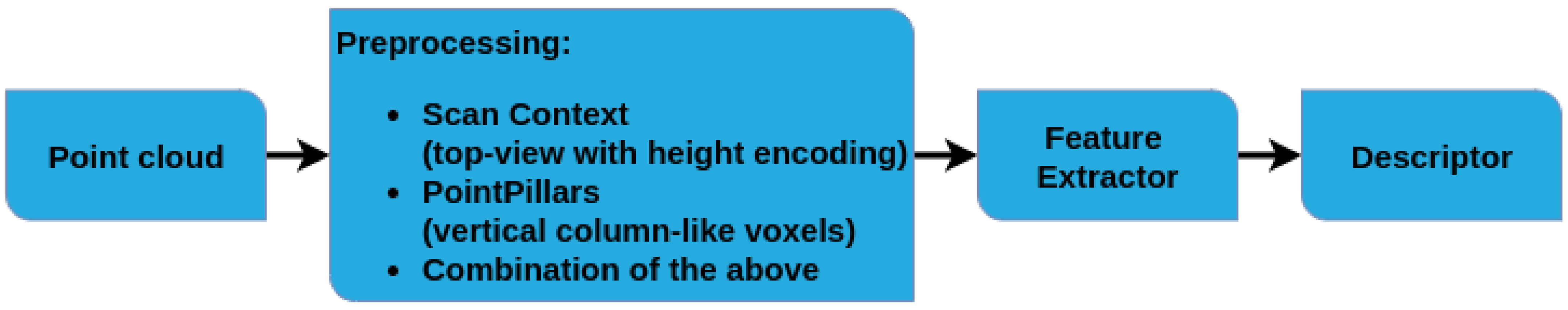


- The same network and processing pipeline for every configuration.
- Pre-trained triplet VGG model trained with positive and negative examples simultaneously, forming a triplet loss setup.
- Fine-tuning with hard negatives (closer to the neutral frame) once the training plateau was observed.
- Test data is separated from training data.

Results and conclusions

Testing conditions	Place recognition system		
	Camera	LiDAR	Camera LiDAR
Sunny	82.08%	81.25%	85.61%
Cloudy	84.78%	80.24%	87.67%
Sunny/Cloudy	86.98%	82.71%	89.38%
After Rain	85.53%	80.24%	88.99%
Sunset	82.39%	81.39%	87.86%
Very Cloudy	84.68%	82.09%	88.58%
Mean accuracy	**83.49%**	**81.11%**	**86.91%**

Joint camera-LiDAR-based place recognition achieves the best mean recognition accuracy in all analyzed scenarios.



LiDAR sensor is worth using either as a supplement or as a base solution in place recognition. This research is continued, aiming at:

- creation of a pipeline suitable for point cloud data, with PointPillars, Scan Context or combined preprocessing,
- maximization of LiDAR data usability in place recognition task.

References & contact information

1. K. Żywanowski, A. Banaszczyk, M. Nowicki, “Comparison of camera-based and 3D LiDAR-based place recognition across weather conditions” 16th International Conference on Control, Automation, Robotics and Vision (ICARCV) Shenzhen, China, 2020, 886-891.
2. W. Zhou et al., “The USyd Campus Dataset”, IEEE Dataport, 2019. Available: http://dx.doi.org/10.21227/sk74-7419
3. A. H. Lang, et al., “Pointpillars: Fast encoders for object detection from point clouds”, CVPR, pp. 12697-12705, 2019
4. G. Kim et al., “1-Day Learning 1-Year Localization: Long-Term LiDAR Localization Using Scan Context Image”, IEEE Robotics and Automation Letters, vol. 4, no. 2, pp. 1948-1955, 2019

{kamil.zywanowski,adam.banaszczyk}@student.put.poznan.pl, michal.nowicki@put.poznan.pl