Visual SLAM with automatic map update in a dynamic environment

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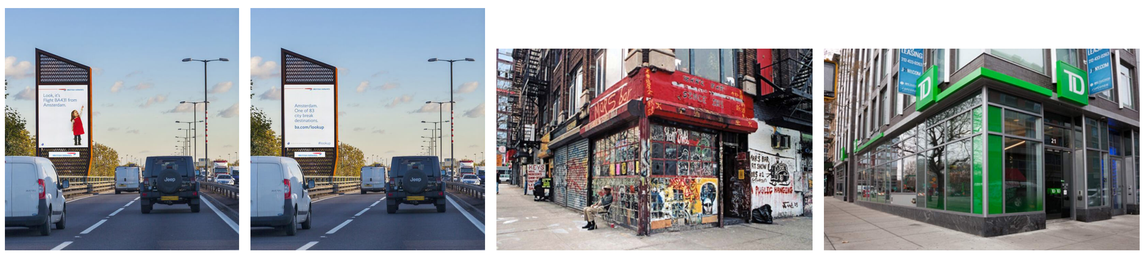
Introduction

- In recent years, Simultaneous Localization and Mapping (SLAM) has emerged as a powerful algorithm for real-time localization of smart vehicles in urban environments. Current algorithms are adapted to an environment supposed to be rigid and static in time. But the environment is constantly changing. Automatic updating of the 3D model is a difficult problem but crucial from an application point of view. There are several types of changes that need to be treated differently. Typically in an urban scene:
  - Some elements are long-term stable (buildings, streets, floor, ...). These elements are modified rarely and for long durations.
  - Some elements are temporary like parked cars but are always in the same areas.
  - Other elements have a stable geometry but change their appearance (for example an advertising board which displays is changed).



Challenges

- Seasons
- Day/Night
- Viewpoint

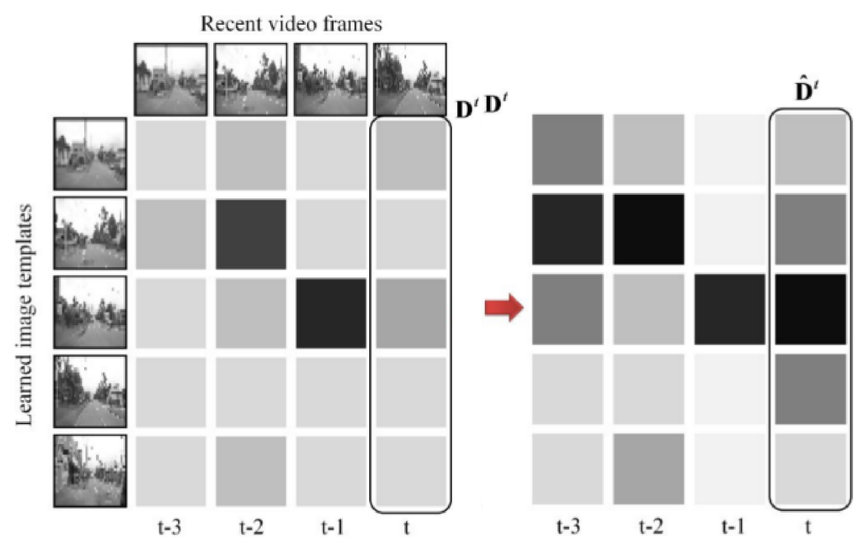
Loop closure

- Loop-closure detection is crucial for enhancing the robustness of both topological and metrical SLAM algorithms. This problem consists in detecting when the robot has returned to a past location after having discovered new terrain for a while. Such detection makes it possible to increase the precision of the actual pose estimate. Recognizing previously mapped locations can also be relevant for addressing the global localization problem. Hence, solving the loop-closure detection problem not only improves SLAM performances, but it enables additional capabilities to mobile robots.

(a) Aerial photo (b) Before loop closure (c) After loop closure

SeqSLAM

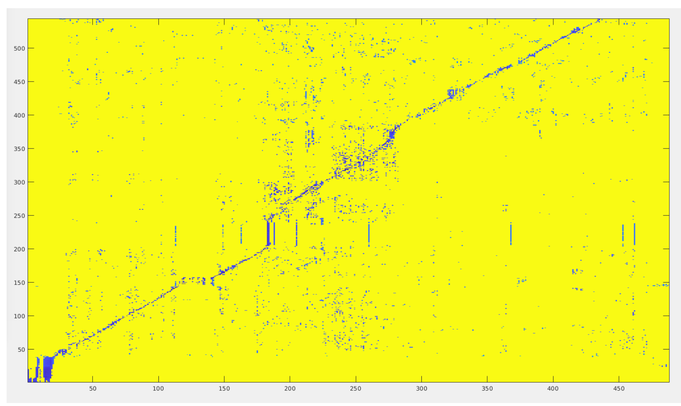
- A loop closing is performed when the robot revisits a familiar place. In order to detect if the current location is already visited in the past or if it is a new place, we use SeqSLAM[1] which consists of calculating the best candidate matching location within every local navigation sequence. Localization is then achieved by recognizing coherent sequences of these local best matches.



Results:

- We applied the algorithm on different datasets. We have obtained the following matching and similarity matrix on the University of Bonn dataset[2].

Corresponding frames



Smiliarity matrix

Conclusion

- SeqSLAM has shown good performance on recognizing places across seasons and under luminosity changes (example : day/night). However, most of global image descriptors lack viewpoint invariance, which may lead to undetecting familiar places on the revisit and thus, loop closure will not be performed when necessary.
- Future work will try to fuse global image descriptor and local feature descriptor together to improve the performance when viewpoints changes.

References

[1] M. J. Milford and G. F. Wyeth.
Seqslam: Visual route-based navigation for sunny summer days and stormy winter nights.
pages 1643–1649, May 2012.

[2] Olga Vysotska and Cyrill Stachniss.
Lazy data association for image sequences matching under substantial appearance changes.
2016.

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