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Adaptive SLAM with synthetic stereo dataset generation for real-time dense 3D reconstruction

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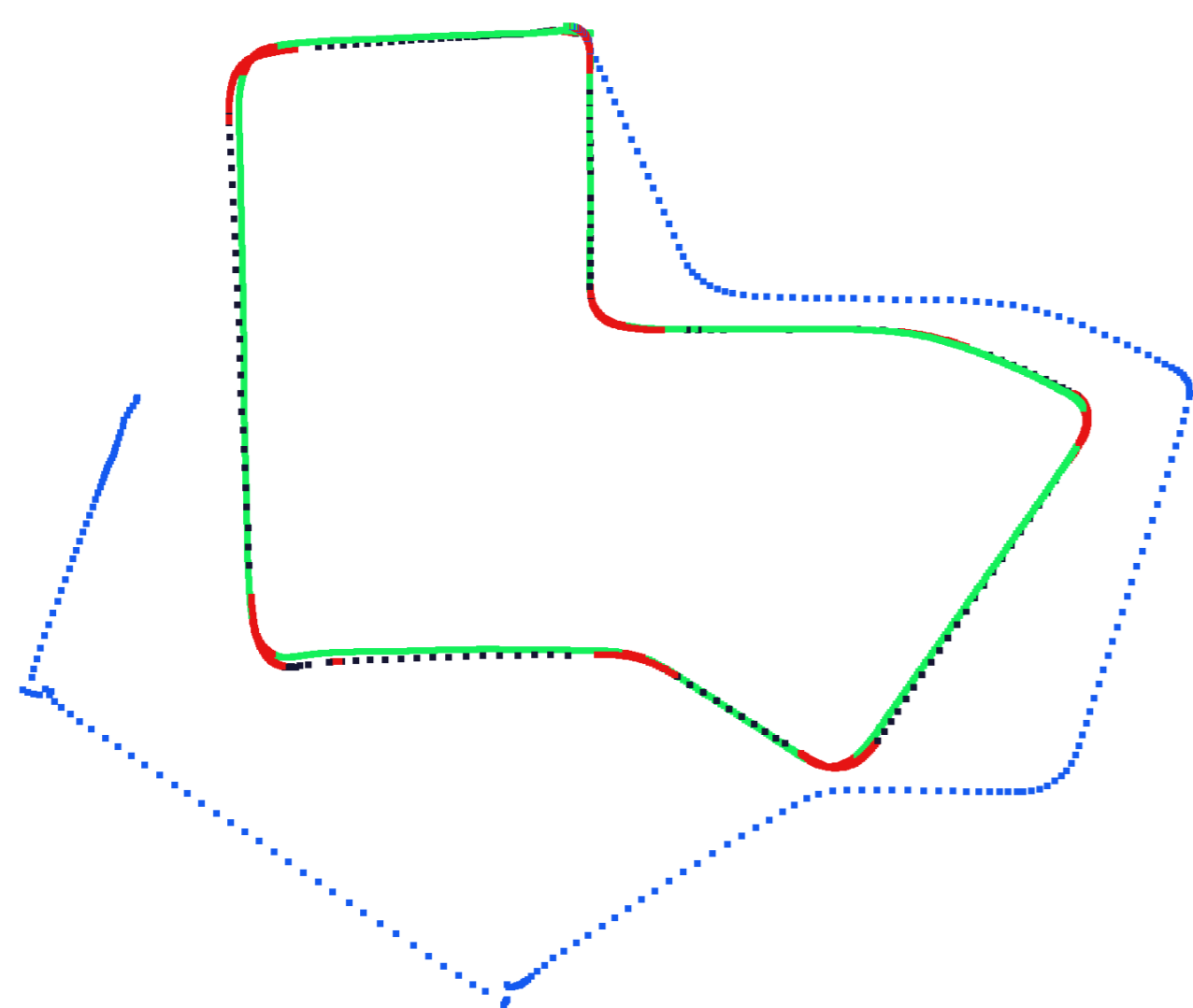
Abstract

In robotic mapping and navigation, of prime importance today with the trend for autonomous cars, simultaneous localization and mapping (SLAM) algorithms often use stereo vision to extract 3D information of the surrounding world. Whereas the number of creative methods for stereo-based SLAM is continuously increasing, the variety of datasets is relatively poor and the size of their contents quite small. Because today most of these technologies are embedded on on-board systems, the power consumption and real-time constraints turn to be key requirements. Our contribution is twofold: we propose an adaptive SLAM method that reduces the number of processed frames with minimum impact error, and we make available a synthetic flexible stereo dataset with absolute ground truth, which allows to run new benchmarks for visual odometry challenges.

This dataset is available online at alastor.labri.fr.

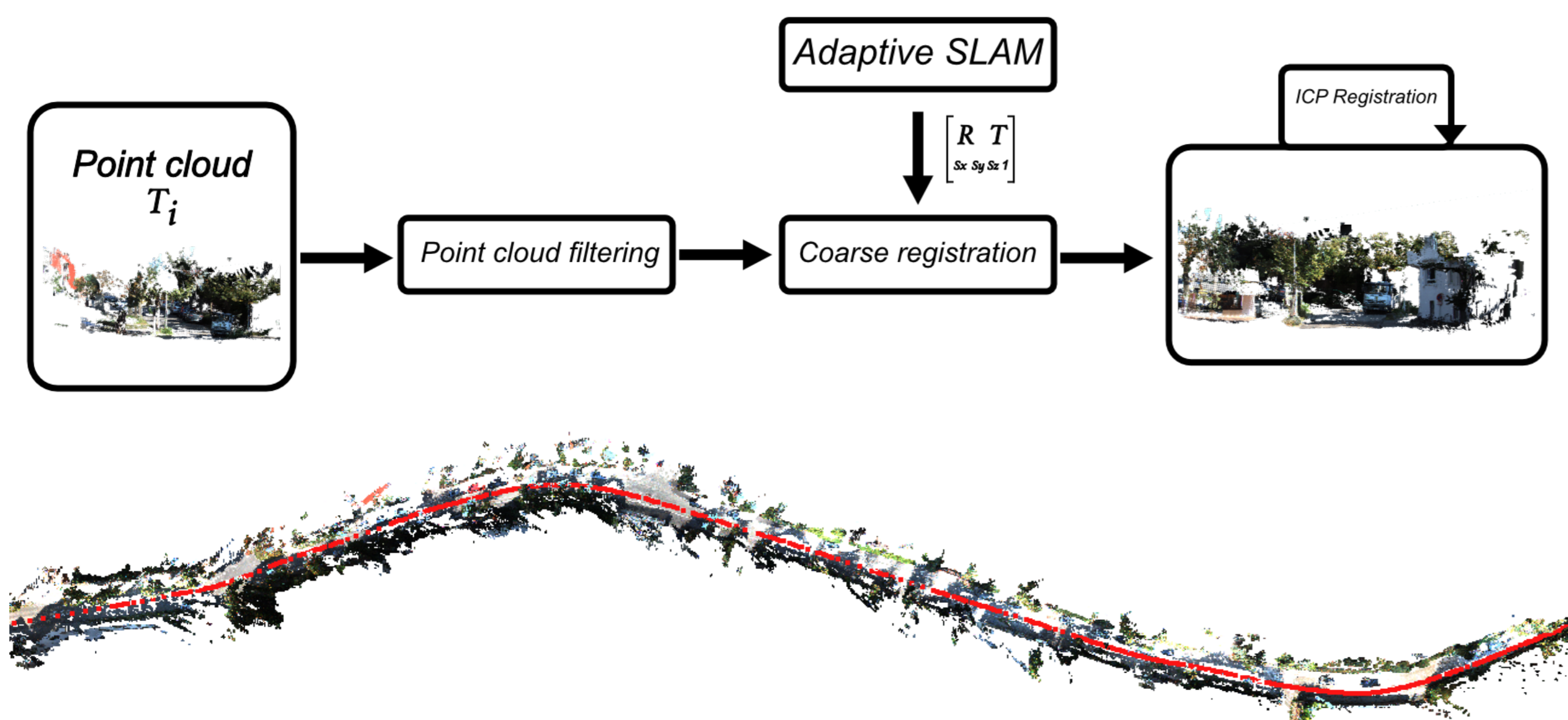
Adaptive SLAM Algorithm

Our algorithm smartly select the most usefull frames that are going to be processed by a SLAM algorithm. It focuses on strongly reducing the number of frames when the trajectory is mostly straight, and keeping a high frame rate during rotations. The figure below illustrates two outputs of the same SLAM algorithm with the same number of input frames with and without our adaptive frames selection. With **our method** (in black and red) the estimated trajectory fits perfectly the **ground truth** (in green) while **a naive frame selection** (in blue) strongly moves away.



Real-time Dense 3D Reconstruction Pipeline

Our adaptive SLAM method lets us build a real-time dense 3D reconstruction process on a small device (such as a Raspberry Pi) without the need of a huge computationnal cost. The figure below shows the reconstructed point cloud correctly fitting the unused given **GPS coordinates** (in red).



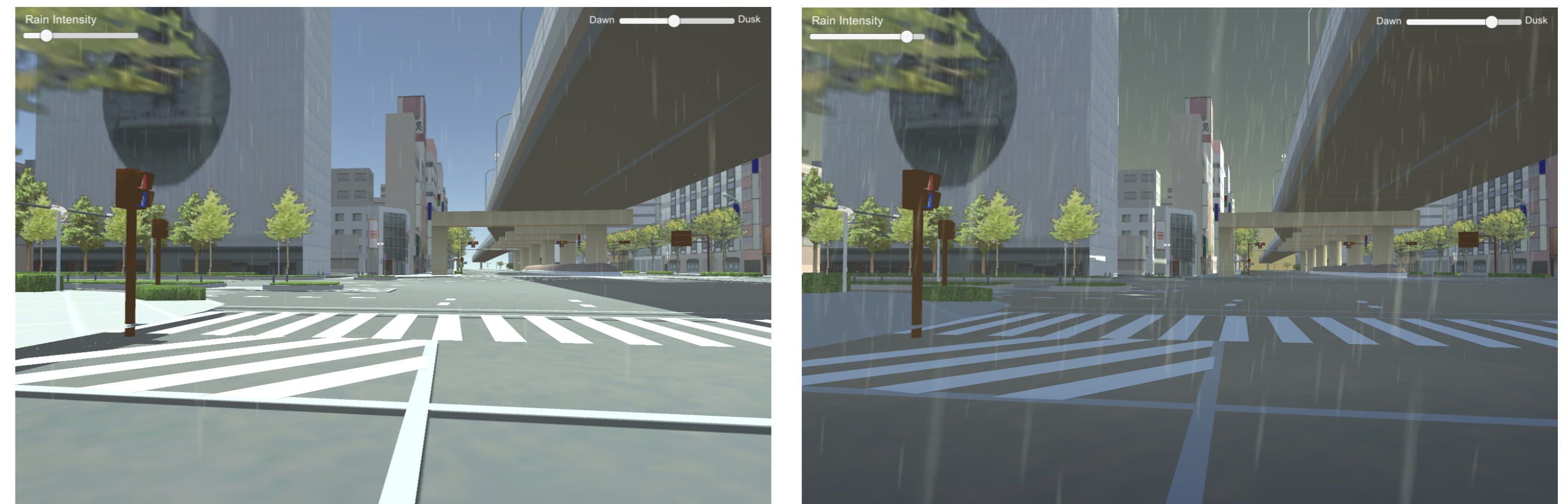
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The Alastor Dataset

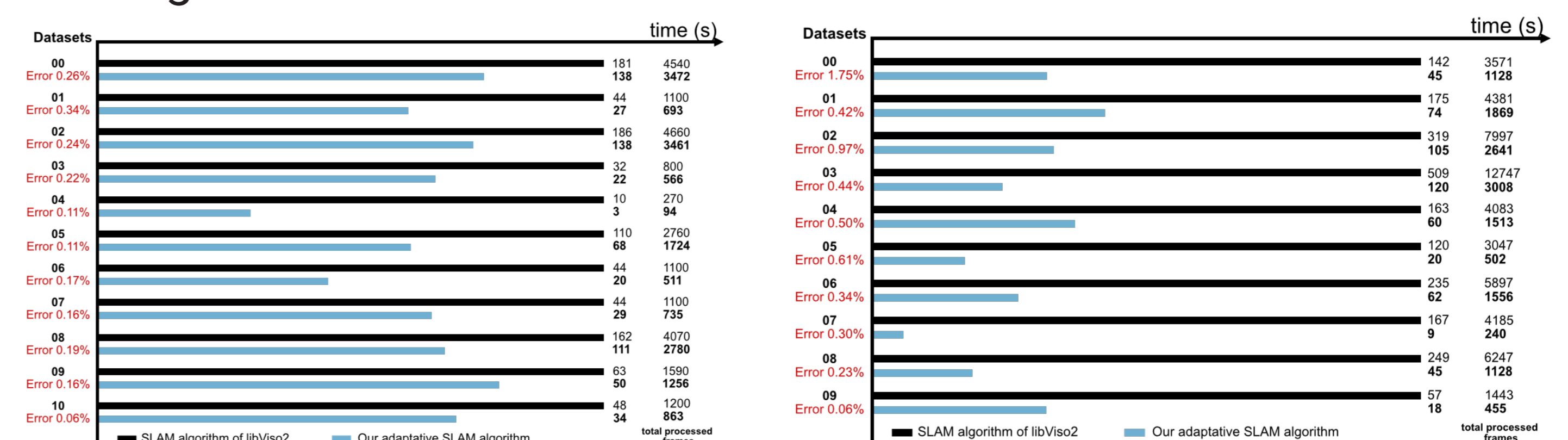
Alastor is, to our knowledge, the first synthetic stereo dataset for SLAM algorithms. The real advantages of synthetic dataset:

- 🚗 Alastor allows you to switch to any vector car or UAV.
- 📍 Alastor comes with absolute ground truth.
- ⏮ Alastor lets you adjust the frame rate you need.
- ☁ Alastor can simulate any lightning conditions.

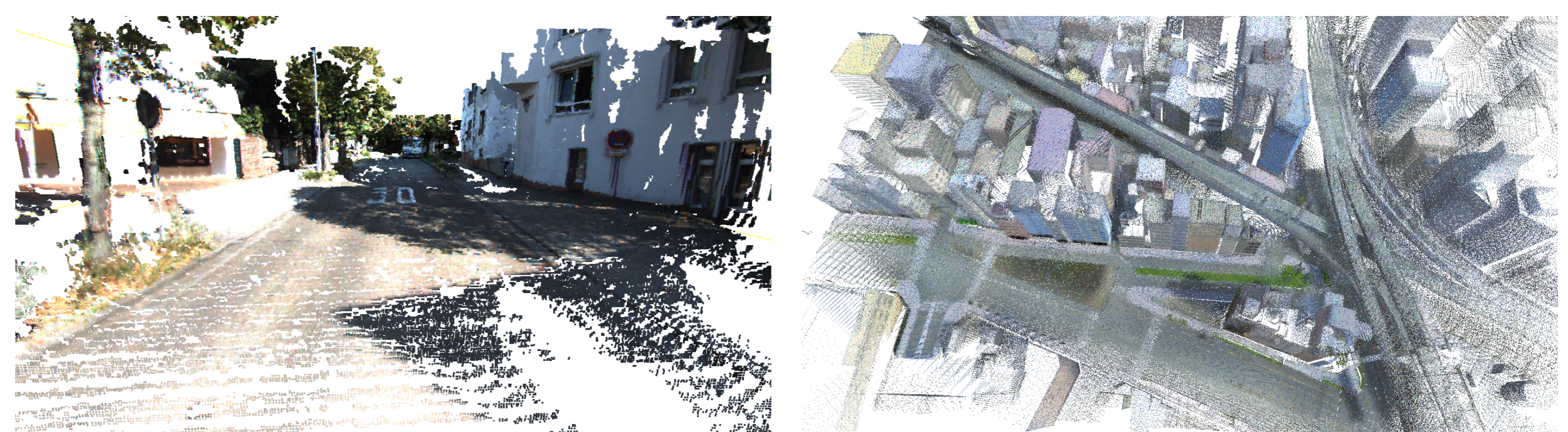


Results

Evaluation of adaptive SLAM algorithm using to libviso2: on the KITTI dataset (left) and on the Alastor dataset (right). Those diagrams show that we efficiently reduce the number of processed frames without increasing the overall error.



Examples of generated dense point clouds for each dataset:



Conclusions

We have presented an optimization of SLAM algorithms that reduces the number of processed frames without increasing the resulting error. Increasing performances in real-time scenarios, and applicable to well known datasets. We have shown that the results are perfectly suitable for real-time dense reconstruction. Additionally, we made available the first synthetic stereo dataset for SLAM applications: Alastor. The experiments that we have conducted have shown that adaptive SLAM performs great on simulated datasets. We hope that our dataset will help design and evaluate innovative methods that will take advantage of the tunable parameters in order to improve the effectiveness of SLAM solving algorithms in the future.

Main references

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- ▶ A. Howard. Real-time stereo visual odometry for autonomous ground vehicles. In *Intelligent Robots and Systems, 2008. IROS 2008. IEEE/RSJ International Conference on*, pages 3946–3952. IEEE, 2008.