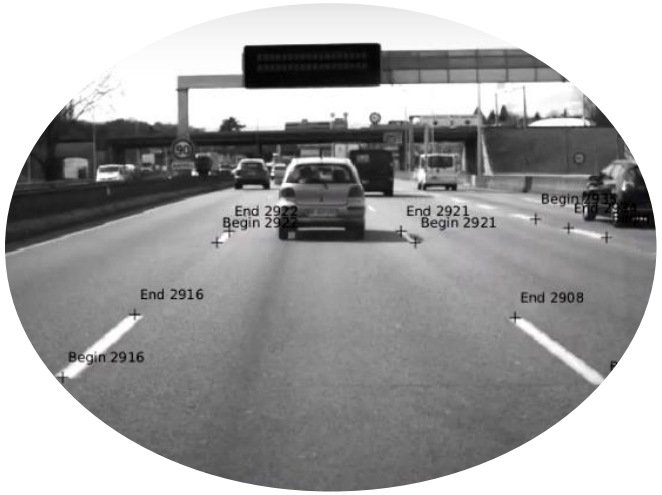
Lane markings-based relocalization on highway

Marc REVILLOUD – Emmanuel DOUCET



CONTENTS

INTRODUCTION

Context :
Vehicle equipped with a simple GNSS receptor and a single gray-level camera on highway

Objective :
Locate the vehicle with decimetric accuracy

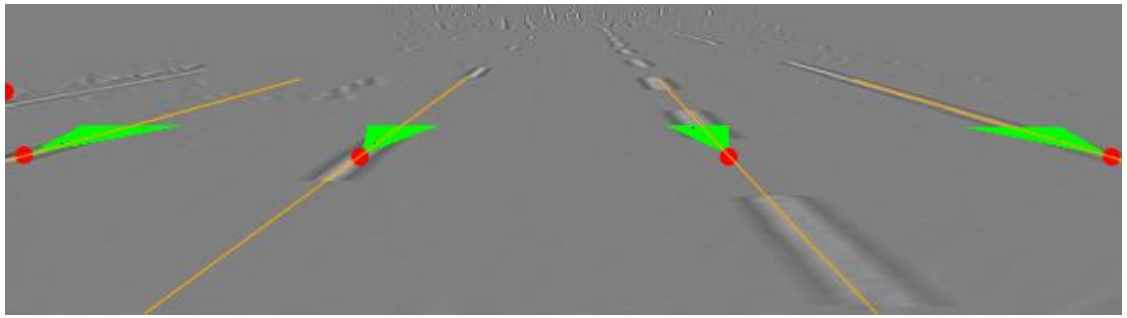
Prior knowledge :
Lane markings respect some form of specification (shape, size, spacing…)

Input :

- Confidence map
- Road markings shapes

Output :

Curvilinear abcissa of the beginning and ending of each lane marker along the marking shape.



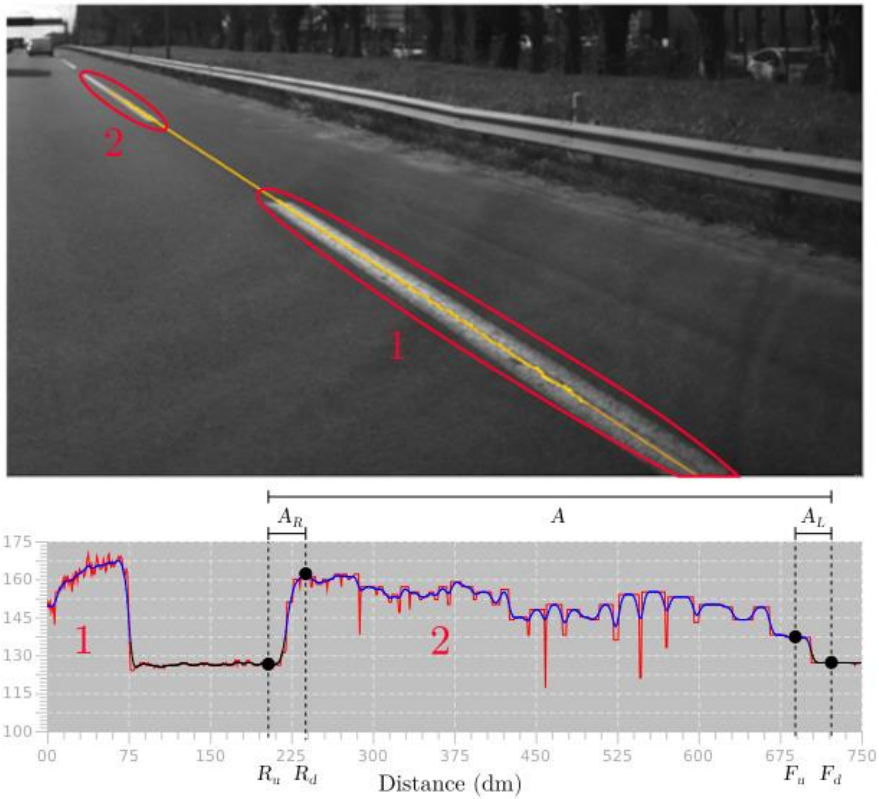
Output of the multi-agent road markings detection algorithm used [1]. Shapes are shown in yellow, agents in red with their FOV in green

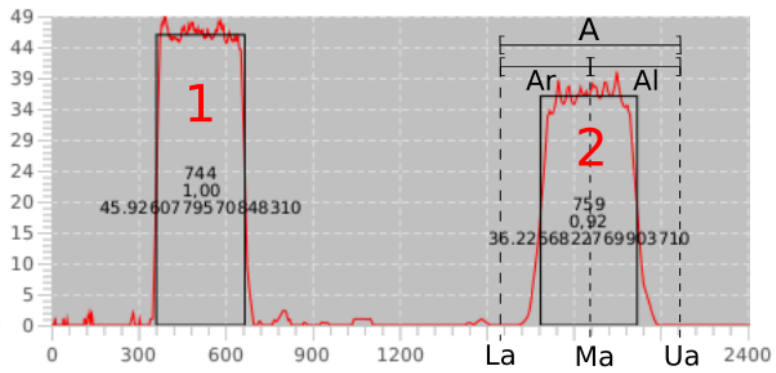
[1] M. Revilloud, D. Gruyer, and M.-C. Rahal, "A lane marker estimation method for improving lane detection," in *2016 IEEE 19th International Conference on Intelligent Transportation Systems (ITSC).* IEEE, 2016, pp. 289–295.

LANE MARKER EDGE DETECTION AND MAPPING

Lane marker edge detection

- Intensity of confidence along marking shape bilinearly interpolated to centimetric precision
- Detection of search areas from inflection point around threshold crossing
- Lane marker edge position estimation with a minimization of the error with a perfect edge front





LANE MARKER EDGE DETECTION AND MAPPING

Lane marker edge mapping

- Mapping performed by a vehicle equipped with RTK-GNSS and accurate camera calibration
- Project lane marker edge position into a geodetic frame
- Store the coordinates corresponding to the observation when the marker is the closest to the mapping vehicle
- If the distance between two observations are
  less than 1m → increase confidence,
  Otherwise → new entry

EXEMPLE OF LANE MARKER EDGE MAPPING

Lane marker edge mapping

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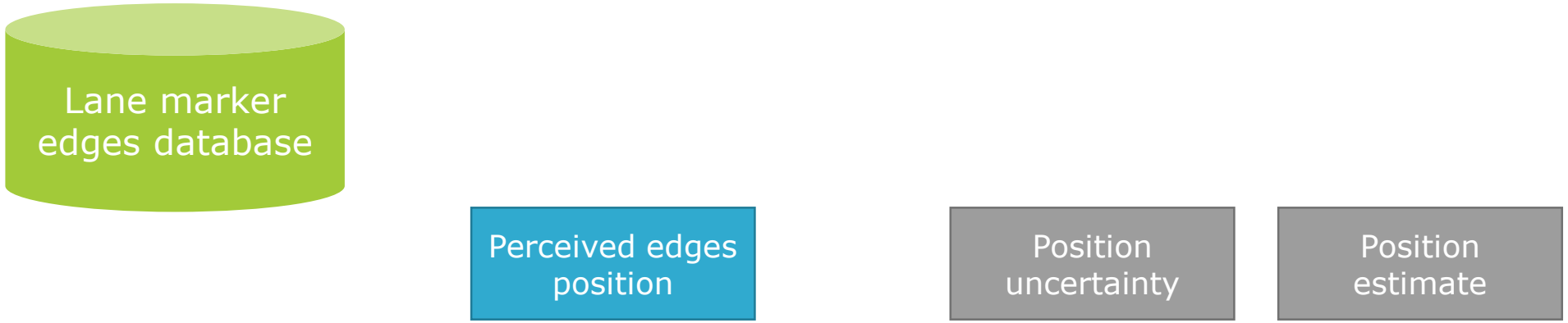
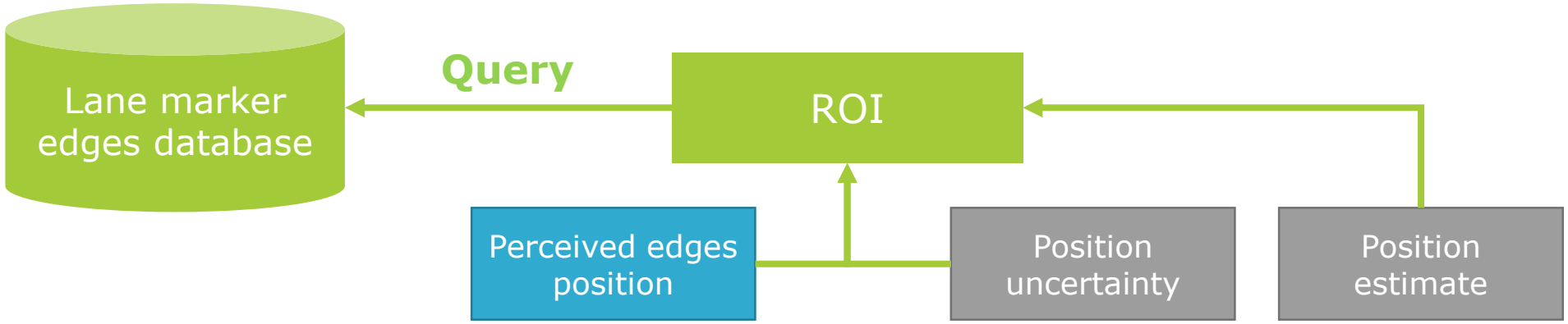
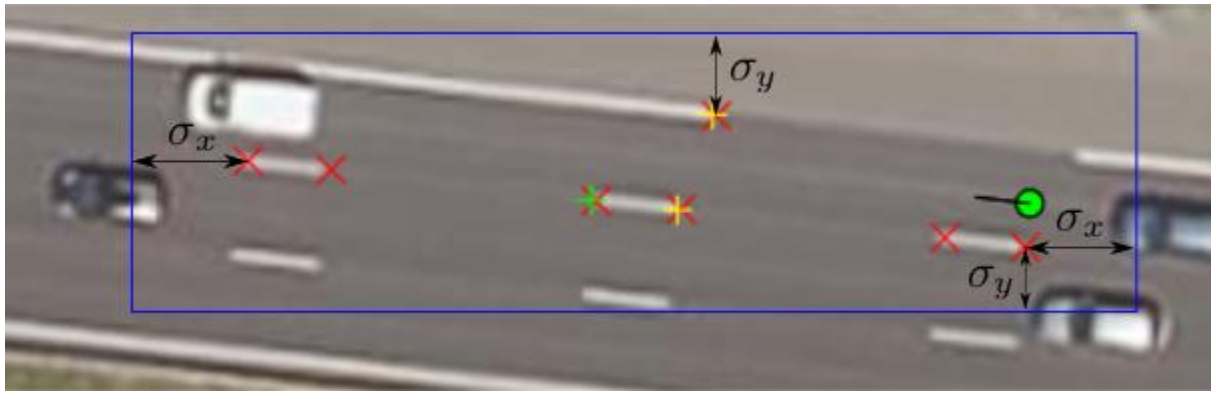
Lane marker edge mapping

RELOCALIZATION FRAMEWORK
Step 1

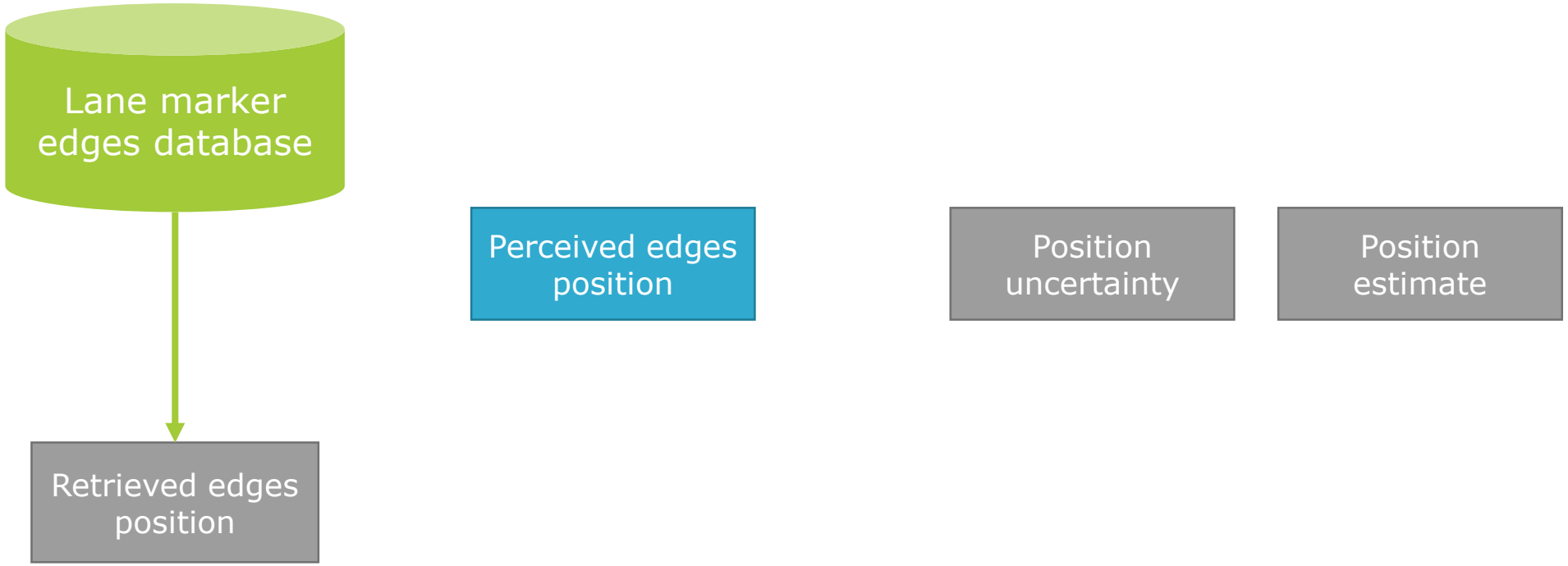


RELOCALIZATION FRAMEWORK
Step 2

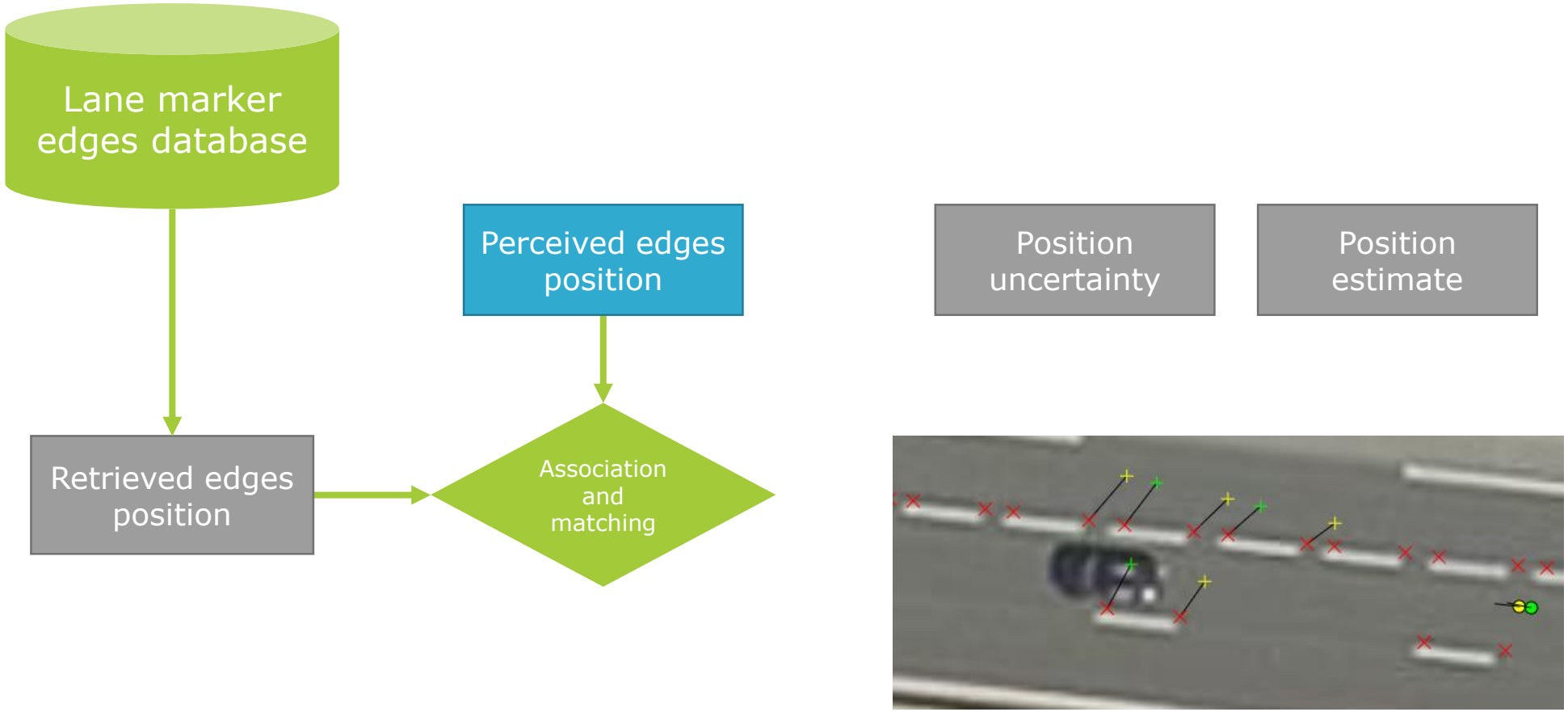




RELOCALIZATION FRAMEWORK
Step 3

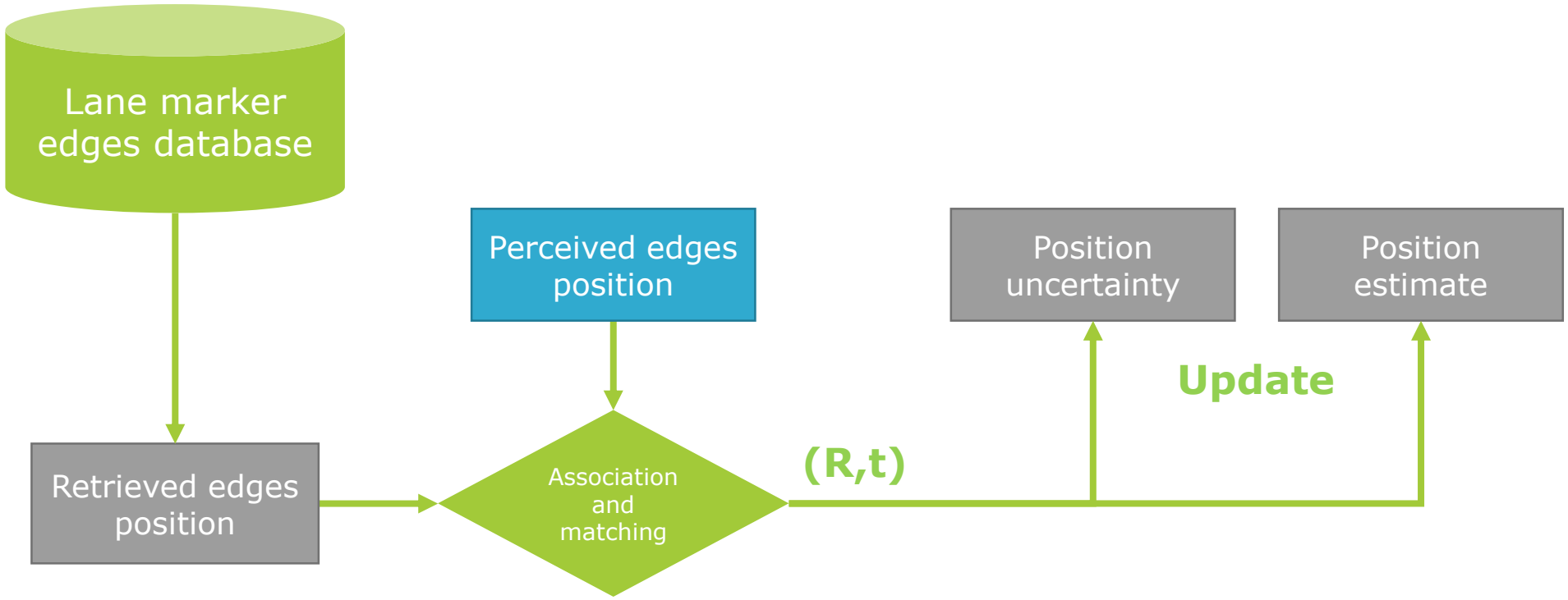


RELOCALIZATION FRAMEWORK
Step 4

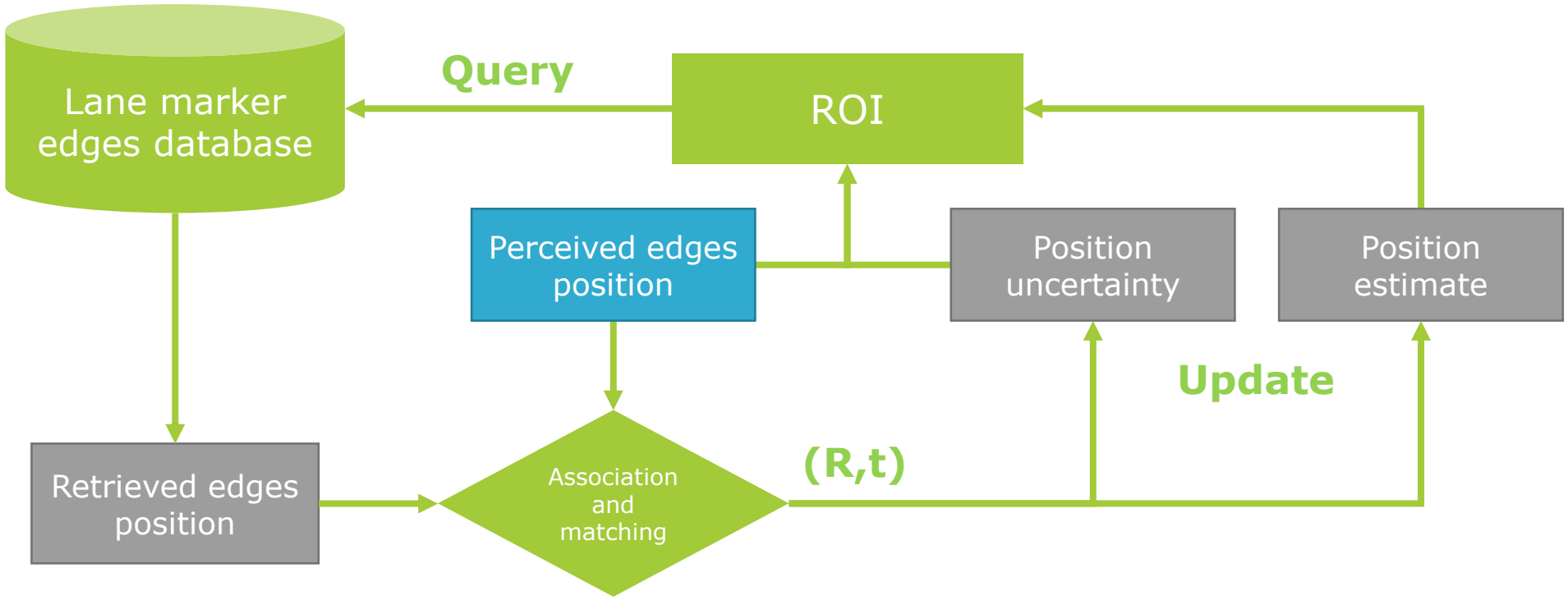


RELOCALIZATION FRAMEWORK

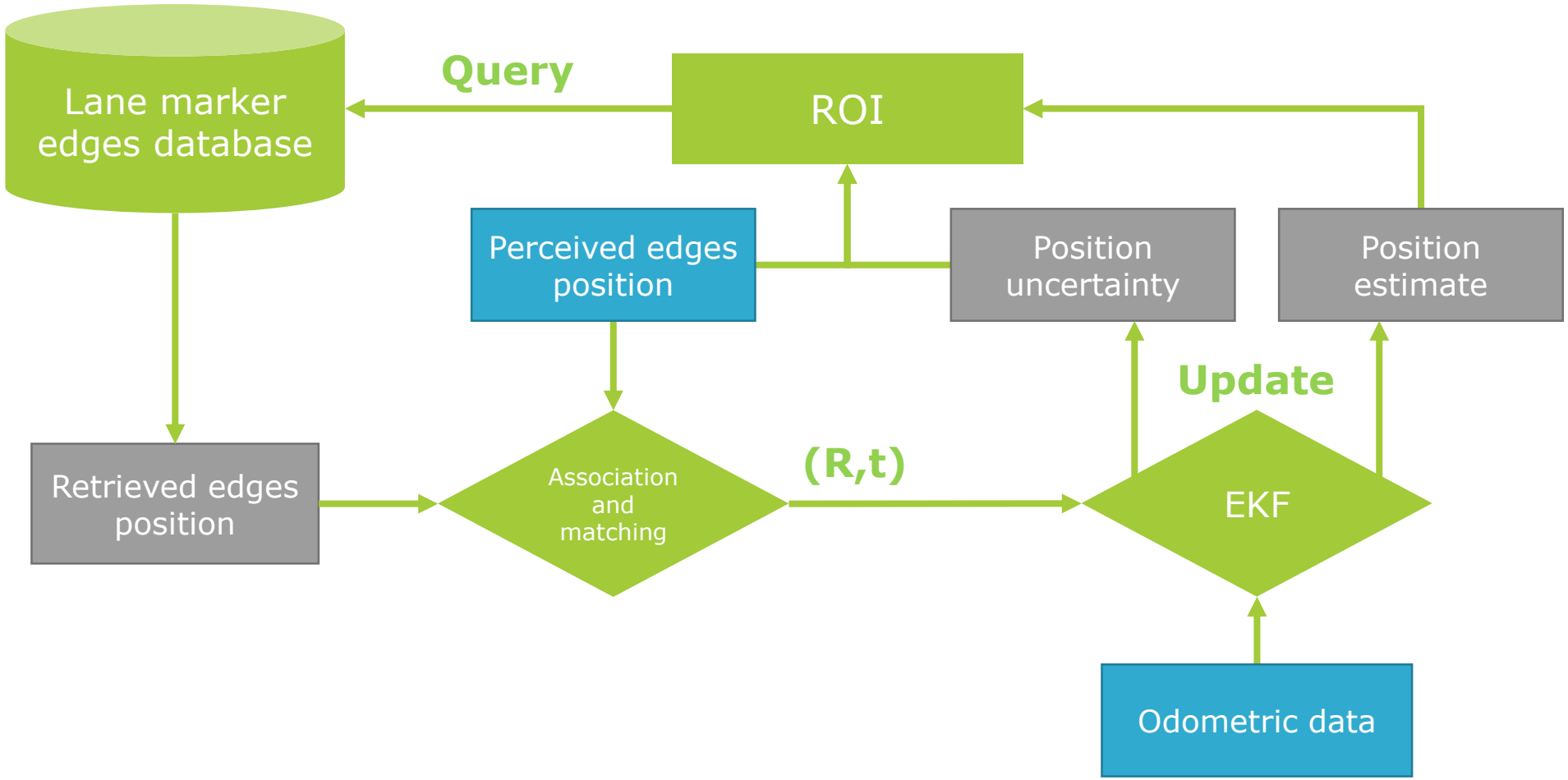
Step 5



RELOCALIZATION FRAMEWORK
Step 6



RELOCALIZATION FRAMEWORK
Step 7



EXPERIMENTS AND RESULTS
Experimental protocol

- Vehicle : Renault Scenic equipped with
  - RTK-GNSS + IMU
  - 1 front camera BlackFly 23s6c-c
  - Rear wheels-mounted odometer
- Mapping pass using RTK
- Relocalization pass with or without odometer
- ~10km highway circuit south of Paris

Circuit used for the experiments (roadworks in the red area)

Vehicle used for the experiments

Evaluation metrics :

- Ground truth data : INS data when RTK available

- Relocalization error (lateral, longitudinal and heading) without using odometric data
- Relocalization error (lateral, longitudinal and heading) using odometric data

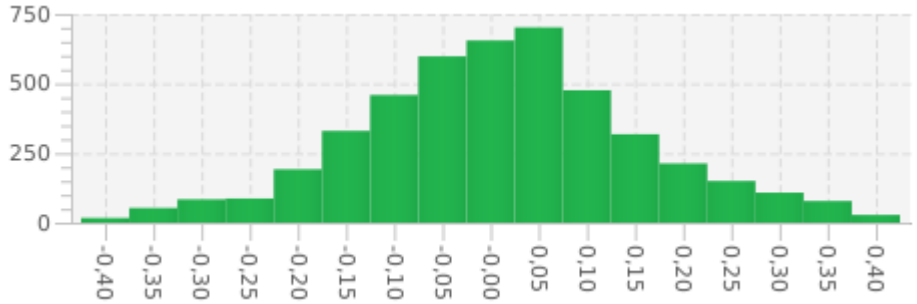
} same dataset

Algorithm performance :

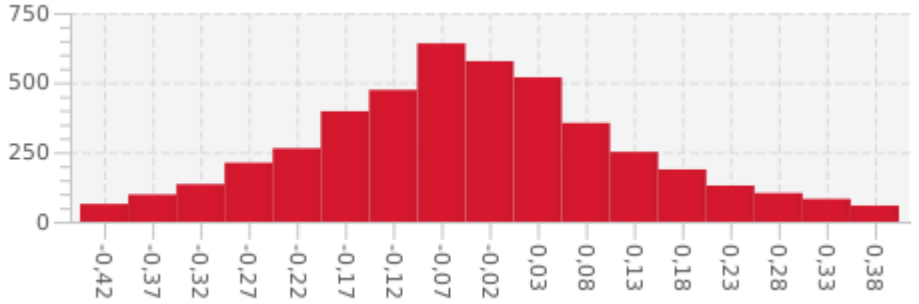
All experiments run at 12,5Hz on an Intel Core i7-4930K (1 core)

Results without odometric data :

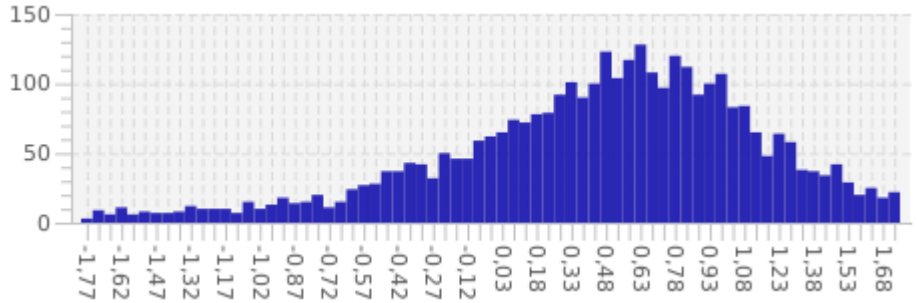
1% extreme values have been removed in the distribution figures for readability



Lateral error distribution (m)



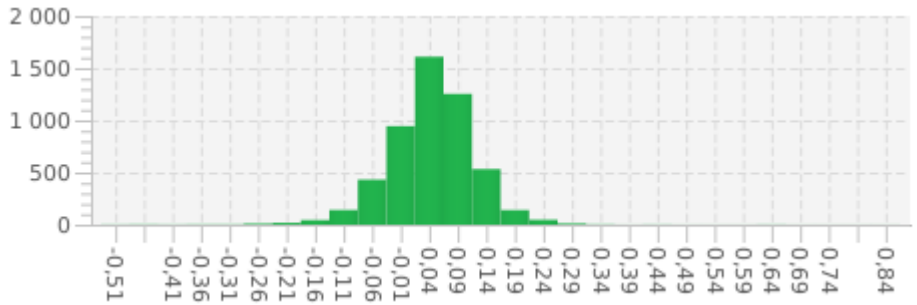
Longitudinal error distribution (m)



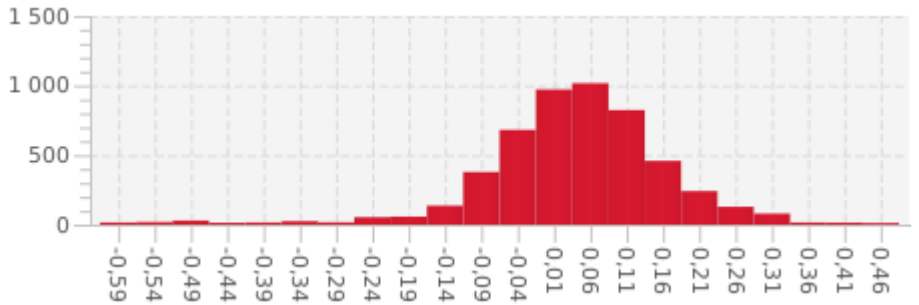
Heading error distribution (deg)

	Lateral (m)	Longitudinal (m)	Heading (deg)
Mean	0	0	0.6
Standard deviation	0.449	0.449	1.6

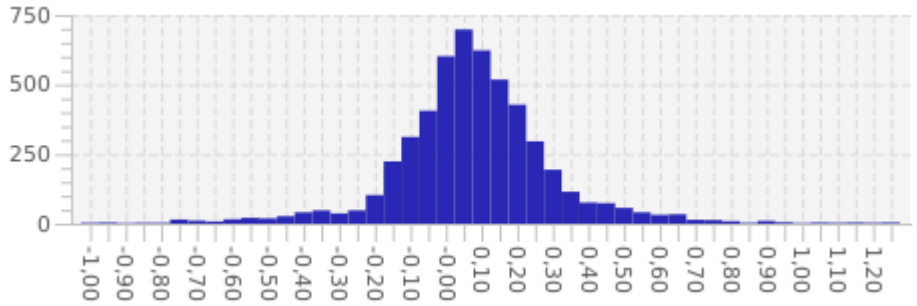
Results with odometric data and EKF :



Lateral error distribution (m)



Longitudinal error distribution (m)



Heading error distribution (deg)

	Lateral (m)	Longitudinal (m)	Heading (deg)
Max	0.446	0.846	1.00
Min	0.097	0.075	0.17
Standard deviation	0.132	0.080	0.23

Merging of two lanes

→ no more lane marking information on the ego lane.

Too dark images

→ no more detectable lane marking information.

Comparison to State of the Art [2] :

	Our method	Ghallabi
Mean error (m)	longitudinal : 0.10 lateral : 0.08	0.04
Error std deviation (m)	longitudinal : 0.13 lateral : 0.08	0.22

Future work :

- Remove need for RTK-GNSS initialization
- Remove flat world hypothesis by estimating 3D position of lane markers using multi-view
- Multicamera algorithm (front and back)

[2] F. Ghallabi, F. Nashashibi, G. El-Haj-Shhade, and M.-A. Mittet, "Lidar-based lane marking detection for vehicle positioning in an hd map," in *2018 21st International Conference on Intelligent Transportation Systems (ITSC).* IEEE, 2018, pp. 2209–2214.

VIDEO