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TÉCNICO LISBOA

Real-Time 3D Tracking of Simple Objects with an RGB Camera

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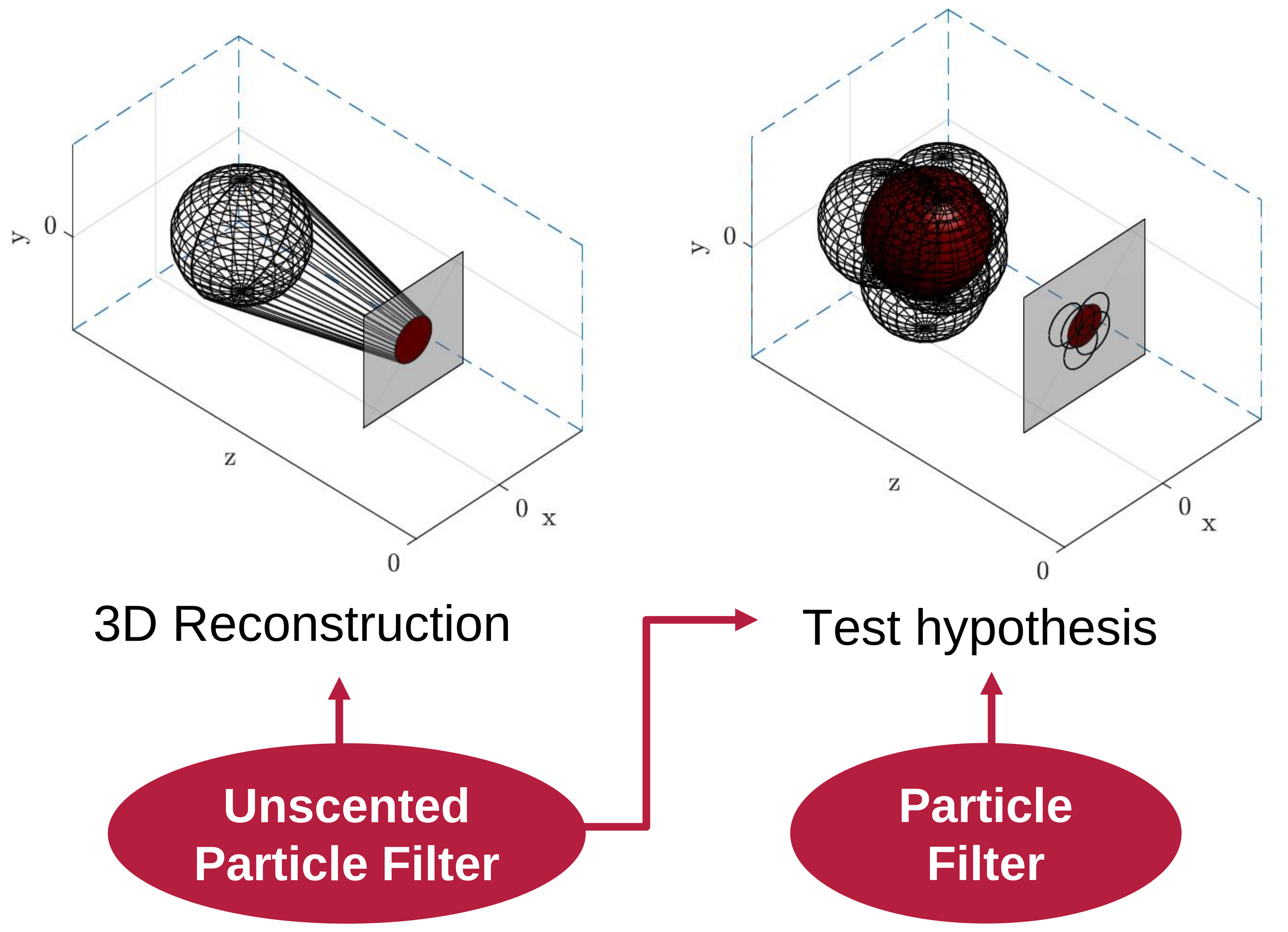
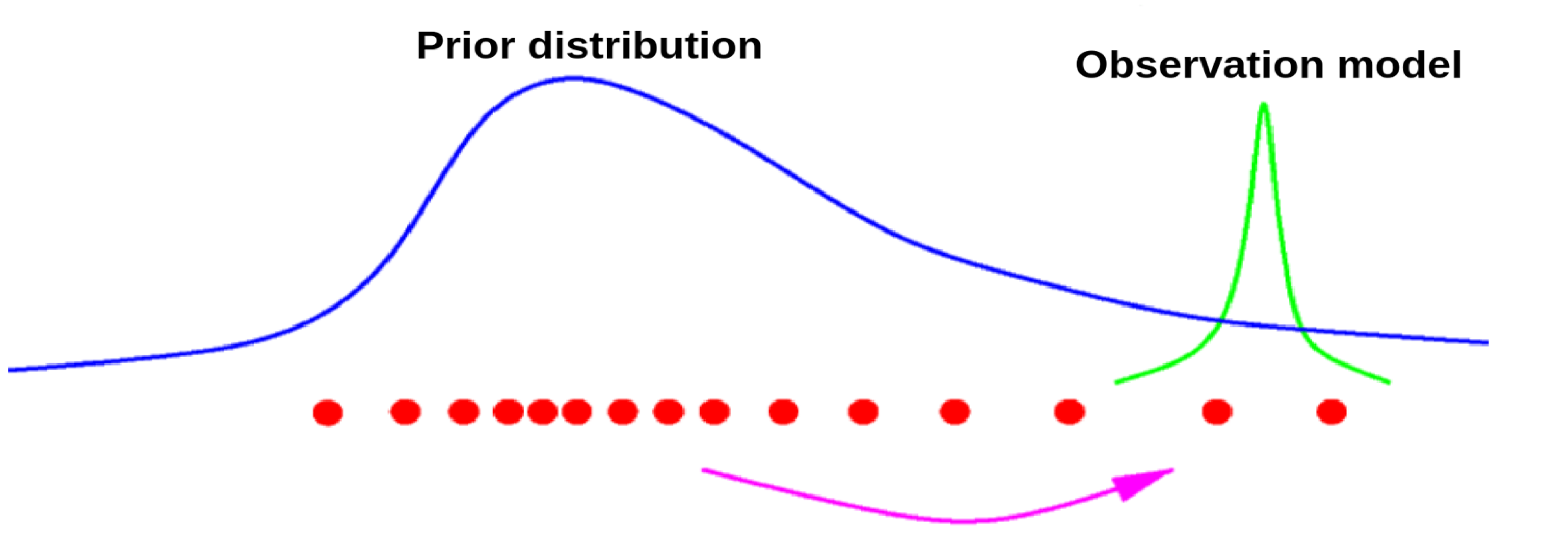
1 Motivation

This work intends to improve a monocular region-based tracking algorithm using an RGB camera. The algorithm to be improved, derives from a particle filter where each particle represents a hypothesis of the state of the object in 3D.

	3D Reconstruction	Test hypothesis
Precision	Low	High
Velocity of Estimation	Fast	Slow
Localization	Easy	Hard



2 PF *vs* UPF



The literature mentions that the particle filter (PF) uses a very limited importance distribution to propagate the particles. Given the limitation of the PF, an unscented particle filter (UPF) is proposed. This one obtains an approximation to the optimal importance distribution, by adding a current observation of the state.

PF:

$$\mathbf{x}_t^{(i)} \sim p(\mathbf{x}_t|\mathbf{x}_{t-1}^{(i)})$$

UPF:

$$(\boldsymbol{\mu}_t^{(i)}, \mathbf{P}_t^{(i)}) = UKF(\mathbf{x}_{t-1}^{(i)}, \mathbf{P}_{t-1}^{(i)}, \mathbf{z}_t)$$

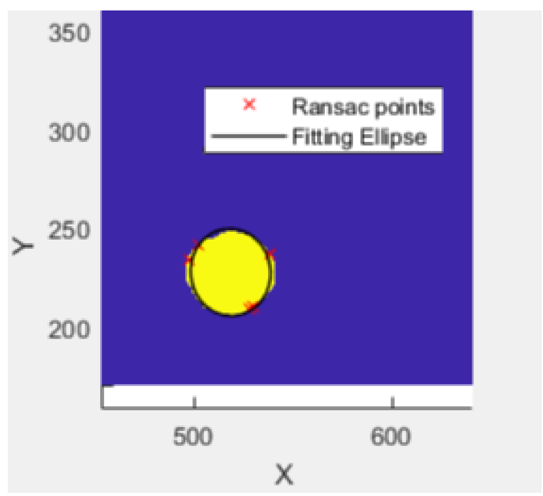
$$\mathbf{x}_t^{(i)} \sim \mathcal{N}(\boldsymbol{\mu}_t^{(i)}, \mathbf{P}_t^{(i)})$$

3 Methodology

Prediction Model

PF:
Constant Velocity Model

UPF:
Constant Velocity Model +

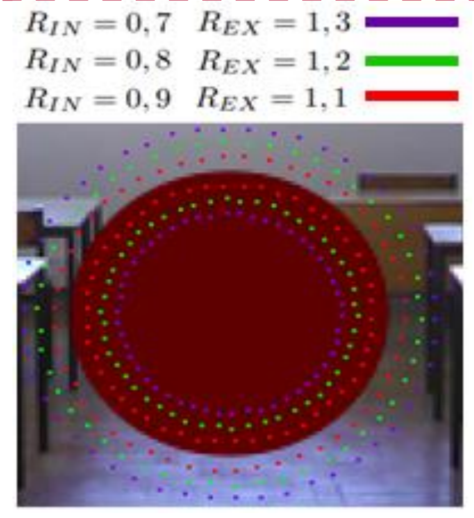


Reconstruction of the ball position

Observation Model

From these points normalized colors histograms are created. The likelihood of a particle is considered high, if the inner and model histograms are similar and at the same time, the inner and outer histograms are different.

$$p(\mathbf{z}_t|\mathbf{x}_t^{(i)}) \propto e^{-\frac{\mathcal{D}}{\epsilon}}$$



4 Results

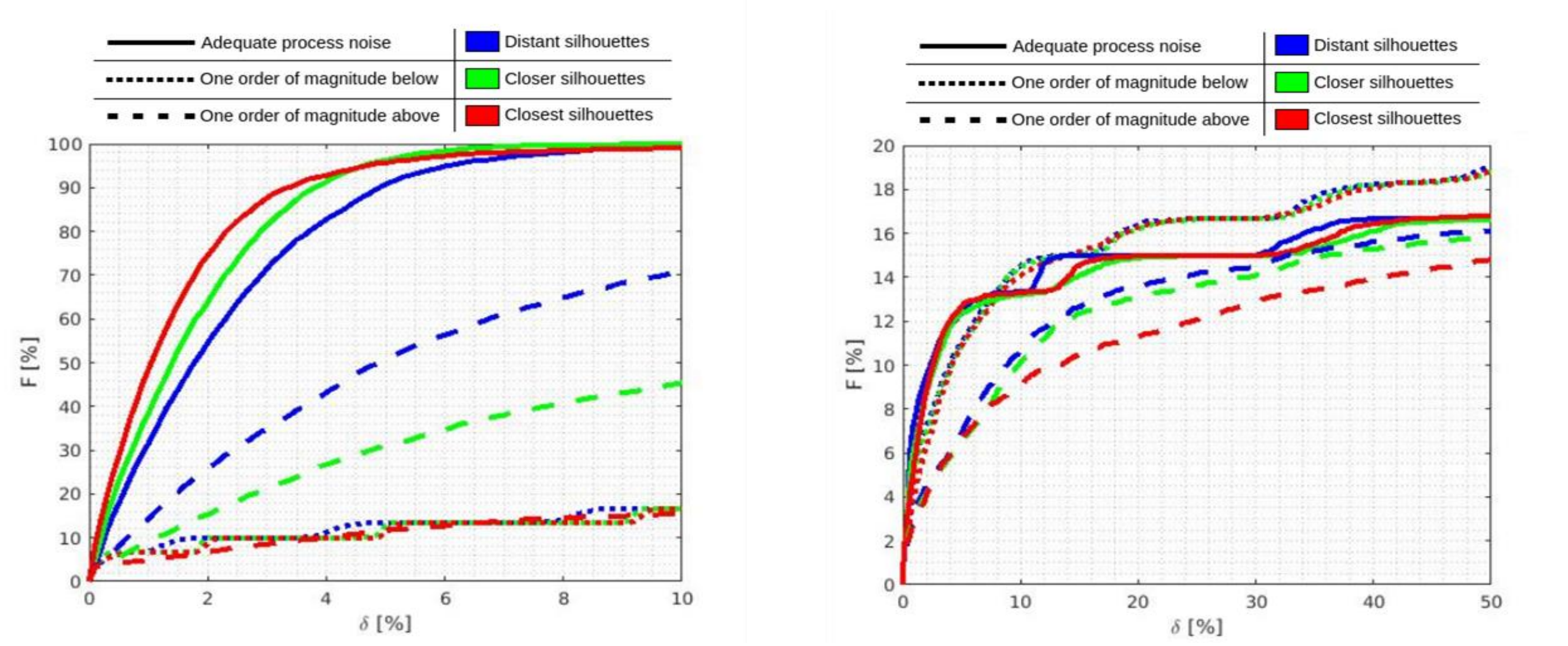
$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1}^{N}||\mathbf{x}_i - \hat{\mathbf{x}}_i||^2}$$

N	128	256	1024
PF	6.32×10^8	392.35	24.13
UPF	27.05	26.04	23.98

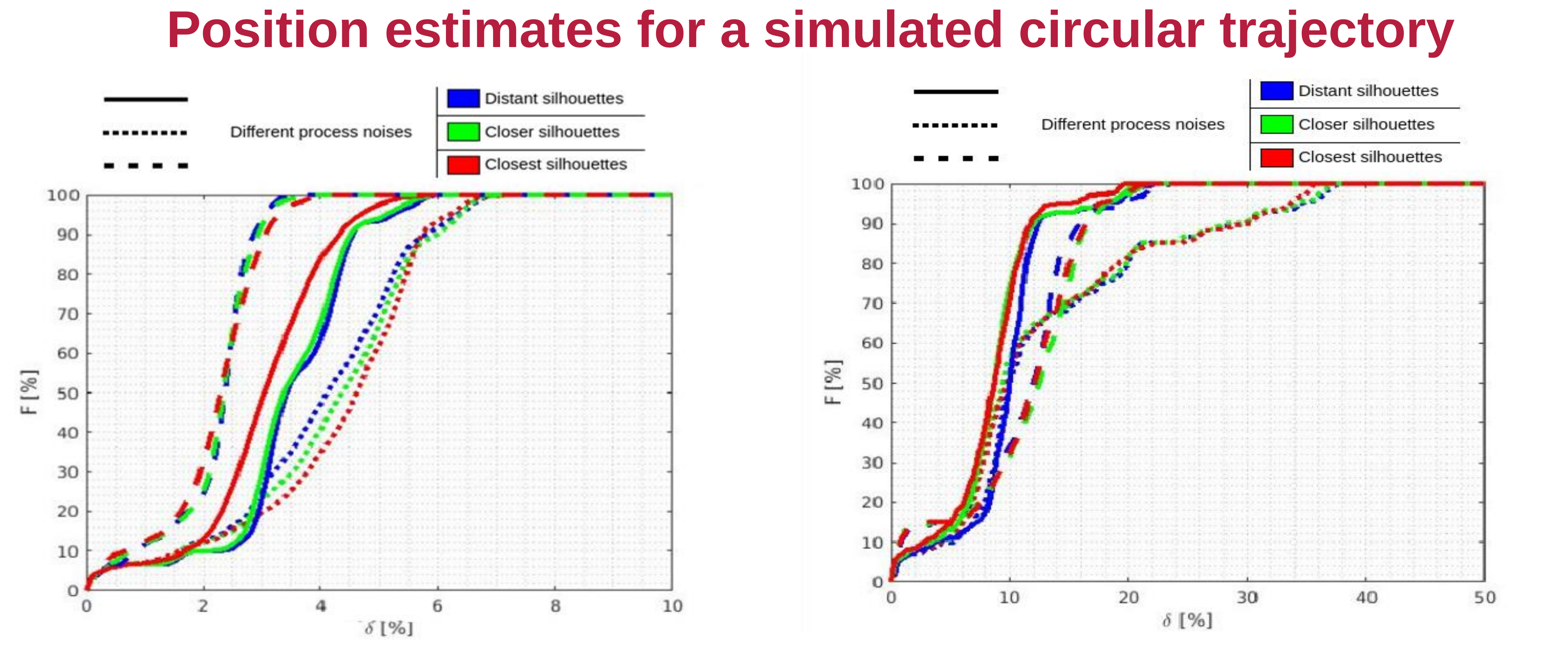
RMSE error in mm for different number of particles

$$F = \frac{100}{N}\sum_{i=1}^{N} H\left(\delta - \frac{||\mathbf{x}_i - \hat{\mathbf{x}}_i||}{||\mathbf{x}_i||}\right) [\%]$$

Precision plots express the percentage of estimates that possess an error below a given error threshold, as the error threshold increases. The considered error threshold is the relative error δ.



Position estimates for a simulated circular trajectory



Position estimates for a real free-fall trajectory

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