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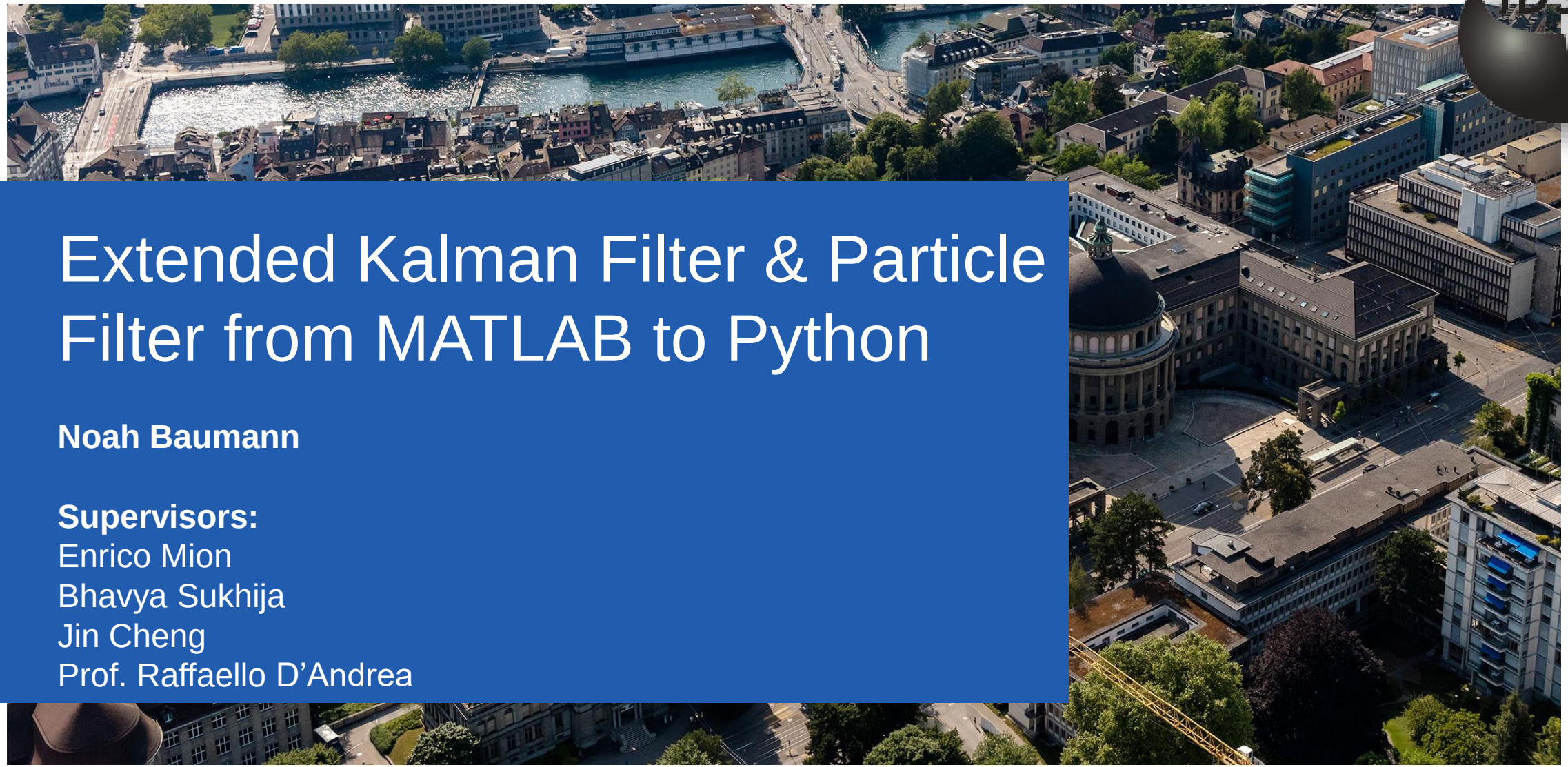

Extended Kalman Filter & Particle Filter from MATLAB to Python

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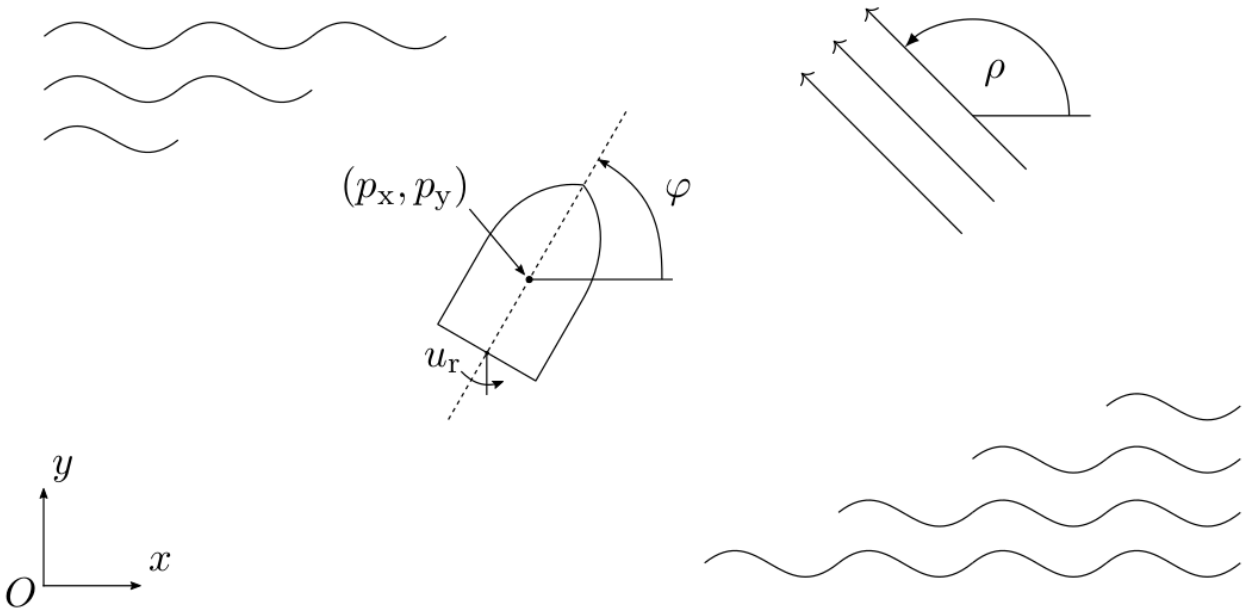
Content

Extended Kalman Filter (EKF) Exercise

- The EKF exercise consists of keeping track of all the five states of the boat: x- & y-position, x- & y-velocity and the rotation
- 2021 version:
  - Distance sensors A,B are availbla at constant time steps
  - Distance sensor C is given at random
- 2022 version:
  - Distance sensor A,B & C are all given at the same random time step
- Problem: implementing **Simulator.p** python will not be the same as for the MATLAB version, due to python & MATLAB different RNGs

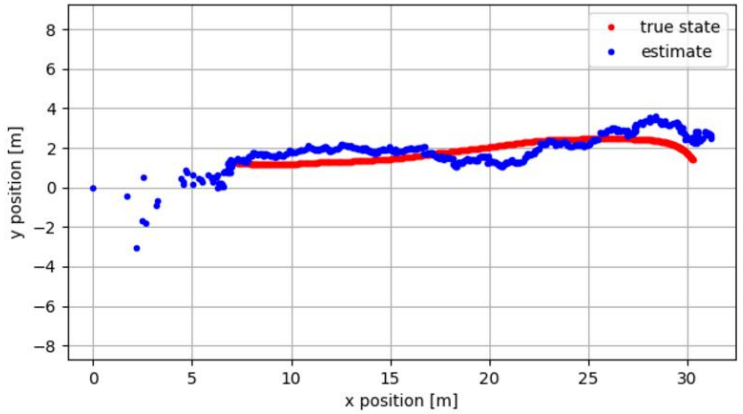


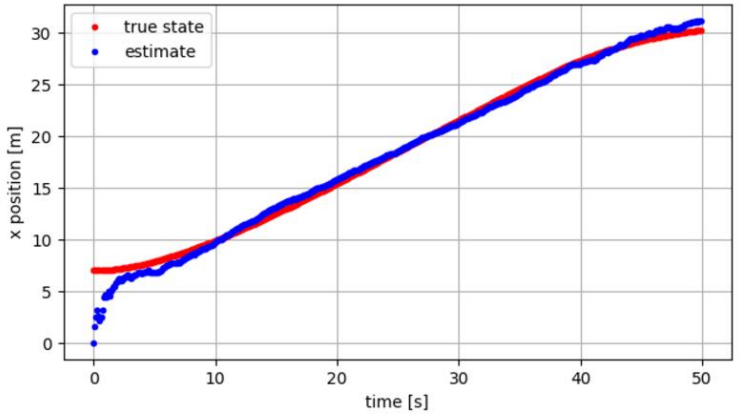
Comparing python & MATLAB RNGs

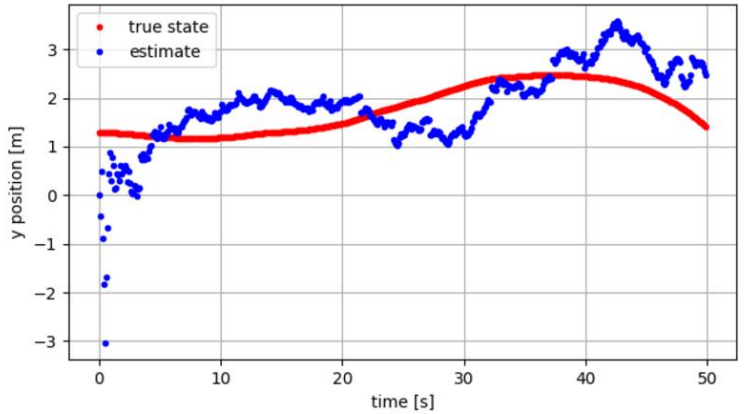
- Python & MATLAB use the same kind of uniform distribution
- But different Type of normal distr. RNGs:
  - **NumPy**: Box-Muller algorithm
  - **MATLAB**: Ziggurat algorithm
- This meant no side-to-side comparison
- But we can compare them over multiple runs and take the mean & var
- **Simulator.p** from the EKF 2021 & 2022 exercise accuracy over 1000 runs ->

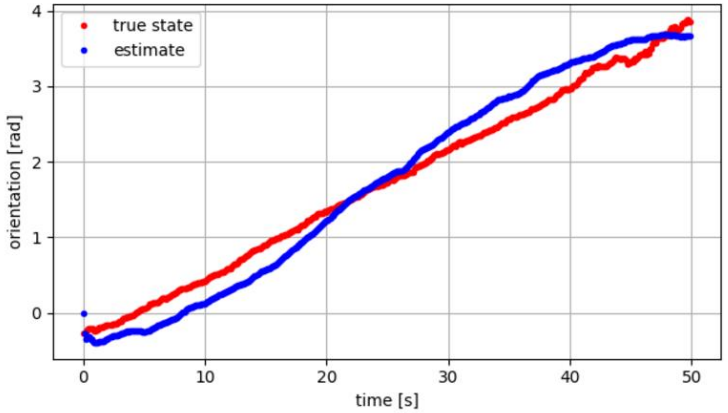
		python		MATLAB	
		mean	variance	mean	variance
state means	p_x	16.174	6.883	17.149	6.610
	p_y	3.033	14.583	2.939	11.523
	s_x	0.436	9.025e-3	0.479	0.010
	s_y	8.735e-4	0.027	-0.006	0.019
	φ	-2.148e-3	2.772	-0.093	2.982
state vars	p_x	51.612	288.530	61.497	396.562
	p_y	7.242	5.659	5.362	39.039
	s_x	0.025	1.385e-4	0.029	3e-4
	s_y	0.014	1.341e-4	0.015	2e-4
	φ	0.953	0.4137	1.424	0.529
wind means	ρ	-0.006	0.180	-0.007	0.179
wind vars	ρ	0.082	0.005	0.083	0.005
drift means		-0.006	0.150	-0.007	0.164
drift vars		0.082	0.005	0.081	0.006
input means	u_t	0.050	2.423e-5	0.050	0.000
	u_r	-7.501e-5	1.128e-3	-0.002	0.001
input vars	u_t	8e-4	1.646e-8	8.050e-4	1.570e-8
	u_r	5e-4	1.242e-8	5.280e-4	1.210e-8
sense means	z_a	1.427e3	9.758	1.424e3	8.496
	z_b	1.984e3	6.908	1.983e3	6.665
	z_c	1.997e3	15.061	1.997e3	11.853
	z_g	-8.254e-3	2.938	-0.100	3.049
	z_n	-4.190e-3	2.779	-0.100	2.995
sense vars	z_a	49.697	342.056	54.859	357.930
	z_b	71.241	296.411	81.405	413.755
	z_c	12.250	62.927	10.529	45.475
	z_g	1.048	0.605	1.469	0.800
	z_n	1.445	0.415	1.918	0.534

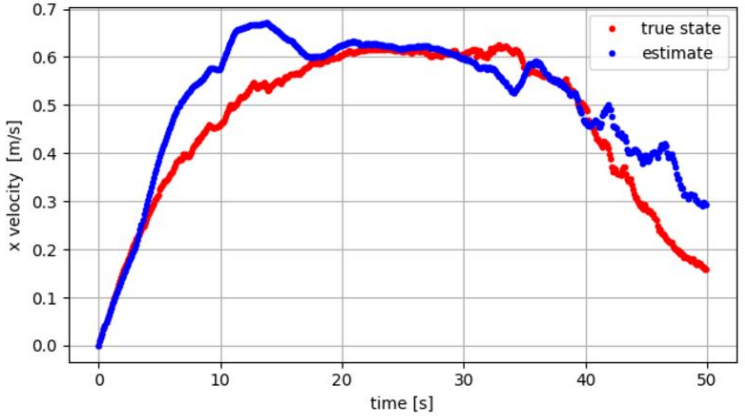
EKF Exercise 2021 plots

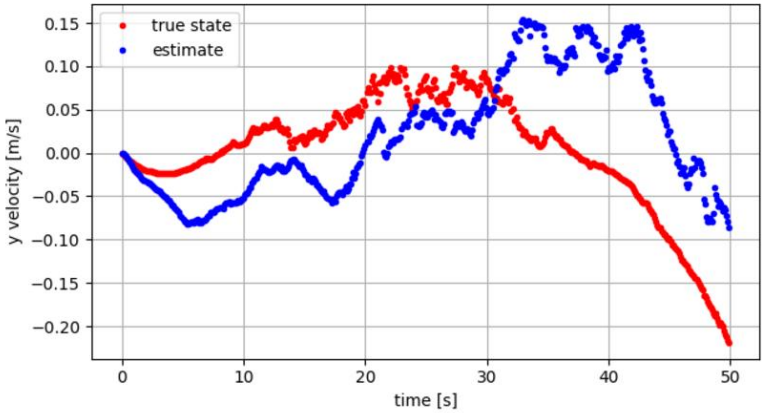


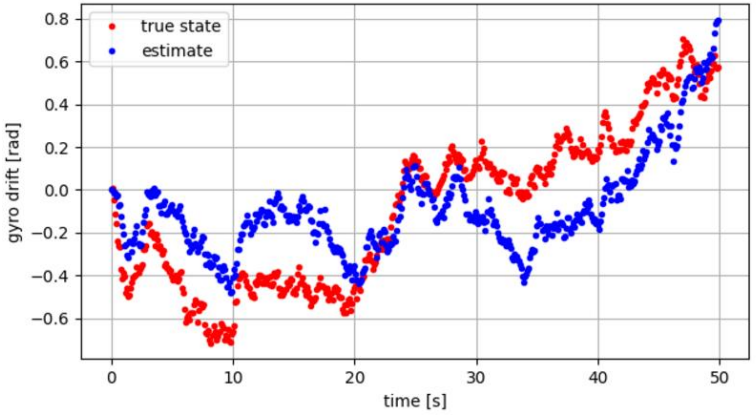


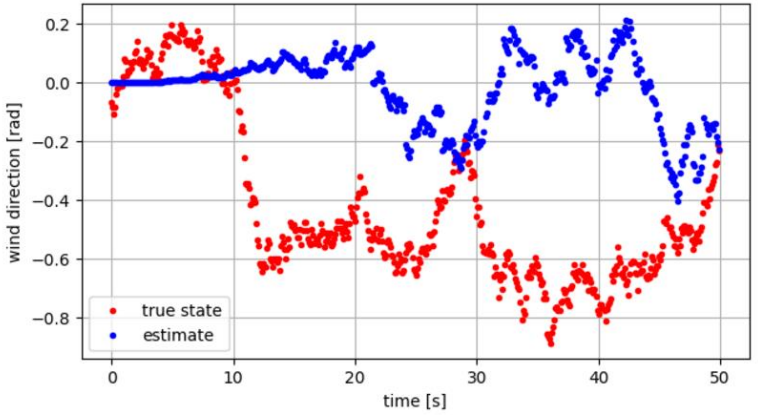




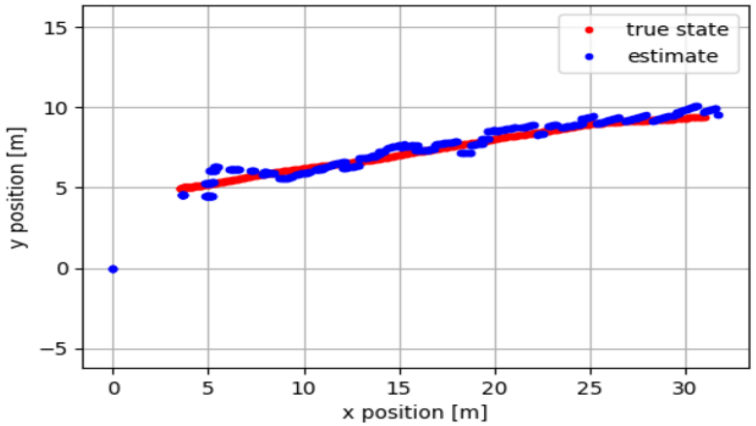


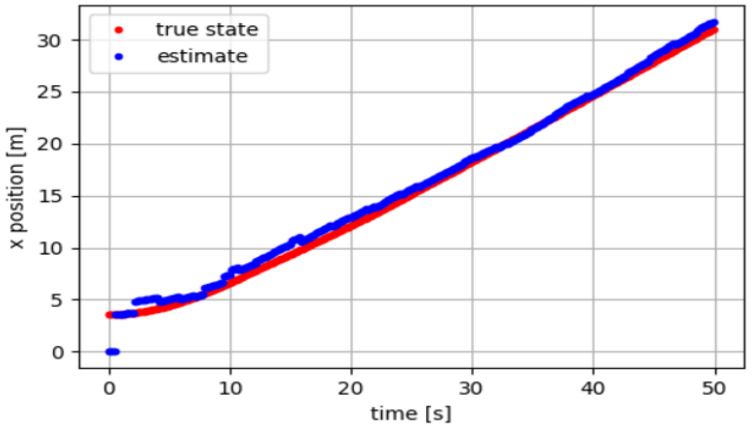


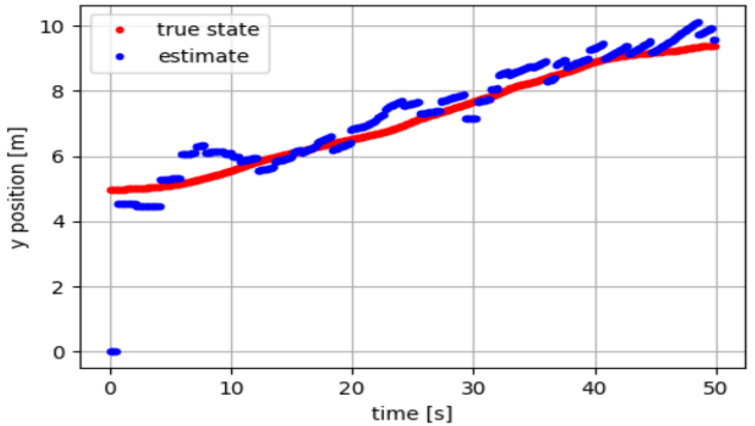


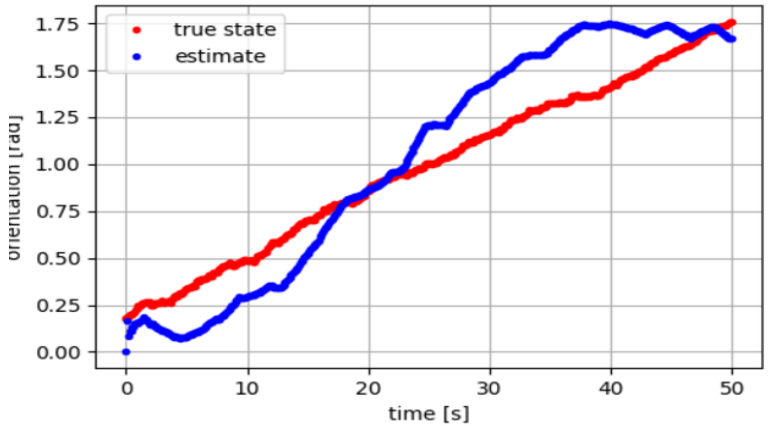


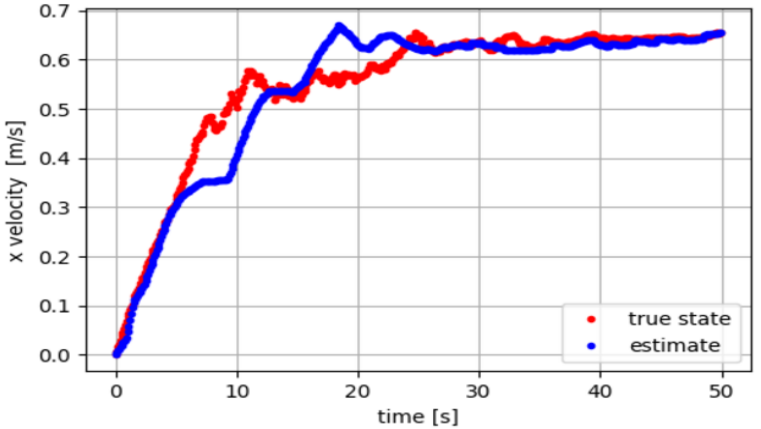
EKF Exercise 2022 plots

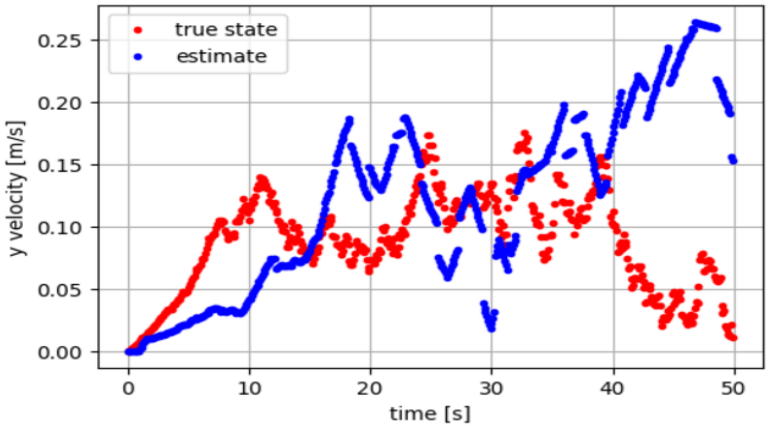


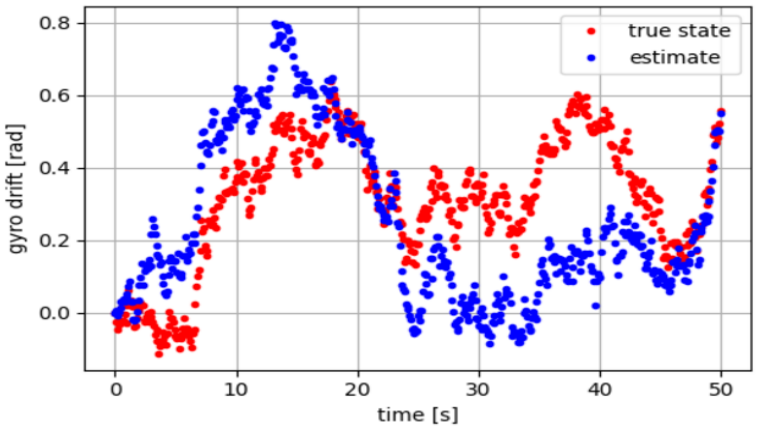


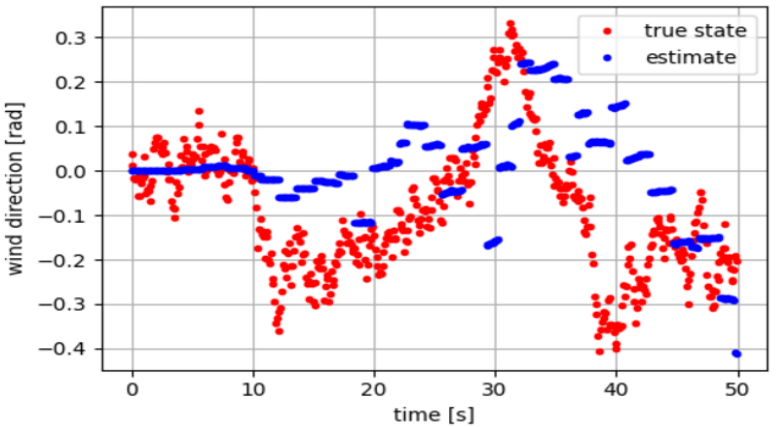












EKF Exercise 2021 vs 2022

1. Performance & accuracy run of the 2021 & 2022 implementation.
2. Each 1000 runs on a R9 5950x CPU 3.4Ghz
3. Both 2021 & 2022 use the same default set of SimulationConst.m & EstimatorConst.m parameters

Exercise 2021

	python		MATLAB	
	mean	variance	mean	variance
trackErrorNorm	1.336	0.128	1.096	0.060
angularErrorNorm	0.240	0.003	0.063	7.400e-4
velocityErrorNorm	0.140	0.002	0.100	0.002
windErrorNorm	0.440	0.031	0.399	0.023
biasErrorNorm	0.242	0.003	0.081	4.762e-4
Avg. exec time [s]	1.572	0.337	0.502	0.005

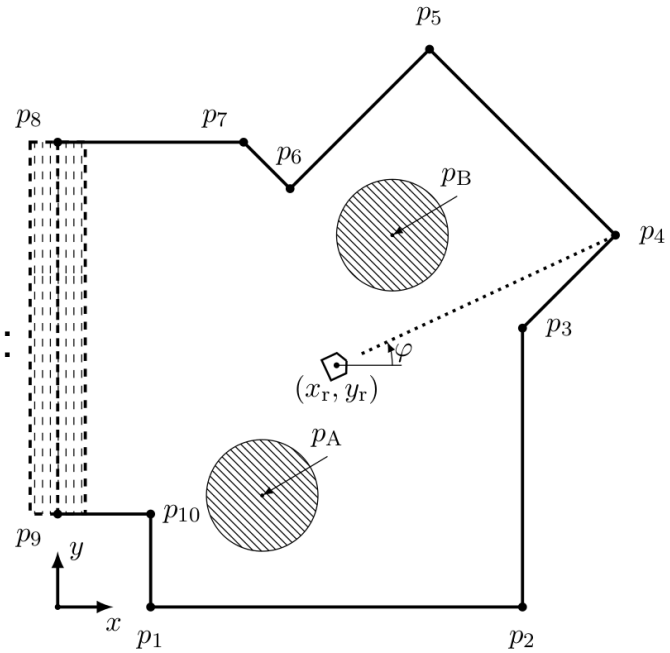
Exercise 2022

	python		MATLAB	
	mean	variance	mean	variance
trackErrorNorm	2.288	0.372	1.923	0.207
angularErrorNorm	0.238	0.003	0.061	7.281e-4
velocityErrorNorm	0.172	0.005	0.103	0.004
windErrorNorm	0.430	0.030	0.209	0.005
biasErrorNorm	0.240	0.003	0.080	4.702e-4
Avg. exec time [s]	1.524	0.318	0.524	0.005

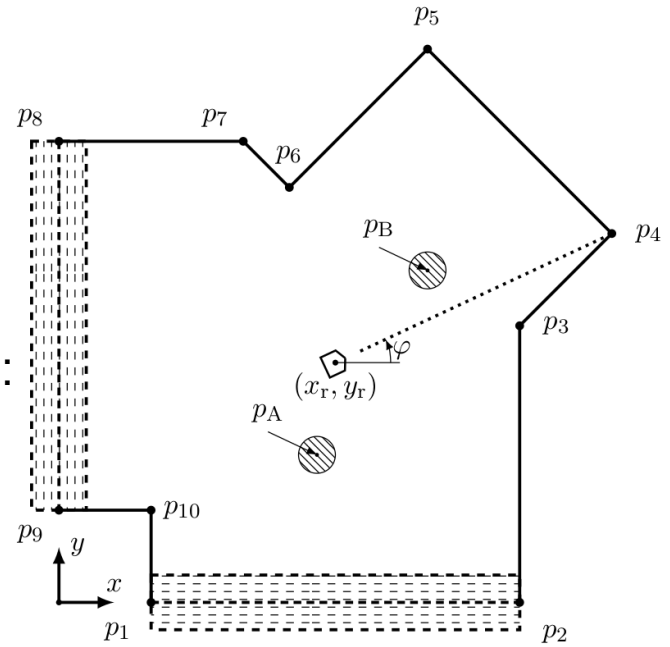
Particle Filter (PF)

- Tracking the movement of a Robot in a closed room
- PF exercise 2021: One wall depth is not known and has to be estimated
- PF exercise 2022: Two walls are not known
- The **Simulator.p** only consists of uniform RNGs, hence no need for comparing the outputs of python & MATLAB

PF exercise 2021:



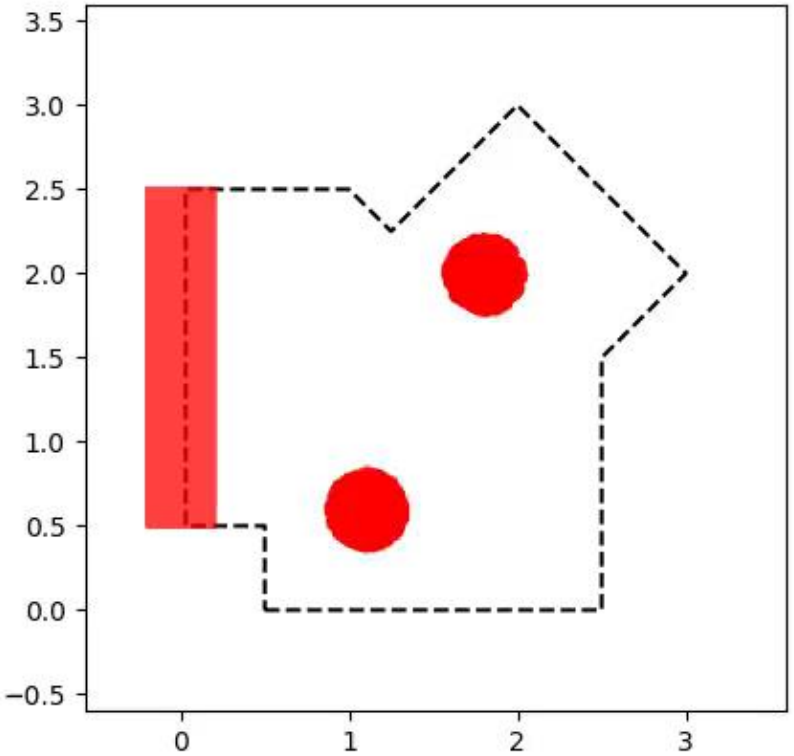
PF exercise 2022:



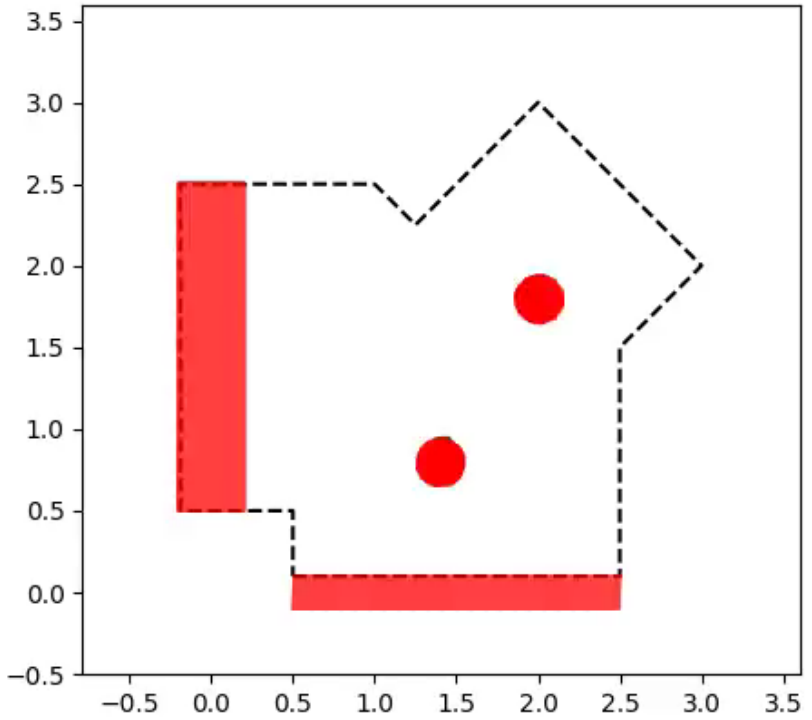
PF Exercise animation

- Comparing the 2021 & 2022 python animation

Python exercise 2021 animation



Python exercise 2022 animation



PF Exercise

1. 1000 runs on R9 5950x 3.4Ghz
2. Exercise 2021 & Exercise 2022 have different set of SimulationConst.m & EstimatorConst.m parameters
3. Exercise 2022 python only 200 runs were made. No time to do more

Exercise 2021

	python		MATLAB	
	mean	variance	mean	variance
trackErrorNorm	1.122	0.116	0.928	0.132
Avg. exec time [s]	48.480	76.811	5.446	1.163

Exercise 2022

	python		MATLAB	
	mean	variance	mean	variance
trackErrorNorm	0.987	0.196	0.664	0.226
Avg. exec time [s]	34.891	0.285	5.255	0.017

Evaluation function 2022

Show git reposetory…

Conclusion

- EKF 2021 & 2022 are working
- PF 2021 & 2022 are working
- Evaluation Function improved
- Still open problems:
  - All of the python implementations are not as accurate as the MATLAB versions
  - All the python codes have no code coverage

Thank you for your attention and have a nice summer!