Train 17 Test 4 Val 6 CNN model with fl Sensors MSE 2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with ir Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E	00 00 00 00 00 00 00 00 00 00 00 00 00	Ave dist. loss (m) 7.88E-02 3.94E-02 2.78E-02 2.40E-02 1.95E-02 1.89E-02 4 Ave dist. loss (m) 7.93E-02 2.75E-02 2.50E-02 2.30E-02	Accuracy 23.07% 59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44%		Conv2D kernel(3x3x7) blas(40) ReLU BatchNormaliz gamma(40) beta(40) moving_mean(40) moving_variance Conv2D kernel(3x3x40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_mean(60) moving_mean(60)
Train 17 Test 4 Val 6 CNN model with fl Sensors MSE 1 9.78E 2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with ir Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E	00 00 00 00 00 00 00 00	Ave dist. loss (m) 7.88E-02 3.94E-02 2.78E-02 2.40E-02 1.95E-02 1.89E-02 1.793E-02 1.95E-02 2.75E-02 2.30E-02 2.30E-02	Accuracy 23.07% 59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%	s of 4 cm are	Input 7x8 InputLaye Conv2D kernet(3x3x7x) blas(40) ReLU BatchNormaliz gamma(40) beta(40) moving_mean(40) moving_variance MaxPooling Endu BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_mean(60) moving_mean(60) moving_mean(60) moving_mean(60) moving_mean(60) moving_mean(60)
Test Val 4 Val 4 Threshold 0 CNN model with fl Sensors MSE 1 9.78E 2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E	00 O O O O O O O O O	Ave dist. loss (m) 7.88E-02 3.94E-02 2.78E-02 2.40E-02 1.95E-02 1.89E-02 1.793E-02 1.95E-02 2.75E-02 2.30E-02 2.30E-02	Accuracy 23.07% 59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%	s of 4 cm are	Conv2D kernel(3×3×7× blas(40) ReLU BatchNormaliz gamma(40) beta(40) moving_mean(40) moving_variance MaxPooling Dropout Conv2D kernel(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_mean(60) moving_variance
Val A CNN model with fl Sensors MSE 1 9.78E 2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with ir Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	Max dist. loss (m)	Ave dist. loss (m) 7.88E-02 3.94E-02 2.78E-02 2.40E-02 1.95E-02 1.89E-02 1.793E-02 1.95E-02 2.75E-02 2.30E-02 2.30E-02	Accuracy 23.07% 59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%	s of 4 cm are	Conv2D kernel(3×3×7×blas′40) ReLU BatchNormaliz gamma(40) beta(40) moving_mean(40) moving_variance Conv2D kernel(3×3×40) blas′60) ReLU BatchNormaliz gamma(60) beta′60) moving_mean(60) moving_mean(60) moving_mean(60)
Threshold 0 CNN model with fl Sensors MSE 1 9.78E 2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E	Max dist. loss (m)	Ave dist. loss (m) 7.88E-02 3.94E-02 2.78E-02 2.40E-02 1.95E-02 1.89E-02 1.793E-02 1.95E-02 2.75E-02 2.30E-02 2.30E-02	Accuracy 23.07% 59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%	s of 4 cm are	ReLU BatchNormaliz gamma(40) beta(40) moving_mean(40) moving_wariance Conv2D kernel(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_mean(60)
CNN model with fl Sensors MSE 1 9.78E 2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E	max dist. loss (m) 7.67E-0 6.44E-0 1.17E-0 1.19E-0 1.85E-0 1.19E-0 1.18E-0 1.19E-0 1.18E-0 1.18E-0 1.19E-0 1.18E-0 1.1	Ave dist. loss (m) 7.88E-02 3.94E-02 2.78E-02 2.40E-02 1.95E-02 1.89E-02 1.793E-02 1.95E-02 2.75E-02 2.30E-02 2.30E-02	Accuracy 23.07% 59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%	s of 4 cm are	ReLU BatchNormaliz gamma(40) beta(40) moving_mean(40) moving_variance Conv2D kernel(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_mean(60) moving_mean(60)
Sensors MSE 1 9.78E 2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with flowed CNN model with flowed 6 7 7 CNN model with flowed 6 7 7 CNN model with flowed 7 7 7 7 7 7 7 7 7	Max dist. loss (m	7.88E-02 3.94E-02 2.78E-02 2.40E-02 2.23E-02 1.95E-02 1.89E-02 Ave dist. loss (m) 7.93E-02 2.75E-02 2.30E-02	23.07% 59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%		BatchNormaliz gamma(40) beta(40) moving_mean(40) moving_variance MaxPooling; Dropout Conv2D kernel(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_mean(60) moving_mean(60)
1 9.78E 2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	7.67E-0 7.67E-	7.88E-02 3.94E-02 2.78E-02 2.40E-02 2.23E-02 1.95E-02 1.89E-02 Ave dist. loss (m) 7.93E-02 2.75E-02 2.30E-02	23.07% 59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%		gamma(40) beta(40) moving_mean(40) moving_mean(40) moving_variance: MaxPooling; Dropout Conv2D kerne((3×3×40) bias(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_mean(60) moving_variance:
2 2.35E 3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	03 6.44E-0 03 1.89E-0 04 1.85E-0 04 1.17E-0 04 1.19E-0 8 quantization. Max dist. loss (m 03 7.45E-0 03 6.86E-0 03 2.00E-0 04 1.83E-0 04 1.48E-0 04 1.19E-0	3.94E-02 2.78E-02 2.40E-02 2.23E-02 1 1.95E-02 1 1.89E-02 1 7.93E-02 1 7.93E-02 1 2.75E-02 2.50E-02 1 2.30E-02	59.71% 81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82%		beta (40) moving_mean (40) moving_wariance MaxPooling; Dropout Conv2D kerne((3×3×40)) blas (60) peta (60) moving_mean (60) moving_mean (60) moving_mean (60) moving_wariance
3 1.12E 4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	1.89E-0 1.85E-0 1.44E-0 1.44E-0 1.17E-0 1.19E-0 1.19E-0 1.19E-0 1.189E-0 1.19E-0 1.19E-0 1.19E-0 1.19E-0 1.19E-0 1.19E-0 1.19E-0 1.19E-0	2.78E-02 2.40E-02 2.23E-02 1 .95E-02 1 .89E-02 1 .89E-02 1 .793E-02 2.75E-02 2.30E-02	81.59% 88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82%		moving_variance MaxPooling: Dropout Conv2D kernel(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_mean(60) moving_variance
4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with ir Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	1.85E-0 1.4 1.85E-0 1.4 1.44E-0 1.4 1.17E-0 1.4 1.19E-0 1.5 quantization. Max dist. loss (m) 1.3 7.45E-0 1.3 6.86E-0 1.3 2.00E-0 1.4 1.83E-0 1.4 1.48E-0 1.4 1.19E-0	2.40E-02 2.23E-02 1 1.95E-02 1 1.89E-02 1 Ave dist. loss (m) 7.93E-02 1 2.75E-02 2.50E-02 1 2.30E-02	88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82%		Conv2D kerne(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_variance
4 8.73E 5 7.76E 6 6.17E 7 5.87E CNN model with ir Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	1.85E-0 1.4 1.85E-0 1.4 1.44E-0 1.4 1.17E-0 1.4 1.19E-0 1.5 quantization. Max dist. loss (m) 1.3 7.45E-0 1.3 6.86E-0 1.3 2.00E-0 1.4 1.83E-0 1.4 1.48E-0 1.4 1.19E-0	2.40E-02 2.23E-02 1 1.95E-02 1 1.89E-02 1 Ave dist. loss (m) 7.93E-02 1 2.75E-02 2.50E-02 1 2.30E-02	88.08% 91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82%		Conv2D kerne(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_variance
5 7.76E 6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	1.44E-0 1.17E-0 1.19E-0	2.23E-02 1.95E-02 1.89E-02 1 Ave dist. loss (m) 7.93E-02 1 3.99E-02 2.75E-02 1 2.30E-02	91.49% 94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%		Conv2D kernel(3×3×40) bias(60) ReLU BatchNormaliz gamma(60) beta(60) moving_wariance MaxPooling;
6 6.17E 7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	1.17E-0 1.19E-0	1.95E-02 1.89E-02 1 Ave dist. loss (m) 7.93E-02 1 3.99E-02 2.75E-02 2.50E-02 1 2.30E-02	94.66% 95.45% Accuracy 23.16% 59.44% 81.82% 86.32%		kernet(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_wariance: MaxPooling:
7 5.87E CNN model with in Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	8 quantization. Max dist. loss (m 03 7.45E-0 03 6.86E-0 03 2.00E-0 04 1.83E-0 04 1.19E-0	1.89E-02 Ave dist. loss (m) 7.93E-02 3.99E-02 2.75E-02 2.50E-02 2.30E-02	95.45% Accuracy 23.16% 59.44% 81.82% 86.32%		kernet(3×3×40) blas(60) ReLU BatchNormaliz gamma(60) beta(60) moving_wariance: MaxPooling:
Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	Max dist. loss (m 03 7.45E-0 03 6.86E-0 03 2.00E-0 04 1.83E-0 04 1.19E-0	7.93E-02 3.99E-02 2.75E-02 2.50E-02 2.30E-02	23.16% 59.44% 81.82% 86.32%		BatchNormaliz gamma(60) beta(60) moving_mean(60) moving_variance
Sensors MSE 1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	Max dist. loss (m 03 7.45E-0 03 6.86E-0 03 2.00E-0 04 1.83E-0 04 1.19E-0	7.93E-02 3.99E-02 2.75E-02 2.50E-02 2.30E-02	23.16% 59.44% 81.82% 86.32%		beta(60) moving_mean(60) moving_variance(
1 9.92E 2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	7.45E-0 7.45E-0 7.45E-0 7.45E-0 7.45E-0 7.45E-0 7.45E-0 7.45E-0 7.45E-0 7.45E-0	7.93E-02 3.99E-02 2.75E-02 2.50E-02 2.30E-02	23.16% 59.44% 81.82% 86.32%		beta(60) moving_mean(60) moving_variance: MaxPooling:
2 2.46E 3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	03 6.86E-0 03 2.00E-0 04 1.83E-0 04 1.48E-0 04 1.19E-0	3.99E-02 2.75E-02 2.50E-02 2.30E-02	59.44% 81.82% 86.32%		MaxPooling)
3 1.11E 4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	2.00E-0 1.83E-0 1.48E-0 1.19E-0	2.75E-02 2.50E-02 2.30E-02	81.82% 86.32%		
4 9.29E 5 8.17E 6 6.51E 7 5.96E CNN model with fl	1.83E-0 1.4 1.48E-0 1.19E-0	2.50E-02 2.30E-02	86.32%		
5 8.17E 6 6.51E 7 5.96E CNN model with fl	1.48E-0 04 1.19E-0	2.30E-02			Dropout
6 6.51E 7 5.96E	04 1.19E-0		90.82%		1
7 5.96E		2 025-02	00.0270		Conv2D
CNN model with fl		2.02L-02	93.89%		kernel(3×3×60× bias(120)
	04 1.23E-0	1.91E-02	95.33%		ReLU
	ote (S4E4M4) augus	ination			BatchNormaliz
	Max dist. loss (m		Accuracy	Accuracy gain (float6 over float32)	gamma〈120〉 beta〈120〉 moving_mean〈12 moving_variance
1 1.06E	02 7.32E-0	8.12E-02	23.96%	0.89%	MaxPooling
2 2.17E				5.15%	Dropout
3 8.16E			90.14%	8.55%	
4 5.87E				6.77%	Flatten
5 5.70E			95.36%	3.87%	Dense
6 5.79E			94.75%	0.09%	kernel<240×3 bias<32>
7 5.12E			96.27%	0.83%	ReLU
. 5.122	1.202 0		23.2.70	2.0070	Dense
CNN model with fl	at5 (S1E3M1) quan	ization.			kernel(32×2) bias(2)
Sensors MSE	Max dist. loss (m	Ave dist. loss (m)	Accuracy	Accuracy gain (float5 over float32)	Sigmoid dense_1