Data Explanation of Lower Limb Activities

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This document mainly explains the lower limb activity data and the classification results by using TMC-Hist-based adaptive on-line classifying method.

1 Experiment explanation

Six subjects are involved in the experiments, one subject is asked to conduct a short time period experiment for training data, and the other five subjects are asked to conduct five individual experiments for testing data. The details of the subjects can be seen in Table. 1.

Table 1: Information of each subject.

	Gender	**Age**	**Height (cm)**	**Weight (kg)**	**Data type**	**Data duration (min)**
Subject 0	Male	28	184	72	Training	6.5
Subject 1	Female	27	160	53	Testing	34.39
Subject 2	Male	30	177	71	Testing	34.82
Subject 3	Male	47	178	83	Testing	28.77
Subject 4	Female	28	162	53	Testing	33.11
Subject 5	Male	25	170	52	Testing	33.6

1.1 Experiment for training data

The experiment for training data is carefully designed, it does not need to last very long time but must cover all activities and all possible activity switches. The details will be displayed in section 2.

1.2 Experiment for testing data

The place of the experiments is chosen at a 4-floor building in the campus of École Centrale de Lyon (France), walking and running are accomplished around this building, where the path consists of flat, ascent and descent ramp road conditions. Stair ascent and descent are accomplished in the building. The sequence of the activities among all the five testing experiments is determined, it is like this:

1. 600 meters of walking,
2. 600 meters of running,
3. four round trips of climbing stairs from ground floor to the 4th floor and back to the ground floor,
4. repeat the procedure from 1 to 3 again.

The procedures from 1 to 3 are called as one section here, thus one experiment consists of two same sections, and totally involves $1200m$ of walking and running, 32 floors of stair ascent and descent, respectively. The average time consumption of one experiment is about 30 minutes. All the subjects perform the activities at their preferred speeds, but are asked to keep the same speed within one experiment as much as possible. This ensures that the activity patterns and speeds vary among the subjects, but keep constant within one experiment. The speeds of the activities among all the five subjects are shown in Table. 2.

Table 2: Activity speeds of subject, for the testing data.

	Walking (m/s)	Running (m/s)	Stair ascent (stair/min)	Stair descent (stair/min)
Subject 1	1.2687	2.4013	89.7953	111.3364
Subject 2	1.1674	2.6869	94.0617	106.4287
Subject 3	1.6781	3.0394	94.489	105.5059
Subject 4	1.2671	2.1373	123.6822	133.6888
Subject 5	1.1423	3.1555	103.928	106.0547

2 Results of training experiment

The training experiment is conducted by subject 1, with a duration of $6.5min$. The speeds of the four activities are $1.37m/s$, $3.47m/s$, $103.72stair/min$, $114.80stair/min$. The iteration number for ICE is set to 200. The overall accuracy of from training data is 93.02%, and the MCC[1] is 0.89. The classified activity of training data and its confusion matrix are shown in Fig. 1 and Tab. 3

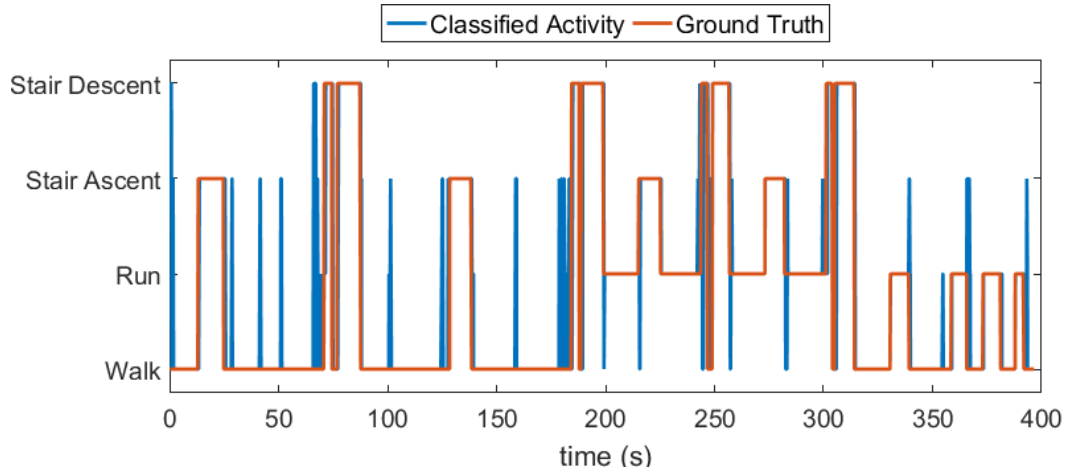


Figure 1: Classified activities of training data, data obtained from subject 0. Overall accuracy and MCC are 93.02% and 0.89 respectively

Table 3: Confusion matrix of activity from training data.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walking**	91.6025%	2.1511%	4.5717%	1.6747%
	Running	2.0464%	95.8155%	1.3846%	0.7534%
	Stair ascent	2.2850%	0.8354%	96.8796%	0.0000%
	Stair descent	6.2203%	1.3867%	2.0800%	90.3130%

3 Results of testing experiment

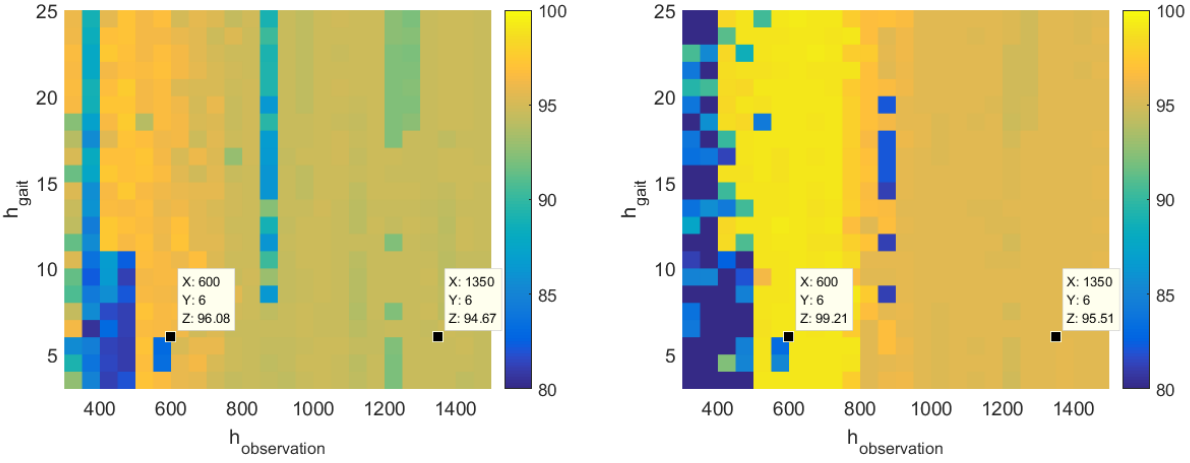
First, a global view of the five testing will be displayed. Then, the results of each experiment will be displayed separately.

3.1 The overall results

The adaptive on-line algorithm is performed under different values of thresholds $h_{observation}$ and h_{gait}, the ranges of the thresholds are $200:50:1500$ and $3:1:25$ respectively. Fig. 2 shows the overall accuracy among all the subjects, *w.r.t.* corresponding threshold. Then, set $h_{observation} = 600$ and $h_{gait} = 600$, we

[1]MCC is a measure for multi-category classification, it can balance the influence that produced by the different proportion of each category, a value close to 1 means a perfect classification.

can obtain the corresponding results. The overall accuracy, MCC, the confusion matrices and the accuracy most recent 2000 samples are show in Tab. 4-6 and Fig. 3.



(a) (b)

Figure 2: Overall accuracy corresponding to $h_{observation}$ and h_{gait}. (a): first section of experiment. (b): second section of experiment.

Table 4: Overall accuracy and MCC of two experiment sections.

	First section	**Second section**
Overall accuracy	96.0792%	99.2116%
MCC	0.9298	0.9870

Table 5: Confusion matrix of the first section of experiments.

		Prediected as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.00%	0.46%	1.47%	0.06%
	Running	0.33%	99.60%	0.07%	0.00%
	Stair ascent	1.31%	0.00%	92.02%	6.68%
	Stair descent	1.05%	0.24%	10.66%	88.05%

Table 6: Confusion matrix of the second section of experiments.

		Prediected as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.27%	0.18%	0.43%	0.11%
	Running	0.13%	99.86%	0.01%	0.00%
	Stair ascent	0.24%	0.00%	99.37%	0.39%
	Stair descent	0.18%	0.00%	2.08%	97.74%

The five subjects' results will be displayed just like the overall results, overall accuracy of the two experiment sections *w.r.t.* the same range of the two thresholds, the confusion matrix and accuracy in most recent 2000 samples *w.r.t.* the same value of the two thresholds.

3.2 Results of subject 1

Fig. 4 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 600$ and $h_{gait} = 600$, Fig. 5 is the classified activities, Tab. 7 shows the overall accuracy and MCC in the two experiment sections, Tab. 8- 9 are the confusion matrices, Fig. 6 is the accuracy in most recent 2000 samples.

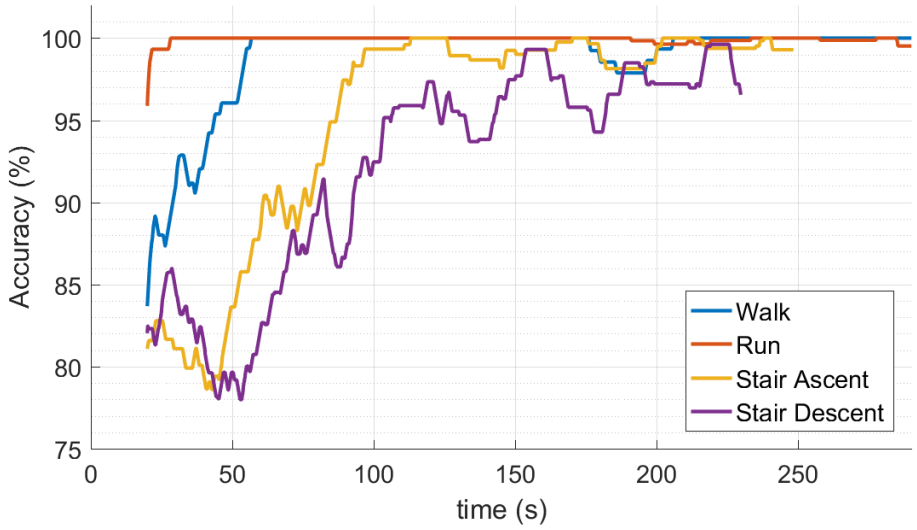
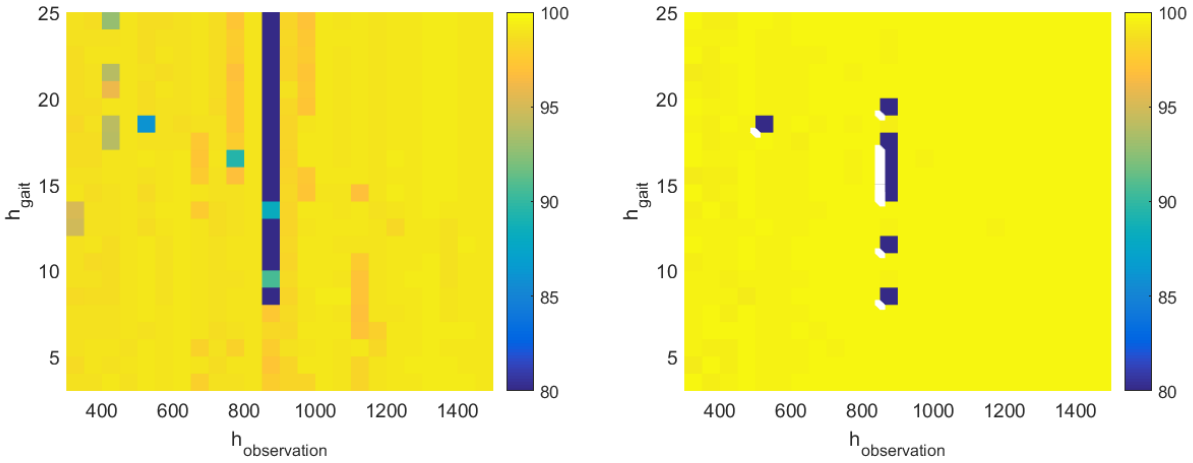


Figure 3: Accuracy in the most recent 2000 samplings *w.r.t.* each activities.



(a) (b)

Figure 4: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 1. (a): first section of experiment. (b): second section of experiment.

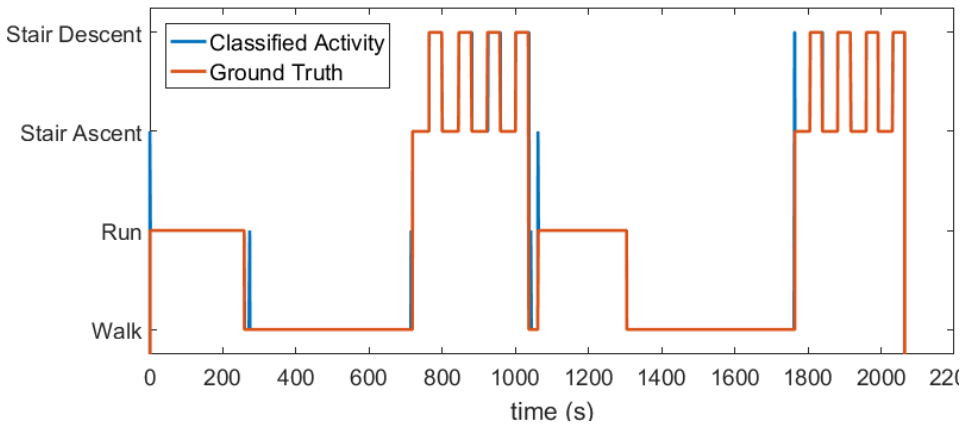


Figure 5: Classified acttivities and the Ground Truth, Subject 1.

Table 7: Overall accuracy and MCC of the two experiment sections, Subject 1.

	First section	**Second section**
Overall accuracy	99.14%	99.67%
MCC	0.9869	0.9947

Table 8: Confusion matrix of the first section of experiments, Subject 1.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.83%	0.65%	0.23%	0.28%
	Running	0.00%	99.69%	0.31%	0.00%
	Stair ascent	0.00%	0.00%	99.59%	0.41%
	Stair descent	0.00%	0.00%	1.33%	98.67%

Table 9: Confusion matrix of the second section of experiments, Subject 1.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.84%	0.00%	0.00%	0.16%
	Running	0.00%	99.95%	0.05%	0.00%
	Stair ascent	0.00%	0.00%	99.25%	0.75%
	Stair descent	0.00%	0.00%	0.58%	99.42%

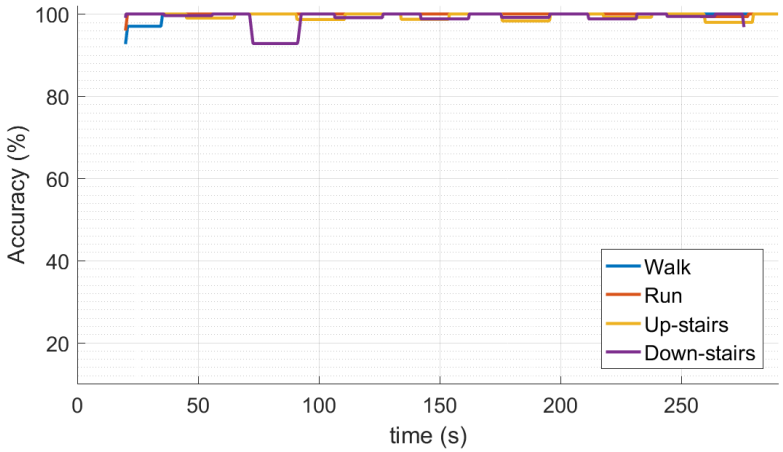
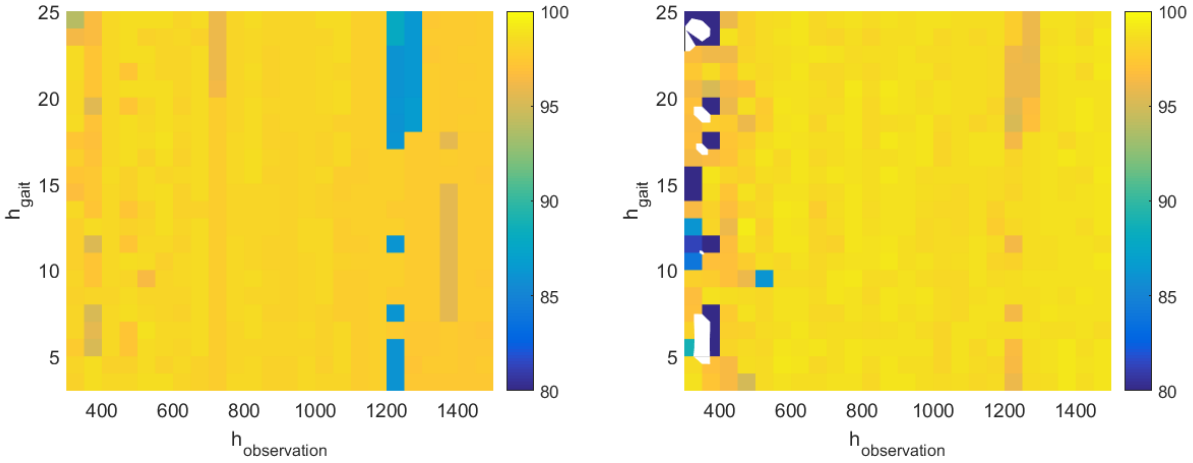


Figure 6: Accuracy in the most recent 2000 samplings *w.r.t.* each activities, Subject 1.

3.3 Results of subject 2

Fig. 7 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 600$ and $h_{gait} = 600$, Fig. 8 is the classified activities, Tab. 10 shows the overall accuracy and MCC in the two experiment sections, Tab. 11- 12 are the confusion matrices, Fig. 9 is the accuracy in most recent 2000 samples.



(a) (b)

Figure 7: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 2. (a): first section of experiment. (b): second section of experiment.

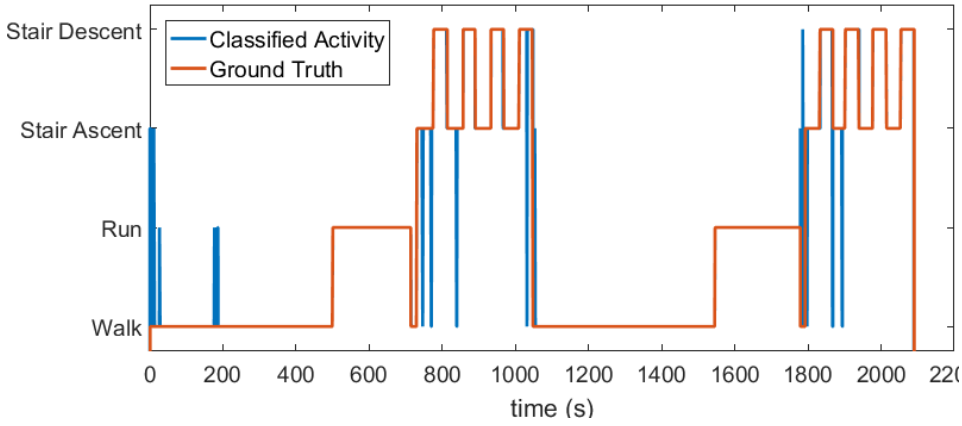


Figure 8: Classified acttivities and the Ground Truth, Subject 2.

Table 10: Overall accuracy and MCC of the two experiment sections, Subject 2.

	First section	**Second section**
Overall accuracy	98.29%	99.03%
MCC	0.9741	0.9848

Table 11: Confusion matrix of the first section of experiments, Subject 2.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.53%	0.71%	0.77%	0.00%
	Running	0.05%	99.95%	0.00%	0.00%
	Stair ascent	2.67%	0.00%	97.33%	0.00%
	Stair descent	0.82%	0.00%	3.05%	96.13%

Table 12: Confusion matrix of the second section of experiments, Subject 2.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.87%	0.00%	0.84%	0.28%
	Running	0.06%	99.93%	0.01%	0.00%
	Stair ascent	1.23%	0.00%	98.56%	0.22%
	Stair descent	0.82%	0.00%	0.56%	98.62%

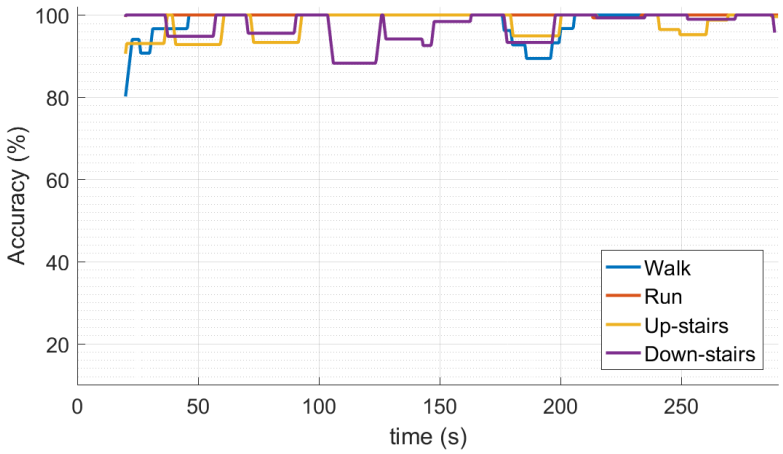


Figure 9: Accuracy in the most recent 2000 samplings *w.r.t.* each activities, Subject 2.

3.4 Results of subject 3

Fig. 10 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 600$ and $h_{gait} = 600$, Fig. 11 is the classified activities, Tab. 13 shows the overall accuracy and MCC in the two experiment sections, Tab. 14- 15 are the confusion matrices, Fig. 12 is the accuracy in most recent 2000 samples.

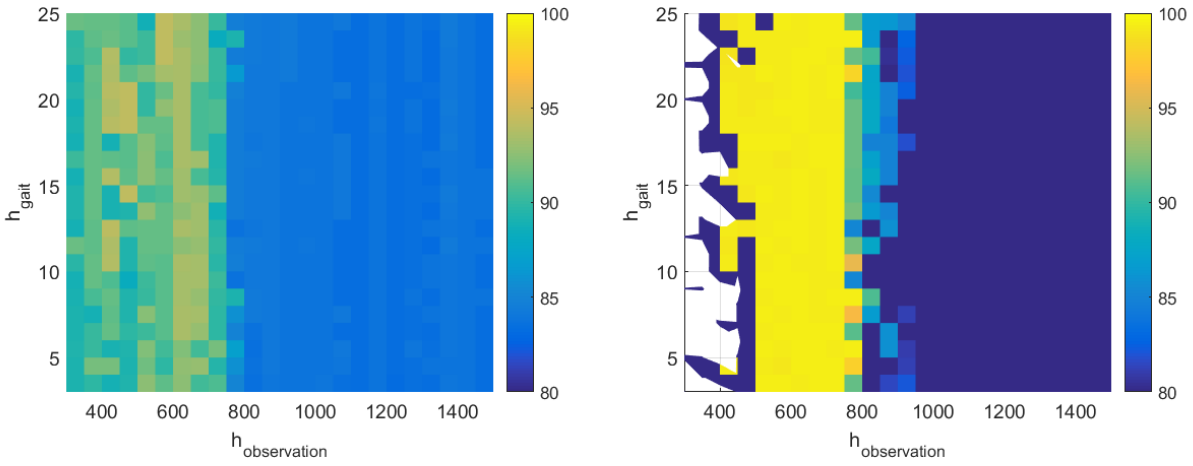


Figure 10: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 3. (a): first section of experiment. (b): second section of experiment.

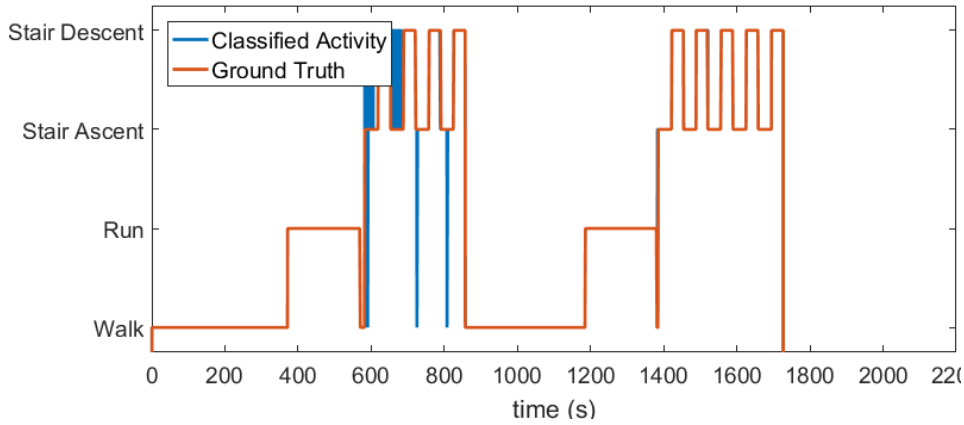


Figure 11: Classified acttivities and the Ground Truth, Subject 3.

Table 13: Overall accuracy and MCC of the two experiment sections, Subject 3.

	First section	**Second section**
Overall accuracy	93.45%	99.42%
MCC	0.8885	0.9918

Table 14: Confusion matrix of the first section of experiments, Subject 3.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	100.00%	0.00%	0.00%	0.00%
	Running	0.10%	99.90%	0.00%	0.00%
	Stair ascent	3.72%	0.00%	62.73%	33.55%
	Stair descent	0.00%	0.00%	1.50%	98.50%

Table 15: Confusion matrix of the second section of experiments, Subject 3.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.22%	0.01%	0.65%	0.13%
	Running	0.09%	99.91%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	99.42%	0.58%
	Stair descent	0.00%	0.00%	0.75%	99.25%

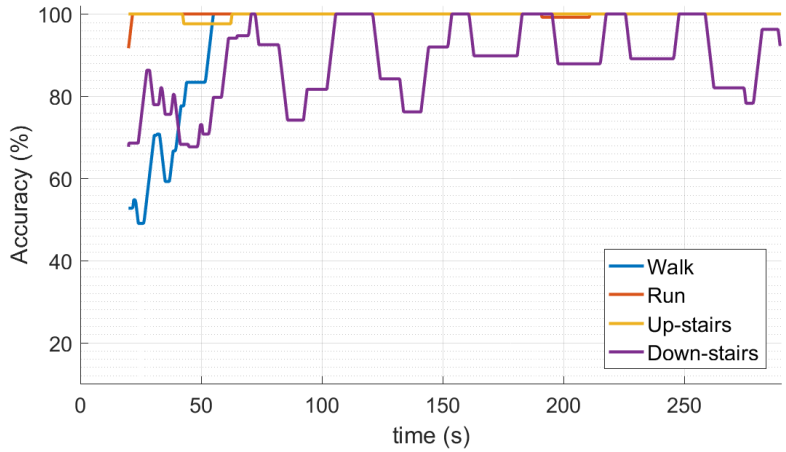
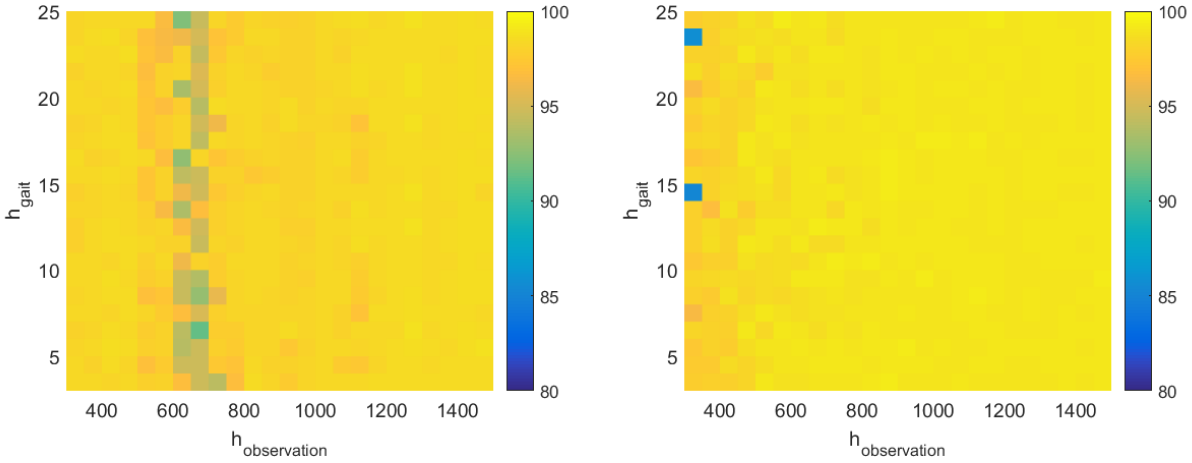


Figure 12: Accuracy in the most recent 2000 samplings *w.r.t.* each activities, Subject 3.

3.5 Results of subject 4

Fig. 13 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 600$ and $h_{gait} = 600$, Fig. 14 is the classified activities, Tab. 16 shows the overall accuracy and MCC in the two experiment sections, Tab. 14- 18 are the confusion matrices, Fig. 15 is the accuracy in most recent 2000 samples.



(a) (b)

Figure 13: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 4. (a): first section of experiment. (b): second section of experiment.

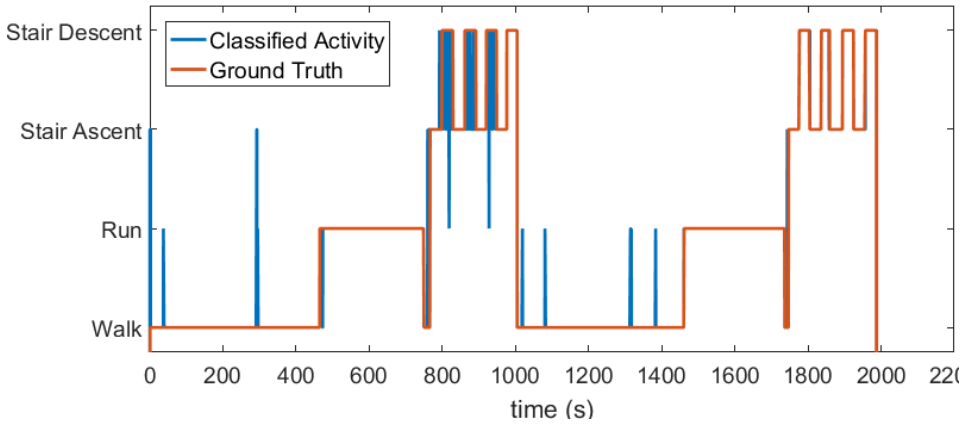


Figure 14: Classified acttivities and the Ground Truth, Subject 4.

Table 16: Overall accuracy and MCC of the two experiment sections, Subject 4.

	First section	**Second section**
Overall accuracy	94.09%	99.00%
MCC	0.8756	0.9847

Table 17: Confusion matrix of the first section of experiments, Subject 4.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.07%	0.64%	1.26%	0.03%
	Running	0.65%	99.35%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	98.74%	1.26%
	Stair descent	0.00%	1.44%	39.41%	59.15%

Table 18: Confusion matrix of the second section of experiments, Subject 4.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.64%	0.92%	0.44%	0.00%
	Running	0.35%	99.65%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	99.70%	0.30%
	Stair descent	0.00%	0.00%	2.04%	97.96%

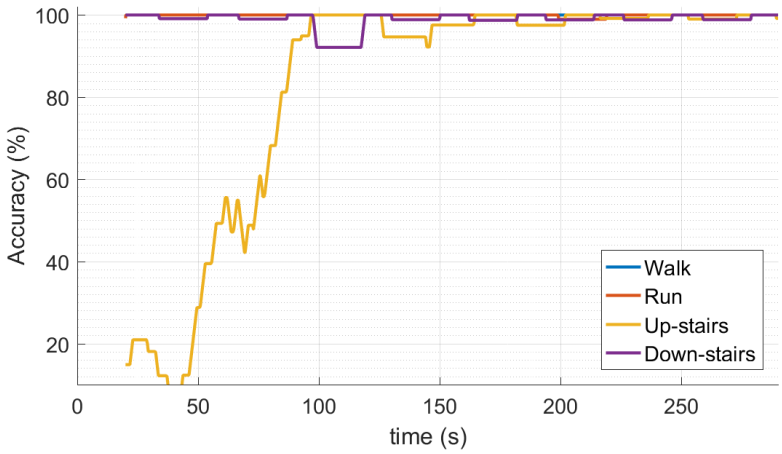
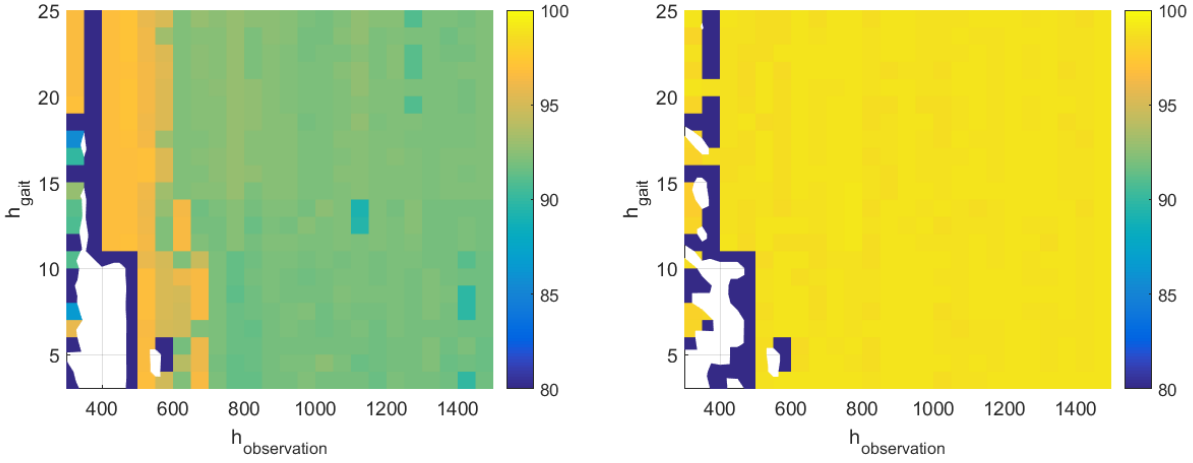


Figure 15: Accuracy in the most recent 2000 samplings *w.r.t.* each activities, Subject 4.

3.6 Results of subject 5

Fig. 16 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 600$ and $h_{gait} = 600$, Fig. 17 is the classified activities, Tab. 19 shows the overall accuracy and MCC in the two experiment sections, Tab. 14- 21 are the confusion matrices, Fig. 18 is the accuracy in most recent 2000 samples.



(a) (b)

Figure 16: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 5. (a): first section of experiment. (b): second section of experiment.

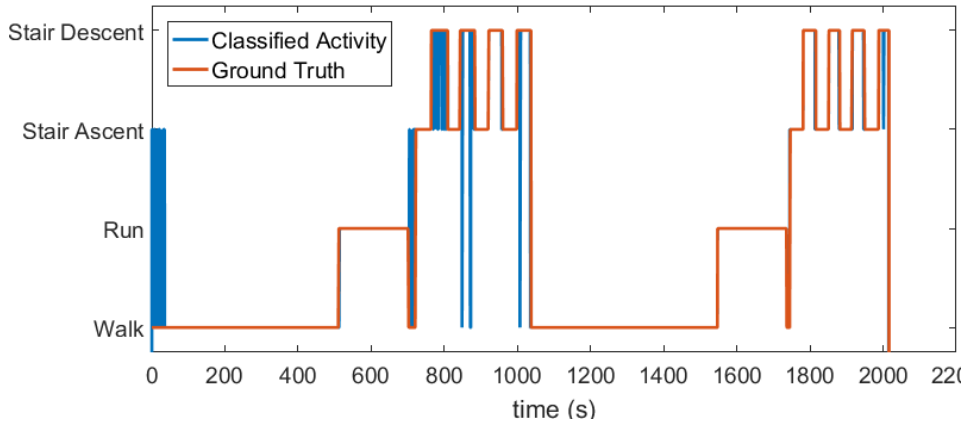


Figure 17: Classified acttivities and the Ground Truth, Subject 5.

Table 19: Overall accuracy and MCC of the two experiment sections, Subject 5.

	First section	**Second section**
Overall accuracy	94.86%	98.91%
MCC	0.9217	0.9785

Table 20: Confusion matrix of the first section of experiments, Subject 5.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	95.23%	0.22%	4.54%	0.00%
	Running	0.87%	99.13%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	99.69%	0.31%
	Stair descent	3.75%	0.00%	12.12%	84.13%

Table 21: Confusion matrix of the second section of experiments, Subject 5.

		Predicted as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.73%	0.02%	0.26%	0.00%
	Running	0.08%	99.92%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	100.00%	0.00%
	Stair descent	0.00%	0.00%	7.17%	92.83%

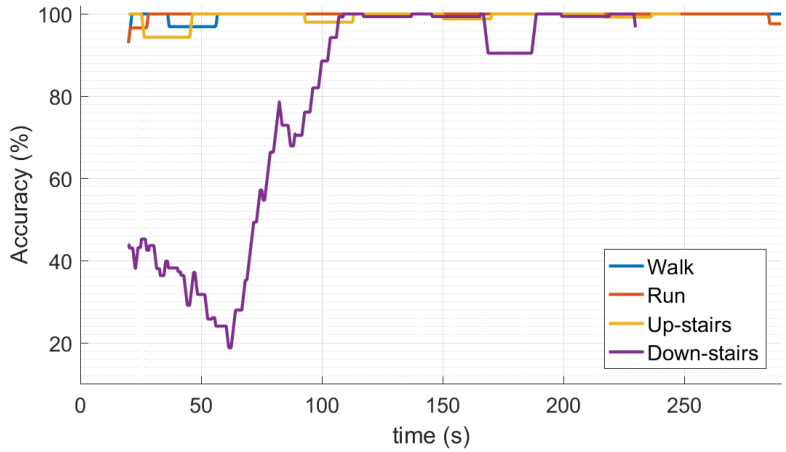


Figure 18: Accuracy in the most recent 2000 samplings *w.r.t.* each activities, Subject 5.