Data Explanation of Lower Limb Activities

April 6, 2019

Contents

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

Ten healthy subjects are involved in the experiments. The details of the subjects can be seen in Table. 1.

Table 1: Information of each subject.

	Gender	Age	Height (cm)	Weight (kg)	Data duration (min)
Subject 0	Male	28	184	72	28.77
Subject 1	Female	27	160	53	34.39
Subject 2	Male	30	177	71	34.82
Subject 3	Male	47	178	83	28.77
Subject 4	Female	28	162	53	33.11
Subject 5	Male	25	170	52	33.6
Subject 6	Male	31	176	62	33.6
Subject 7	Male	27	177	73	33.52
Subject 8	Male	29	170	70	32.29
Subject 9	Female	28	160	47	35.20

1.1 Details of experiment activity

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:

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 0	1.3767	3.4783	103.7215	114.8020
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	94.4890	105.5059
Subject 4	1.2671	2.1373	123.6822	133.6888
Subject 5	1.1423	3.1555	103.9280	106.0547
Subject 6	1.4444	2.8957	113.0620	140.9741
Subject 7	1.2738	2.8623	93.0552	96.0725
Subject 8	1.1539	3.2994	123.4343	107.6871
Subject 9	1.0919	2.6799	117.0202	101.4551

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.

1.2 Cross-validation

The data are tested a 2-fold cross-validation method,*i.e.* the ten subjects are equally separated into two groups. The first group includes subjects 0 to 4 and the second group includes the subject 5 to 9. Then, using the first group data to obtain trained model and test on the other group, and vice versa.

2 Results of testing experiment

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

2.1 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. 1 shows the overall accuracy among all the subjects, *w.r.t.* corresponding threshold. Then, set $h_{observation} = 700$ and $h_{gait} = 6$, we can obtain the corresponding results. The overall accuracy, MCC, the confusion matrices and the accuracy most recent 2000 samples are show in Tab. 3-5 and Fig. 2.

Table 3: Overall accuracy and MCC of two experiment sections.

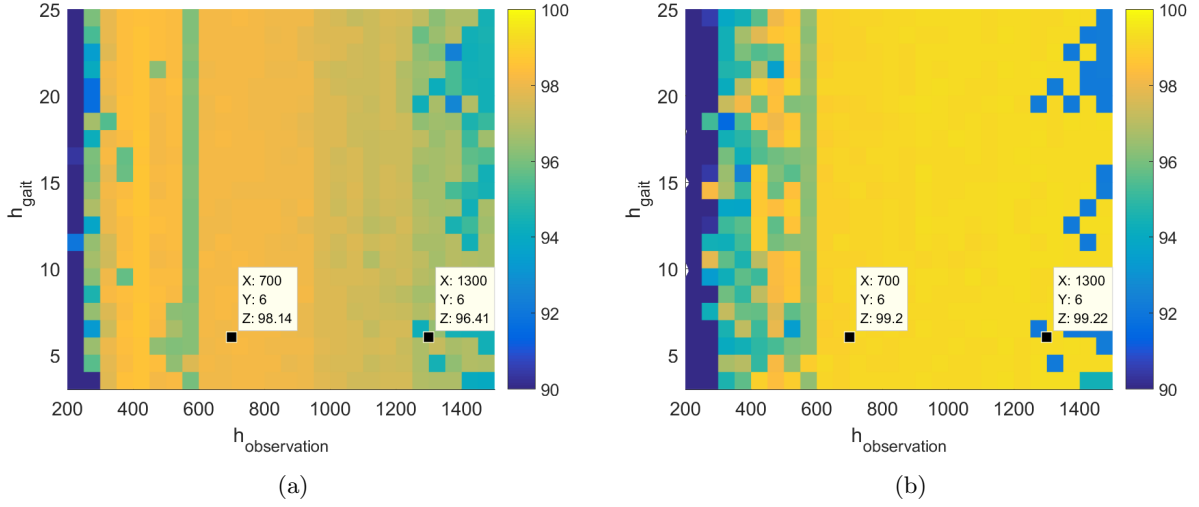|	First section	Second section
Overall accuracy	98.1354%	99.2025%
MCC	0.9682	0.9869

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

Table 4: Confusion matrix of the first section of experiments.

		Prediected as			
		Walking	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.69%	0.58%	1.37%	0.36%
	Running	0.48%	99.44%	0.00%	0.08%
	Stair ascent	0.13%	1.18%	97.65%	1.05%
	Stair descent	0.29%	0.05%	4.96%	94.70%

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

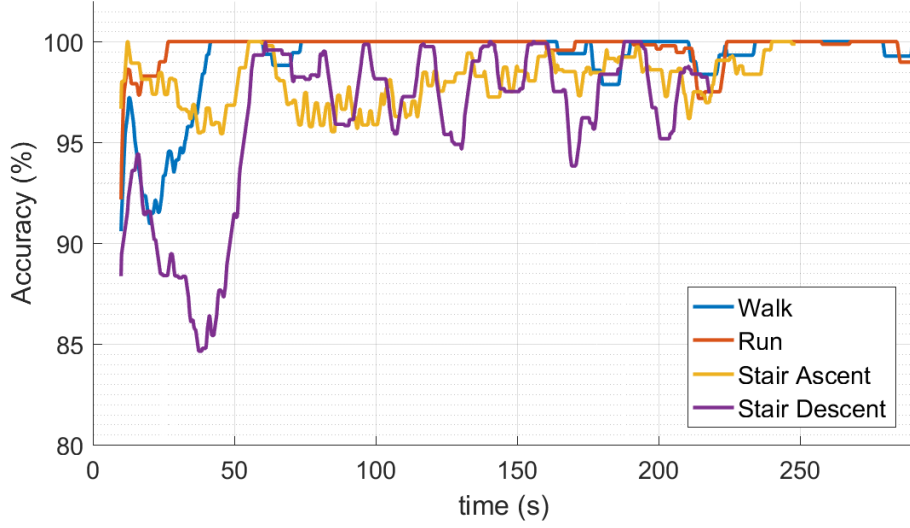|		Prediected as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.39%	0.21%	0.23%	0.16%
	Running	0.16%	99.83%	0.01%	0.00%
	Stair ascent	0.86%	0.00%	98.62%	0.52%
	Stair descent	0.09%	0.00%	1.71%	98.20%

Figure 2: Accuracy in the most recent 1000 samplings *w.r.t.* each activities.

The ten 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.

2.2   Results of Subject 0

Fig. 3 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 4 is the classified activities, Tab. 6 shows the overall accuracy and MCC in the two experiment sections, Tab. 7- 8 are the confusion matrices, Fig. 5 is the accuracy in most recent 1000 samples.
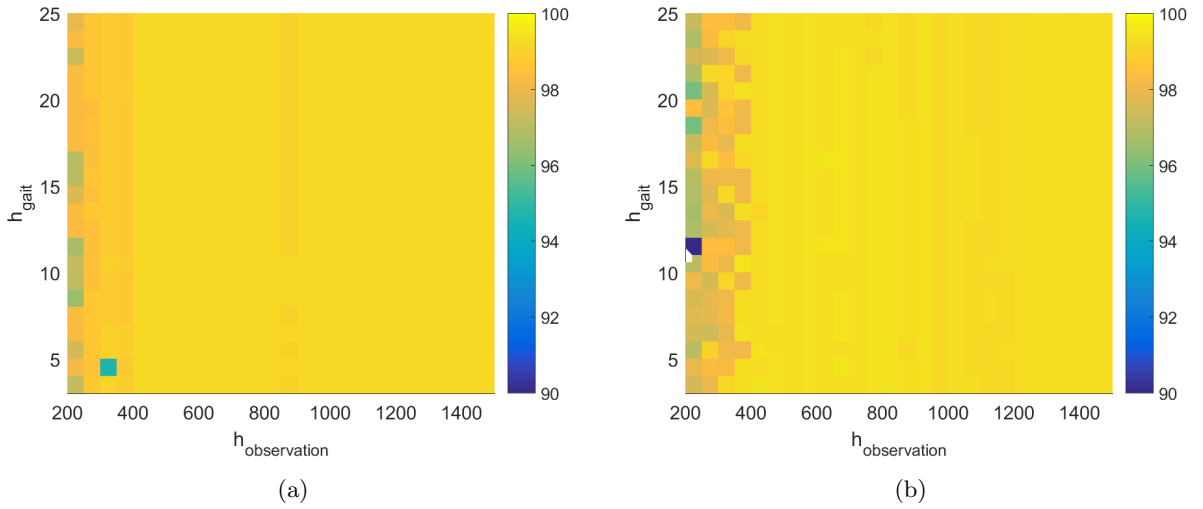

Figure 3: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 0. (a): first section of experiment. (b): second section of experiment.
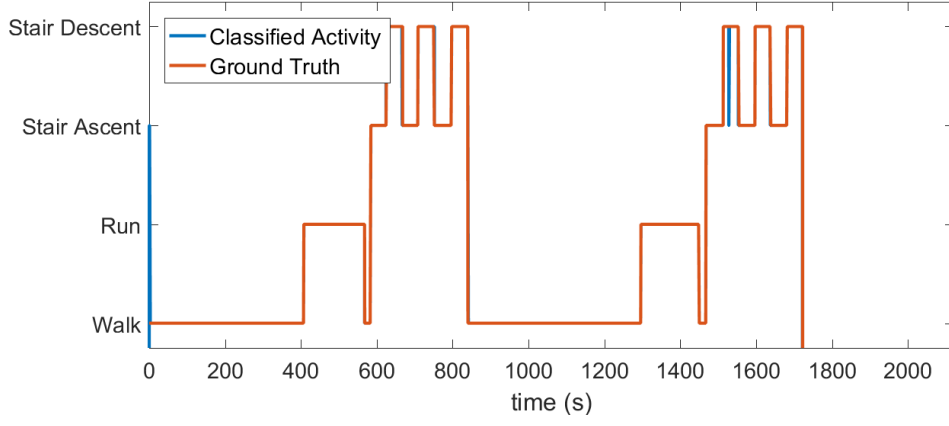
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Figure 4: Classified acttivities and the Ground Truth, Subject 0.

Table 6: Overall accuracy and MCC of the two experiment sections, Subject 0.

	First section	Second section
Overall accuracy	99.17%	99.30%
MCC	0.9861	0.9870

Table 7: Confusion matrix of the first section of experiments, Subject 0.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
	Walkijng	99.35%	0.00%	0.65%	0.00%
Actual activity	**Running**	0.29%	99.71%	0.00%	0.00%
	Stair ascent	0.06%	0.00%	98.37%	1.57%
	Stair descent	0.00%	0.00%	1.25%	98.75%

Table 8: Confusion matrix of the second section of experiments, Subject 0.

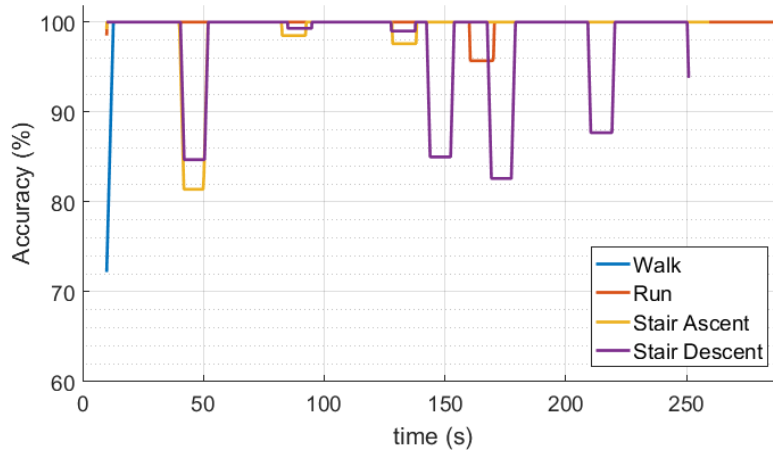|		Predieted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
	Walkijng	99.74%	0.01%	0.23%	0.02%
Actual activity	**Running**	0.08%	99.92%	0.00%	0.00%
	Stair ascent	0.18%	0.00%	99.82%	0.00%
	Stair descent	0.00%	0.00%	3.72%	96.28%

Figure 5: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 0.

2.3 Results of subject 1

Fig. 6 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 7 is the classified activities, Tab. 9 shows the overall accuracy and MCC in the two experiment sections, Tab. 10- 11 are the confusion matrices, Fig. 8 is the accuracy in most recent 1000 samples.
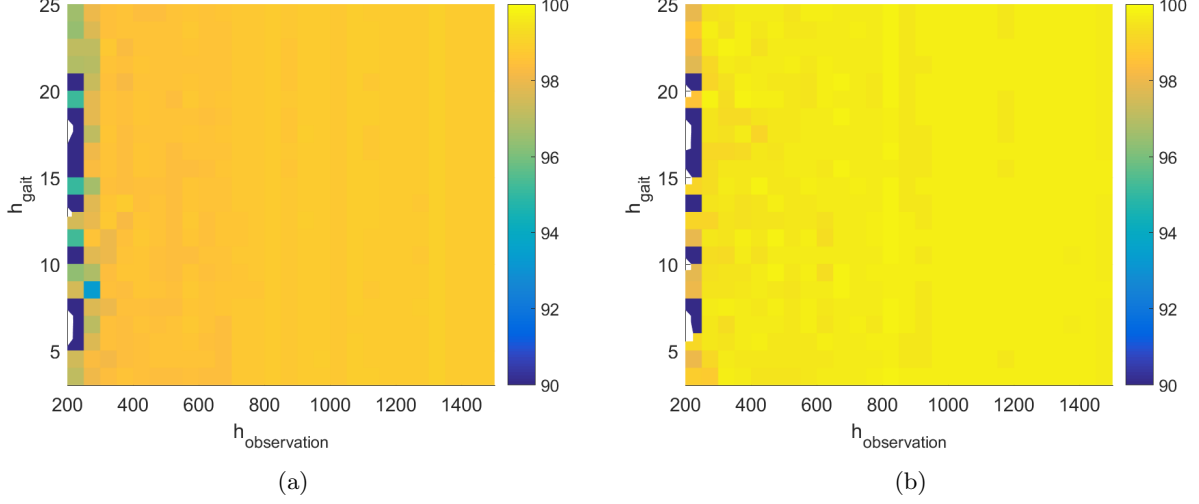

Figure 6: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 1. (a): first section of experiment. (b): second section of experiment.
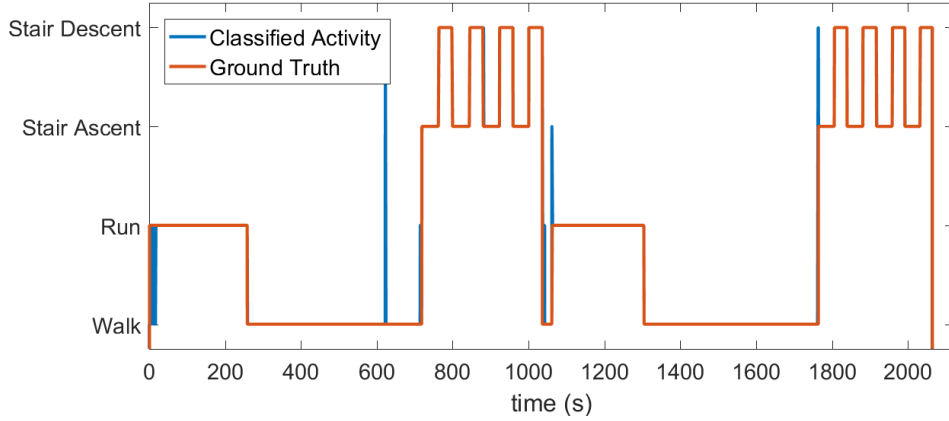

Figure 7: Classified acttivities and the Ground Truth, Subject 1.

Table 9: Overall accuracy and MCC of the two experiment sections, Subject 1.

	First section	Second section
Overall accuracy	98.68%	99.72%
MCC	0.9814	0.9947

Table 10: Confusion matrix of the first section of experiments, Subject 1.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.77%	0.53%	0.20%	0.49%
	Running	2.04%	97.96%	0.00%	0.00%
	Stair ascent	0.13%	0.00%	98.79%	1.08%
	Stair descent	0.00%	0.00%	0.46%	99.54%

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Table 11: Confusion matrix of the second section of experiments, Subject 1.

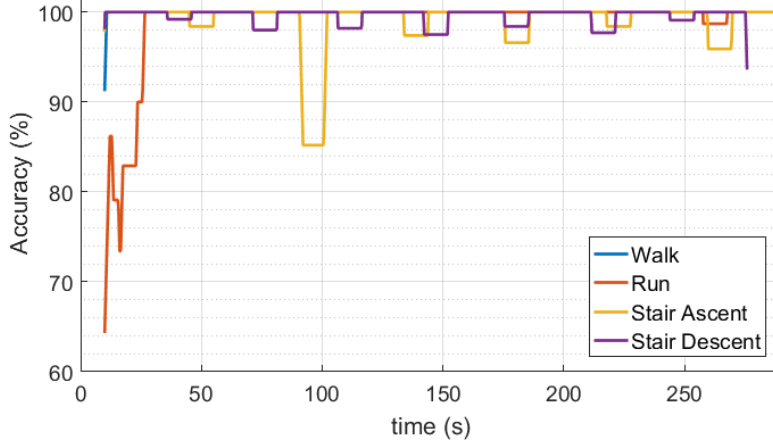|		Prediected as			
		Walkijng	Running	Stair ascent	Stair descent
Actual activity	**Walkijng**	99.84%	0.00%	0.00%	0.16%
	Running	0.00%	99.95%	0.05%	0.00%
	Stair ascent	0.00%	0.00%	99.25%	0.75%
	Stair descent	0.00%	0.00%	0.55%	99.45%

Figure 8: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 1.

2.4 Results of Subject 2

Fig. 9 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 10 is the classified activities, Tab. 12 shows the overall accuracy and MCC in the two experiment sections, Tab. 13- 14 are the confusion matrices, Fig. 11 is the accuracy in most recent 1000 samples.
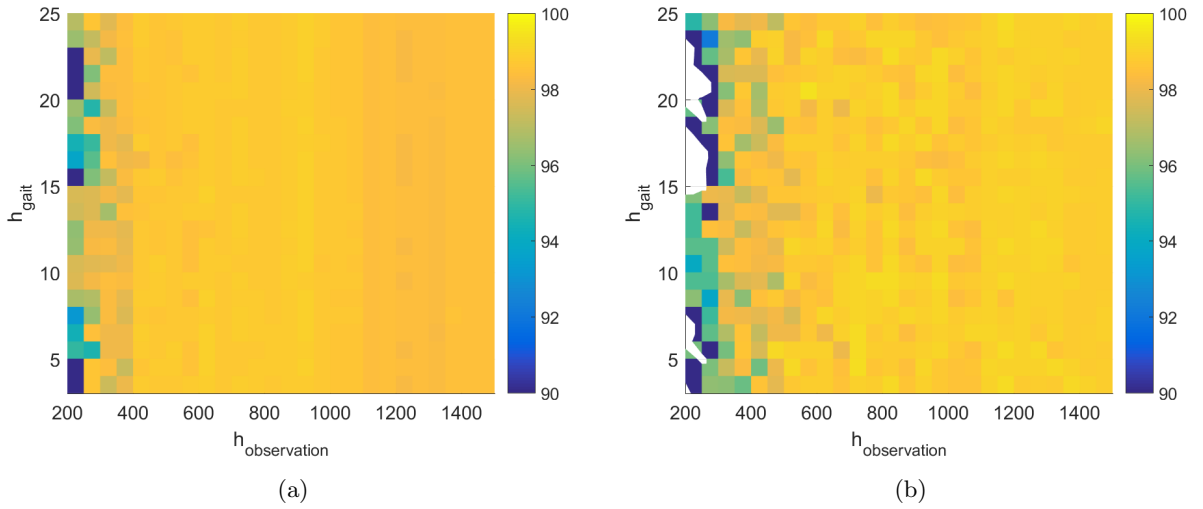

Figure 9: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 2. (a): first section of experiment. (b): second section of experiment.
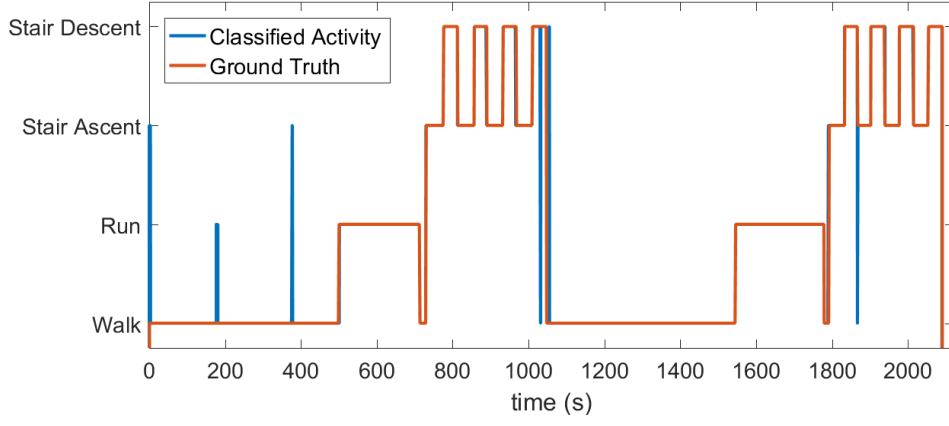
Figure 10: Classified acttivities and the Ground Truth, Subject 2.

Table 12: Overall accuracy and MCC of the two experiment sections, Subject 2.

	First section	Second section
Overall accuracy	98.83%	99.25%
MCC	0.9818	0.9881

Table 13: Confusion matrix of the first section of experiments, Subject 2.

		Prediected as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.79%	0.29%	0.92%	0.00%
	Running	0.42%	99.58%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	100.00%	0.00%
	Stair descent	0.45%	0.00%	3.10%	96.45%

Table 14: Confusion matrix of the second section of experiments, Subject 2.

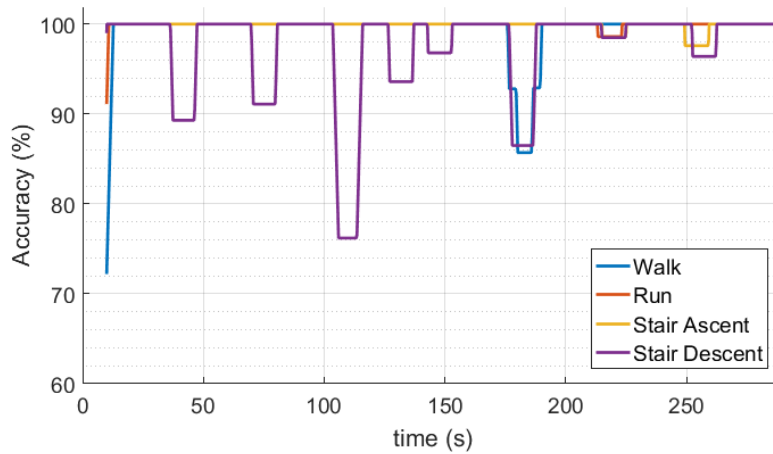|		Prediected as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.00%	0.00%	0.65%	0.35%
	Running	0.06%	99.94%	0.00%	0.00%
	Stair ascent	0.10%	0.00%	99.74%	0.16%
	Stair descent	0.83%	0.00%	0.67%	98.50%

Figure 11: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 2.

2.5 Results of Subject 3

Fig. 12 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 13 is the classified activities, Tab. 15 shows the overall accuracy and MCC in the two experiment sections, Tab. 16- 17 are the confusion matrices, Fig. 14 is the accuracy in most recent 1000 samples.
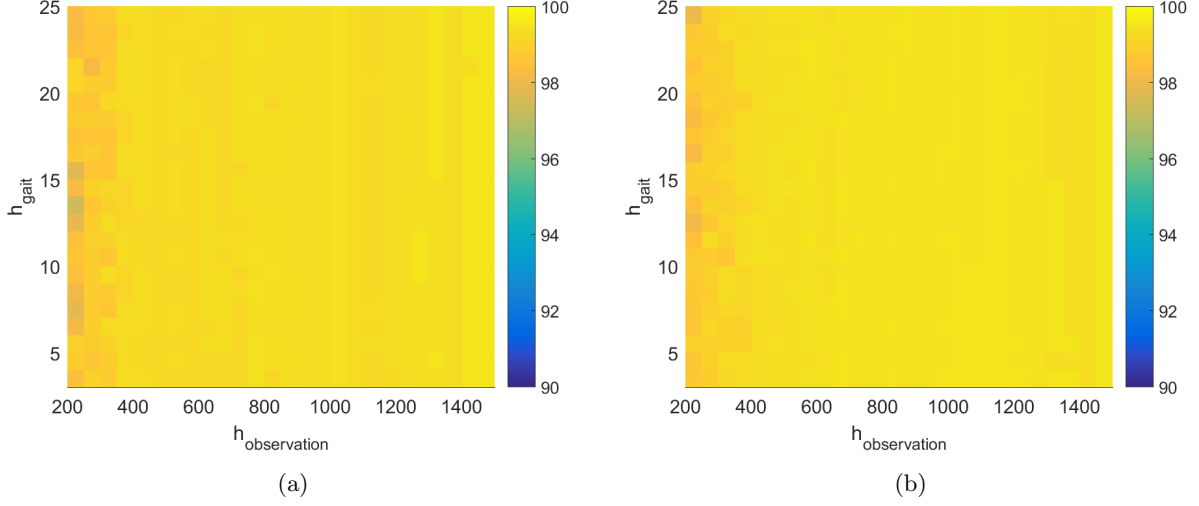

Figure 12: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 3. (a): first section of experiment. (b): second section of experiment.
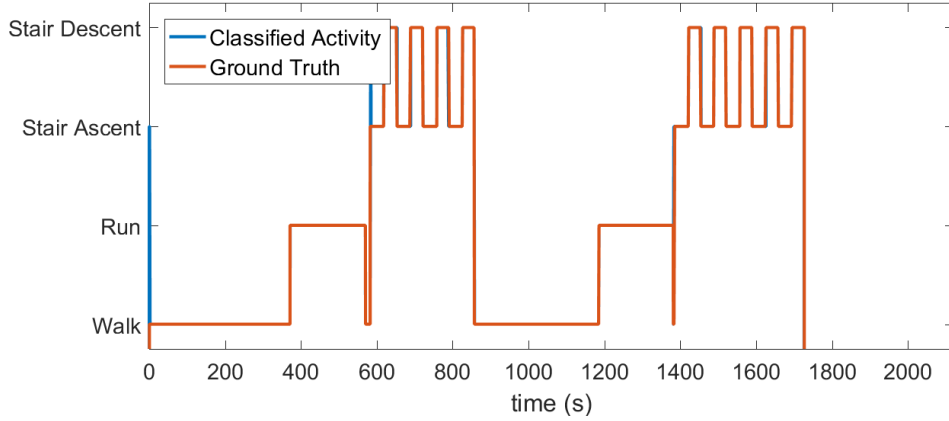

Figure 13: Classified acttivities and the Ground Truth, Subject 3.

Table 15: Overall accuracy and MCC of the two experiment sections, Subject 3.

	First section	Second section
Overall accuracy	99.21%	99.42%
MCC	0.9865	0.9918

Table 16: Confusion matrix of the first section of experiments, Subject 3.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
	Walkijng	99.60%	0.00%	0.40%	0.00%
	Running	0.09%	99.91%	0.00%	0.00%
Actual activity	**Stair ascent**	0.21%	0.00%	98.03%	1.76%
	Stair descent	0.00%	0.00%	1.69%	98.31%

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Table 17: Confusion matrix of the second section of experiments, Subject 3.

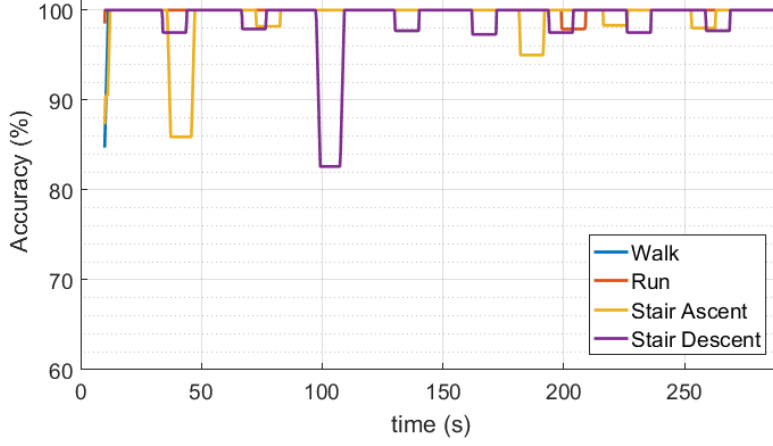|		Prediected as			
		Walkijng	Running	Stair ascent	Stair descent
Actual activity	**Walkijng**	99.22%	0.01%	0.65%	0.13%
	Running	0.09%	99.91%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	99.43%	0.57%
	Stair descent	0.00%	0.00%	0.76%	99.24%

Figure 14: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 3.

2.6 Results of Subject 4

Fig. 15 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 16 is the classified activities, Tab. 18 shows the overall accuracy and MCC in the two experiment sections, Tab. 19- 20 are the confusion matrices, Fig. 17 is the accuracy in most recent 1000 samples.
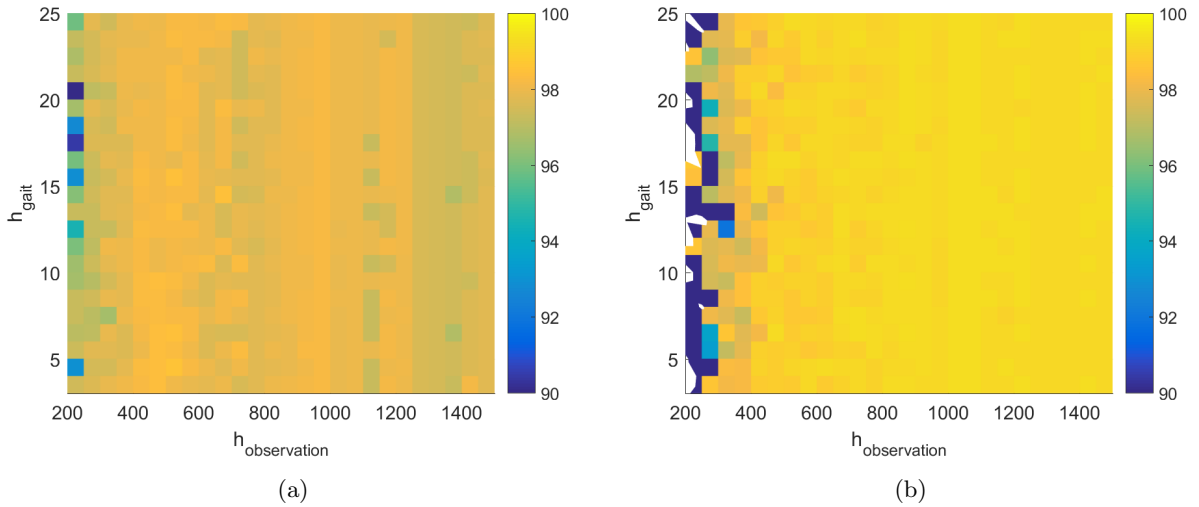

(a)

(b)

Figure 15: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 4. (a): first section of experiment. (b): second section of experiment.
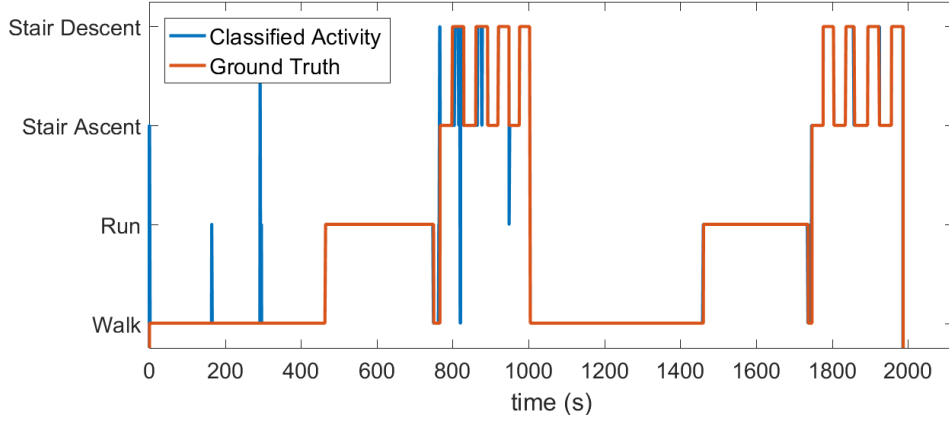
Figure 16: Classified acttivities and the Ground Truth, Subject 4.

Table 18: Overall accuracy and MCC of the two experiment sections, Subject 4.

	First section	Second section
Overall accuracy	97.56%	99.34%
MCC	0.9522	0.9888

Table 19: Confusion matrix of the first section of experiments, Subject 4.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.34%	0.90%	0.28%	0.48%
	Running	0.40%	99.60%	0.00%	0.00%
	Stair ascent	0.00%	0.50%	98.64%	0.85%
	Stair descent	1.20%	0.00%	10.70%	88.10%

Table 20: Confusion matrix of the second section of experiments, Subject 4.

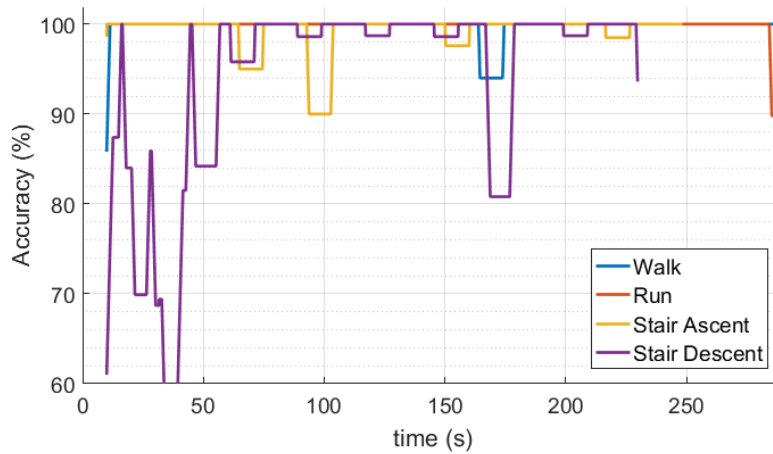|		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.40%	0.32%	0.28%	0.00%
	Running	0.34%	99.66%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	99.70%	0.30%
	Stair descent	0.00%	0.00%	2.07%	97.93%

Figure 17: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 4.

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2.7 Results of Subject 5

Fig. 18 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 19 is the classified activities, Tab. 21 shows the overall accuracy and MCC in the two experiment sections, Tab. 22- 23 are the confusion matrices, Fig. 20 is the accuracy in most recent 1000 samples.
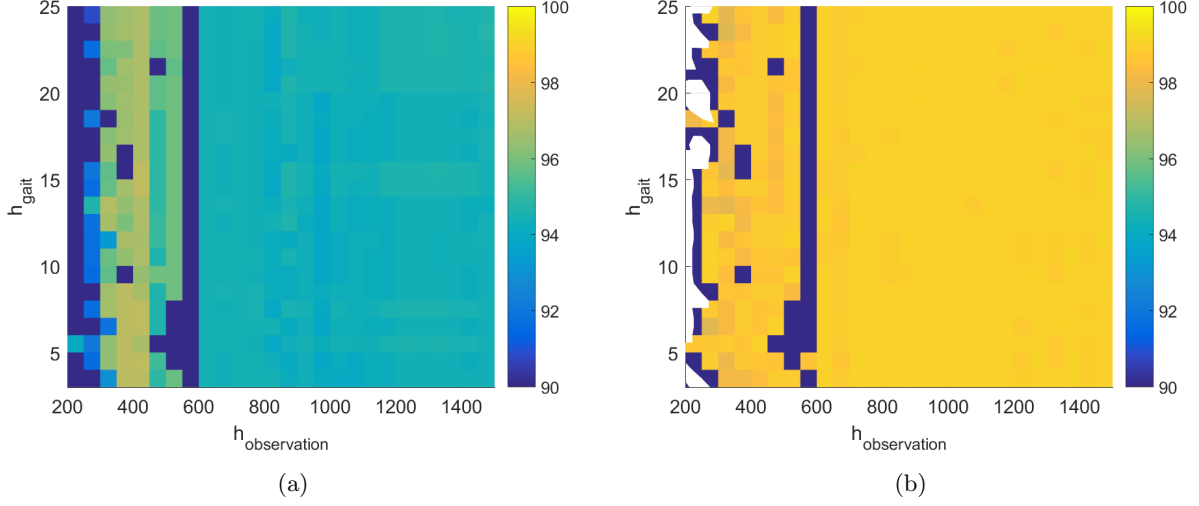

Figure 18: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 5. (a): first section of experiment. (b): second section of experiment.
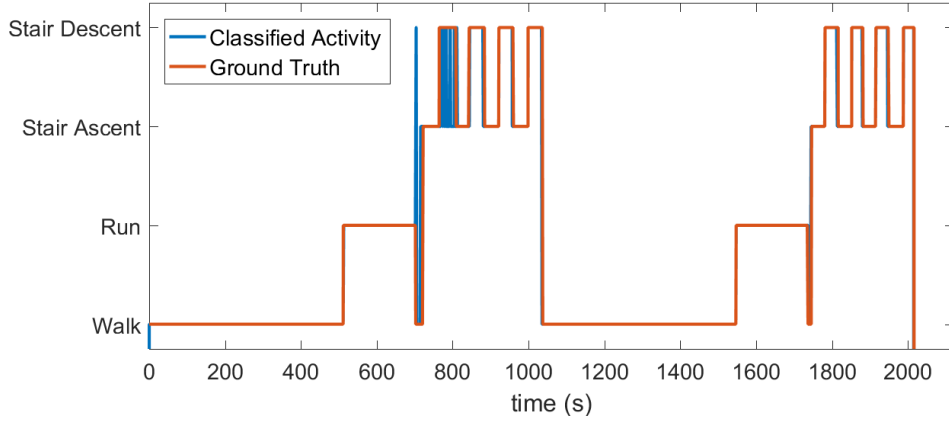

Figure 19: Classified acttivities and the Ground Truth, Subject 5.

Table 21: Overall accuracy and MCC of the two experiment sections, Subject 5.

	First section	Second section
Overall accuracy	94.49%	98.99%
MCC	0.9055	0.9800

Table 22: Confusion matrix of the first section of experiments, Subject 5.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.25%	0.34%	1.24%	0.17%
	Running	0.54%	99.46%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	99.25%	0.75%
	Stair descent	1.20%	0.00%	26.90%	71.89%

Table 23: Confusion matrix of the second section of experiments, Subject 5.

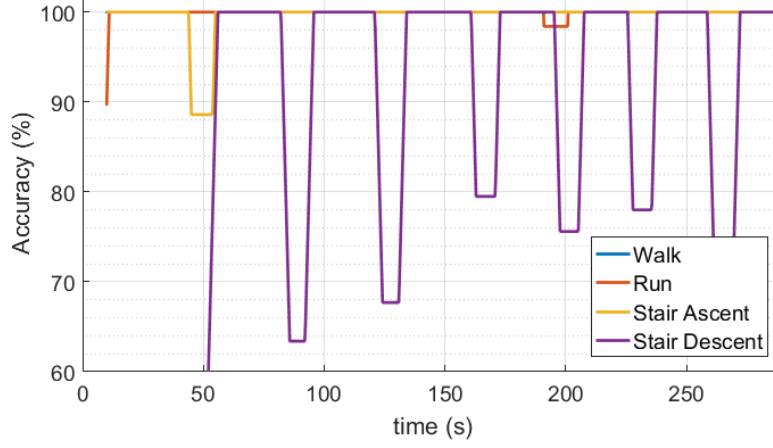|		Prediected as			
		Walkijng	Running	Stair ascent	Stair descent
Actual activity	**Walkijng**	99.73%	0.02%	0.26%	0.00%
	Running	0.08%	99.92%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	100.00%	0.00%
	Stair descent	0.00%	0.00%	6.60%	93.40%

Figure 20: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 5.

2.8 Results of Subject 6

Fig. 21 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 22 is the classified activities, Tab. 24 shows the overall accuracy and MCC in the two experiment sections, Tab. 25- 26 are the confusion matrices, Fig. 23 is the accuracy in most recent 1000 samples.
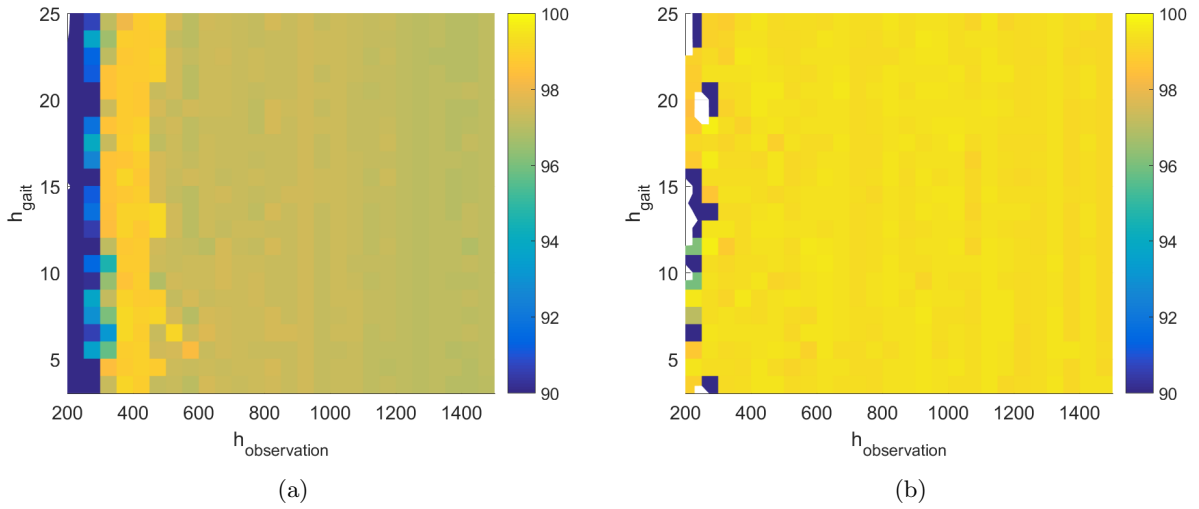

Figure 21: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 6. (a): first section of experiment. (b): second section of experiment.
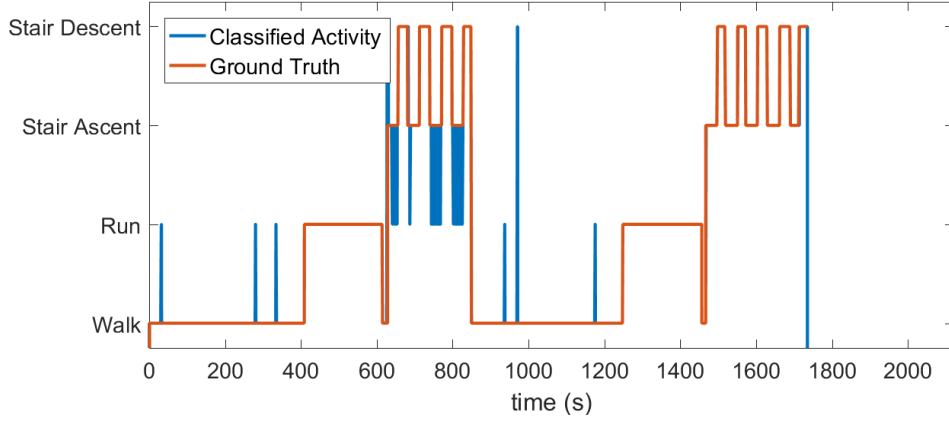
Figure 22: Classified acttivities and the Ground Truth, Subject 6.

Table 24: Overall accuracy and MCC of the two experiment sections, Subject 6.

	First section	Second section
Overall accuracy	97.32%	99.30%
MCC	0.9548	0.9888

Table 25: Confusion matrix of the first section of experiments, Subject 6.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.20%	0.49%	0.00%	0.31%
	Running	0.16%	99.84%	0.00%	0.00%
	Stair ascent	0.00%	13.53%	84.62%	1.86%
	Stair descent	0.00%	0.00%	0.31%	99.69%

Table 26: Confusion matrix of the second section of experiments, Subject 6.

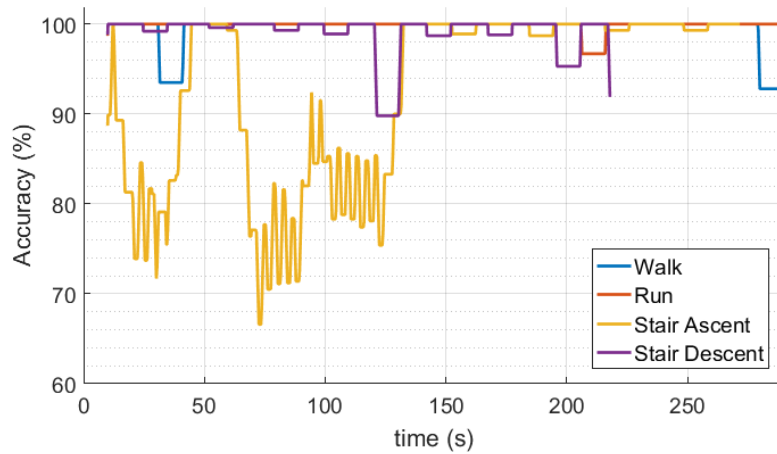|		Prediected as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.33%	0.34%	0.00%	0.33%
	Running	0.13%	99.87%	0.00%	0.00%
	Stair ascent	0.66%	0.00%	99.08%	0.25%
	Stair descent	0.00%	0.00%	1.57%	98.43%

Figure 23: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 6.

2.9 Results of Subject 7

Fig. 24 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 25 is the classified activities, Tab. 27 shows the overall accuracy and MCC in the two experiment sections, Tab. 28- 29 are the confusion matrices, Fig. 26 is the accuracy in most recent 1000 samples.
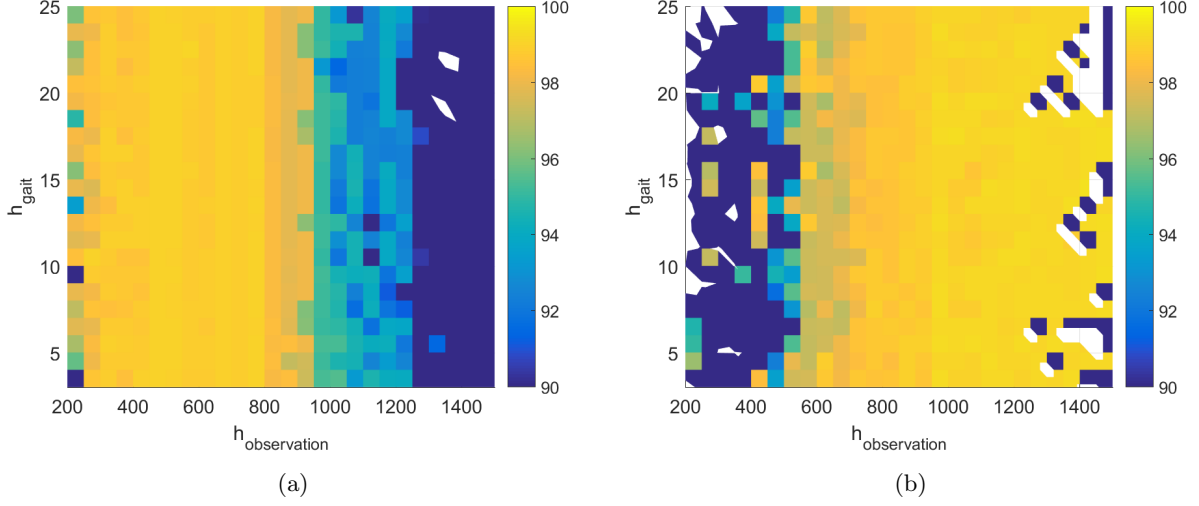

Figure 24: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 7. (a): first section of experiment. (b): second section of experiment.
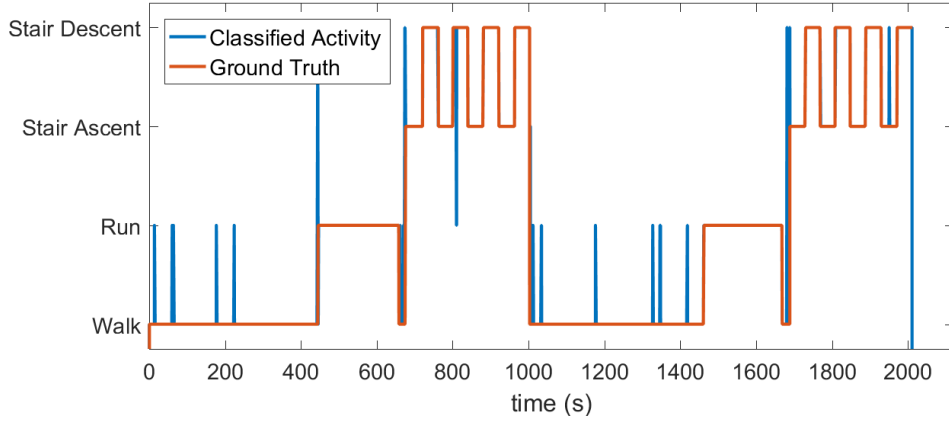

Figure 25: Classified acttivities and the Ground Truth, Subject 7.

Table 27: Overall accuracy and MCC of the two experiment sections, Subject 7.

	First section	Second section
Overall accuracy	98.83%	98.56 %
MCC	0.9836	0.9787

Table 28: Confusion matrix of the first section of experiments, Subject 7.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	98.21%	1.17%	0.00%	0.62%
	Running	0.33%	99.57%	0.00%	0.09%
	Stair ascent	0.00%	0.00%	99.60%	0.40%
	Stair descent	0.00%	0.39%	0.75%	98.86%

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Table 29: Confusion matrix of the second section of experiments, Subject 7.

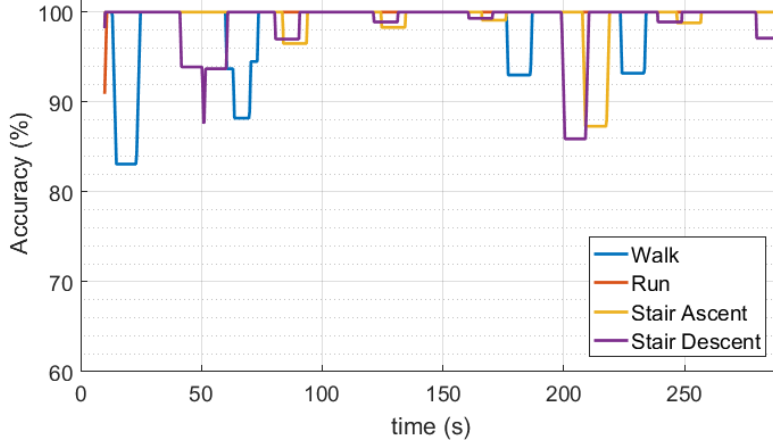|		Predicted as			
		Walkijng	Running	Stair ascent	Stair descent
Actual activity	Walkijng	97.99%	1.31%	0.34%	0.36%
	Running	0.08%	99.92%	0.00%	0.00%
	Stair ascent	0.00%	0.00%	98.30%	1.70%
	Stair descent	0.00%	0.00%	1.19%	98.81%

Figure 26: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 7.

2.10 Results of Subject 8

Fig. 27 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 28 is the classified activities, Tab. 30 shows the overall accuracy and MCC in the two experiment sections, Tab. 31- 32 are the confusion matrices, Fig. 29 is the accuracy in most recent 1000 samples.
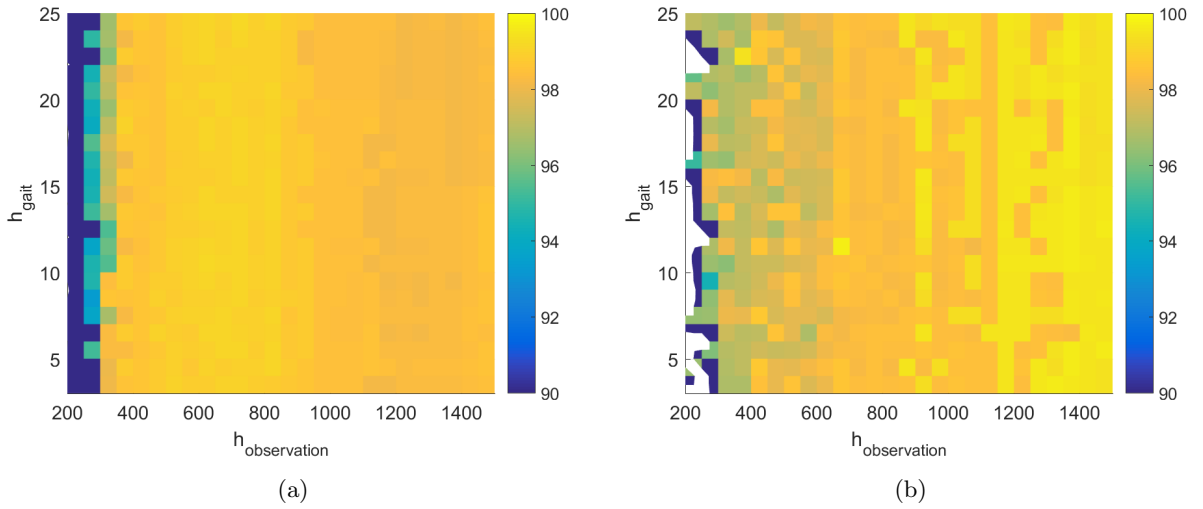

(a)

(b)

Figure 27: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 8. (a): first section of experiment. (b): second section of experiment.
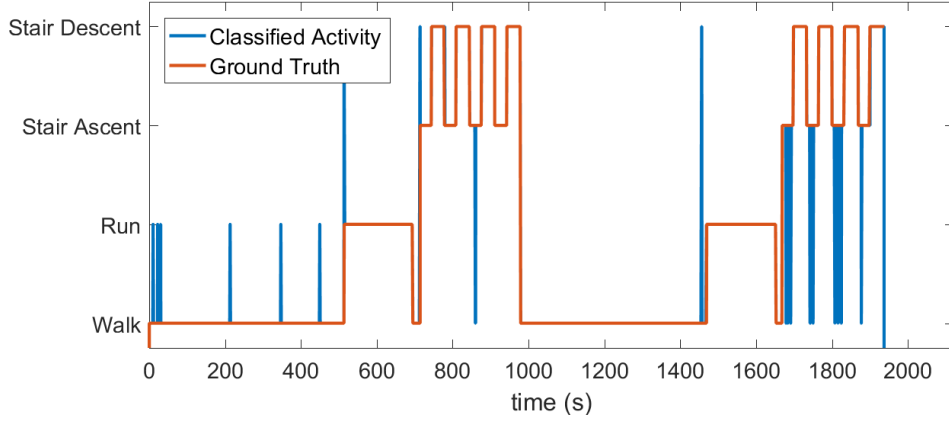
Figure 28: Classified acttivities and the Ground Truth, Subject 8.

Table 30: Overall accuracy and MCC of the two experiment sections, Subject 8.

	First section	Second section
Overall accuracy	98.83%	98.41 %
MCC	0.9835	0.9745

Table 31: Confusion matrix of the first section of experiments, Subject 8.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.06%	0.71%	0.00%	0.23%
	Running	0.00%	99.60%	0.00%	0.40%
	Stair ascent	0.88%	0.00%	97.73%	1.39%
	Stair descent	0.00%	0.00%	0.70%	99.30%

Table 32: Confusion matrix of the second section of experiments, Subject 8.

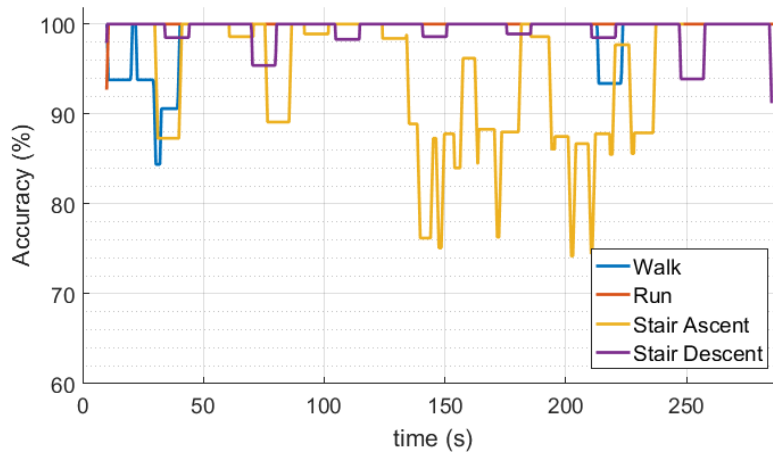|		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.65%	0.15%	0.00%	0.20%
	Running	0.00%	100.00%	0.00%	0.00%
	Stair ascent	8.91%	0.00%	90.49%	0.60%
	Stair descent	0.00%	0.00%	0.70%	99.30%

Figure 29: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 8.

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2.11 Results of Subject 9

Fig. 30 shows the overall accuracy of the two sections, *w.r.t.* corresponding threshold. At the value of $h_{observation} = 700$ and $h_{gait} = 6$, Fig. 31 is the classified activities, Tab. 33 shows the overall accuracy and MCC in the two experiment sections, Tab. 34- 35 are the confusion matrices, Fig. 32 is the accuracy in most recent 1000 samples.
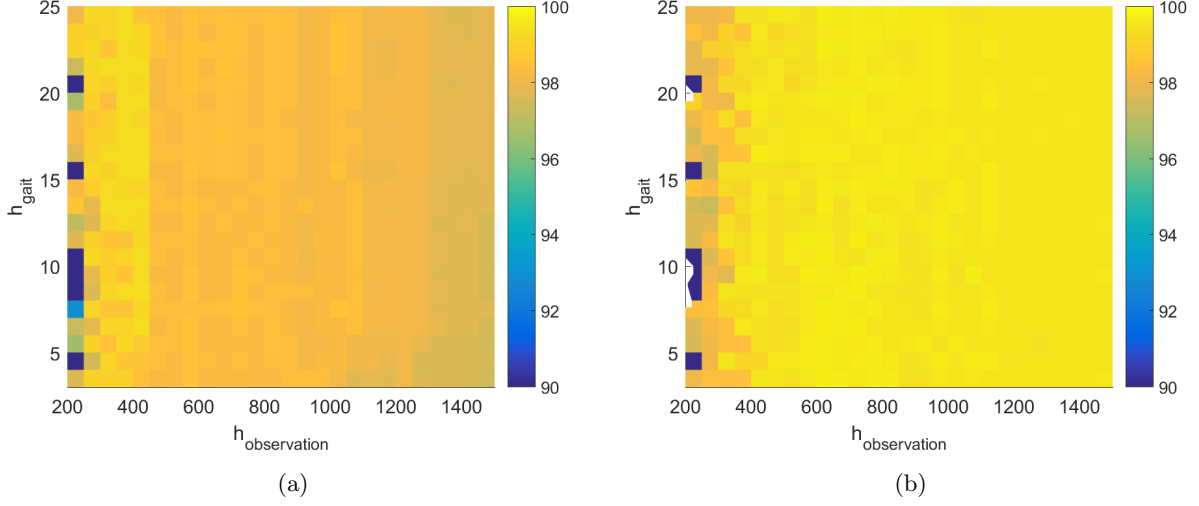

Figure 30: Overall accuracy corresponding to $h_{observation}$ and h_{gait}, Subject 9. (a): first section of experiment. (b): second section of experiment.
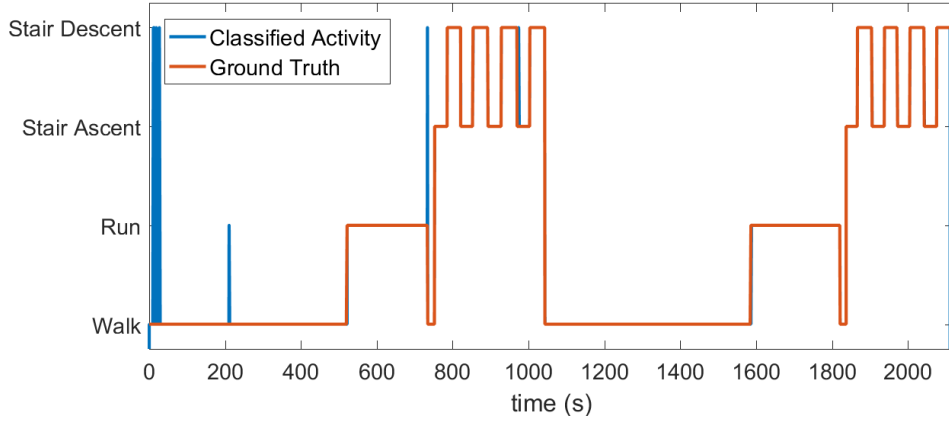

Figure 31: Classified acttivities and the Ground Truth, Subject 9.

Table 33: Overall accuracy and MCC of the two experiment sections, Subject 9.

	First section	Second section
Overall accuracy	98.47%	99.69 %
MCC	0.9773	0.9948

Table 34: Confusion matrix of the first section of experiments, Subject 9.

		Predicted as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	97.72%	1.18%	0.00%	1.10%
	Running	0.08%	99.54%	0.00%	0.39%
	Stair ascent	0.10%	0.00%	98.54%	1.36%
	Stair descent	0.00%	0.00%	0.47%	99.53%

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Table 35: Confusion matrix of the second section of experiments, Subject 9.

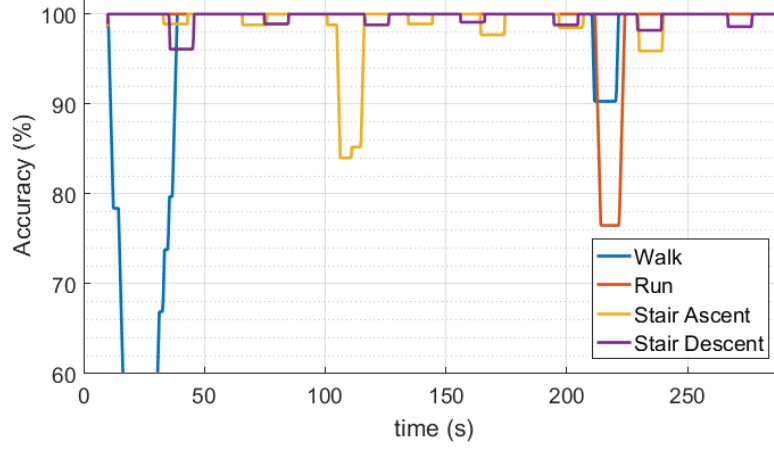|		Prediected as			
		Walkijng	**Running**	**Stair ascent**	**Stair descent**
Actual activity	**Walkijng**	99.93%	0.01%	0.00%	0.06%
	Running	0.64%	99.36%	0.00%	0.00%
	Stair ascent	0.09%	0.00%	99.30%	0.62%
	Stair descent	0.00%	0.00%	0.36%	99.64%

Figure 32: Accuracy in the most recent 1000 samplings *w.r.t.* each activities, Subject 9.