Hybrid algorithm for floor detection using GSM signals in indoor localisation task

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Introduction

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- In the method, we measure vectors of GSM signals strengths (fingerprints) in points labelled by three coordinates: x, y, and z.
- Using machine learning techniques – random forests – one can create a model that map fingerprints into coordinates
- The method allow the user to obtain good results for horizontal localisation

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- Even one floor error is a gross error that can make a localisation useless.
- A pure classification method may be not good enough to solve the floor detection problem using GSM data.

Solution

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  - detection of the points that can be used to change a floor
  - regression of the height that allows us to estimate the direction and the change of the height
- The solution cannot be used in real–time applications, but it is useful to monitor the behaviour of paroling units both human and robots.

Floor detection algorithm - learning

- As a learning set a single record of the learning track is used.
  - The track is an ordered set of points with recorded fingerprints
  - The points are also labelled with a horizontal coordinate z [m]
  - All following point with $\delta z > 0.1$ are labelled as *Change*

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  - All following point with $\delta z > 0.1$ are labelled as *Change*
- The learning trace is used to create
  - A classification method that detects *Change* points
    - SVM, One–Class SVM, RUSBoost
  - A regression function to estimate the height on the track
    - bagging regression tree

Floor detection algorithm - implementation

On the testing track that contains similar points

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- For each sequence of *Change* points the regression function recognises a direction
- Each sequence obtains a high difference estimated on the base of the number of points in the sequence and the constant d [m],
- The heigh on the whole route is normalised using the regression results.

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$$\bar{f}_i = \frac{\max \hat{f}(f_i - \min_i(f_i))}{\max_i(f_i) - \min_i(f_i)} \text{ for } i = 1, \ldots, h, \qquad (1)$$

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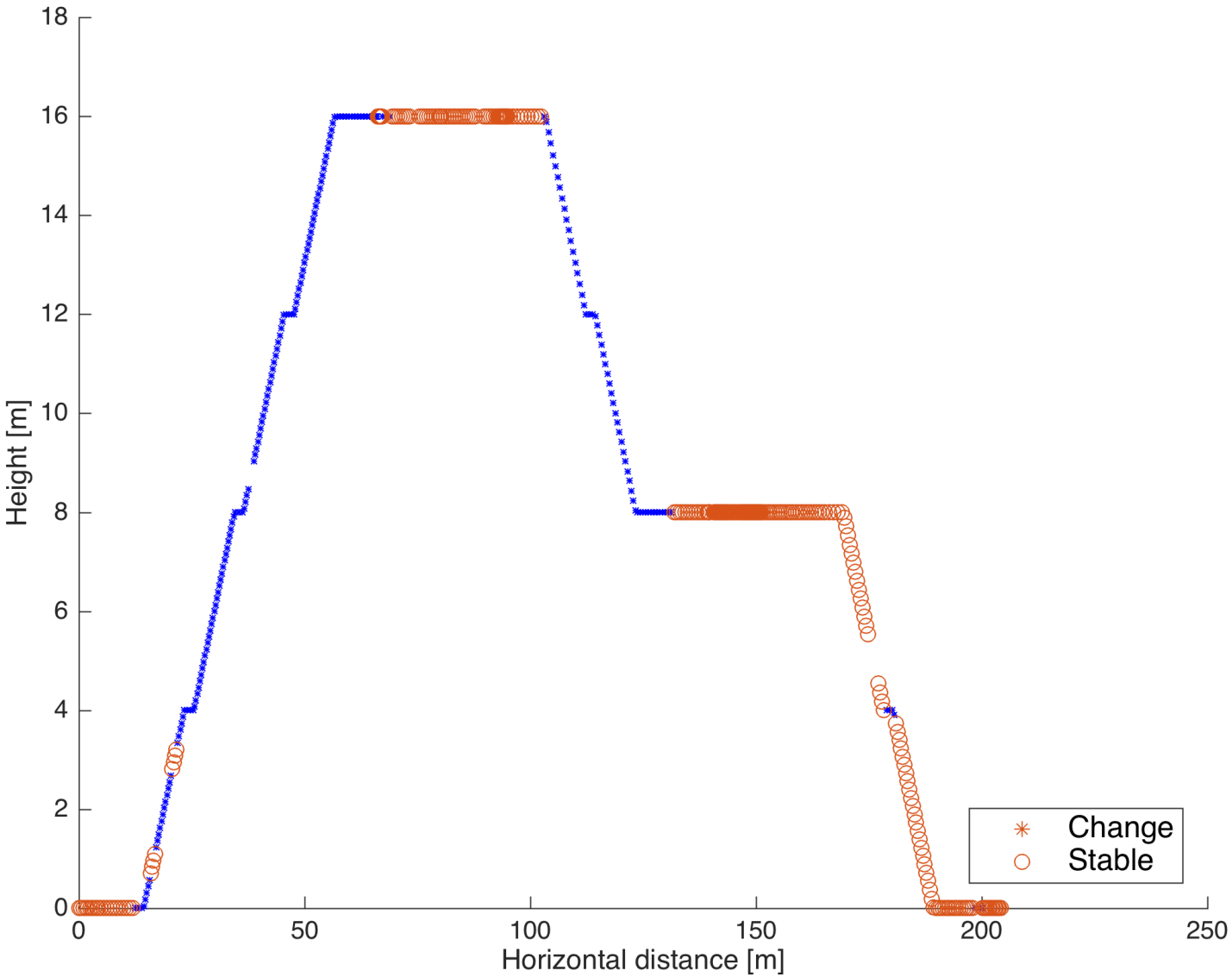
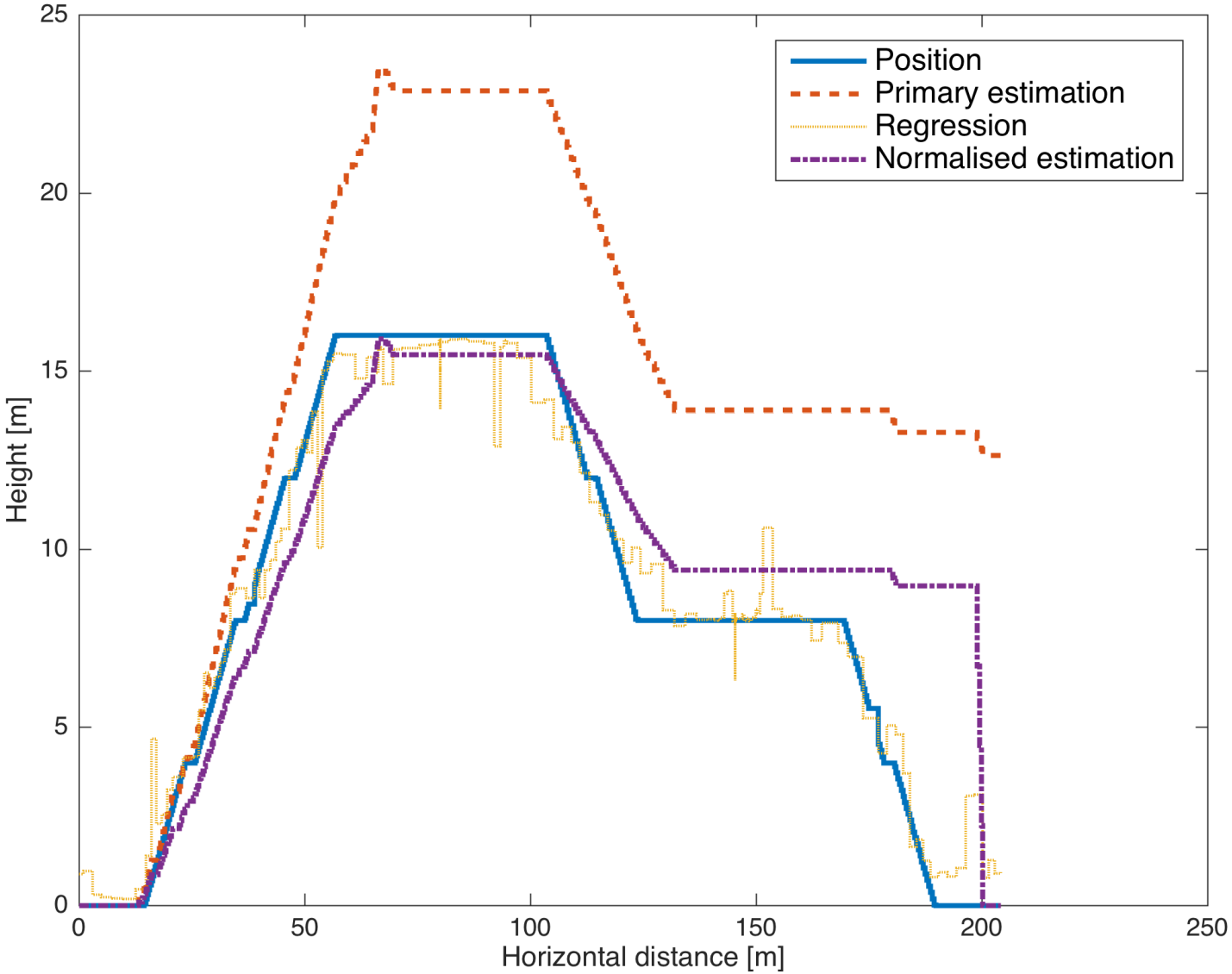
The second part of points is normalised using the following formula

$$\bar{f}_i = \frac{\bar{f}_h(f_i - f_h)}{f_h - \min_i(f_i)} + \bar{f}_h \text{ for } i = h+1, \ldots, n \tag{2}$$

Change detection



Height estimation



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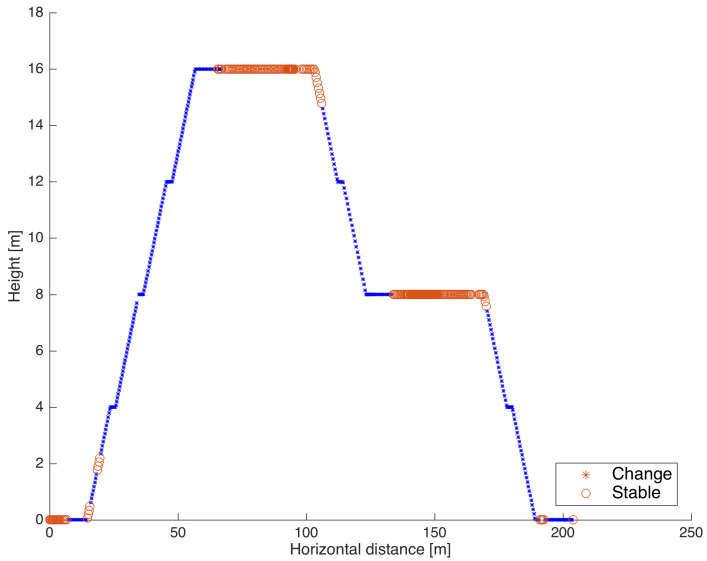
- All tracks were registered by a mobile phone held in a hand.

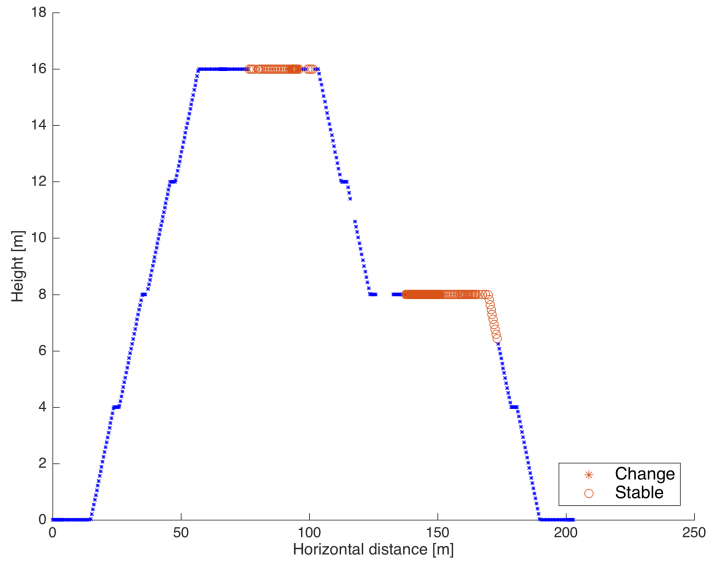
Floor change detection

Table: Height change detection using SVM

Track	TP	FP	TN	FN	TPR	FPR	ACC	F1
41944	155	50	597	60	0.72	0.08	0.87	0.74
41935	118	24	505	357	0.25	0.05	0.62	0.38
41942	235	29	538	135	0.64	0.05	0.82	0.74
41945	122	36	318	84	0.59	0.10	0.79	0.67
45268	205	9	639	146	0.58	0.01	0.84	0.73
49055	193	19	365	108	0.64	0.05	0.81	0.75
49057	174	10	262	144	0.55	0.04	0.74	0.69

Floor change detection tests





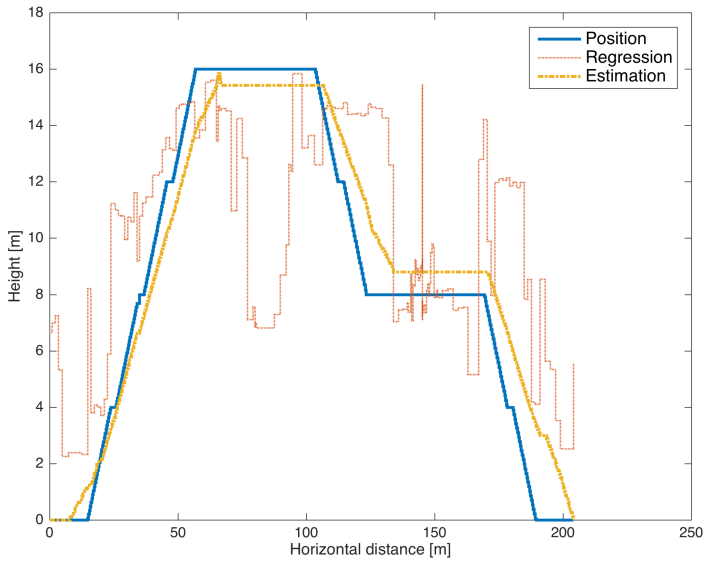
Floor change detection obtained a month after registration of the learning track.

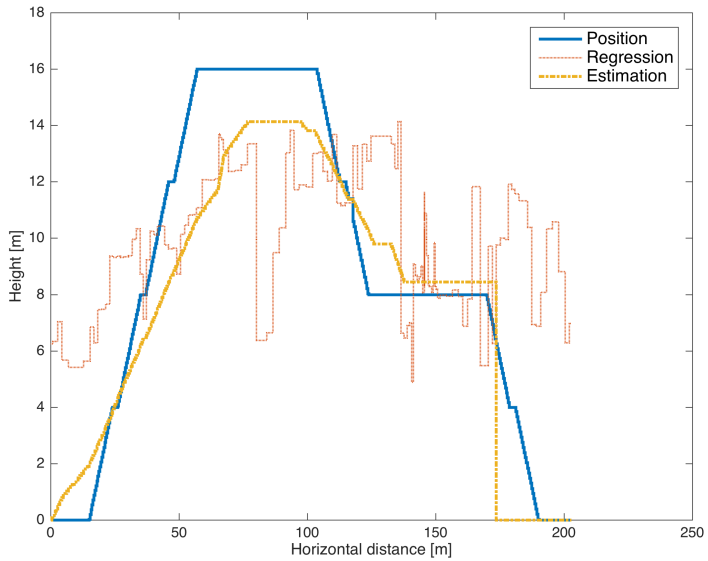
Height estimation

Table: Height estimation using GSM signals and SVM

Track	Reg. mean	Est. mean	Reg. median	Est. median	Reg. 80 perc	Est. 80 perc
41944	0.44	1.49	0.16	1.41	0.76	1.42
41935	2.66	1.10	1.84	0.91	4.83	1.83
41942	2.34	3.10	1.62	3.37	4.63	4.41
41945	2.16	1.23	1.14	0.56	3.94	2.14
45268	2.38	0.82	1.56	0.56	4.45	1.10
49055	3.42	1.06	2.31	0.76	6.69	1.62
49057	3.47	1.47	2.83	0.91	6.08	2.20

Height estimation tests





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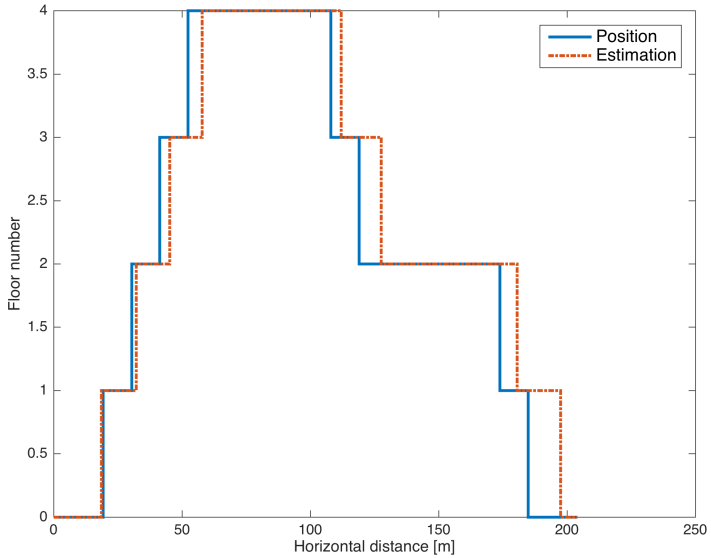
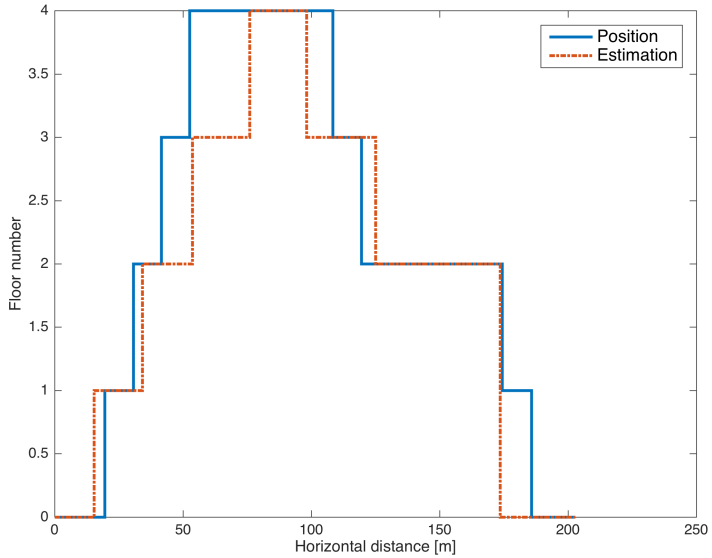
Floor detection accuracy

Table: Floor detection using SVM

Track	Regression [%]	Estimation [%]	Regression [m]	Estimation [m]
41944	92.46	84.57	31.04	47.72
41935	49.30	81.27	22.41	50.89
41942	53.90	41.09	21.17	41.02
41945	60.89	75.54	50.87	50.87
45268	51.45	87.59	18.83	63.09
49055	42.77	82.92	17.17	50.27
49057	33.56	71.69	17.54	48.49

Floor detection tests





Floor detection obtained a month after registration of the learning track.

Conclusions

- The proposed algorithm solves the floor detection problem for a route observation using the floor change points detection and the height regression.

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- The accuracy for data collected one month after the training data was 71.7 and 82.9 percent for the two analysed tracks.

Conclusions

- The proposed algorithm solves the floor detection problem for a route observation using the floor change points detection and the height regression.
- We obtained results that are several dozen percent better that the results obtained by the pure regression.
- The accuracy for data collected one month after the training data was 71.7 and 82.9 percent for the two analysed tracks.
- In the future we want to compare the obtained results with other floor detection methods such as using pressure measurement and to use a wider set of route scenarios.

Acknowledgement

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