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Heuristic for Channel Prediction of WLAN Channels

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Abstract

Impairments in wireless data communication due to time and location dependent errors can be overcome by using channel-adaptive techniques, like channel-aware scheduling or adaptive modulation. These techniques require information about future channel behaviour obtainable from channel predictors. In this report, we compare the performance of three heuristics for the prediction of signal strength: one assumes that it will have he same value as the last sample (OS); the second one assumes that it will behave according to the average over the last N channel samples (MA); the last one predicts a linear channel behaviour from the last available channel sample, the gradient being obtained from a linear regression over the last N samples (LP). These heuristics are compared with a reference predictor from the literature.

The simulative evaluation of the prediction accuracy is done using channel traces obtained from a measurement campaign in several indoor and outdoor environments typical for WLAN hotspots, and the results averaged over all measurement runs. We measure the performance of the predictors on the mean squared value of the prediction error normalised to the power of the original signal. The results show that up to a prediction horizon of 2 ms the OS predictor is more accurate, but for farther horizons the MA with N=30 performs best. In all cases studied, the reference predictor performed badly und showed instability when channel samples were missing.

We also use simulations to study the performance of a threshold based adaptive modulation scheme based on the prediction of signal strength from the predictors studied. In a capacity study, at least 15% of the capacity is lost for prediction horizons farther than 2 ms, but for shorter horizons the OS can achieve better performance. In a performance study for packetised data, the packet loss rate increases 1 to 2 orders of magnitude when channel prediction is used when compared to the perfect prediction. Further performance losses occur due to the delayed arrival of channel samples at the instance which makes decisions, since the feedback delay increases the necessary prediction horizon. For feedback delays beyond 2 ms, the packet loss rate does not depend on the horizon of packet length used anymore, and stays constant for increasing feedback delay at values 3 orders of magnitude higher than the value for perfect channel prediction.

Contents

Chapter 1

Introduction

The time- and location-dependent error behaviour of the wireless channel causes impairments to data communications. Thus, to enhance the performance of wireless data transmission it is most important to adapt transmission parameters to the channel behaviour, e.g. adaptive modulation and coding [23], channel-aware scheduling [3, 16] or multi-user diversity [13, 22]. All these solutions rely on the existence of an indicator of future channel behaviour, which must be delivered by a *channel predictor*.

Although it has been shown that channel adaptive mechanisms are very efficient in improving the communication over wireless links, it is usually assumed that a perfect channel exists. In most cases, the effects of inaccurate channel prediction in the performance of adaptive techniques is not studied. Further, comparative evaluations of the accuracy of prediction methods are, to our knowledge, not available with the exception of a study by Semmelrodt [19]. The channel predictors presented therein are based on auto-regressive models of the fading process or on adaptive filters, and their accuracy is very sensitive to the time-variance of the channel. Nevertheless we select the best of those predictors as a reference for our study, it will be referred to as ¡D2¿Modified Covariance¡D3¿ (MC)

In this scenario, heuristics are an attractive low-complexity alternative, but an evaluation of their accuracy and a comparison to existing predictors is missing. This report is devoted to a fundamental investigation of the accuracy of three heuristics for the prediction of the amplitude of the received signal:

- the channel indicator does not change, i. e. the predicted value is the same as the last measured one—which we call *one step (OS)* prediction;
- the channel indicator changes according to the average of a certain amount N of recent channel samples—which we call *moving average (MA)* prediction ;
- the channel indicator changes linearly according to the trend of a certain amount N of recent channel samples—which we call *linear prediction (LP)*.

For a more realistic evaluation, we conducted a measurement campaign in several indoor and outdoor environments typical for WLAN and used the traces to assess the accuracy of the prediction through simulations. As metric we use the mean squared value of the prediction error (MSE) normalised to the power of the original signal.

Although the MSE metric is general, its meaning for channel adaptivity hard to grasp. Thus, we study the effects of channel prediction errors in a simple adaptive modulation scheme. We use the average amount of bits per transmitted symbol—a measured of capacity—for a flow of bits. We also study the case of packetised data including the effect of channel samples delayed by feedback; in this case the packet loss rate is the metric.

In the next chapter we give an overview of existing wireless channel prediction algorithms and then introduce in detail the prediction algorithms that we study. In Chapter 3 we describe the measurement campaign which produced the measurement traces used in the simulative study. Chapter 4 we show the performance evaluation in terms of MSE and in Chapter 5 we evaluate the influence of the predictors on the performance of a simple adaptive modulation scheme. We make the concluding remarks in Chapter 6.

Chapter 2

Wireless Channel Prediction

2.1 Related Work

Reference [9] introduces the Long Range Predictor (LRP): a prediction algorithm based on an auto-regressive model (AR) for the fading process that uses the maximum entropy method (MEM) for the estimation of the AR model coefficients. The channel is undersampled to achieve a longer prediction horizon with the same AR model order and complexity; to get prediction values at the data sampling rate, the undersampled predicted values are interpolated. The metric used for accuracy of the prediction is the mean squared value of the prediction error (MSE). The performance of the algorithm is very good for a stationary Jakes channel, but degrades for non-stationary channel parameters. In [5] the authors remark that prediction accuracy is reduced by noisy samples, short observation intervals and mismatch in the AR coefficients (due to non-stationarity and short prediction windows).

Reference [4] proposes to model the channel as an FIR adaptive filter

$$s(n) = \sum_{k=1}^{n_k} h_k(n)u(n-k) + w(n)$$

with time-varying taps $h_k(n)$. The authors argue that it is easier to predict the channel taps because they change in a much slower timescale than the channel fading [20], and propose two predictors for the complex channel taps, one based on an AR model using least squares estimation and another one based on Kalman filters. The power of each tap can be calculated from the squared magnitude of the tap, and the signal power by adding the power of all taps; further a bias is added to compensate for an underestimation of the tap power. As above, the authors identify the need for noise reduction and propose Wiener smoothers, although they introduce delay. They also use sub-sampling to extend the achievable prediction range. The metric used to evaluate the performance of the predictors is the nomalised mean squared error (NMSE) of the signal power. The accuracy of the prediction algorithms according to this metric is evaluated on channel sounding measurements from a cellular provider in an urban environment. Although the algorithms presented in [9] and [4] are evaluated in different scenarios and under different channel conditions, according to the data presented in the references, the second overperforms the first in terms of NMSE for the same fraction of wavelength. The algorithms proposed could not be reproduced from the information available in the papers, and the heuristics presented here cannot be compared to the results in the references.

Reference [12] studies a wireless channel predictor based on neural networks that performs better than the Modified Covariance algorithm [19], which we use for reference. However, it should be taken into account that neural networks are far more complex than the auto-regressive model or adaptive filters.

In the literature it has often [6, 7, 15] been proposed to use the following heuristic for channel prediction: assume that the channel will not change from the last channel sample, i. e. take the last reported channel value as a prediction for the future channel value. Although [7] shows an evaluation of the accuracy of this heuristic, it is based on a good/bad Gilbert-Elliot channel model, which is realistic only to a certain extent, and an inappropriate channel model for the adaptation of transmission parameters like modulation or coding.

In the single comparative study known to us [19], Semmelrodt et al. proposes several methods for estimating the coefficients of an auto-regressive (AR) model and adaptive filters, and evaluates the prediction results using theoretical Rayleigh channels. The metric used is the normalised mean squared value of the prediction error (NMSE) for a certain fraction of wavelength. Comparing the results shown in references [19], [9] and [4], prediction of the signal envelope obtained with the best algorithms in [19] are more accurate than LRP [9] or [4] for one wavelength.

The channel predictors presented are complex and, except for the neural networks, require different calibration for specific environments. Further, they are sensitive to the time-variant nature of the wireless channel and to noise, but it has not been studied in detail to which extent. In this scenario, heuristics are an attractive low-complexity alternative, but an evaluation of their accuracy and a comparison to existing predictors is missing. In this report we evaluate the accuracy of three heuristics for channel prediction using the NMSE as metric and compare it to a reference scheduler—the Modified Covariance (MC) that performed best in the comparative study [19].

2.2 Heuristics for Wireless Channel Prediction

This section formally describes the heuristics for prediction of the signal strength. Let $s(i)$ be the received signal amplitude at discrete time instant i and $\hat{s(i)}_h$ the amplitude of the received signal at time $i+h$, predicted at time i. We compare the performance of the following three heuristics for prediction of the wireless channel:

One Step (OS)

$$\hat{s(i)}_h = s(i) \tag{2.1}$$

Moving Average (MA)

$$\hat{s(i)}_h = \frac{1}{N}\sum_{k=0}^{N-1} s(i-k), \tag{2.2}$$

i. e. the predicted value is the average of the last N channel samples.

Linear Prediction (LP)

$$\hat{s(i)}_h = (i-h) * \frac{\sum_{k=0}^{N-1} s(i-k) * k - \sum_{k=0}^{N-1} s(i-k) \sum_{k=0}^{N-1} k}{\sum_{k=0}^{N-1} k^2 - \left(\sum_{k=0}^{N-1} k\right)^2}, \tag{2.3}$$

i. e. the predicted value is given by a linear regression over the last N channel samples.

Reference Predictor For reference we chose the prediction algorithm that performed best in the comparative study [19]—Modified Covariance (MC). The MC models the received signal $s(i)$ as an AR process of order p:

$$s(i) = \sum_{k=1}^{p} a_k \cdot s(i-k) + e(i)\, i = 0 \ldots N-1 \tag{2.4}$$

where $e(i)$ is a complex white Gaussian noise process and a_k the coefficients of the AR polynomial. A linear predictor is used to extrapolate the behaviour of the process beyond the available channel samples [19, 8]:

$$s(\hat{i}) = \sum_{k=1}^{p} a_k \cdot s(i-k) \tag{2.5}$$

To obtain a predicted value it is necessary to estimate the coefficients of the model a_k. Since the wireless channel varies in time due to movement in the environment and of the sender or receiver, the model is also time-variant. However, assuming that the model remains invariant over short periods of time, the coefficients can be estimated solving a system of linear equations. Thus, the time-variant wireless channel is modeled as an AR process with time-variant coefficients $a_k(i)$, that are calculated anew each time that channel prediction is required. The MC prediction algorithm uses the least squares method to solve the system of linear equations for calculation of the model coefficients $a_k(i)$. We use a model order p=15 as proposed in [19] to predict a single signal sample $s(i \hat{+} 1)$. To predict several samples in the future, several linear predictors are cascaded, each using the previously extrapolated signal samples as input (Figure 2.1 illustrates this). Since the input to predictors down the chain are extrapolated samples (themselves inaccurate), the prediction error propagates for increasing horizons.

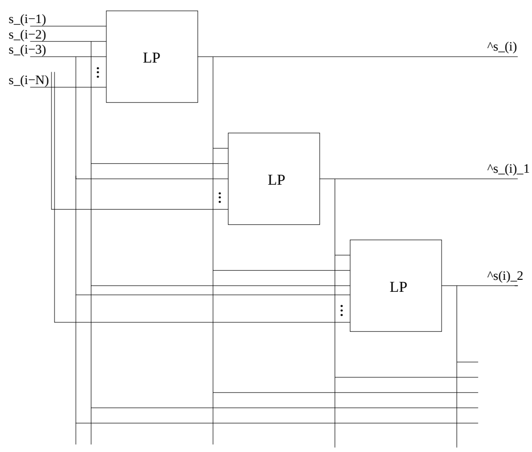


Figure 2.1: Cascaded linear predictors (LP) for predictions farther than h=1 (in the figure h=1 is represented as h=0). If $s(\hat{i})_1$ produces big errors, the errors for h¿1 will be even bigger due to the errors propagation down the chain of LP).

Chapter 3

WLAN Channel measurements

For the evaluation we used traces obtained from a wireless LAN channel measurement campaign. Here we describe briefly the setup and results of the measurement; further details can be found in [2, 1].

The measurements were performed using two laptops running the Linux operating system (kernel 2.4.17) and equipped with Lucent WLAN cards with the the PRISM2 [10] chipset. The choice was made due the availability of the source code of the card drivers, which needed to be changed. We changed the driver of the WLAN cards [11] so that no acknowledgments were sent, since waiting for link layer acknowledgements would increase the time interval between two channel samples, and we are not interested in whether packets suffer bit errors. Also, packets with a wrong CRC-check were not discarded so that we could also have signal samples for packet that suffered from bit errors, increasing the number of channel samples at low signal. The sender had a packet generator that sent UDP packets carrying 1 Byte of data every 1.3 ms. This was the minimum possible sending interval for our measurement setup due to the delays in the Linux protocol stack; although we tried shorter send intervals, packets never arrived at shorter intervals at the card.

Due to variations of the processing times inside the Linux protocol stack and internal buffering in the WLAN cards, which we could not control, the packets were not sent at exactly equidistant times and were also not equidistantly traced at the receiver. To overcome this and retrieve an equidistant time series, we re-sampled the originally measured trace of received signal at 1 KHz, where the signal value was always obtained by interpolation of the two closest measured values. Afterwards, to reduce noise, they were filtered by a moving average filter of length 30, a value that showed to be a good compromise between noise reduction and information kept.

We conducted the channel measurements in environments where WLAN coverage is plausible. The criteria for the choice of the measurement scenarios was that they should have the characteristics, in terms of mobility and surroundings, of environments where WLAN coverage might be available. Table 3.1 shows a brief description of the environments where we carried out the measurements, and Figure 3.1 shows examples of the signal variations over time for each environment. Figures 3.2 and 3.3 show the histograms and the auto-correlation function of the received signal. Table 3.2 shows the variance of the measured signal amplitude for each run and for each environment; since we measured the recieved signal amplitude on both directons, there are two traces for each run. There we can see that the signal variance increases with the mobility of the environments. The measured signal in environments with low mobility like, Maths or Mensa, has lower variance than in environments with higher

Table 3.1: Measurement scenarios. N is the number of measurement runs made in each scenario. K is the total number of sample values in each scenario after re-sampling at 1 KHz.

Scenario	N	K	Environment	Mobility
Archi	7	888249	Busy roundabout	Traffic between Base and Mobile
Carpark	7	1084395	Parking lot surrounded by buildings on 3 sides	No mobility
Maths	4	618950	Foyer of Maths building during intervals between lectures	People moving between and around Base and Mobile
Mensa	7	1088694	Student canteen of the TU Berlin at busy hour	People moving between and around Base and Mobile
Road	7	892994	Busy street	Traffic between Base and Mobile
Stadium1	2	342189	Wide open area in front of the Olympic Stadium	Pedestrian
Stadium2	2	341960	Wide open area in front of the Olympic Stadium	No mobility
Walk	3	408778	Grass surrounded by trees and bushes	Pedestrian speed

mobility, like Stadium, Road or Walk.

In the next chapter we evaluate the accuracy of the signal amplitude prediction for each environment separately, thereby averaging the MSE of an environment over all runs. In Chapter 5, we show the results obtained by averaging over all runs and all environments.

Archi

Run	S^2
1 b	0.160
1 m	0.114
2 b	0.145
2 m	0.096
3 b	0.140
3 m	0.114
4 b	0.124
4 m	0.107
5 b	0.140
5 m	0.103
6 b	0.185
6 m	0.172

Carpark

Run	S^2
1 b	0.185
1 m	0.253
2 b	0.142
2 m	0.134
3 b	0.134
3 m	0.229
4 b	0.125
4 m	0.233
5 b	0.099
5 m	0.167
6 b	0.138
6 m	0.208
7 b	0.114
7 m	0.203

Stadium 1

Run	S^2
1 b	0.438
1 m	0.773
2 b	0.433
2 m	0.784

Stadium 2

Run	S^2
1 b	0.506
1 m	0.639
2 b	0.449
2 m	0.510

Mensa

Run	S^2
1 b	0.031
1 m	0.079
2 b	0.015
2 m	0.048
3 b	0.017
3 m	0.045
4 b	0.021
4 m	0.041
5 b	0.019
5 m	0.039
6 b	0.030
6 m	0.089
7 b	0.114
7 m	0.121

Road

Run	S^2
1 b	0.154
1 m	0.243
2 b	0.236
2 m	0.183
3 b	0.313
3 m	0.225
4 b	0.478
4 m	0.353
5 b	0.237
5 m	0.208
6 b	0.355
6 m	0.245

Maths

Run	S^2
1 b	0.240
1 m	0.095
2 b	0.130
2 m	0.077
3 b	0.082
3 m	0.042
4 b	0.128
4 m	0.106

Walk

Run	S^2
1 b	0.478
1 m	0.165
2 b	0.580
2 m	0.362
3 b	0.286
3 m	0.225

Table 3.2: Variance of the each measurement run per environment.

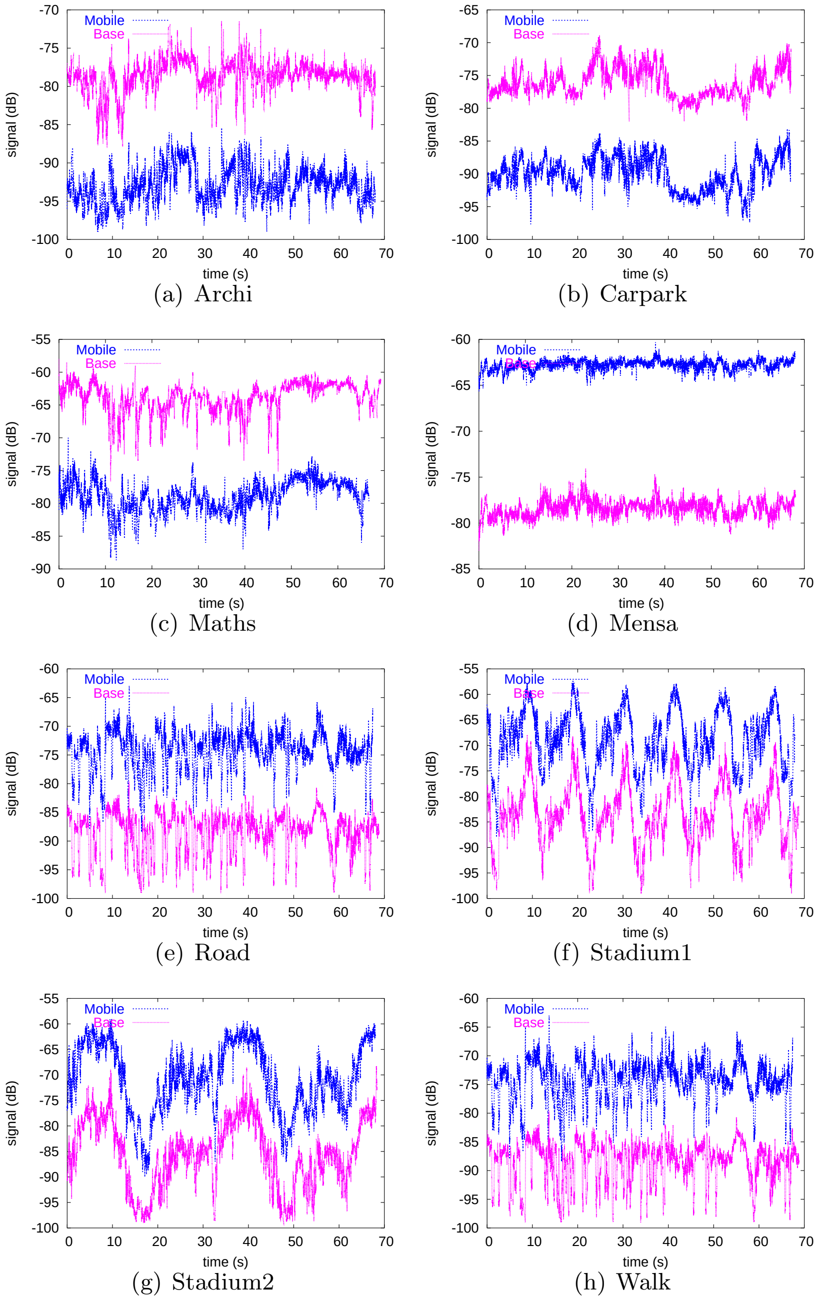


Figure 3.1: Measured received signal (after re-sampling and noise filtering).

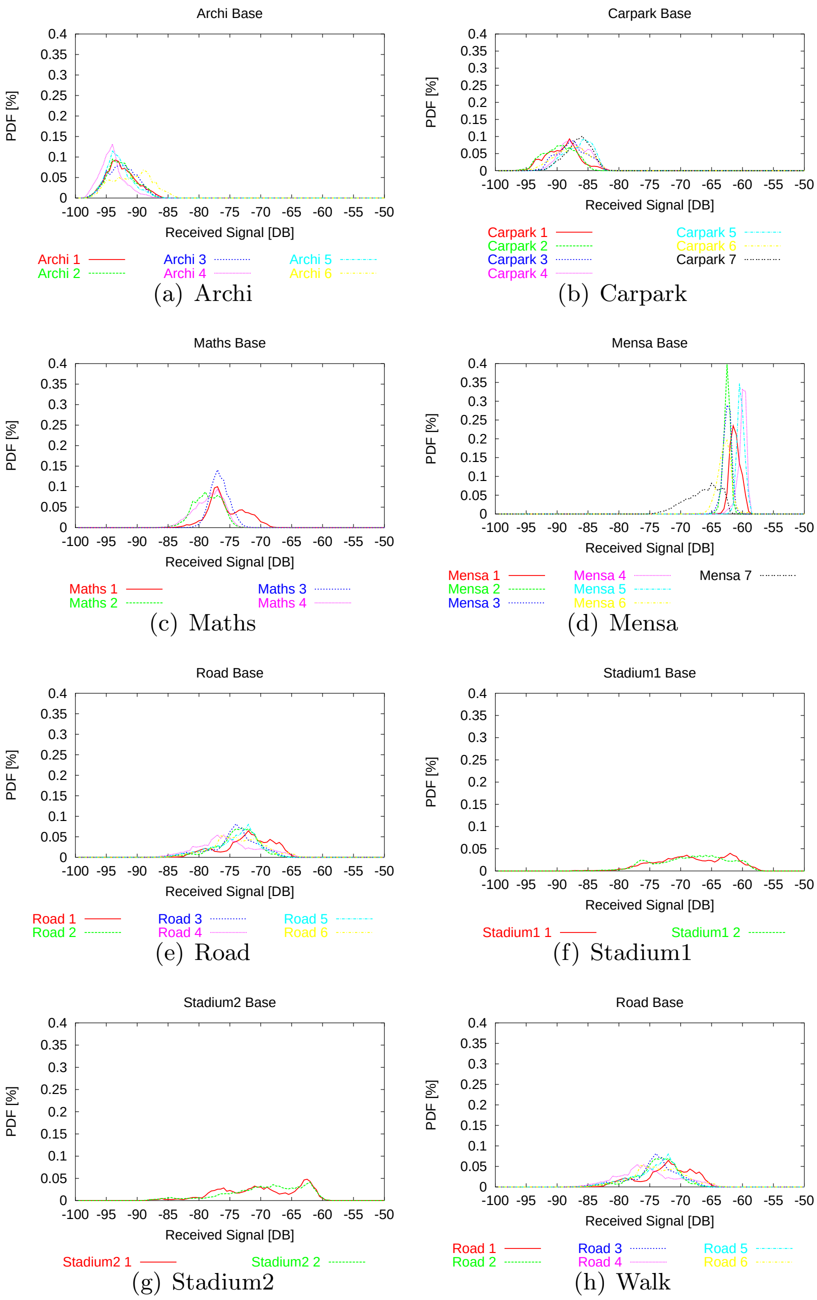
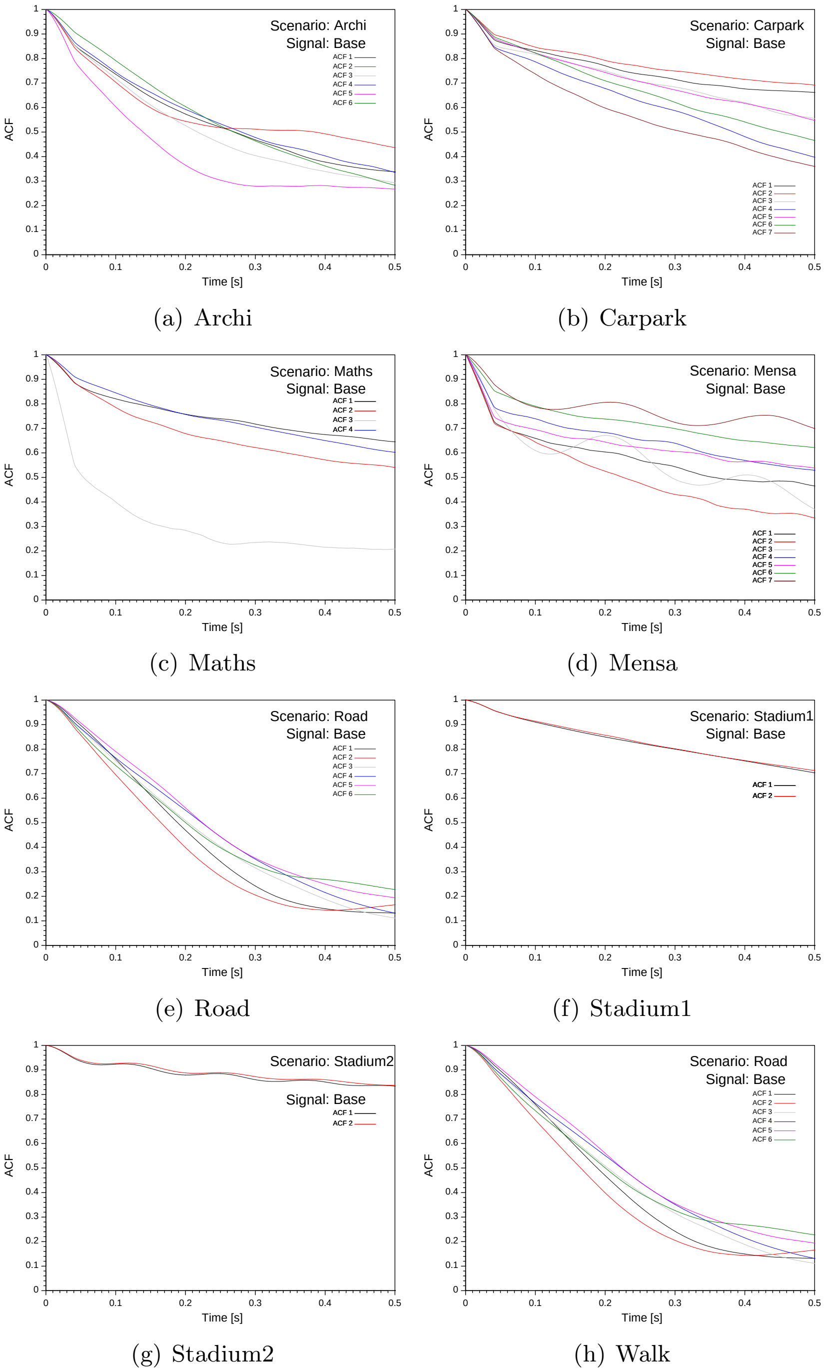


Figure 3.2: Distribution of the received signal (after re-sampling and noise filtering).



(a) Archi (b) Carpark

(c) Maths (d) Mensa

(e) Road (f) Stadium1

(g) Stadium2 (h) Walk

Figure 3.3: Autocorrelation function of the received signal (after re-sampling and noise filtering).

Chapter 4

Statistics of the accuracy

In this chapter we evaluate the accuracy of the prediction heuristics for signal amplitude in term of the normalised mean squared error. First, we describe the procedure for the calculation of the prediction errors and the metric used. Then we look at the results for each heuristic and the reference predictor, and compare them at the end of the chapter.

4.1 Simulation of Channel Prediction and Metric

We predict, at each discrete time instant i, the values of the **amplitude of the received signal** for prediction horizons h between 1 and 15 ms. Then, we calculate the prediction error—the difference between the predicted and the actual signal amplitudes $e(i)_h = \hat{s(i)}_h - s(i+h)$— for each horizon h.

The metric used to compare the performance of the channel predictors is the the *mean squared value of the normalised prediction error (NMSE)*, similarly to [9, 4, 19]:

$$\mathrm{NMSE}(h) = \frac{1}{K} \sum_{i=0}^{K-1} \frac{(e(i)_h)^2}{\sqrt{\frac{1}{K}\sum_{i=0}^{K-1} |s(i)|^2}}, \tag{4.1}$$

where K is the number of channel samples. The metric is expressed in dB

$$\mathrm{NMSE}(h)[\mathrm{dB}] = 10 \cdot \log(\mathrm{NMSE}(h)), \tag{4.2}$$

and the more negative the values, the higher the accuracy of the predictor. An NMSE of 0 dB expresses errors ith power similar to the power of the signal.

The significance of the results is calculated in terms of the 95% confidence interval of the NMSE

$$\mathrm{NMSE}(h) \pm t_{\infty,0.975}\sqrt{\frac{S^2}{K}}, \tag{4.3}$$

where $t_{\infty,0.975} = 1.960$ from Table T.1 in reference [14], and S^2 is the variance of the normalised squared error

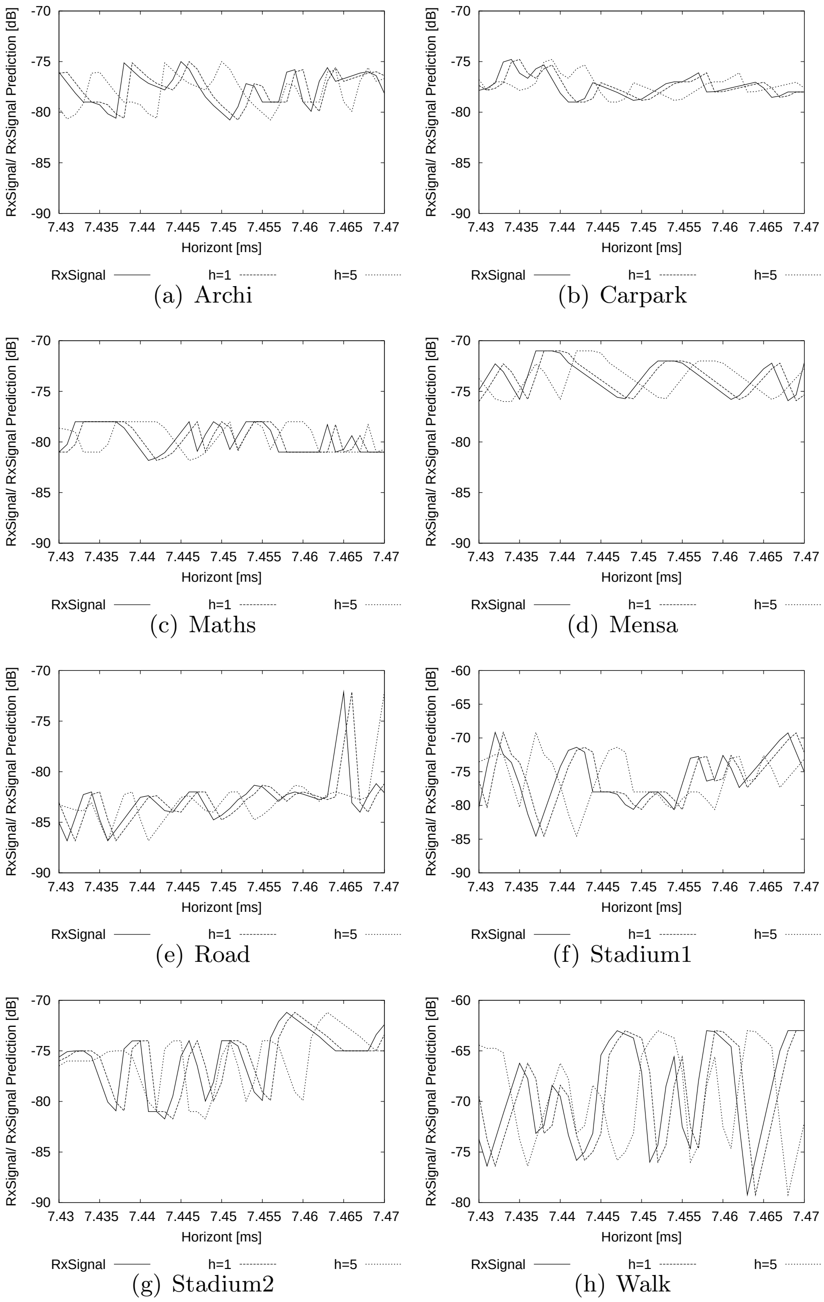
$$S^2 = \frac{1}{K} \sum_{i=0}^{K-1} \left(\frac{e(i)_h}{\sqrt{\frac{1}{K}\sum_{i=0}^{K-1} |s(i)|^2}} - \mathrm{NM\ SE}(h) \right)^2. \tag{4.4}$$

The following sections show the normalised mean squared error (NMSE) of the received signal prediction as a function of the prediction horizon h for the predictors studied. The 95% confidence intervals of the NMSE for each case are listed in Appendix A. For each predictor there are figures showing an example of the time behaviour of the received signal and its prediction for h=1 ms and h=5 ms, i. e. for time intant t_i those plots show the measured received signal and the received signal that was predicted for t_i at time instant t_{i-h}.

4.2 One Step — OS

Looking at the examples for the time behaviour of the measured an predicted signals in Figure 4.1, we see that, due to the slow signal variations, the prediction for h =1 ms follows the signal closely. For increasing horizons, the predicted signal increasingly deviates from the original signal; for $h = 5$ ms the predicted signal has no relation to the measured signal.

The NMSE in Figure 4.2 expresses these behaviours, having the lowest values for $h = 1$ ms, increasing with h and staying constant for $h \geq 4$ ms. For environments with low variability like Maths, Mensa and Archi, the NMSE is lower than for environments with higher mobility, like Walk or Stadium. As can be seen in Figure 4.1, this is due to the lower variance of the original signal amplitude in environments of low mobility.



(a) Archi (b) Carpark (c) Maths (d) Mensa (e) Road (f) Stadium1 (g) Stadium2 (h) Walk

Figure 4.1: Examples of OS channel prediction for h=1 ms and h=5 ms.

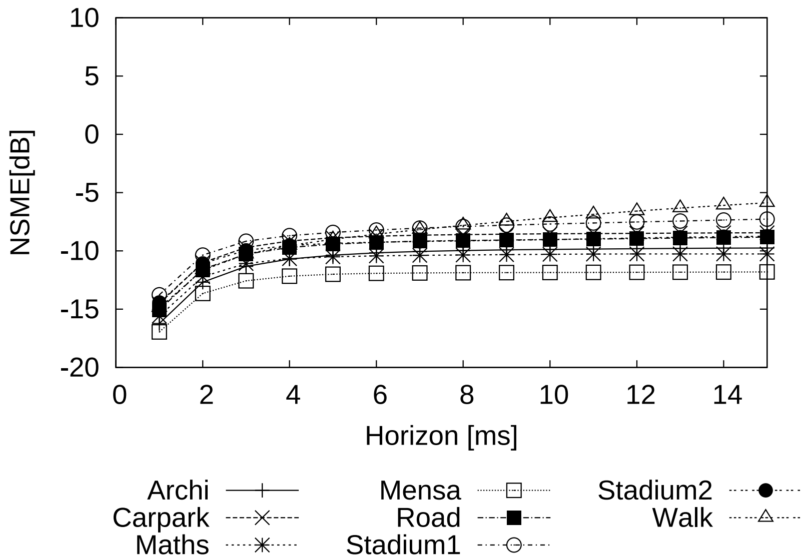


Figure 4.2: NMSE in dB of the OS predictor.

4.3 Moving Average — MA

The amount of samples used for the calculation of the moving average was varied from 5 to 30, corresponding to 5 to 30 ms. Figures 4.5 and 4.6 show samples of the received signal together with the predicted signal for horizons of 1 and 5 ms; Figures 4.3 to 4.8 show the resulting NMSE.

In Figure 4.5 we can see that for N=5, although the predicted signal takes values in the same range as the measured signal, at each time instant the predicted signal does not follow the actual signal. I. e. the prediction is random, but the variance of the predicted signal is similar to the variance of the measured signal. This is why the NMSE in Figure 4.3 for environments with bigger variations of the signal amplitude, like Road stadium and Walk, are bigger than for environment with less variation like Maths or Mensa (4.3). Further, due to the randomness of the prediction the NMSE is independent of the prediction horizon.

The MA with $N \geq 10$ samples averages out the fading, so that the predicted signal has almost no variations: it is almost constant at the average signal value (resultant from pathloss and shadowing), as can be seen in Figure 4.6) for N=30. The NMSE for each value of N is plotted in Figures 4.3 to 4.8 and Figure 4.9 shows the NMSE for varying N in each environment. The NMSE does not change with increasing N, as is expected from an average value, and the (in)accuracy does not vary with the prediction horizon (the reason for this was given in the previous paragraph).

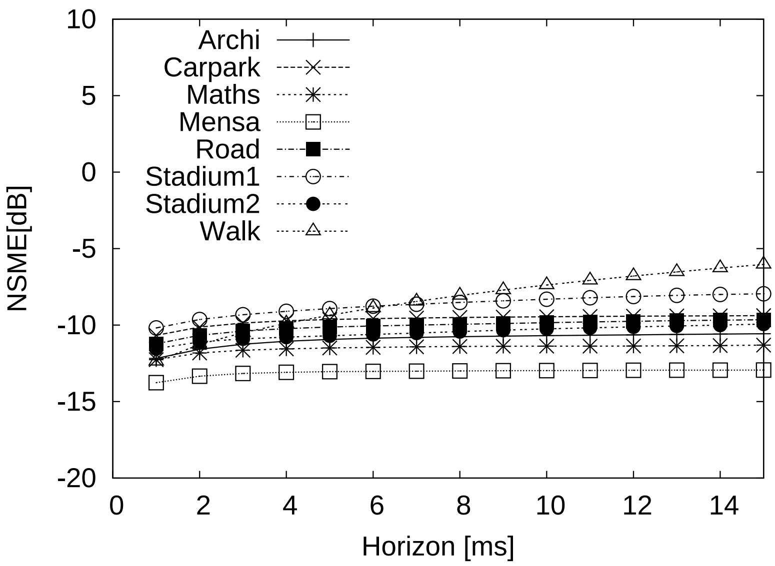


Figure 4.3: NMSE of the MA prediction algorithm with N=5.

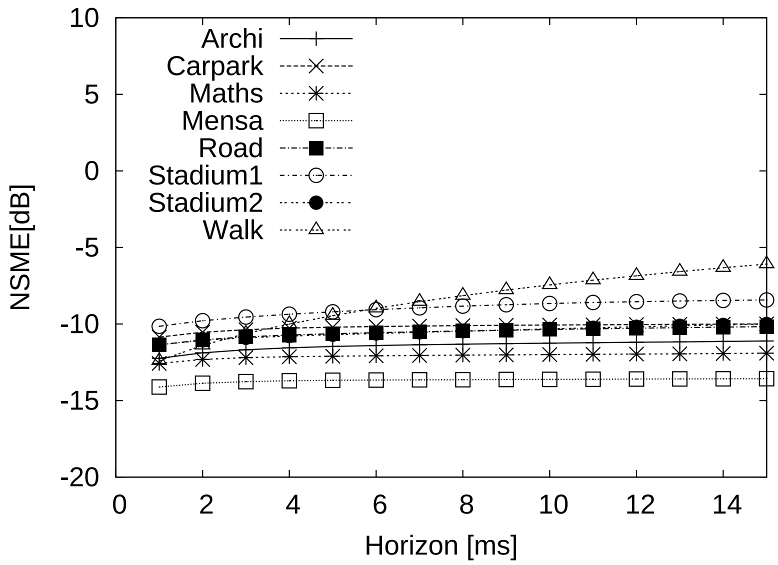
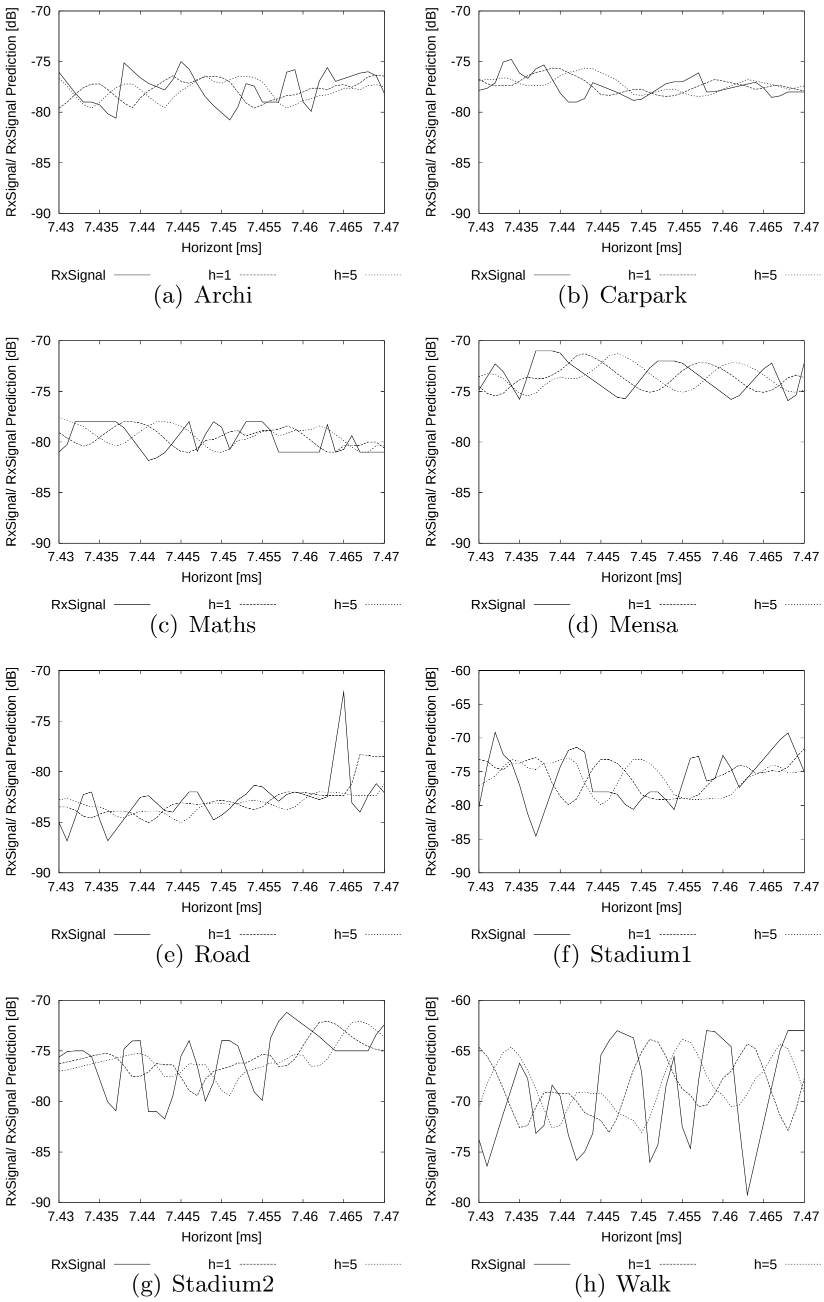
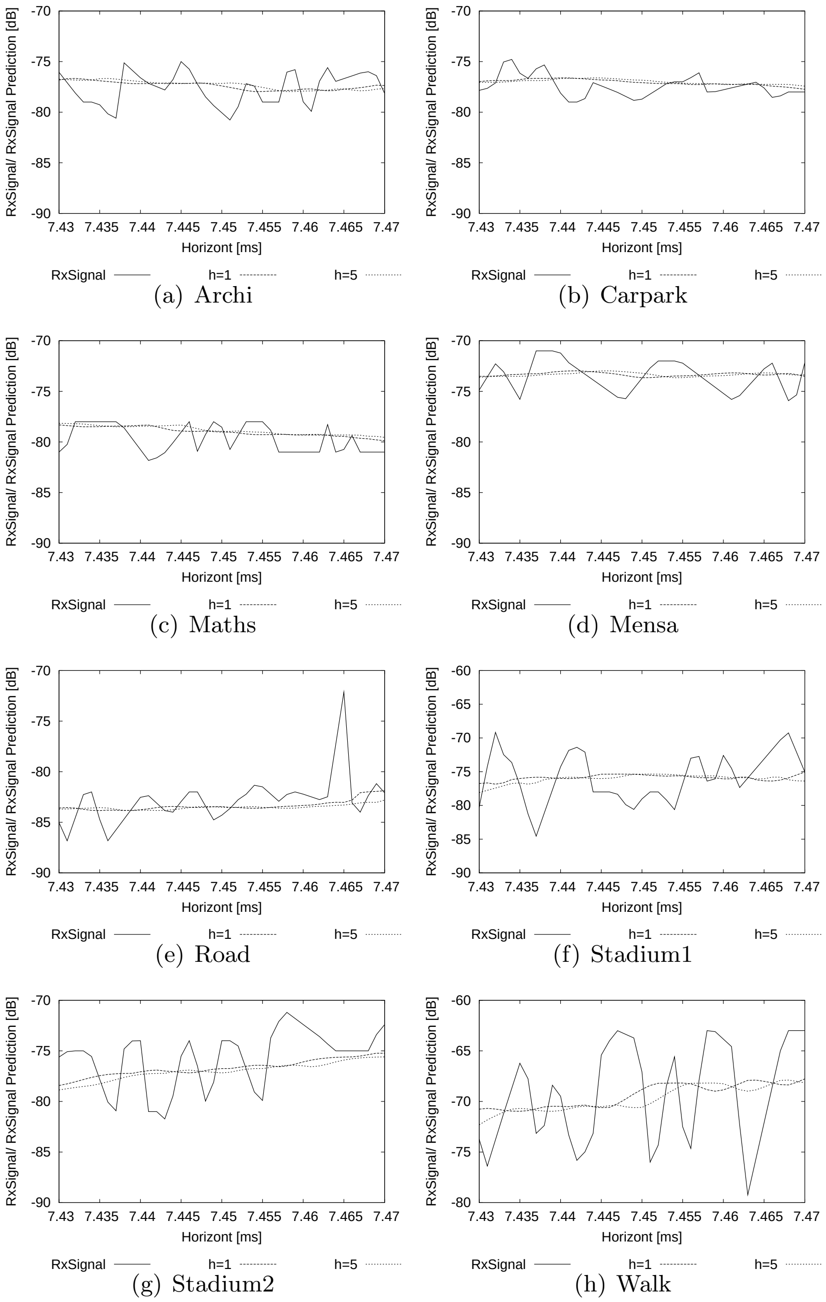


Figure 4.4: NMSE of the MA prediction algorithm with N=10.



(a) Archi (b) Carpark (c) Maths (d) Mensa (e) Road (f) Stadium1 (g) Stadium2 (h) Walk

Figure 4.5: Examples of MA channel prediction with N=5 for h=1 ms and h=5 ms.



(a) Archi (b) Carpark (c) Maths (d) Mensa (e) Road (f) Stadium1 (g) Stadium2 (h) Walk

Figure 4.6: Examples of MA channel prediction with N=30 for h=1 ms and h=5 ms.

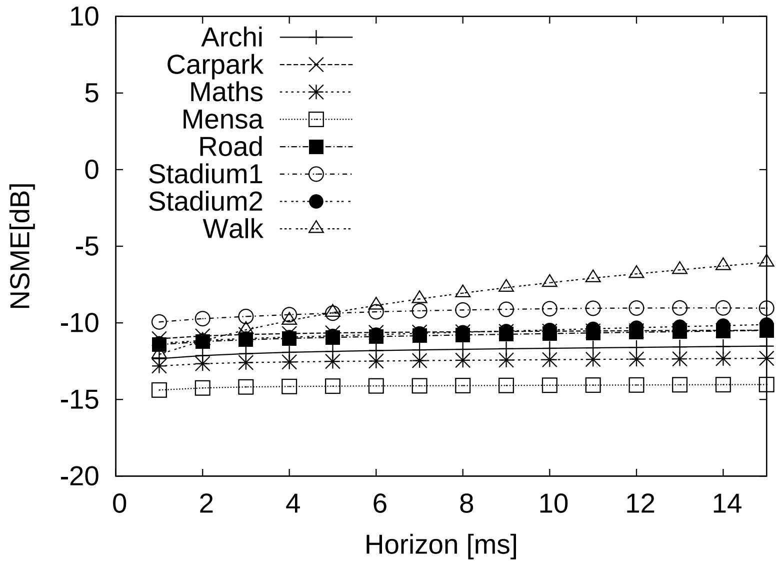


Figure 4.7: NMSE of the MA prediction algorithm with N=20.

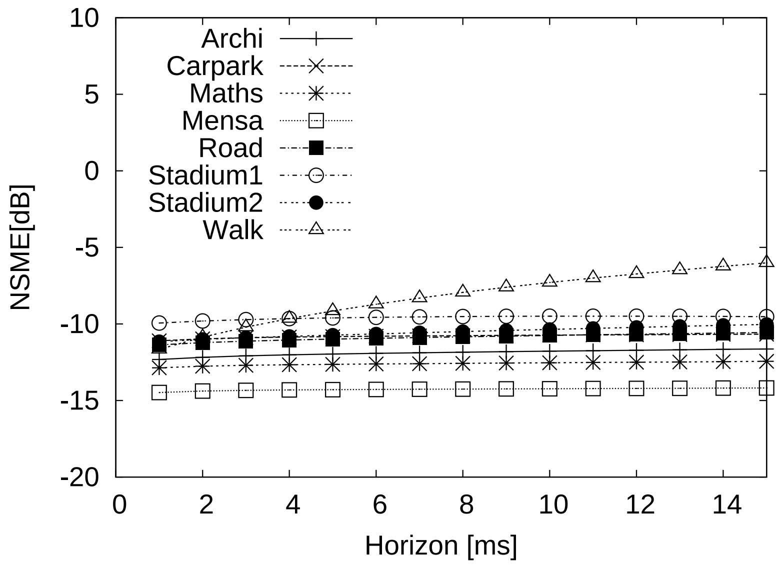
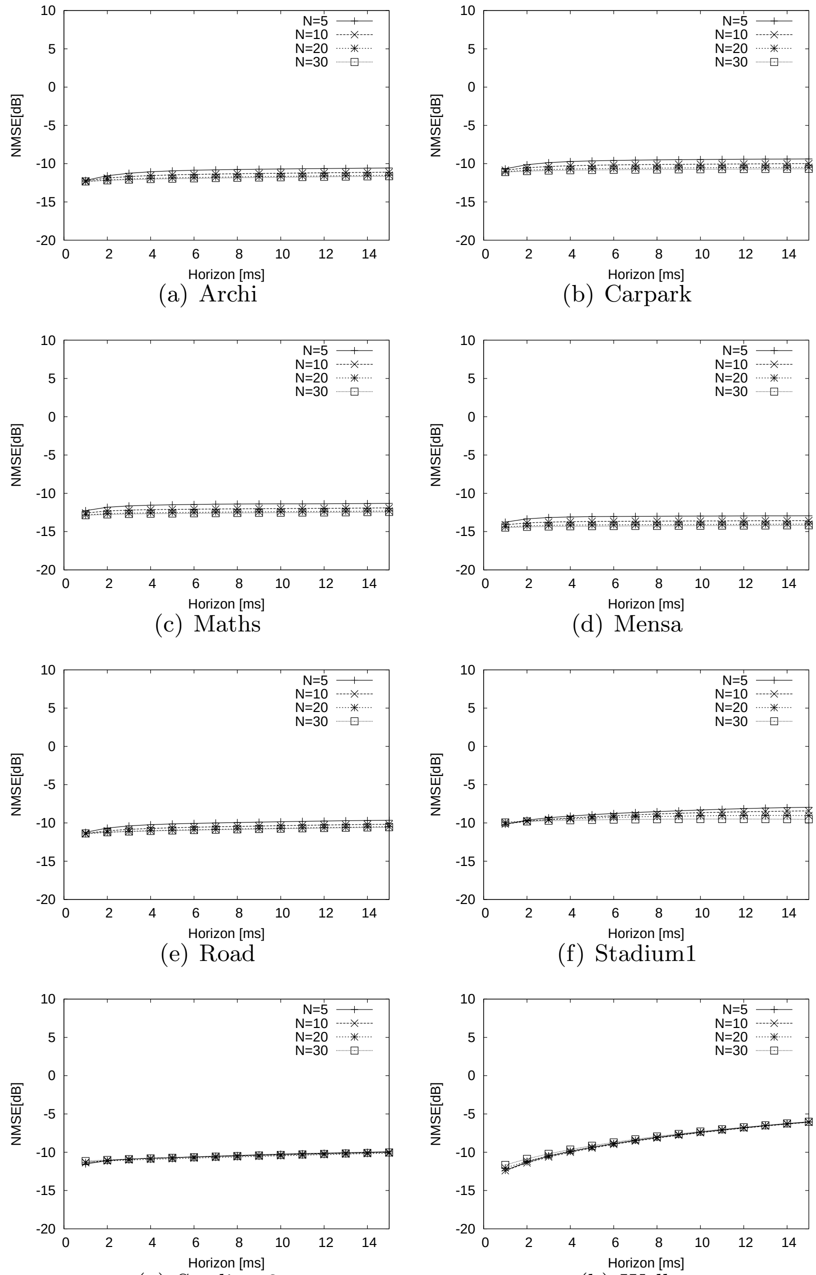


Figure 4.8: NMSE of the MA prediction algorithm with N=30.



(a) Archi (b) Carpark (c) Maths (d) Mensa (e) Road (f) Stadium1 (g) Stadium2 (h) Walk

Figure 4.9: Comparison of the number of samples used in the calculation of the average of the MA predictor for different speeds.

4.4 Linear Prediction—LP

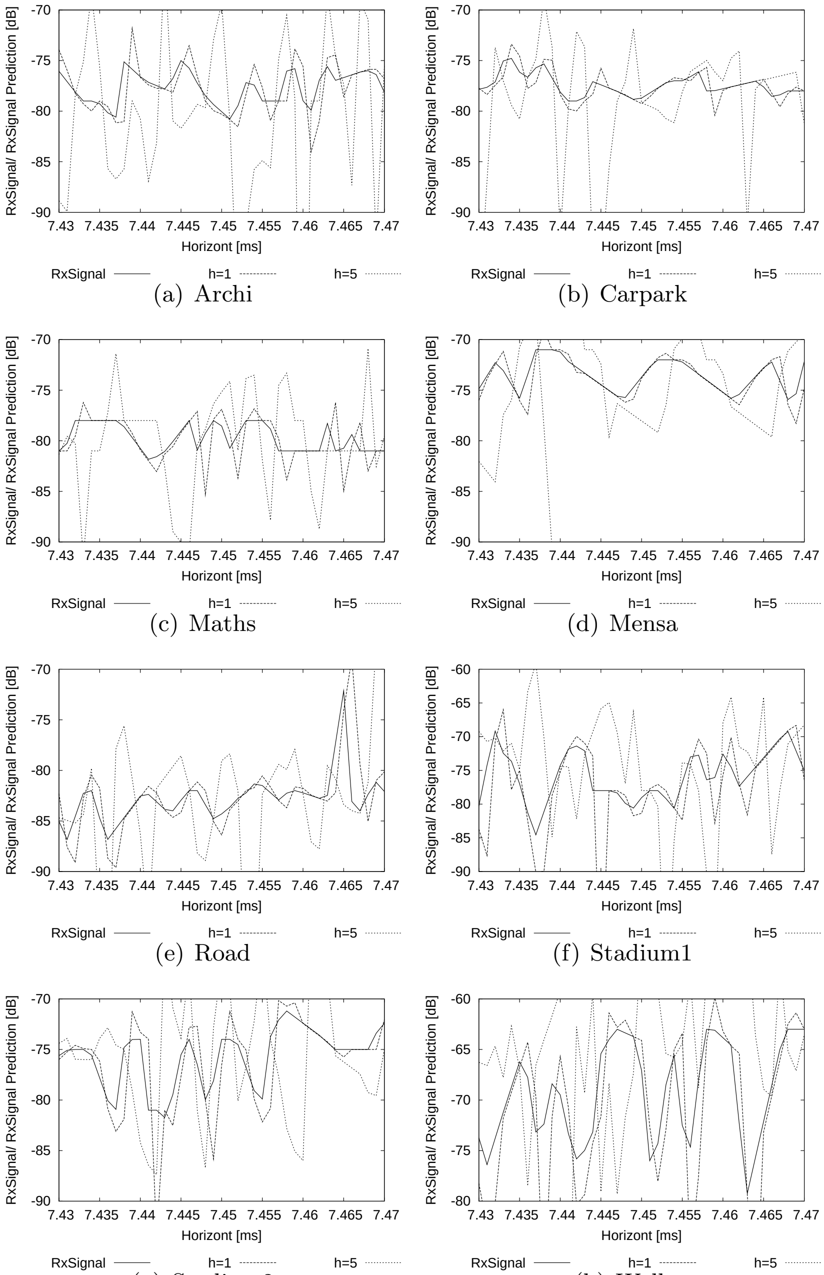
Figures 4.10 and 4.13 show examples of the LP predicted signal with N=2 and N=30 samples for h=1 and 5 ms together with the original measured received signal; Figures 4.11 to 4.17 show the NMSE for the LP prediction with increasing amount of the samples used in the regression, and Figure 4.26 shows, for each measurement environment, the NMSE for varying N.

In Figure 4.10, for N=2, the predicted signal follows the received signal quite well; however, for $h = 5$ the errors increase due to the strong variations of the measured signal. Although the measured signal was filtered to reduce noise, it is still sharp and has fast changes, which lead to high gradients when the linear regression uses few channel samples; high gradients lead to very high or low values when the prediction horizon grows. The effect is the fast increase in the NMSE that can be seen for N=2 and N=5 in Figures 4.11 and 4.12.

When more and more samples are used in the linear regression, the gradients become very close to 0, and the resulting predicted signal, very close to the OS predictor, stays within the same range as the actual received signal, as can be seen in Figure 4.13. There we can also see that for h=1, the predicted signal follows the actual signal well, as was already the case for N=2.

These behaviours are expressed in the NMSE plotted in Figures 4.14 to 4.17. The LP prediction, as had already been the case with the MA and OS, is less inaccurate in the environments where the variance of the original signal is low. As in the previous cases, since the prediction is more or less random stays in the same range as the original signal, the NMSE depends on the variance of the original signal.

Figure 4.26 shows the NMSE for N=2, 5, 10, 15, 20 and 30 samples for increasing horizon for each measurement environment. Clearly, N=30 achieves the highest accuracy for all environments.



(a) Archi (b) Carpark

(c) Maths (d) Mensa

(e) Road (f) Stadium1

(g) Stadium2 (h) Walk

Figure 4.10: Examples of LP channel prediction with N=2 for h=1 ms and h=5 ms.

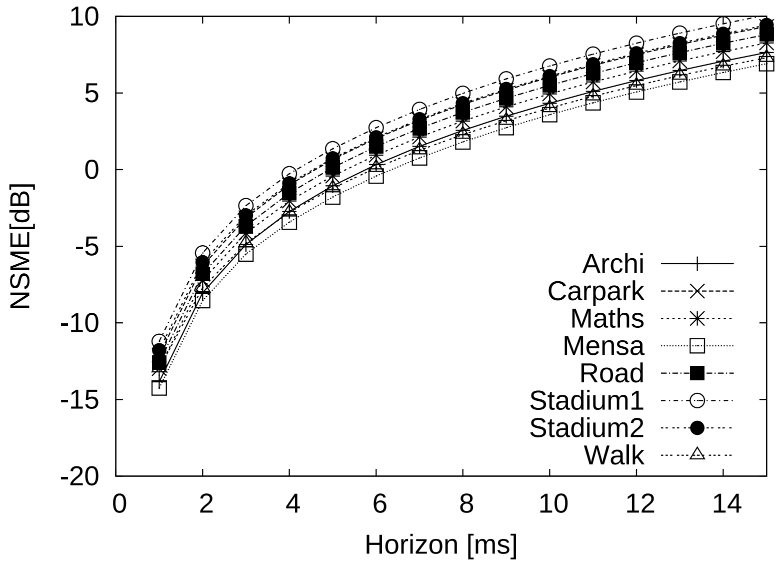


Figure 4.11: NMSE of the LP prediction algorithm using N=2 samples.

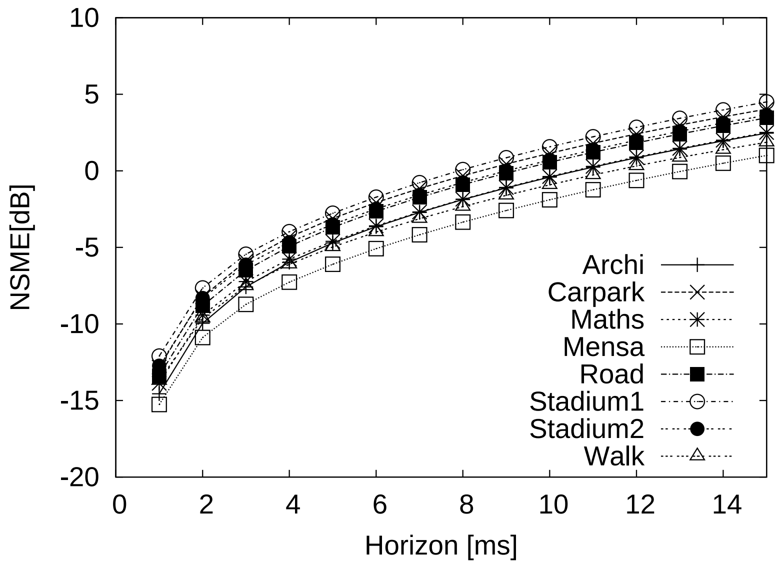


Figure 4.12: NMSE of the LP prediction algorithm using N=5 samples.

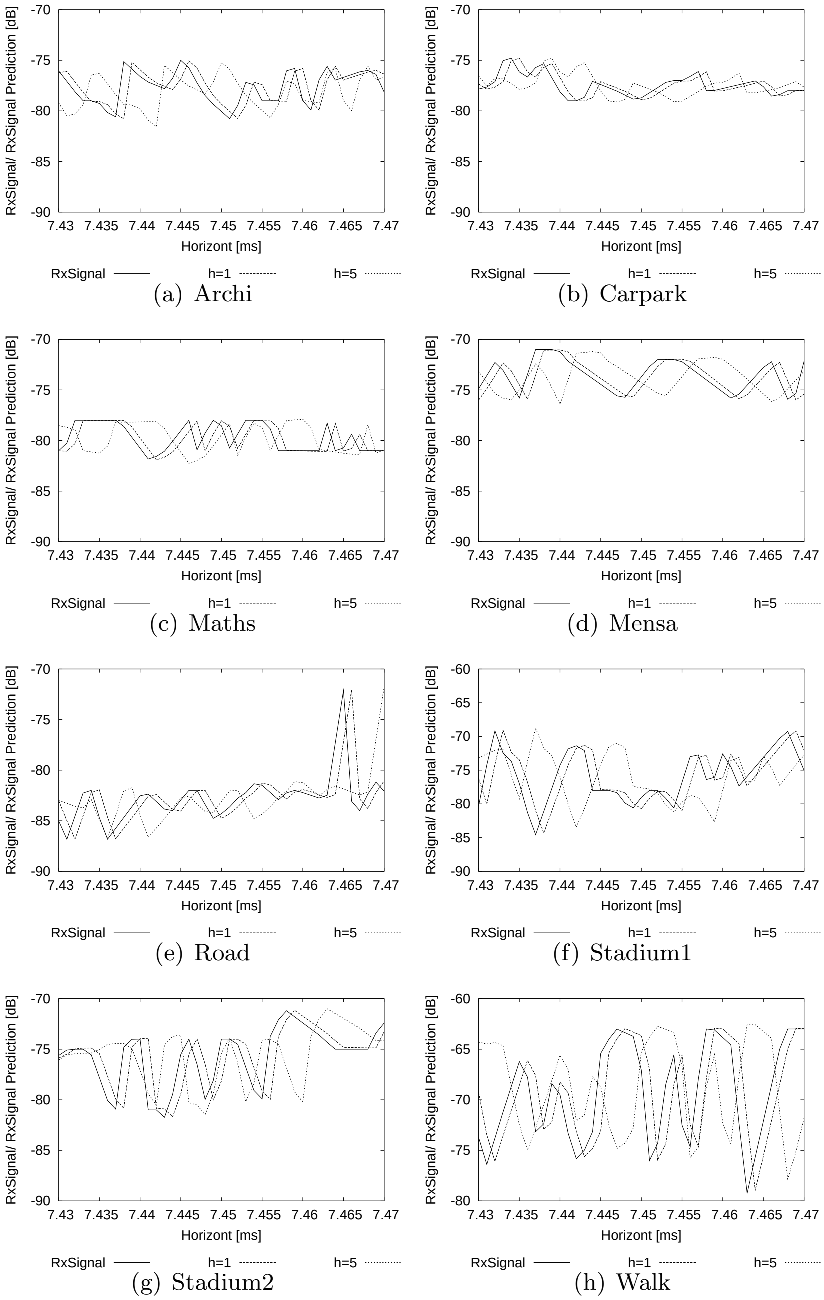


Figure 4.13: Examples of LP channel prediction with N=30 for h=1 ms and h=5 ms.

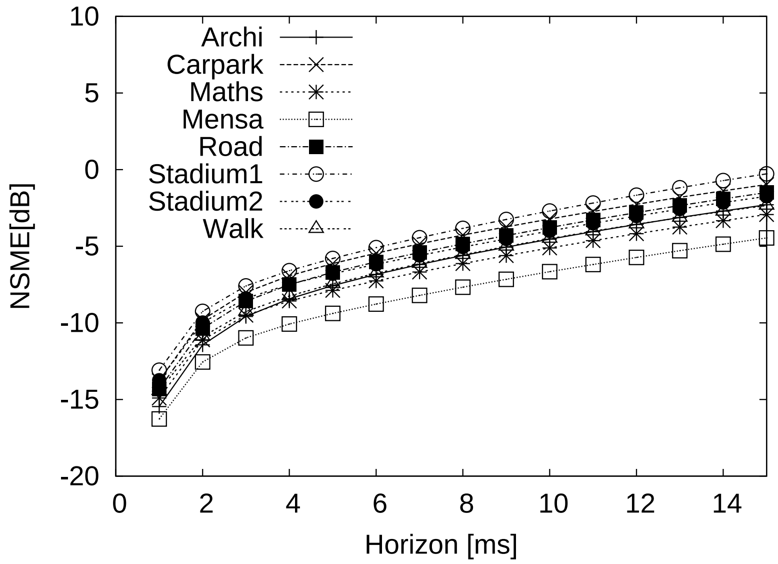


Figure 4.14: NMSE of the LP prediction algorithm using N=10 samples.

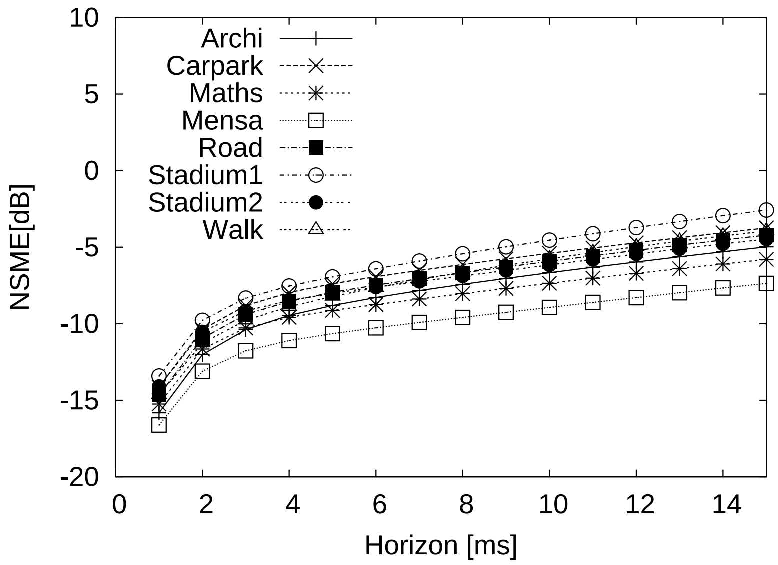


Figure 4.15: NMSE of the LP prediction algorithm using N=15 samples.

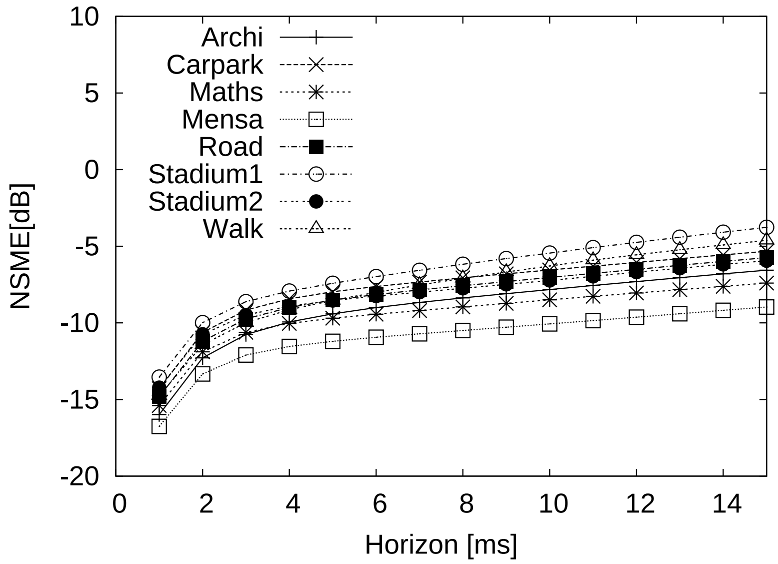


Figure 4.16: NMSE of the LP prediction algorithm using N=20 samples.

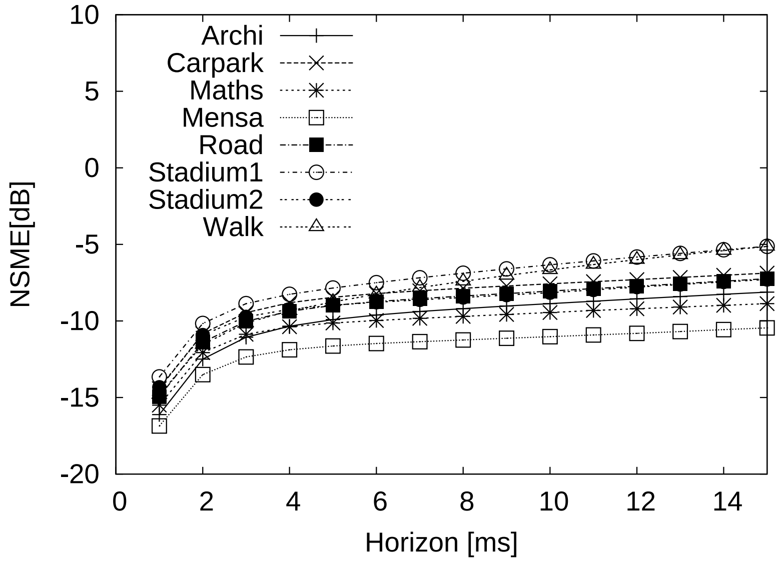


Figure 4.17: NMSE of the LP prediction algorithm using N=30 samples.

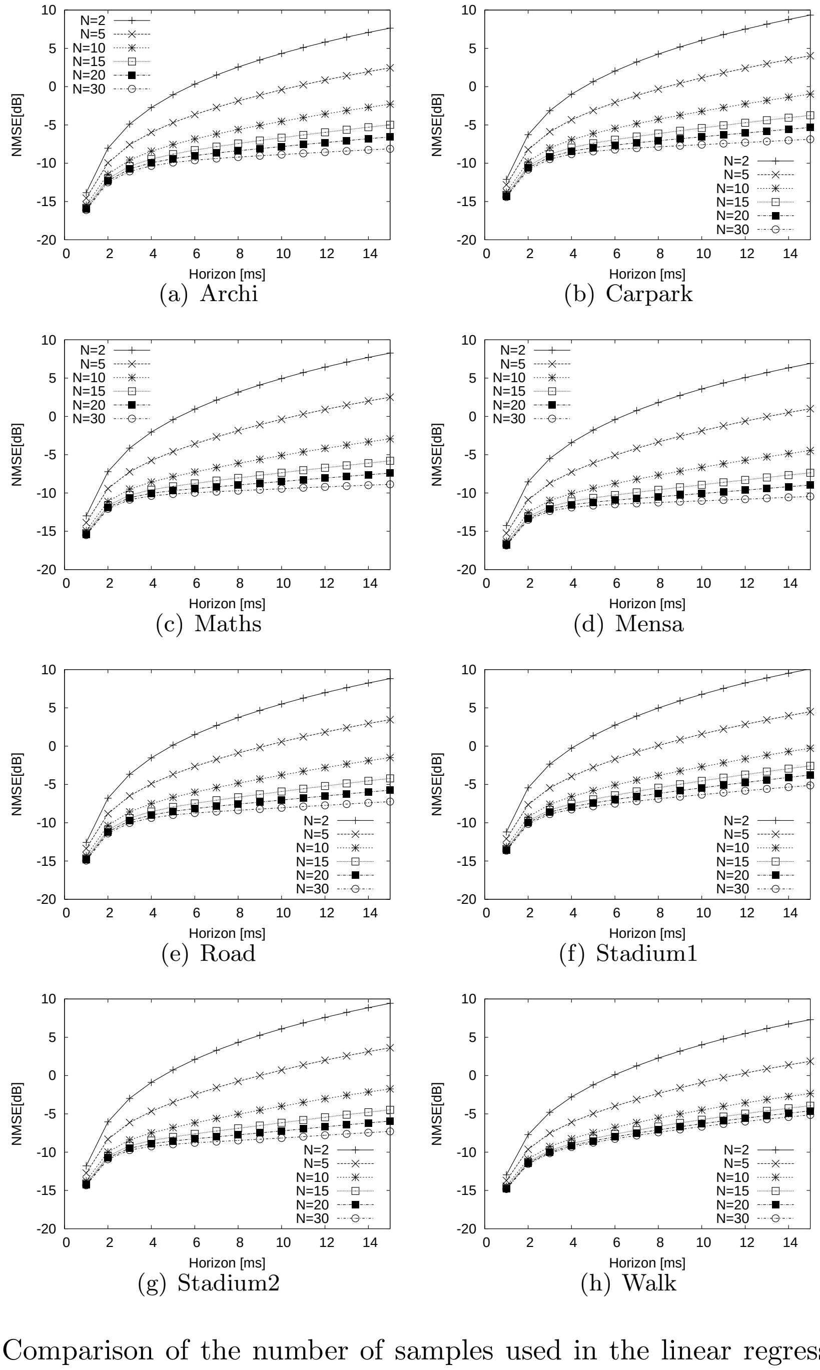


Figure 4.18: Comparison of the number of samples used in the linear regression of the LP predictor for different speeds.

4.5 Modified Covariance—MC (reference predictor

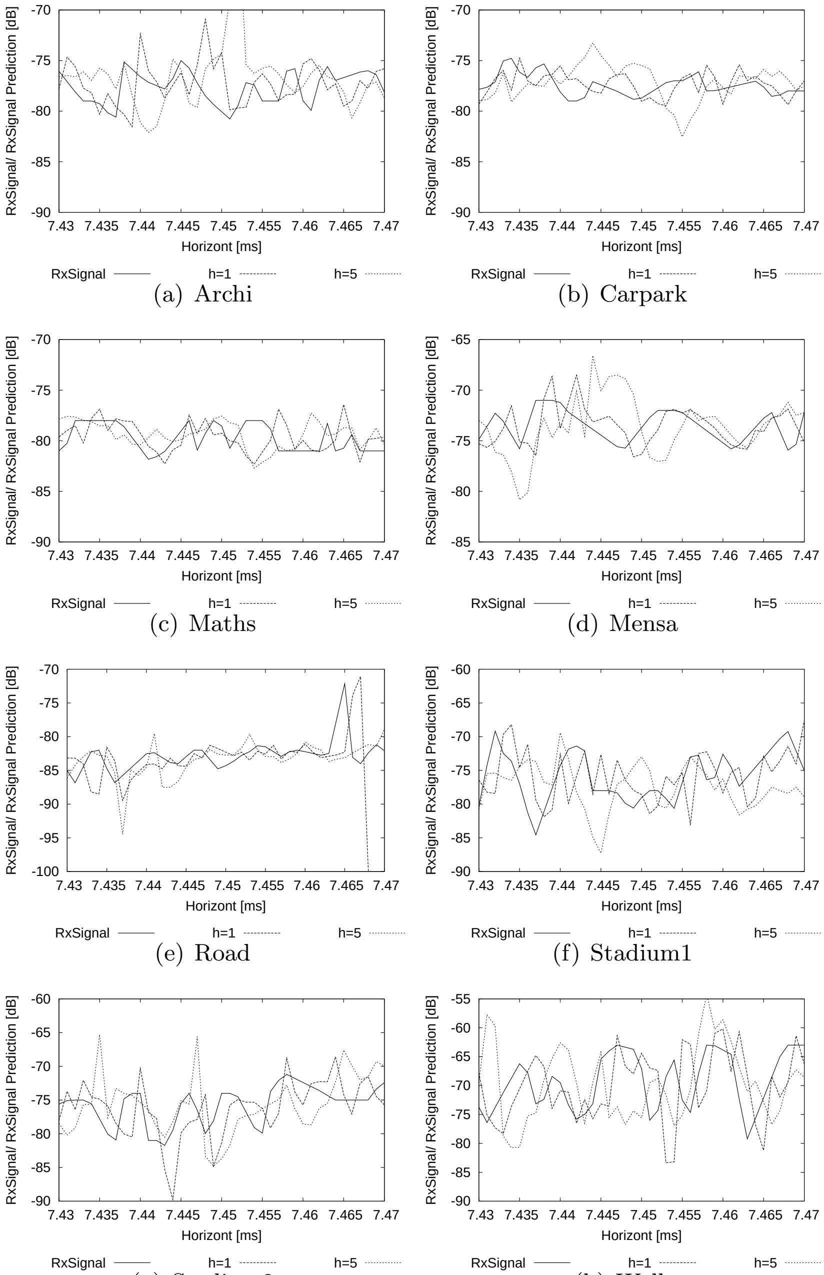
The reference predictor becomes unstable outputting predicted values that are several orders of magnitude bigger or smaller than the signal to be predicted. This behaviour can always be observed after periods when the channel is linear for some samples and is due to false tracking of the AR model coefficients, i. e. the a_k coefficients in Equation 2.5 are inappropriate, producing absurd predicted signal values. The periods of linear channel occur for time intervals when values were missing in the measured time series. During the interpolation and re-sampling process (see Chapter 3) missing samples were substituted by the values obtained from a linear interpolation. This behaviour indicates that the MC predictor is not capable of correctly tracking the channel in periods of missing samples, something that can occur in the praxis.

The huge values of the prediction error are a problem for the calculation of the NMSE, since they bias its value to infinity. To work around this, the calculation of the NMSE for the MC predictor used only the prediction errors smaller than the 99% percentile for the prediction horizon h; i. e. for the calculation of the NMSE the values belonging to the highest percentile are not taken into account. In Section A.4 of the Appendix A, Figures A.12 to A.19 show the empyrical CDF of all errors next to the CDF of the errors after removing the highest percentile. We can see that this procedure shifts the ECDF slightly to the left side for small values of h, inducing a bias on NMSE, which is underestimated.

Figure 4.19 shows example plots of the time behaviour of the measured signal and the prediction for $h = 1$ ms and $h = 5$ ms. We can see that even for $h = 1$ ms the predicted signal does not follow the measured signal, showing the inaccuracy of this predictor, which further suffers from error propagation for farther horizons. The NMSE for the 99-percentile of the prediction errors are plotted in Figures 4.20 to 4.25 for P varying between 2 and 40. For $P \leq 10$ the NMSE is very big even for $h \leq 5$ ms and consequently the prediction inadequate. The NMSE is lower than 0 dB up to $h = 5$ ms only for $P \geq 30$, but even then there are very big errors for farther horizons in some environments, due to error propgation.

Figure 4.26 shows the NMSE for varying P per environment. In general, $P = 40$ leads to the lowest errors. However, for the environments Maths, Road and Walk error propagation leads to very big NMSE for $h > 5$ ms and in these cases the lowest errors are achieved by $P = 20$, $P = 30$, $P = 30$, respectively.

The instability of this predictor in the presence of missing channel samples, as well as the error propagation strongly disencourages its usage in WLAN environments.



(a) Archi (b) Carpark (c) Maths (d) Mensa (e) Road (f) Stadium1 (g) Stadium2 (h) Walk

Figure 4.19: Examples of MC channel prediction with P=15 for h=1 ms and h=5 ms.

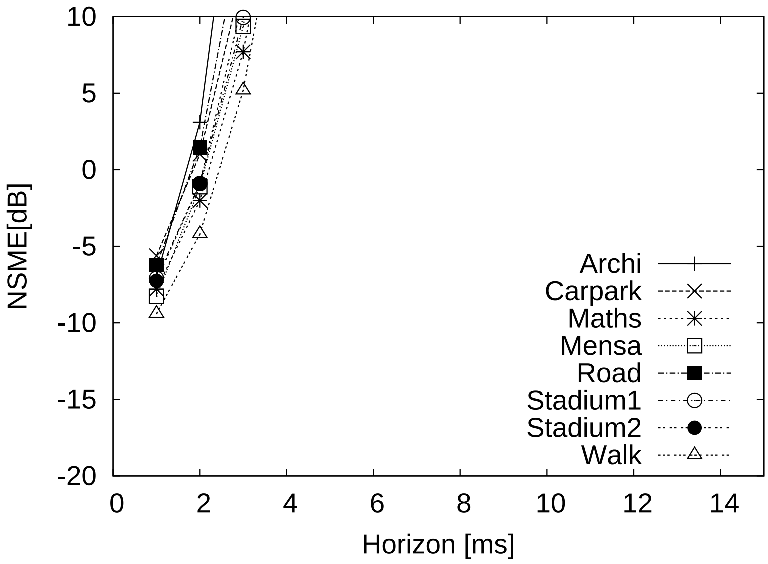


Figure 4.20: NMSE of the MC prediction algorithm for an AR model of order P=5.

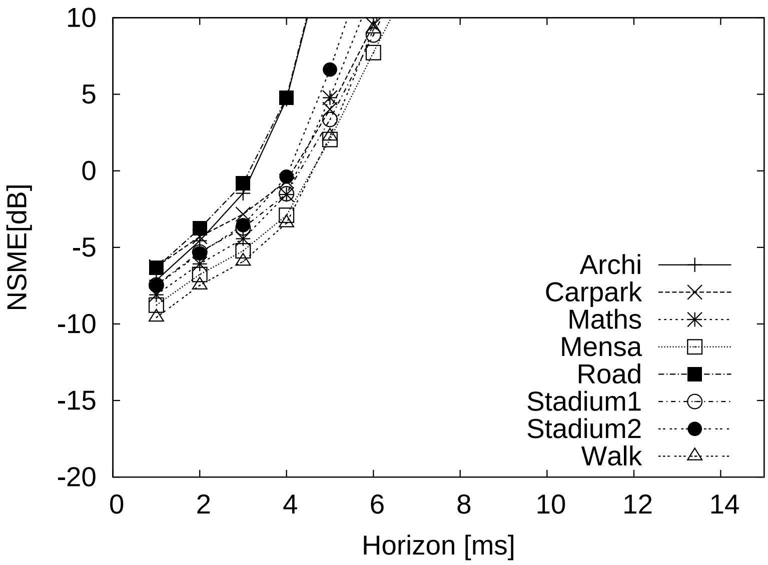


Figure 4.21: NMSE of the MC prediction algorithm for an AR model of order P=10.

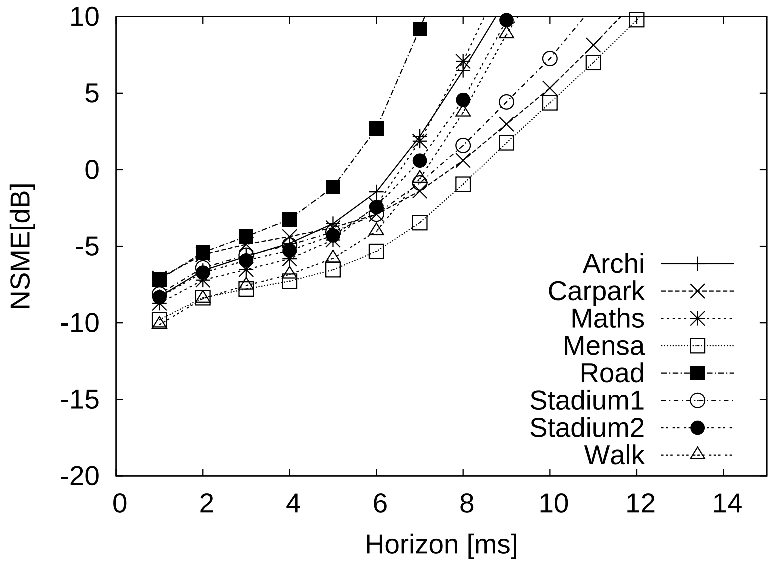


Figure 4.22: NMSE of the MC prediction algorithm for an AR model of order P=15.

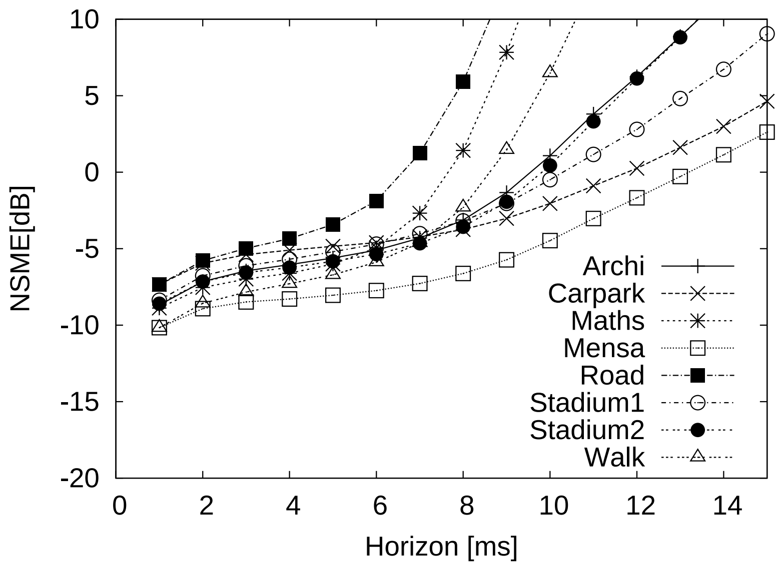


Figure 4.23: NMSE of the MC prediction algorithm for an AR model of order P=20.

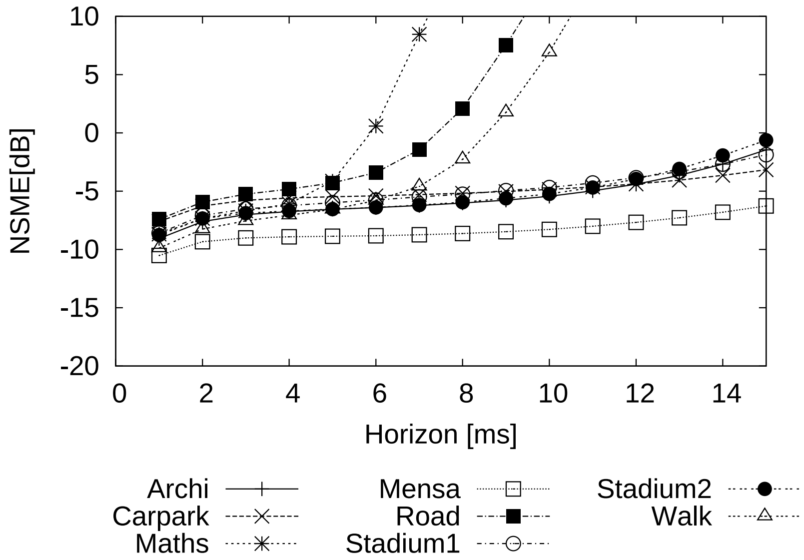


Figure 4.24: NMSE of the MC prediction algorithm for an AR model of order P=30.

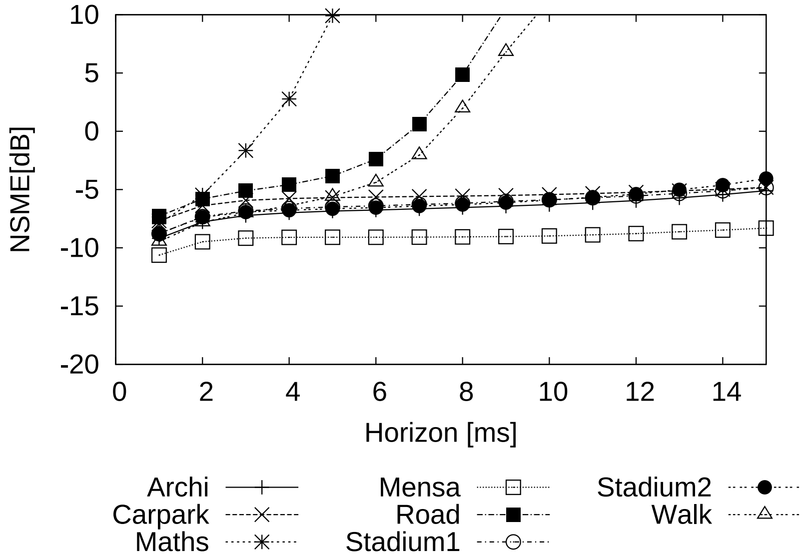
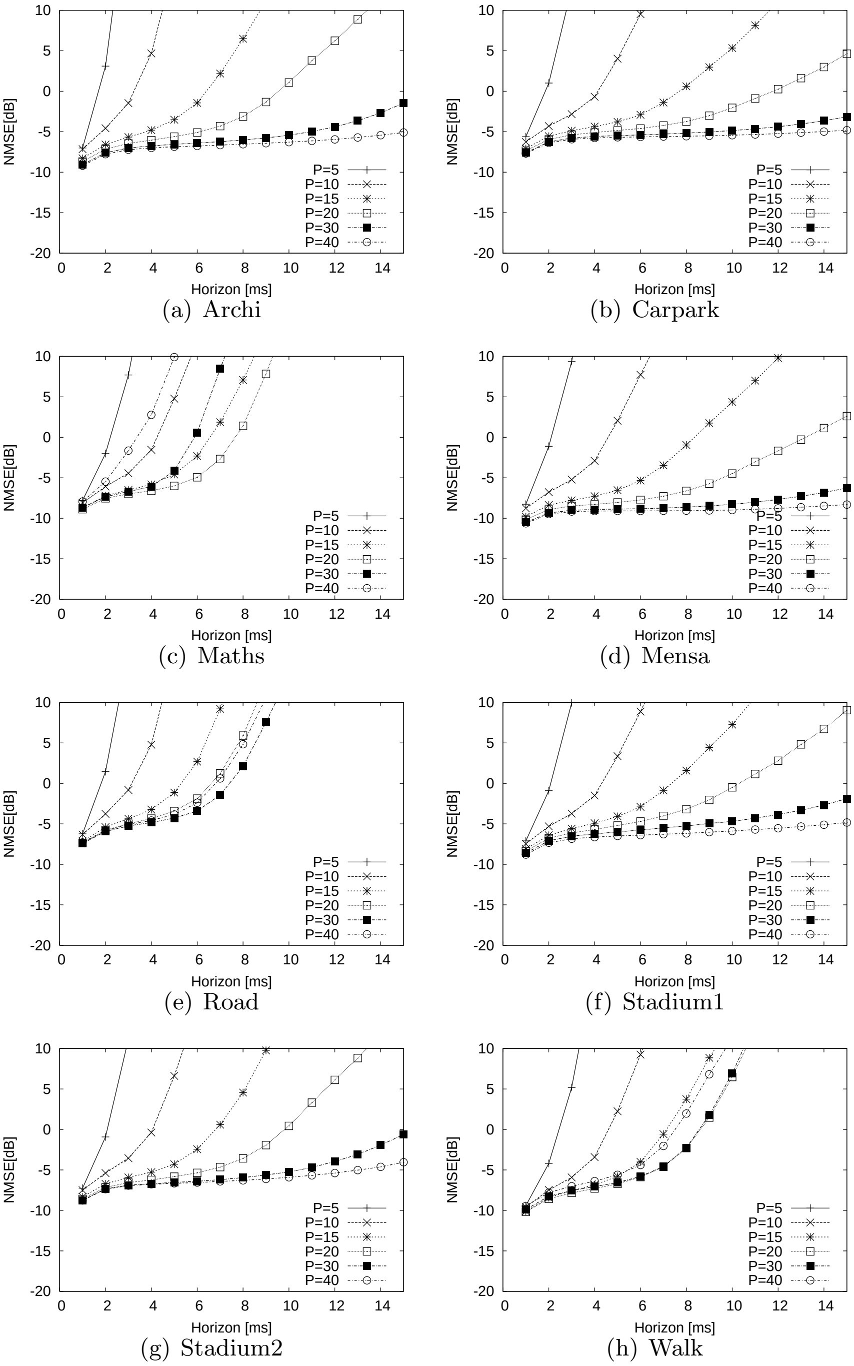


Figure 4.25: NMSE of the MC prediction algorithm for an AR model of order P=40.



(a) Archi (b) Carpark (c) Maths (d) Mensa (e) Road (f) Stadium1 (g) Stadium2 (h) Walk

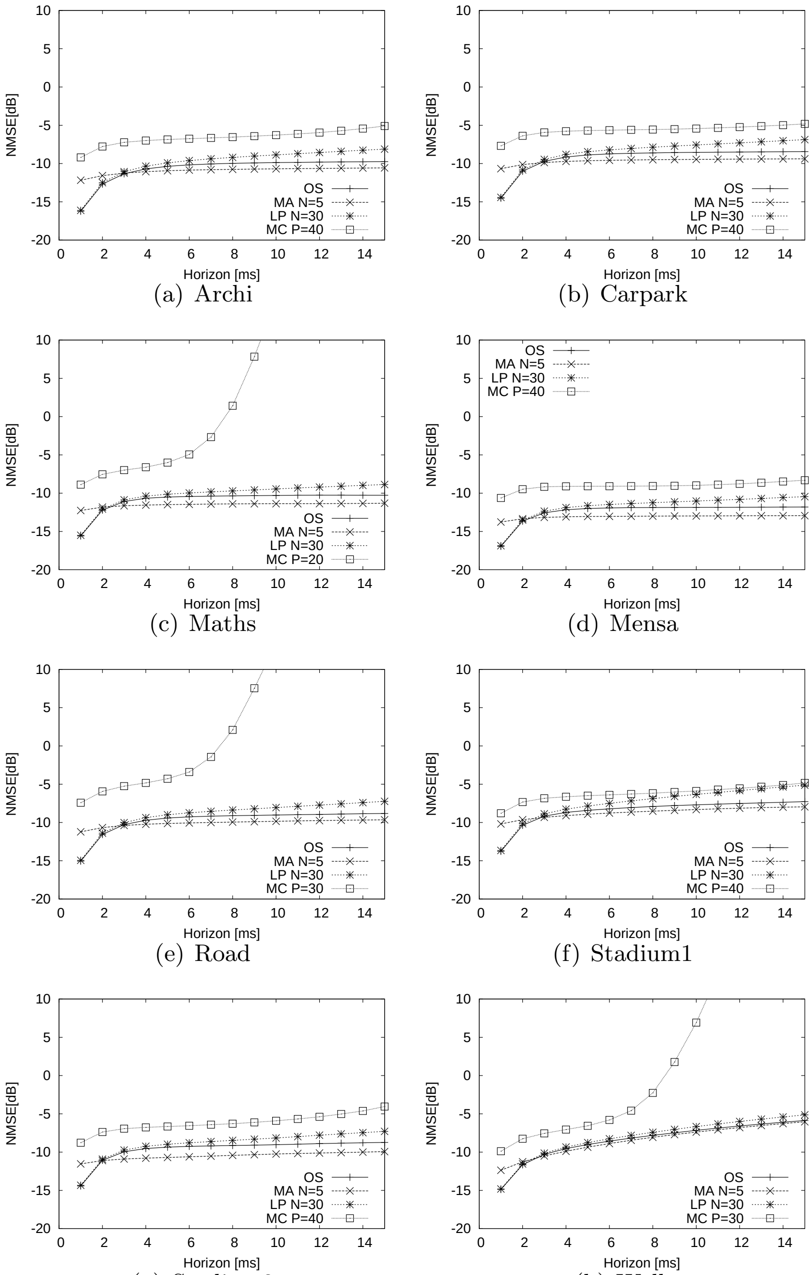
Figure 4.26: Comparison of the order of the AR process model of the MC predictor.

4.6 Comparison of the channel prediction performance

Figure 4.27 shows, for each environment, the NMSE for each predictor for increasing prediction horizon. The MC performs worst in all environments, due to its instability and error propagation. Even if for some environments the errors are limited when the order of the AR model is high ($P = 40$), the power of the prediction errors approaches the signal power and we can conclude that the MC is not appropriate for predicting this type of channel. The LP with $N = 30$ and the OS produce the lowest NMSE for $h \leq 2$ ms in all environments. For $h > 2$ ms, the MA with $N = 30$ performs best, followed by the OS.

As was mentioned in the previous sections, in the environments with the lowest variance of the fast fading the NMSE is smaller. This is not due to the predicted signal following better the actual received signal, but due to the "randomness" of the prediction: since the predicted signal is a "random" prediction in the same range of values as the variations themselves, the power of the difference between the two signals is proportional to the power of the original signal.

Finally, Figure 4.28 shows the NMSE averaged over all environments. All in all, the MA with $N = 30$ has the highest accuracy in terms of NMSE, i. e. the best prediction that can be made is the average SNR. Consequently, we conclude that none of the prediction methods studied can predict the fast variation of noisy channels as measured by a WLAN card for horizons greater than 2 ms. For prediction horizons up to 2 ms the straightforward OS predictor should be used.



(a) Archi (b) Carpark

(c) Maths (d) Mensa

(e) Road (f) Stadium1

(g) Stadium2 (h) Walk

Figure 4.27: Comparison of the NMSE in dB of the different heuristics in the different environments.

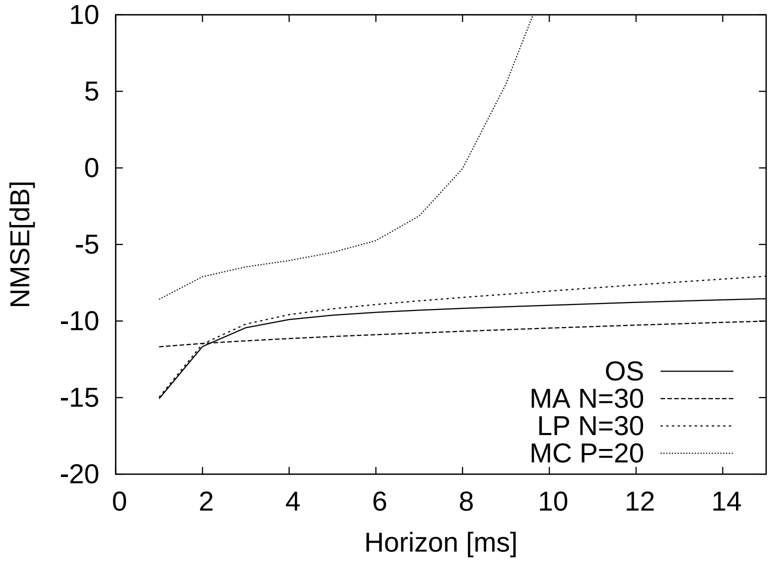


Figure 4.28: Overall NMSE of the predictors studied.

Chapter 5

Effects of Channel Prediction Errors on Adaptive Modulation

The previous chapter documented the comparison of the accuracy of the prediction algorithms in terms of statistics of the prediction errors. In this chapter, we study the performance of an adaptive modulation scheme when its decision is based on an imperfect channel prediction.

5.1 Adaptive Modulation Scheme

The scenario comprises of a sender that has an infinite amount of data to send to a receiver over a wireless. Due to variations in the environment, the received signal is subject to short-term variations, in this case modelled by the channel traces resulting of WLAN measurements as described in Chapter 3. The sender can use for the transmission one of the modulations in a pre-defined set. The modulation is chosen according to the predicted SNR; the range of possible SNR values is divided into intervals, each corresponding to a modulation; the thresholds of the intervals are chosen according to a pre-defined maximum acceptable bit error rate (BER). In this chapter only results over all environments are considered.

First, in Section 5.1.1, this study concentrates on the capacity achievable by the adaptive modulation scheme when the modulation is adapted for each discrete channel sample; afterwards, in Section 5.1.2 the case of packetised data is investigated.

5.1.1 Capacity

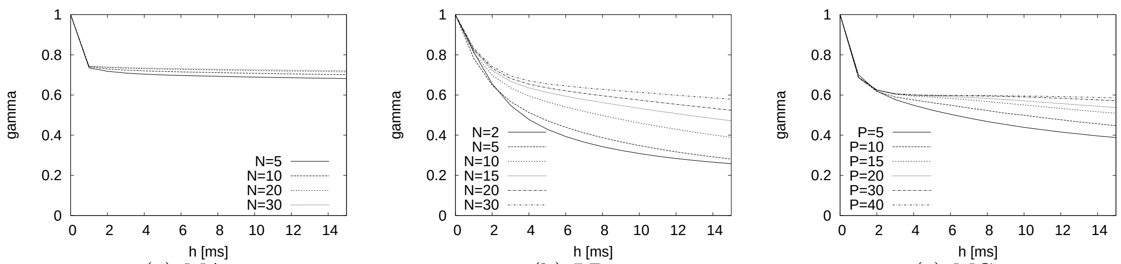
In this first study, the sender chooses the modulation at each discrete time instant i and the modulation is used up to the next time $i+1$. This implicitly assumes that the channel stays constant between two samples, i. e. that the coherence time [18] of the channel is less than the sampling interval—1 ms—; according to the autocorrelation functions shown in Chapter 3 this assumption is valid.

For each discrete time instant i a modulation is chosen from Table 5.2 according to the predicted SNR value. The thresholds were chosen such that a maximum bit error rate (BER) of $\mathrm{BER}_{\max} = 10^{-3}$ is not exceeded for k-PSK modulations [17]. The choice of the modulation is done twice for each time instant i, once based on the measured received signal and once based on the predicted received signal.

The measure of the channel capacity achievable by the threshold-based adaptive modulation scheme is calculated as the average amount of bits per symbol over all channel samples.

Modulation	M	SNR threshold (per Symbol) [dB]
BPSK	1	6.80
QPSK	2	9.80
8PSK	3	14.79
16PSK	4	20.37
32PSK	5	26.13
64PSK	6	31.96

Table 5.1: (a): SNR thresholds for changing the modulation for a target BER of 10^{-4}; (b): Channel coherence times for 2.4 GHz.



(a) MA (b) LP (c) MC

Figure 5.1: Capacity achieved by the adaptive modulation scheme based on the studied predictors with varying amount of channel history.

Let $m(i)$ be the number of bits per symbol of the modulation chosen at discrete time i according to the actual channel value; $\hat{m(i)}$ is the amount of bits per symbol for the modulation chosen according to the predicted SNR. Then, the average amount of bits per symbol for the first case is $m = 1/N \sum_N m(i)$. For the latter case, the average amount of bits per symbol is calculated as follows:

$$\hat{m} = \frac{1}{N} \sum_N \begin{cases} \hat{m(i)} & \text{, if } \hat{m(i)} \leq m(i) \\ 0 & \text{, otherwise} \end{cases} ,$$

where it is assumed that whenever a modulation is chosen based on the predicted signal that is higher than the actual received signal allows, the capacity of the interval is lost[1]. The metric used for the evaluation is the capacity achieved with the adaptive modulation scheme based on predicted signal values relative to the achievable capacity based on the actual channel values (perfect prediction):

$$\gamma = \frac{\hat{m}}{m}.$$

Figure 5.1 shows γ for the MA, LP and reference predictor MC for varying amount of channel history used:

- for the MA predictor, although N does does significantly influence the value of γ, N=20,30 performs slightly better than smaller N;
- for the LP, N=2 performs better for h=1 ms, but for $h \geq 2$ ms the more channel history is used, the better;

[1]This is a conservative approach, since too high a modulation only leads to a too high probability of packet error.

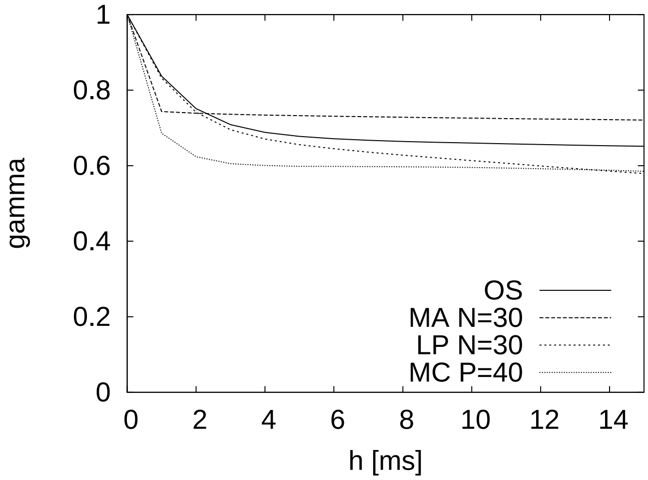


Figure 5.2: Comparison of the capacity achievable by the adaptive modulation scheme using the studied predictors.

- for the reference predictor MC a similar behaviour can be observed, the highest γ being achieved for P=40.

These behaviours had already been watched in the previous chapter and confirm that the moving average is the best prediction that can be made for $h \geq 2$ ms. Figure 5.2 shows γ for the studied predictors where the best values of N were chosen for the MA, LP and MC. We see that for $h < 2$ ms the OS and LP N=30 perform very similarly and better than the other predictors studied. For $h \geq 2$ ms, the capacity achievable by the adaptive modulation scheme is highest when using the MA predictor with N>20 although it lies 15% below the capacity achievable with perfect channel prediction. The reference predictor MC performs worse than any of the heuristics studied, achieving only 40% of the capacity achievable without channel prediction errors.

5.1.2 Packetised Adaptive Modulation

In this section, the data to be sent is no longer a bit flow, but is organised in packets of length L which should be transmitted as a whole. The modulation to use is chosen according to the minimum predicted SNR for the duration of the packet, thereby taking into account that the packet's duration d depends on the modulation to use: $d = t_{\text{symbol}} \cdot \frac{L}{M}$, where M is the amount of bits per symbol of the chosen modulation and $t_{\text{symbol}} = \frac{1}{W}$, with W the channel bandwidth. The modulation is chosen according to the *predicted* minimum SNR. The receiver checks whether the packet suffered errors according to the *actual* channel SNR:

- the average SNR between every two channel samples in the packet is calculated;
- the amount of bit errors for each interval is evaluated as a realisation of a binomial random variable with n the number of bits in that interval (determined by the modulation used) and p the BER corresponding to the SNR (obtained in the previous step);
- the packet is correctly received if no errors occur.

The metric used is the *packet loss rate* (PLR)

$$\text{PLR} = \frac{\text{number of transmitted packets} - \text{number of correctly received packets}}{\text{number of transmitted packets}}$$

		SNR threshold (per Symbol) [dB]			packet duration [ms]		
Modulation	M	L=400	L=800	L=1200	L=400	L=800	L=1200
BPSK	1	10.18	10.46	10.60	2	4	6
QPSK	2	13.21	13.47	13.63	1	2	3
8PSK	3	18.37	18.65	18.81	0.67	1.33	2
16PSK	4	24.09	24.39	24.55	0.5	1	1.5
32PSK	5	29.98	30.28	30.44	0.4	0.8	1.2
64PSK	6	35.92	36.20	36.38	0.33	0.67	1

Table 5.2: SNR thresholds for changing the modulation for a target PER of 10^{-3}.

We study the case of perfect channel prediction, of predicted channel with instantaneous feedback of channel samples and predicted channel with channel samples delayed 1, 2, 4, 6 and 8 ms. We run the simulation for packet lengths L of 400, 800 and 1200 bits with a target maximum packet error rate of $\text{PER}_{\text{max}} = 10^{-3}$; the available bandwidth is W =200 KHz and the average SNR of the channels is 20 dB. Of importance for the prediction-based adaptation of the modulation is the duration of a packet on the channel, as it defines the necessary prediction horizon. For a high modulation the packet is short and only short prediction horizons are required; whereas for a low, robust modulation, the same amount of data takes longer to be transmitted and channel prediction farther in the future is required for the adaptation of the modulation. Table 5.2 shows the duration of the packets on the channel for the used channel and modulations.

The PLRs for perfect channel prediction and channel prediction with instantaneous feedback are shown in Table 5.3: the first line shows the achievable PLR for perfect prediction, followed by the PLR for the predictors studied when the prediction is not delayed. We see that real prediction increases the PLR one order of magnitude for short (400 bit) packets and even 2 orders of magnitude for long packets (800 and 1200 bits). Looking at the evolution of the PLR in each line of the table, we can conclude that the packet loss increases with increasing duration of the packet to transmit due to the farther prediction horizon necessary for longer packets, as was explained above.

Comparing the amount of channel history used for the MA, LP and MC predictors, we can conclude that

- the MA performs better the more samples are used to calculate the average SNR, in this case $N = 30$;
- the LP performs best with $N = 2$, contrarily to the results in Section 4.4;
- the order of the AR model that leads to the best performance of the MC depends on the duration of the packets used, but overall $P = 30$ performs best.

Comparing now the channel predictors among with each other, the lowest packet loss rate is always achieved by the MA with N=30. We can also see that the OS performs worst of all predictors for all packet durations.

Predictor	L [bits]	PLR [%] 400	800	1200
Perfect		$7.10{\cdot}10^{-5}$	$5.10{\cdot}10^{-5}$	$4.09{\cdot}10^{-5}$
OS		$7.14{\cdot}10^{-4}$	$3.16{\cdot}10^{-3}$	$8.08{\cdot}10^{-3}$
MA N=5		$4.25{\cdot}10^{-4}$	$1.99{\cdot}10^{-3}$	$5.14{\cdot}10^{-3}$
MA N=10		$4.11{\cdot}10^{-4}$	$1.97{\cdot}10^{-3}$	$4.76{\cdot}10^{-3}$
MA N=20		$3.75{\cdot}10^{-4}$	$1.82{\cdot}10^{-3}$	$4.48{\cdot}10^{-3}$
MA N=30		$3.47{\cdot}10^{-4}$	$1.82{\cdot}10^{-3}$	$4.46{\cdot}10^{-3}$
LP N=2		$4.97{\cdot}10^{-4}$	$2.08{\cdot}10^{-3}$	$5.71{\cdot}10^{-3}$
LP N=5		$5.90{\cdot}10^{-4}$	$2.60{\cdot}10^{-3}$	$7.08{\cdot}10^{-3}$
LP N=10		$6.66{\cdot}10^{-4}$	$2.89{\cdot}10^{-3}$	$7.73{\cdot}10^{-3}$
LP N=15		$6.78{\cdot}10^{-4}$	$3.06{\cdot}10^{-3}$	$7.64{\cdot}10^{-3}$
LP N=20		$6.98{\cdot}10^{-4}$	$3.01{\cdot}10^{-3}$	$7.91{\cdot}10^{-3}$
LP N=30		$6.64{\cdot}10^{-4}$	$3.13{\cdot}10^{-3}$	$7.68{\cdot}10^{-3}$
MC P=5		$5.46{\cdot}10^{-4}$	$2.26{\cdot}10^{-3}$	$5.60{\cdot}10^{-3}$
MC P=10		$5.30{\cdot}10^{-4}$	$2.09{\cdot}10^{-3}$	$5.19{\cdot}10^{-3}$
MC P=15		$5.21{\cdot}10^{-4}$	$2.11{\cdot}10^{-3}$	$4.89{\cdot}10^{-3}$
MC P=20		$4.72{\cdot}10^{-4}$	$2.04{\cdot}10^{-3}$	$4.93{\cdot}10^{-3}$
MC P=30		$4.98{\cdot}10^{-4}$	$2.01{\cdot}10^{-3}$	$4.59{\cdot}10^{-3}$
MC P=40		$5.14{\cdot}10^{-4}$	$2.09{\cdot}10^{-3}$	$4.56{\cdot}10^{-3}$

Table 5.3: Packet loss rate (PLR) on the wireless link when adaptive modulation is used with the predictors studied.

Figure 5.3 shows the PLR for the MA, LP and MC preditors when the channel samples are delayed, for example due to feedback. A channel sample delay of 0 stands for instantaneous channel samples (same value as in Table 5.3). For the MA the value of N has little influence on the PLR of the adaptive modulation scheme, similarly to the results in the previous chapter. For the LP, the more samples are used in the linear regression, the better for the adaptive modulation scheme, as had already been seen in Section 4.4. For the MC the PLR also decreases with increasing order of the AR model. When either the MA or the MC predictors are used, the lenght of the packet does not play a role in the achieved packet loss rate, probably because the predictors are predicting “only” the average channel behaviour. An influence of the packet length on the PLR achieved by the adaptive modulation scheme can only be seen for the LP predictor for sample delays shorter than 2 ms. This will be looked into further later on, when the predictors are compared to each other.

In Figure 5.3 we can also observe that, although the PLR achieved for instantaneous samples differs from one predictor to the other and increases with increasing packet length (see Table 5.3), there are only little differences in the best performance obtained with the different predictors when the channel samples are delayed. Furthermore, the PLR does only depend on the sample delay for the LP; for the MA and MC there is no increasing loss due to an increase in the channel sample delay. This happens because the errors do not increase

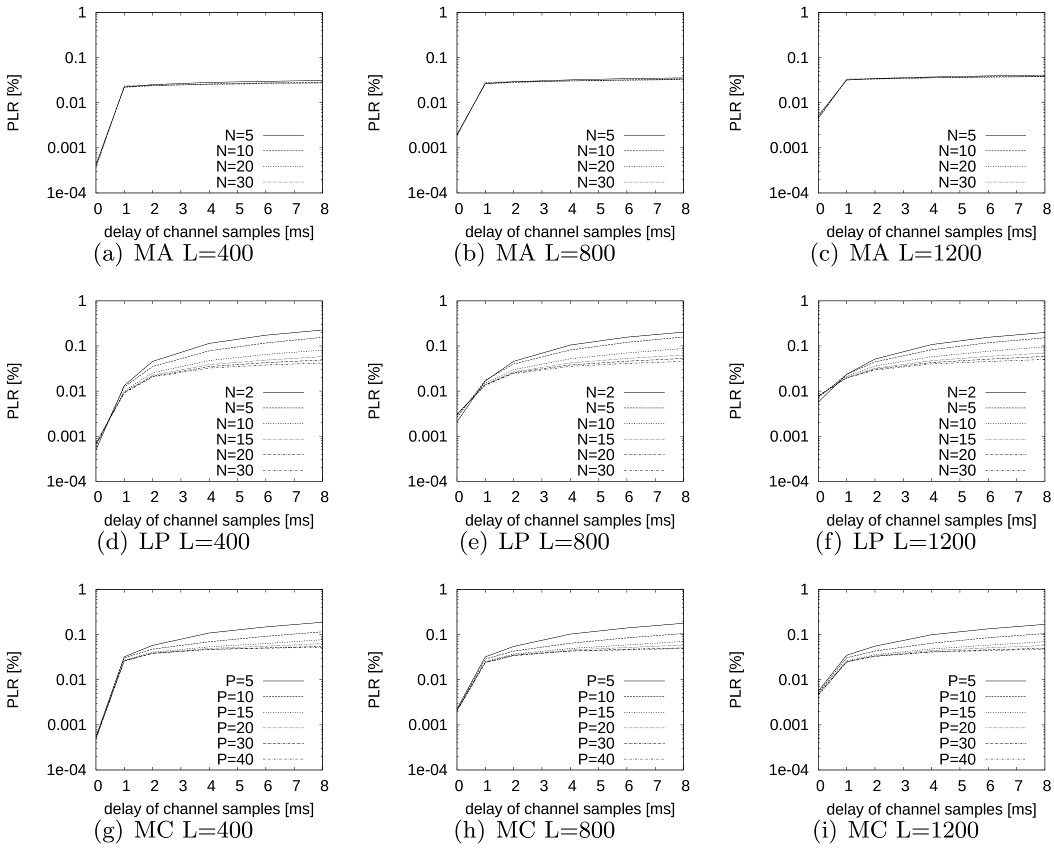
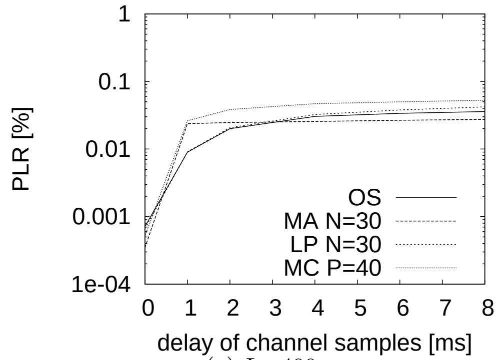
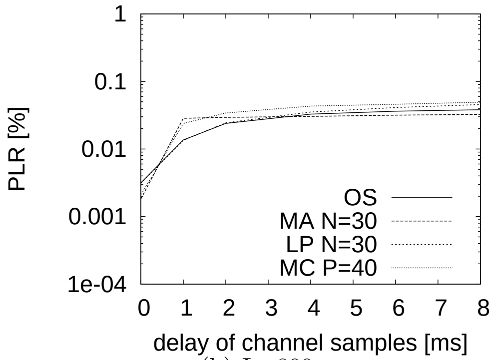


Figure 5.3: Packet loss rate (PLR) on the wireless link when channel samples are delayed.

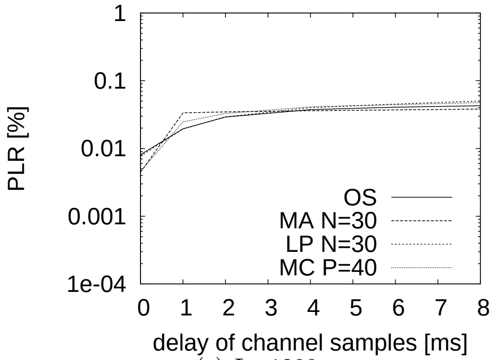
with increasing prediction horizon, as has been seen in Section 4.3.



(a) L=400



(b) L=800



(c) L=1200

Figure 5.4: Packet loss rate (PLR) on the wireless link when channel samples are delayed. For perfect prediction: $\text{PLR}_{400} = 7.10 \cdot 10^{-5}$, $\text{PLR}_{800} = 5.10 \cdot 10^{-5}$, $\text{PLR}_{1200} = 4.09 \cdot 10^{-5}$.

Figure 5.4 shows the packet loss rate achieved for adaptive modulation with all studied predictors, where the best case N was used for the MA and LP and the best case P for the MC reference predictor. We can see a big increase in the PLR, dependent on the packet length, when channel samples are delayed. The maximum duration of short packets makes only short prediction horizons necessary for the adaptation, whereas long packets require the adaptive scheme to look at channel prediction farther in the future, making bigger errors. Consequentlyly, the PLR for instantaneous channel samples is smaller for shorter packets, but suffers more when the prediction is delayed. When channel samples are delayed, the PLR for the MA and the reference predictor, MC, has values that are similar for all packet lengths and channel sample delay whereby the MA has the lowest PLR and MC the highest. The LP and OS perform similarly to each other within the limits set by those predictors for delays bigger than 3 ms. For prediction delays below 3 ms, the adaptive modulation performs better with the LP N=30 and the OS than with the other predictors.

Chapter 6

Conclusions

In this report we present the results of a detailed study of the accuracy of heuristics for wireless channel prediction and compared them to a reference predictor from the literature [19]. The simulative study is made using channel traces obtained from a WLAN channel measurement campaign in low mobility environments described in [2]. The measured signal was filtered to reduce noise and missing samples were substituted by a linear interpolation of the closest values to the right and left.

In a first approach, the accuracy was evaluated using the normalised mean squared value of the prediction error. From the results presented we can draw the following conclusions:

- the reference predictor is not adequate for the prediction of the channels used in this study, as it shows the highest NMSE in all environments for all prediction horizons and shows some instability when channel samples were missing;
- for prediction horizons h≤2 ms the LP and OS predictors perform similarly, in which case the OS should be chosen for simplicity;
- for prediction horizons h≥2 ms, the best performance is achieved by a moving average over many samples (MA N=30) for all horizons in all environments;
- the previous result leads us to conclude that the short term fading of the channels presented cannot be predicted by the heuristics studied for horizons greater than 2 ms;
- the acceptable delay for channel samples to be used in channel prediction must stay under 2 ms, since that delay increases the necessary prediction horizon;

To evaluate the effect of the prediction accuracy on an application we studied the performance of a threshold based adaptive modulation scheme in terms of capacity and for packetised data transmission. The capacity study confirmed that for horizons shorter than 2 ms the OS and LP with $N = 30$ channel samples perform best and for prediction horizons beyond 2 ms the MA with $N = 30$ is the most accurate of the studied heuristics. When this predictor is used a capacity loss of 15% with respect to the case when perfect channel prediction is used. The use of the reference predictor leads to the lowest achievable capacity for all prediction horizons, with capacity loss of around 40% with respect to adaptive modulation with perfect channel prediction.

We also studied the case of transmission of packetised data for 3 different packet sizes and for different feedback delays of the channel prediction. In this case, the metric used to compare the performance of the adaptive modulation scheme is the packet loss rate (PLR). The results show that for feedback delays bigger than 2 ms the packet length does not influence the achievable PLR and the best performance is achieved for the MA predictor, what is a consequence of the previous results. For packets that last less than 2 ms on the channel and feedback delays below 2 ms, the OS and LP with $N = 30$ perform better than the other predictors studied, since the horizon necessary for the data transmission stays below 2 ms. For longer packet, however, the advantage of these predictors is marginal since the packet duration plays a bigger role than the feedback delay in the prediction horizon necessary to adapt the modulation. All these results are consequences of the results of the previous studies and confirm them.

Finally, the results obtained in this report lead to the hypothesis that it may be of interest to fragment packets in a way that the required prediction horizon stays below 2 ms, a study that is out of the scope of this report.

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Appendix A

Significance of the Results

A.1 One Step — OS

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$2.3810^{-2} \pm 4.13\%$	$3.5210^{-2} \pm 2.92\%$	$2.7610^{-2} \pm 3.74\%$	$2.0210^{-2} \pm 4.73\%$
2	$5.3910^{-2} \pm 1.99\%$	$7.9410^{-2} \pm 1.41\%$	$6.0010^{-2} \pm 1.91\%$	$4.3110^{-2} \pm 2.34\%$
3	$7.3610^{-2} \pm 1.49\%$	$1.0710^{-1} \pm 1.06\%$	$7.7910^{-2} \pm 1.51\%$	$5.5410^{-2} \pm 1.84\%$
4	$8.5110^{-2} \pm 1.29\%$	$1.2210^{-1} \pm 0.94\%$	$8.5810^{-2} \pm 1.38\%$	$6.0710^{-2} \pm 1.69\%$
5	$9.1910^{-2} \pm 1.20\%$	$1.2910^{-1} \pm 0.88\%$	$8.9010^{-2} \pm 1.34\%$	$6.3010^{-2} \pm 1.62\%$
6	$9.6110^{-2} \pm 1.15\%$	$1.3410^{-1} \pm 0.85\%$	$9.0610^{-2} \pm 1.31\%$	$6.4210^{-2} \pm 1.60\%$
7	$9.8910^{-2} \pm 1.12\%$	$1.3610^{-1} \pm 0.84\%$	$9.1510^{-2} \pm 1.30\%$	$6.4710^{-2} \pm 1.58\%$
8	$1.0110^{-1} \pm 1.10\%$	$1.3810^{-1} \pm 0.83\%$	$9.2210^{-2} \pm 1.29\%$	$6.5010^{-2} \pm 1.58\%$
9	$1.0210^{-1} \pm 1.08\%$	$1.3910^{-1} \pm 0.82\%$	$9.2810^{-2} \pm 1.28\%$	$6.5110^{-2} \pm 1.57\%$
10	$1.0310^{-1} \pm 1.08\%$	$1.4010^{-1} \pm 0.82\%$	$9.3410^{-2} \pm 1.27\%$	$6.5310^{-2} \pm 1.57\%$
11	$1.0410^{-1} \pm 1.07\%$	$1.4110^{-1} \pm 0.81\%$	$9.4010^{-2} \pm 1.26\%$	$6.5410^{-2} \pm 1.57\%$
12	$1.0410^{-1} \pm 1.06\%$	$1.4110^{-1} \pm 0.81\%$	$9.4210^{-2} \pm 1.26\%$	$6.5510^{-2} \pm 1.57\%$
13	$1.0510^{-1} \pm 1.05\%$	$1.4210^{-1} \pm 0.80\%$	$9.4110^{-2} \pm 1.26\%$	$6.5710^{-2} \pm 1.56\%$
14	$1.0510^{-1} \pm 1.05\%$	$1.4310^{-1} \pm 0.80\%$	$9.4110^{-2} \pm 1.25\%$	$6.5910^{-2} \pm 1.56\%$
15	$1.0610^{-1} \pm 1.04\%$	$1.4310^{-1} \pm 0.80\%$	$9.4110^{-2} \pm 1.25\%$	$6.5910^{-2} \pm 1.55\%$

Table A.1: MSE and respective 95% confidence interval for the OS predictor.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$3.1210^{-2} \pm 3.65\%$	$4.1910^{-2} \pm 3.61\%$	$3.6110^{-2} \pm 3.95\%$	$3.2510^{-2} \pm 4.64\%$
2	$6.9610^{-2} \pm 1.79\%$	$9.2010^{-2} \pm 1.88\%$	$7.8110^{-2} \pm 2.08\%$	$6.8410^{-2} \pm 2.24\%$
3	$9.3810^{-2} \pm 1.36\%$	$1.2110^{-1} \pm 1.47\%$	$1.0110^{-1} \pm 1.66\%$	$9.3510^{-2} \pm 1.81\%$
4	$1.0710^{-1} \pm 1.20\%$	$1.3510^{-1} \pm 1.32\%$	$1.1110^{-1} \pm 1.51\%$	$1.1110^{-1} \pm 1.50\%$
5	$1.1410^{-1} \pm 1.12\%$	$1.4410^{-1} \pm 1.24\%$	$1.1610^{-1} \pm 1.45\%$	$1.2610^{-1} \pm 1.42\%$
6	$1.1810^{-1} \pm 1.08\%$	$1.5110^{-1} \pm 1.18\%$	$1.1910^{-1} \pm 1.41\%$	$1.3910^{-1} \pm 1.36\%$
7	$1.2110^{-1} \pm 1.06\%$	$1.5710^{-1} \pm 1.14\%$	$1.2110^{-1} \pm 1.38\%$	$1.5210^{-1} \pm 1.30\%$
8	$1.2310^{-1} \pm 1.04\%$	$1.6210^{-1} \pm 1.11\%$	$1.2210^{-1} \pm 1.36\%$	$1.6610^{-1} \pm 1.19\%$
9	$1.2410^{-1} \pm 1.03\%$	$1.6610^{-1} \pm 1.07\%$	$1.2310^{-1} \pm 1.34\%$	$1.7910^{-1} \pm 1.15\%$
10	$1.2510^{-1} \pm 1.02\%$	$1.7010^{-1} \pm 1.05\%$	$1.2510^{-1} \pm 1.32\%$	$1.9210^{-1} \pm 1.06\%$
11	$1.2610^{-1} \pm 1.00\%$	$1.7410^{-1} \pm 1.02\%$	$1.2710^{-1} \pm 1.30\%$	$2.0610^{-1} \pm 1.04\%$
12	$1.2810^{-1} \pm 0.99\%$	$1.7710^{-1} \pm 1.00\%$	$1.2910^{-1} \pm 1.28\%$	$2.2010^{-1} \pm 1.01\%$
13	$1.2910^{-1} \pm 0.98\%$	$1.8010^{-1} \pm 0.99\%$	$1.3110^{-1} \pm 1.26\%$	$2.3310^{-1} \pm 0.95\%$
14	$1.3010^{-1} \pm 0.97\%$	$1.8410^{-1} \pm 0.97\%$	$1.3210^{-1} \pm 1.24\%$	$2.4610^{-1} \pm 0.89\%$
15	$1.3110^{-1} \pm 0.97\%$	$1.8710^{-1} \pm 0.95\%$	$1.3410^{-1} \pm 1.23\%$	$2.5910^{-1} \pm 0.85\%$

Table A.2: MSE and respective 95% confidence interval for the OS predictor.

A.2 Moving Average — MA

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$6.0510^{-2} \pm 1.67\%$	$8.5710^{-2} \pm 1.23\%$	$5.9410^{-2} \pm 1.78\%$	$4.2010^{-2} \pm 2.23\%$
2	$6.9510^{-2} \pm 1.48\%$	$9.7010^{-2} \pm 1.10\%$	$6.5710^{-2} \pm 1.63\%$	$4.6410^{-2} \pm 2.04\%$
3	$7.5010^{-2} \pm 1.38\%$	$1.0310^{-1} \pm 1.04\%$	$6.8510^{-2} \pm 1.57\%$	$4.8310^{-2} \pm 1.97\%$
4	$7.8310^{-2} \pm 1.32\%$	$1.0710^{-1} \pm 1.01\%$	$6.9910^{-2} \pm 1.54\%$	$4.9110^{-2} \pm 1.93\%$
5	$8.0510^{-2} \pm 1.29\%$	$1.0910^{-1} \pm 0.99\%$	$7.0810^{-2} \pm 1.52\%$	$4.9610^{-2} \pm 1.92\%$
6	$8.2110^{-2} \pm 1.27\%$	$1.1010^{-1} \pm 0.98\%$	$7.1510^{-2} \pm 1.51\%$	$4.9810^{-2} \pm 1.91\%$
7	$8.3210^{-2} \pm 1.25\%$	$1.1110^{-1} \pm 0.97\%$	$7.2010^{-2} \pm 1.50\%$	$5.0010^{-2} \pm 1.91\%$
8	$8.4010^{-2} \pm 1.24\%$	$1.1210^{-1} \pm 0.96\%$	$7.2410^{-2} \pm 1.49\%$	$5.0110^{-2} \pm 1.90\%$
9	$8.4710^{-2} \pm 1.23\%$	$1.1310^{-1} \pm 0.96\%$	$7.2710^{-2} \pm 1.48\%$	$5.0310^{-2} \pm 1.90\%$
10	$8.5310^{-2} \pm 1.22\%$	$1.1310^{-1} \pm 0.95\%$	$7.2810^{-2} \pm 1.48\%$	$5.0410^{-2} \pm 1.89\%$
11	$8.5810^{-2} \pm 1.21\%$	$1.1410^{-1} \pm 0.95\%$	$7.2910^{-2} \pm 1.48\%$	$5.0510^{-2} \pm 1.89\%$
12	$8.6410^{-2} \pm 1.21\%$	$1.1410^{-1} \pm 0.95\%$	$7.3010^{-2} \pm 1.47\%$	$5.0610^{-2} \pm 1.88\%$
13	$8.6910^{-2} \pm 1.20\%$	$1.1510^{-1} \pm 0.94\%$	$7.3210^{-2} \pm 1.46\%$	$5.0710^{-2} \pm 1.88\%$
14	$8.7310^{-2} \pm 1.19\%$	$1.1510^{-1} \pm 0.94\%$	$7.3510^{-2} \pm 1.46\%$	$5.0810^{-2} \pm 1.88\%$
15	$8.7810^{-2} \pm 1.18\%$	$1.1510^{-1} \pm 0.94\%$	$7.3910^{-2} \pm 1.45\%$	$5.0810^{-2} \pm 1.87\%$

Table A.3: MSE and respective 95% confidence interval for the MA predictor with N=5.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$7.5510^{-2} \pm 1.55\%$	$9.5810^{-2} \pm 1.63\%$	$7.0110^{-2} \pm 2.29\%$	$5.7910^{-2} \pm 2.46\%$
2	$8.5710^{-2} \pm 1.38\%$	$1.0910^{-1} \pm 1.46\%$	$7.7610^{-2} \pm 2.10\%$	$7.4710^{-2} \pm 1.89\%$
3	$9.1510^{-2} \pm 1.30\%$	$1.1710^{-1} \pm 1.36\%$	$8.1310^{-2} \pm 2.01\%$	$8.9110^{-2} \pm 1.74\%$
4	$9.4910^{-2} \pm 1.25\%$	$1.2310^{-1} \pm 1.29\%$	$8.3510^{-2} \pm 1.96\%$	$1.0310^{-1} \pm 1.63\%$
5	$9.7110^{-2} \pm 1.23\%$	$1.2810^{-1} \pm 1.24\%$	$8.5110^{-2} \pm 1.92\%$	$1.1610^{-1} \pm 1.43\%$
6	$9.8710^{-2} \pm 1.20\%$	$1.3310^{-1} \pm 1.20\%$	$8.6810^{-2} \pm 1.88\%$	$1.2910^{-1} \pm 1.27\%$
7	$1.0010^{-1} \pm 1.19\%$	$1.3710^{-1} \pm 1.17\%$	$8.8710^{-2} \pm 1.85\%$	$1.4310^{-1} \pm 1.23\%$
8	$1.0110^{-1} \pm 1.17\%$	$1.4110^{-1} \pm 1.14\%$	$9.0710^{-2} \pm 1.81\%$	$1.5610^{-1} \pm 1.11\%$
9	$1.0210^{-1} \pm 1.16\%$	$1.4410^{-1} \pm 1.11\%$	$9.2610^{-2} \pm 1.78\%$	$1.7010^{-1} \pm 1.02\%$
10	$1.0410^{-1} \pm 1.14\%$	$1.4810^{-1} \pm 1.09\%$	$9.4510^{-2} \pm 1.75\%$	$1.8310^{-1} \pm 0.94\%$
11	$1.0510^{-1} \pm 1.13\%$	$1.5110^{-1} \pm 1.07\%$	$9.6010^{-2} \pm 1.72\%$	$1.9610^{-1} \pm 0.87\%$
12	$1.0610^{-1} \pm 1.12\%$	$1.5410^{-1} \pm 1.05\%$	$9.7410^{-2} \pm 1.70\%$	$2.0910^{-1} \pm 0.82\%$
13	$1.0710^{-1} \pm 1.11\%$	$1.5610^{-1} \pm 1.03\%$	$9.8610^{-2} \pm 1.68\%$	$2.2310^{-1} \pm 0.77\%$
14	$1.0810^{-1} \pm 1.10\%$	$1.5910^{-1} \pm 1.02\%$	$1.0010^{-1} \pm 1.66\%$	$2.3610^{-1} \pm 0.72\%$
15	$1.0810^{-1} \pm 1.09\%$	$1.6010^{-1} \pm 1.01\%$	$1.0110^{-1} \pm 1.63\%$	$2.4910^{-1} \pm 0.68\%$

Table A.4: MSE and respective 95% confidence interval for the MA predictor with N=5.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$5.9710^{-2} \pm 1.66\%$	$8.2210^{-2} \pm 1.24\%$	$5.5210^{-2} \pm 1.85\%$	$3.8810^{-2} \pm 2.36\%$
2	$6.4810^{-2} \pm 1.54\%$	$8.8410^{-2} \pm 1.16\%$	$5.8710^{-2} \pm 1.76\%$	$4.1010^{-2} \pm 2.24\%$
3	$6.7910^{-2} \pm 1.48\%$	$9.1910^{-2} \pm 1.12\%$	$6.0310^{-2} \pm 1.71\%$	$4.2110^{-2} \pm 2.19\%$
4	$7.0010^{-2} \pm 1.44\%$	$9.3910^{-2} \pm 1.10\%$	$6.1110^{-2} \pm 1.69\%$	$4.2610^{-2} \pm 2.16\%$
5	$7.1310^{-2} \pm 1.42\%$	$9.5310^{-2} \pm 1.09\%$	$6.1610^{-2} \pm 1.67\%$	$4.2910^{-2} \pm 2.15\%$
6	$7.2410^{-2} \pm 1.40\%$	$9.6310^{-2} \pm 1.08\%$	$6.2010^{-2} \pm 1.66\%$	$4.3010^{-2} \pm 2.14\%$
7	$7.3210^{-2} \pm 1.38\%$	$9.7010^{-2} \pm 1.07\%$	$6.2310^{-2} \pm 1.65\%$	$4.3210^{-2} \pm 2.14\%$
8	$7.3910^{-2} \pm 1.37\%$	$9.7610^{-2} \pm 1.06\%$	$6.2610^{-2} \pm 1.65\%$	$4.3310^{-2} \pm 2.13\%$
9	$7.4510^{-2} \pm 1.36\%$	$9.8110^{-2} \pm 1.06\%$	$6.2910^{-2} \pm 1.64\%$	$4.3410^{-2} \pm 2.13\%$
10	$7.5010^{-2} \pm 1.35\%$	$9.8510^{-2} \pm 1.06\%$	$6.3210^{-2} \pm 1.63\%$	$4.3510^{-2} \pm 2.12\%$
11	$7.5510^{-2} \pm 1.34\%$	$9.8910^{-2} \pm 1.05\%$	$6.3410^{-2} \pm 1.62\%$	$4.3610^{-2} \pm 2.12\%$
12	$7.6010^{-2} \pm 1.33\%$	$9.9210^{-2} \pm 1.05\%$	$6.3610^{-2} \pm 1.62\%$	$4.3710^{-2} \pm 2.11\%$
13	$7.6410^{-2} \pm 1.32\%$	$9.9510^{-2} \pm 1.05\%$	$6.3910^{-2} \pm 1.61\%$	$4.3810^{-2} \pm 2.11\%$
14	$7.6910^{-2} \pm 1.31\%$	$9.9810^{-2} \pm 1.04\%$	$6.4110^{-2} \pm 1.60\%$	$4.3810^{-2} \pm 2.10\%$
15	$7.7410^{-2} \pm 1.30\%$	$1.0010^{-1} \pm 1.04\%$	$6.4510^{-2} \pm 1.59\%$	$4.3910^{-2} \pm 2.10\%$

Table A.5: MSE and respective 95% confidence interval for the MA predictor with N=10.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$7.3110^{-2} \pm 1.54\%$	$9.6610^{-2} \pm 1.54\%$	$7.3210^{-2} \pm 1.89\%$	$5.7510^{-2} \pm 2.40\%$
2	$7.8910^{-2} \pm 1.44\%$	$1.0510^{-1} \pm 1.43\%$	$7.8310^{-2} \pm 1.78\%$	$7.2610^{-2} \pm 1.89\%$
3	$8.2410^{-2} \pm 1.38\%$	$1.1110^{-1} \pm 1.36\%$	$8.1310^{-2} \pm 1.72\%$	$8.6610^{-2} \pm 1.56\%$
4	$8.4710^{-2} \pm 1.35\%$	$1.1610^{-1} \pm 1.31\%$	$8.3410^{-2} \pm 1.68\%$	$1.0010^{-1} \pm 1.49\%$
5	$8.6410^{-2} \pm 1.32\%$	$1.2010^{-1} \pm 1.27\%$	$8.5110^{-2} \pm 1.64\%$	$1.1310^{-1} \pm 1.31\%$
6	$8.7810^{-2} \pm 1.30\%$	$1.2410^{-1} \pm 1.23\%$	$8.6710^{-2} \pm 1.61\%$	$1.2710^{-1} \pm 1.16\%$
7	$8.8910^{-2} \pm 1.28\%$	$1.2810^{-1} \pm 1.20\%$	$8.8310^{-2} \pm 1.58\%$	$1.4010^{-1} \pm 1.05\%$
8	$9.0010^{-2} \pm 1.27\%$	$1.3110^{-1} \pm 1.17\%$	$8.9810^{-2} \pm 1.55\%$	$1.5310^{-1} \pm 0.95\%$
9	$9.1110^{-2} \pm 1.25\%$	$1.3410^{-1} \pm 1.15\%$	$9.1410^{-2} \pm 1.53\%$	$1.6710^{-1} \pm 0.87\%$
10	$9.2110^{-2} \pm 1.24\%$	$1.3610^{-1} \pm 1.13\%$	$9.2910^{-2} \pm 1.50\%$	$1.8010^{-1} \pm 0.80\%$
11	$9.3010^{-2} \pm 1.23\%$	$1.3810^{-1} \pm 1.12\%$	$9.4410^{-2} \pm 1.48\%$	$1.9310^{-1} \pm 0.75\%$
12	$9.3910^{-2} \pm 1.21\%$	$1.4010^{-1} \pm 1.10\%$	$9.5910^{-2} \pm 1.45\%$	$2.0710^{-1} \pm 0.70\%$
13	$9.4710^{-2} \pm 1.20\%$	$1.4110^{-1} \pm 1.09\%$	$9.7310^{-2} \pm 1.43\%$	$2.2010^{-1} \pm 0.71\%$
14	$9.5410^{-2} \pm 1.19\%$	$1.4310^{-1} \pm 1.08\%$	$9.8710^{-2} \pm 1.41\%$	$2.3310^{-1} \pm 0.72\%$
15	$9.6210^{-2} \pm 1.18\%$	$1.4310^{-1} \pm 1.08\%$	$1.0010^{-1} \pm 1.39\%$	$2.4610^{-1} \pm 0.68\%$

Table A.6: MSE and respective 95% confidence interval for the MA predictor with N=5.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$5.8410^{-2} \pm 1.67\%$	$7.8810^{-2} \pm 1.25\%$	$5.2310^{-2} \pm 1.90\%$	$3.6410^{-2} \pm 2.47\%$
2	$6.1210^{-2} \pm 1.60\%$	$8.2110^{-2} \pm 1.21\%$	$5.4110^{-2} \pm 1.84\%$	$3.7610^{-2} \pm 2.40\%$
3	$6.3010^{-2} \pm 1.56\%$	$8.4010^{-2} \pm 1.19\%$	$5.5110^{-2} \pm 1.81\%$	$3.8210^{-2} \pm 2.37\%$
4	$6.4210^{-2} \pm 1.53\%$	$8.5210^{-2} \pm 1.17\%$	$5.5610^{-2} \pm 1.79\%$	$3.8410^{-2} \pm 2.35\%$
5	$6.5210^{-2} \pm 1.51\%$	$8.6010^{-2} \pm 1.16\%$	$5.6010^{-2} \pm 1.78\%$	$3.8610^{-2} \pm 2.34\%$
6	$6.6010^{-2} \pm 1.49\%$	$8.6610^{-2} \pm 1.16\%$	$5.6410^{-2} \pm 1.77\%$	$3.8810^{-2} \pm 2.34\%$
7	$6.6610^{-2} \pm 1.48\%$	$8.7110^{-2} \pm 1.15\%$	$5.6710^{-2} \pm 1.76\%$	$3.8910^{-2} \pm 2.33\%$
8	$6.7210^{-2} \pm 1.47\%$	$8.7510^{-2} \pm 1.14\%$	$5.7010^{-2} \pm 1.75\%$	$3.9010^{-2} \pm 2.32\%$
9	$6.7710^{-2} \pm 1.46\%$	$8.7910^{-2} \pm 1.14\%$	$5.7310^{-2} \pm 1.74\%$	$3.9110^{-2} \pm 2.32\%$
10	$6.8210^{-2} \pm 1.45\%$	$8.8310^{-2} \pm 1.14\%$	$5.7510^{-2} \pm 1.73\%$	$3.9210^{-2} \pm 2.32\%$
11	$6.8710^{-2} \pm 1.44\%$	$8.8610^{-2} \pm 1.13\%$	$5.7810^{-2} \pm 1.72\%$	$3.9310^{-2} \pm 2.31\%$
12	$6.9210^{-2} \pm 1.43\%$	$8.8910^{-2} \pm 1.13\%$	$5.8010^{-2} \pm 1.72\%$	$3.9310^{-2} \pm 2.31\%$
13	$6.9610^{-2} \pm 1.42\%$	$8.9110^{-2} \pm 1.13\%$	$5.8210^{-2} \pm 1.71\%$	$3.9410^{-2} \pm 2.30\%$
14	$7.0110^{-2} \pm 1.41\%$	$8.9410^{-2} \pm 1.12\%$	$5.8510^{-2} \pm 1.70\%$	$3.9510^{-2} \pm 2.30\%$
15	$7.0610^{-2} \pm 1.40\%$	$8.9610^{-2} \pm 1.12\%$	$5.8710^{-2} \pm 1.69\%$	$3.9610^{-2} \pm 2.29\%$

Table A.7: MSE and respective 95% confidence interval for the MA predictor with N=20.

h[ms]	Environment road	stadium1	stadium2	walk
1	$7.2110^{-2} \pm 1.51\%$	$1.0110^{-1} \pm 1.43\%$	$7.3510^{-2} \pm 1.81\%$	$6.2310^{-2} \pm 2.20\%$
2	$7.5510^{-2} \pm 1.46\%$	$1.0610^{-1} \pm 1.37\%$	$7.6810^{-2} \pm 1.75\%$	$7.6510^{-2} \pm 1.78\%$
3	$7.7610^{-2} \pm 1.42\%$	$1.1010^{-1} \pm 1.33\%$	$7.9010^{-2} \pm 1.70\%$	$9.0110^{-2} \pm 1.49\%$
4	$7.9210^{-2} \pm 1.39\%$	$1.1310^{-1} \pm 1.30\%$	$8.0810^{-2} \pm 1.66\%$	$1.0310^{-1} \pm 1.29\%$
5	$8.0410^{-2} \pm 1.37\%$	$1.1610^{-1} \pm 1.27\%$	$8.2310^{-2} \pm 1.63\%$	$1.1710^{-1} \pm 1.13\%$
6	$8.1510^{-2} \pm 1.35\%$	$1.1810^{-1} \pm 1.25\%$	$8.3810^{-2} \pm 1.60\%$	$1.3010^{-1} \pm 1.01\%$
7	$8.2410^{-2} \pm 1.34\%$	$1.2010^{-1} \pm 1.23\%$	$8.5310^{-2} \pm 1.58\%$	$1.4310^{-1} \pm 1.01\%$
8	$8.3410^{-2} \pm 1.32\%$	$1.2110^{-1} \pm 1.22\%$	$8.6910^{-2} \pm 1.55\%$	$1.5610^{-1} \pm 0.92\%$
9	$8.4310^{-2} \pm 1.31\%$	$1.2310^{-1} \pm 1.21\%$	$8.8410^{-2} \pm 1.53\%$	$1.7010^{-1} \pm 0.85\%$
10	$8.5210^{-2} \pm 1.29\%$	$1.2410^{-1} \pm 1.20\%$	$9.0010^{-2} \pm 1.50\%$	$1.8310^{-1} \pm 0.79\%$
11	$8.6010^{-2} \pm 1.28\%$	$1.2410^{-1} \pm 1.19\%$	$9.1510^{-2} \pm 1.48\%$	$1.9610^{-1} \pm 0.73\%$
12	$8.6910^{-2} \pm 1.27\%$	$1.2510^{-1} \pm 1.19\%$	$9.3010^{-2} \pm 1.46\%$	$2.0910^{-1} \pm 0.74\%$
13	$8.7710^{-2} \pm 1.26\%$	$1.2510^{-1} \pm 1.18\%$	$9.4510^{-2} \pm 1.44\%$	$2.2210^{-1} \pm 0.70\%$
14	$8.8510^{-2} \pm 1.25\%$	$1.2510^{-1} \pm 1.18\%$	$9.5910^{-2} \pm 1.42\%$	$2.3510^{-1} \pm 0.71\%$
15	$8.9310^{-2} \pm 1.24\%$	$1.2510^{-1} \pm 1.18\%$	$9.7410^{-2} \pm 1.40\%$	$2.4810^{-1} \pm 0.71\%$

Table A.8: MSE and respective 95% confidence interval for the MA predictor with N=20.

h[ms]	Environment archi	carpark	maths	mensa
1	$5.8610^{-2} \pm 1.65\%$	$7.7710^{-2} \pm 1.26\%$	$5.1710^{-2} \pm 1.90\%$	$3.5710^{-2} \pm 2.52\%$
2	$6.0510^{-2} \pm 1.61\%$	$7.9910^{-2} \pm 1.23\%$	$5.3010^{-2} \pm 1.85\%$	$3.6510^{-2} \pm 2.47\%$
3	$6.1910^{-2} \pm 1.58\%$	$8.1310^{-2} \pm 1.21\%$	$5.3710^{-2} \pm 1.83\%$	$3.6910^{-2} \pm 2.44\%$
4	$6.2910^{-2} \pm 1.55\%$	$8.2110^{-2} \pm 1.20\%$	$5.4110^{-2} \pm 1.82\%$	$3.7110^{-2} \pm 2.43\%$
5	$6.3710^{-2} \pm 1.54\%$	$8.2710^{-2} \pm 1.19\%$	$5.4510^{-2} \pm 1.81\%$	$3.7210^{-2} \pm 2.42\%$
6	$6.4310^{-2} \pm 1.52\%$	$8.3210^{-2} \pm 1.18\%$	$5.4810^{-2} \pm 1.80\%$	$3.7310^{-2} \pm 2.42\%$
7	$6.4910^{-2} \pm 1.51\%$	$8.3610^{-2} \pm 1.18\%$	$5.5010^{-2} \pm 1.79\%$	$3.7410^{-2} \pm 2.41\%$
8	$6.5410^{-2} \pm 1.50\%$	$8.3910^{-2} \pm 1.18\%$	$5.5310^{-2} \pm 1.78\%$	$3.7510^{-2} \pm 2.41\%$
9	$6.5910^{-2} \pm 1.49\%$	$8.4210^{-2} \pm 1.17\%$	$5.5510^{-2} \pm 1.77\%$	$3.7610^{-2} \pm 2.40\%$
10	$6.6410^{-2} \pm 1.48\%$	$8.4510^{-2} \pm 1.17\%$	$5.5810^{-2} \pm 1.76\%$	$3.7710^{-2} \pm 2.39\%$
11	$6.6810^{-2} \pm 1.47\%$	$8.4810^{-2} \pm 1.16\%$	$5.6010^{-2} \pm 1.75\%$	$3.7810^{-2} \pm 2.39\%$
12	$6.7310^{-2} \pm 1.46\%$	$8.5010^{-2} \pm 1.16\%$	$5.6210^{-2} \pm 1.75\%$	$3.7910^{-2} \pm 2.38\%$
13	$6.7710^{-2} \pm 1.45\%$	$8.5310^{-2} \pm 1.16\%$	$5.6510^{-2} \pm 1.74\%$	$3.8010^{-2} \pm 2.38\%$
14	$6.8210^{-2} \pm 1.44\%$	$8.5510^{-2} \pm 1.16\%$	$5.6710^{-2} \pm 1.73\%$	$3.8110^{-2} \pm 2.37\%$
15	$6.8610^{-2} \pm 1.43\%$	$8.5710^{-2} \pm 1.15\%$	$5.7010^{-2} \pm 1.73\%$	$3.8210^{-2} \pm 2.37\%$

Table A.9: MSE and respective 95% confidence interval for the MA predictor with N=30.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$7.3010^{-2} \pm 1.47\%$	$1.0110^{-1} \pm 1.41\%$	$7.6610^{-2} \pm 1.71\%$	$6.8210^{-2} \pm 2.02\%$
2	$7.5510^{-2} \pm 1.43\%$	$1.0510^{-1} \pm 1.37\%$	$7.9310^{-2} \pm 1.67\%$	$8.1910^{-2} \pm 1.66\%$
3	$7.7210^{-2} \pm 1.40\%$	$1.0710^{-1} \pm 1.35\%$	$8.1310^{-2} \pm 1.63\%$	$9.5310^{-2} \pm 1.56\%$
4	$7.8510^{-2} \pm 1.38\%$	$1.0810^{-1} \pm 1.33\%$	$8.3010^{-2} \pm 1.60\%$	$1.0810^{-1} \pm 1.48\%$
5	$7.9610^{-2} \pm 1.36\%$	$1.1010^{-1} \pm 1.31\%$	$8.4510^{-2} \pm 1.57\%$	$1.2110^{-1} \pm 1.41\%$
6	$8.0610^{-2} \pm 1.35\%$	$1.1110^{-1} \pm 1.30\%$	$8.6110^{-2} \pm 1.54\%$	$1.3510^{-1} \pm 1.26\%$
7	$8.1510^{-2} \pm 1.33\%$	$1.1110^{-1} \pm 1.30\%$	$8.7610^{-2} \pm 1.52\%$	$1.4810^{-1} \pm 1.22\%$
8	$8.2410^{-2} \pm 1.32\%$	$1.1210^{-1} \pm 1.29\%$	$8.9110^{-2} \pm 1.50\%$	$1.6110^{-1} \pm 1.11\%$
9	$8.3210^{-2} \pm 1.31\%$	$1.1210^{-1} \pm 1.28\%$	$9.0610^{-2} \pm 1.47\%$	$1.7410^{-1} \pm 1.02\%$
10	$8.4110^{-2} \pm 1.29\%$	$1.1210^{-1} \pm 1.28\%$	$9.2110^{-2} \pm 1.45\%$	$1.8710^{-1} \pm 1.00\%$
11	$8.4910^{-2} \pm 1.28\%$	$1.1210^{-1} \pm 1.28\%$	$9.3610^{-2} \pm 1.44\%$	$1.9910^{-1} \pm 0.98\%$
12	$8.5710^{-2} \pm 1.27\%$	$1.1210^{-1} \pm 1.28\%$	$9.5110^{-2} \pm 1.41\%$	$2.1210^{-1} \pm 0.96\%$
13	$8.6510^{-2} \pm 1.26\%$	$1.1210^{-1} \pm 1.28\%$	$9.6510^{-2} \pm 1.40\%$	$2.2510^{-1} \pm 0.91\%$
14	$8.7310^{-2} \pm 1.25\%$	$1.1210^{-1} \pm 1.28\%$	$9.7910^{-2} \pm 1.38\%$	$2.3810^{-1} \pm 0.89\%$
15	$8.8010^{-2} \pm 1.24\%$	$1.1210^{-1} \pm 1.28\%$	$9.9310^{-2} \pm 1.36\%$	$2.5110^{-1} \pm 0.84\%$

Table A.10: MSE and respective 95% confidence interval for the MA predictor with N=30.

A.3 Linear Prediction

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$4.1310^{-2} \pm 3.06\%$	$6.1610^{-2} \pm 2.11\%$	$5.0310^{-2} \pm 2.70\%$	$3.7610^{-2} \pm 3.18\%$
2	$1.5710^{-1} \pm 0.96\%$	$2.3610^{-1} \pm 0.65\%$	$1.9010^{-1} \pm 0.89\%$	$1.4010^{-1} \pm 1.01\%$
3	$3.2510^{-1} \pm 0.52\%$	$4.8610^{-1} \pm 0.36\%$	$3.8510^{-1} \pm 0.51\%$	$2.8110^{-1} \pm 0.55\%$
4	$5.3410^{-1} \pm 0.36\%$	$7.9610^{-1} \pm 0.25\%$	$6.2510^{-1} \pm 0.37\%$	$4.5510^{-1} \pm 0.38\%$
5	$7.8410^{-1} \pm 0.28\%$	$1.17 \pm 0.21\%$	$9.0810^{-1} \pm 0.30\%$	$6.6310^{-1} \pm 0.29\%$
6	$1.08 \pm 0.24\%$	$1.60 \pm 0.19\%$	$1.24 \pm 0.27\%$	$9.0910^{-1} \pm 0.25\%$
7	$1.42 \pm 0.22\%$	$2.10 \pm 0.18\%$	$1.63 \pm 0.25\%$	$1.19 \pm 0.22\%$
8	$1.80 \pm 0.21\%$	$2.67 \pm 0.17\%$	$2.07 \pm 0.24\%$	$1.52 \pm 0.20\%$
9	$2.23 \pm 0.20\%$	$3.30 \pm 0.17\%$	$2.57 \pm 0.23\%$	$1.88 \pm 0.19\%$
10	$2.71 \pm 0.19\%$	$4.01 \pm 0.17\%$	$3.12 \pm 0.23\%$	$2.28 \pm 0.18\%$
11	$3.24 \pm 0.19\%$	$4.79 \pm 0.17\%$	$3.73 \pm 0.23\%$	$2.73 \pm 0.18\%$
12	$3.81 \pm 0.19\%$	$5.63 \pm 0.17\%$	$4.40 \pm 0.23\%$	$3.21 \pm 0.18\%$
13	$4.43 \pm 0.19\%$	$6.55 \pm 0.17\%$	$5.11 \pm 0.23\%$	$3.73 \pm 0.18\%$
14	$5.10 \pm 0.19\%$	$7.54 \pm 0.18\%$	$5.89 \pm 0.23\%$	$4.30 \pm 0.18\%$
15	$5.81 \pm 0.19\%$	$8.60 \pm 0.18\%$	$6.71 \pm 0.23\%$	$4.91 \pm 0.18\%$

Table A.11: MSE and respective 95% confidence interval for the LP predictor with N=2.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$5.5310^{-2} \pm 2.64\%$	$7.5810^{-2} \pm 2.69\%$	$6.6310^{-2} \pm 2.92\%$	$5.0610^{-2} \pm 3.71\%$
2	$2.0910^{-1} \pm 0.85\%$	$2.8610^{-1} \pm 0.94\%$	$2.4910^{-1} \pm 1.01\%$	$1.6910^{-1} \pm 1.36\%$
3	$4.2910^{-1} \pm 0.47\%$	$5.8210^{-1} \pm 0.57\%$	$5.0310^{-1} \pm 0.61\%$	$3.3110^{-1} \pm 0.81\%$
4	$7.0210^{-1} \pm 0.33\%$	$9.4010^{-1} \pm 0.45\%$	$8.1410^{-1} \pm 0.46\%$	$5.2610^{-1} \pm 0.58\%$
5	$1.03 \pm 0.27\%$	$1.37 \pm 0.39\%$	$1.19 \pm 0.40\%$	$7.5610^{-1} \pm 0.48\%$
6	$1.41 \pm 0.24\%$	$1.88 \pm 0.36\%$	$1.63 \pm 0.36\%$	$1.03 \pm 0.42\%$
7	$1.86 \pm 0.22\%$	$2.47 \pm 0.34\%$	$2.13 \pm 0.34\%$	$1.34 \pm 0.38\%$
8	$2.36 \pm 0.21\%$	$3.15 \pm 0.34\%$	$2.71 \pm 0.33\%$	$1.69 \pm 0.35\%$
9	$2.92 \pm 0.21\%$	$3.91 \pm 0.33\%$	$3.36 \pm 0.33\%$	$2.09 \pm 0.34\%$
10	$3.55 \pm 0.20\%$	$4.75 \pm 0.33\%$	$4.08 \pm 0.33\%$	$2.52 \pm 0.33\%$
11	$4.24 \pm 0.20\%$	$5.67 \pm 0.33\%$	$4.87 \pm 0.33\%$	$3.01 \pm 0.32\%$
12	$4.98 \pm 0.20\%$	$6.68 \pm 0.33\%$	$5.74 \pm 0.32\%$	$3.54 \pm 0.31\%$
13	$5.80 \pm 0.20\%$	$7.77 \pm 0.33\%$	$6.68 \pm 0.32\%$	$4.11 \pm 0.31\%$
14	$6.67 \pm 0.20\%$	$8.95 \pm 0.33\%$	$7.69 \pm 0.33\%$	$4.72 \pm 0.31\%$
15	$7.61 \pm 0.20\%$	$1.0210^{1} \pm 0.33\%$	$8.78 \pm 0.33\%$	$5.37 \pm 0.31\%$

Table A.12: MSE and respective 95% confidence interval for the LP predictor with N=2.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$3.5010^{-2} \pm 2.94\%$	$5.2210^{-2} \pm 2.03\%$	$4.1010^{-2} \pm 2.64\%$	$2.9810^{-2} \pm 3.32\%$
2	$1.0110^{-1} \pm 1.17\%$	$1.5010^{-1} \pm 0.80\%$	$1.1410^{-1} \pm 1.12\%$	$8.1510^{-2} \pm 1.34\%$
3	$1.7410^{-1} \pm 0.73\%$	$2.5710^{-1} \pm 0.50\%$	$1.8910^{-1} \pm 0.74\%$	$1.3410^{-1} \pm 0.86\%$
4	$2.5310^{-1} \pm 0.53\%$	$3.6910^{-1} \pm 0.37\%$	$2.6510^{-1} \pm 0.57\%$	$1.8810^{-1} \pm 0.65\%$
5	$3.3810^{-1} \pm 0.42\%$	$4.8910^{-1} \pm 0.30\%$	$3.4610^{-1} \pm 0.47\%$	$2.4610^{-1} \pm 0.52\%$
6	$4.3210^{-1} \pm 0.35\%$	$6.2110^{-1} \pm 0.25\%$	$4.3710^{-1} \pm 0.40\%$	$3.1010^{-1} \pm 0.43\%$
7	$5.3510^{-1} \pm 0.30\%$	$7.6710^{-1} \pm 0.22\%$	$5.3910^{-1} \pm 0.35\%$	$3.8210^{-1} \pm 0.36\%$
8	$6.4910^{-1} \pm 0.27\%$	$9.2910^{-1} \pm 0.20\%$	$6.5210^{-1} \pm 0.31\%$	$4.6310^{-1} \pm 0.32\%$
9	$7.7410^{-1} \pm 0.24\%$	$1.11 \pm 0.19\%$	$7.7910^{-1} \pm 0.28\%$	$5.5110^{-1} \pm 0.28\%$
10	$9.1010^{-1} \pm 0.22\%$	$1.30 \pm 0.18\%$	$9.1810^{-1} \pm 0.26\%$	$6.4710^{-1} \pm 0.25\%$
11	$1.06 \pm 0.21\%$	$1.51 \pm 0.17\%$	$1.07 \pm 0.24\%$	$7.5210^{-1} \pm 0.23\%$
12	$1.22 \pm 0.20\%$	$1.74 \pm 0.16\%$	$1.23 \pm 0.23\%$	$8.6710^{-1} \pm 0.21\%$
13	$1.39 \pm 0.19\%$	$1.99 \pm 0.16\%$	$1.40 \pm 0.23\%$	$9.9010^{-1} \pm 0.20\%$
14	$1.57 \pm 0.18\%$	$2.25 \pm 0.16\%$	$1.59 \pm 0.22\%$	$1.12 \pm 0.19\%$
15	$1.76 \pm 0.18\%$	$2.53 \pm 0.16\%$	$1.78 \pm 0.22\%$	$1.26 \pm 0.18\%$

Table A.13: MSE and respective 95% confidence interval for the LP predictor with N=5.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$3.5010^{-2} \pm 2.94\%$	$5.2210^{-2} \pm 2.03\%$	$4.1010^{-2} \pm 2.64\%$	$2.9810^{-2} \pm 3.32\%$
2	$1.0110^{-1} \pm 1.17\%$	$1.5010^{-1} \pm 0.80\%$	$1.1410^{-1} \pm 1.12\%$	$8.1510^{-2} \pm 1.34\%$
3	$1.7410^{-1} \pm 0.73\%$	$2.5710^{-1} \pm 0.50\%$	$1.8910^{-1} \pm 0.74\%$	$1.3410^{-1} \pm 0.86\%$
4	$2.5310^{-1} \pm 0.53\%$	$3.6910^{-1} \pm 0.37\%$	$2.6510^{-1} \pm 0.57\%$	$1.8810^{-1} \pm 0.65\%$
5	$3.3810^{-1} \pm 0.42\%$	$4.8910^{-1} \pm 0.30\%$	$3.4610^{-1} \pm 0.47\%$	$2.4610^{-1} \pm 0.52\%$
6	$4.3210^{-1} \pm 0.35\%$	$6.2110^{-1} \pm 0.25\%$	$4.3710^{-1} \pm 0.40\%$	$3.1010^{-1} \pm 0.43\%$
7	$5.3510^{-1} \pm 0.30\%$	$7.6710^{-1} \pm 0.22\%$	$5.3910^{-1} \pm 0.35\%$	$3.8210^{-1} \pm 0.36\%$
8	$6.4910^{-1} \pm 0.27\%$	$9.2910^{-1} \pm 0.20\%$	$6.5210^{-1} \pm 0.31\%$	$4.6310^{-1} \pm 0.32\%$
9	$7.7410^{-1} \pm 0.24\%$	$1.11 \pm 0.19\%$	$7.7910^{-1} \pm 0.28\%$	$5.5110^{-1} \pm 0.28\%$
10	$9.1010^{-1} \pm 0.22\%$	$1.30 \pm 0.18\%$	$9.1810^{-1} \pm 0.26\%$	$6.4710^{-1} \pm 0.25\%$
11	$1.06 \pm 0.21\%$	$1.51 \pm 0.17\%$	$1.07 \pm 0.24\%$	$7.5210^{-1} \pm 0.23\%$
12	$1.22 \pm 0.20\%$	$1.74 \pm 0.16\%$	$1.23 \pm 0.23\%$	$8.6710^{-1} \pm 0.21\%$
13	$1.39 \pm 0.19\%$	$1.99 \pm 0.16\%$	$1.40 \pm 0.23\%$	$9.9010^{-1} \pm 0.20\%$
14	$1.57 \pm 0.18\%$	$2.25 \pm 0.16\%$	$1.59 \pm 0.22\%$	$1.12 \pm 0.19\%$
15	$1.76 \pm 0.18\%$	$2.53 \pm 0.16\%$	$1.78 \pm 0.22\%$	$1.26 \pm 0.18\%$

Table A.14: MSE and respective 95% confidence interval for the LP predictor with N=2.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$3.5010^{-2} \pm 2.94\%$	$5.2210^{-2} \pm 2.03\%$	$4.1010^{-2} \pm 2.64\%$	$2.9810^{-2} \pm 3.32\%$
2	$1.0110^{-1} \pm 1.17\%$	$1.5010^{-1} \pm 0.80\%$	$1.1410^{-1} \pm 1.12\%$	$8.1510^{-2} \pm 1.34\%$
3	$1.7410^{-1} \pm 0.73\%$	$2.5710^{-1} \pm 0.50\%$	$1.8910^{-1} \pm 0.74\%$	$1.3410^{-1} \pm 0.86\%$
4	$2.5310^{-1} \pm 0.53\%$	$3.6910^{-1} \pm 0.37\%$	$2.6510^{-1} \pm 0.57\%$	$1.8810^{-1} \pm 0.65\%$
5	$3.3810^{-1} \pm 0.42\%$	$4.8910^{-1} \pm 0.30\%$	$3.4610^{-1} \pm 0.47\%$	$2.4610^{-1} \pm 0.52\%$
6	$4.3210^{-1} \pm 0.35\%$	$6.2110^{-1} \pm 0.25\%$	$4.3710^{-1} \pm 0.40\%$	$3.1010^{-1} \pm 0.43\%$
7	$5.3510^{-1} \pm 0.30\%$	$7.6710^{-1} \pm 0.22\%$	$5.3910^{-1} \pm 0.35\%$	$3.8210^{-1} \pm 0.36\%$
8	$6.4910^{-1} \pm 0.27\%$	$9.2910^{-1} \pm 0.20\%$	$6.5210^{-1} \pm 0.31\%$	$4.6310^{-1} \pm 0.32\%$
9	$7.7410^{-1} \pm 0.24\%$	$1.11 \pm 0.19\%$	$7.7910^{-1} \pm 0.28\%$	$5.5110^{-1} \pm 0.28\%$
10	$9.1010^{-1} \pm 0.22\%$	$1.30 \pm 0.18\%$	$9.1810^{-1} \pm 0.26\%$	$6.4710^{-1} \pm 0.25\%$
11	$1.06 \pm 0.21\%$	$1.51 \pm 0.17\%$	$1.07 \pm 0.24\%$	$7.5210^{-1} \pm 0.23\%$
12	$1.22 \pm 0.20\%$	$1.74 \pm 0.16\%$	$1.23 \pm 0.23\%$	$8.6710^{-1} \pm 0.21\%$
13	$1.39 \pm 0.19\%$	$1.99 \pm 0.16\%$	$1.40 \pm 0.23\%$	$9.9010^{-1} \pm 0.20\%$
14	$1.57 \pm 0.18\%$	$2.25 \pm 0.16\%$	$1.59 \pm 0.22\%$	$1.12 \pm 0.19\%$
15	$1.76 \pm 0.18\%$	$2.53 \pm 0.16\%$	$1.78 \pm 0.22\%$	$1.26 \pm 0.18\%$

Table A.15: MSE and respective 95% confidence interval for the LP predictor with N=10.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$3.7110^{-2} \pm 3.08\%$	$4.9110^{-2} \pm 3.05\%$	$4.2210^{-2} \pm 3.36\%$	$3.6010^{-2} \pm 4.09\%$
2	$9.1910^{-2} \pm 1.38\%$	$1.1910^{-1} \pm 1.47\%$	$1.0110^{-1} \pm 1.64\%$	$8.1310^{-2} \pm 2.06\%$
3	$1.3810^{-1} \pm 0.96\%$	$1.7410^{-1} \pm 1.07\%$	$1.4510^{-1} \pm 1.20\%$	$1.1910^{-1} \pm 1.53\%$
4	$1.7810^{-1} \pm 0.77\%$	$2.1910^{-1} \pm 0.89\%$	$1.7810^{-1} \pm 1.01\%$	$1.5010^{-1} \pm 1.21\%$
5	$2.1410^{-1} \pm 0.66\%$	$2.6310^{-1} \pm 0.77\%$	$2.0910^{-1} \pm 0.89\%$	$1.8010^{-1} \pm 1.02\%$
6	$2.5010^{-1} \pm 0.58\%$	$3.1010^{-1} \pm 0.68\%$	$2.4110^{-1} \pm 0.80\%$	$2.1110^{-1} \pm 0.92\%$
7	$2.8810^{-1} \pm 0.51\%$	$3.6010^{-1} \pm 0.61\%$	$2.7510^{-1} \pm 0.73\%$	$2.4310^{-1} \pm 0.84\%$
8	$3.2810^{-1} \pm 0.46\%$	$4.1410^{-1} \pm 0.56\%$	$3.1210^{-1} \pm 0.67\%$	$2.7810^{-1} \pm 0.77\%$
9	$3.7110^{-1} \pm 0.42\%$	$4.7310^{-1} \pm 0.51\%$	$3.5310^{-1} \pm 0.61\%$	$3.1510^{-1} \pm 0.69\%$
10	$4.1910^{-1} \pm 0.38\%$	$5.3710^{-1} \pm 0.48\%$	$3.9810^{-1} \pm 0.57\%$	$3.5510^{-1} \pm 0.65\%$
11	$4.7010^{-1} \pm 0.35\%$	$6.0610^{-1} \pm 0.44\%$	$4.4610^{-1} \pm 0.53\%$	$3.9710^{-1} \pm 0.59\%$
12	$5.2410^{-1} \pm 0.33\%$	$6.8110^{-1} \pm 0.42\%$	$4.9810^{-1} \pm 0.49\%$	$4.4010^{-1} \pm 0.55\%$
13	$5.8210^{-1} \pm 0.31\%$	$7.6210^{-1} \pm 0.40\%$	$5.5310^{-1} \pm 0.46\%$	$4.8610^{-1} \pm 0.54\%$
14	$6.4410^{-1} \pm 0.29\%$	$8.4810^{-1} \pm 0.38\%$	$6.1010^{-1} \pm 0.44\%$	$5.3310^{-1} \pm 0.51\%$
15	$7.0910^{-1} \pm 0.27\%$	$9.3910^{-1} \pm 0.36\%$	$6.7010^{-1} \pm 0.42\%$	$5.8310^{-1} \pm 0.47\%$

Table A.16: MSE and respective 95% confidence interval for the LP predictor with N=10.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$2.6210^{-2} \pm 3.76\%$	$3.8610^{-2} \pm 2.67\%$	$2.9910^{-2} \pm 3.44\%$	$2.1810^{-2} \pm 4.38\%$
2	$6.2810^{-2} \pm 1.72\%$	$9.1710^{-2} \pm 1.23\%$	$6.8310^{-2} \pm 1.68\%$	$4.8910^{-2} \pm 2.08\%$
3	$9.1410^{-2} \pm 1.22\%$	$1.3110^{-1} \pm 0.88\%$	$9.3810^{-2} \pm 1.27\%$	$6.6510^{-2} \pm 1.55\%$
4	$1.1310^{-1} \pm 1.00\%$	$1.6010^{-1} \pm 0.73\%$	$1.1010^{-1} \pm 1.10\%$	$7.7610^{-2} \pm 1.34\%$
5	$1.3210^{-1} \pm 0.87\%$	$1.8210^{-1} \pm 0.65\%$	$1.2210^{-1} \pm 1.01\%$	$8.6110^{-2} \pm 1.22\%$
6	$1.4810^{-1} \pm 0.79\%$	$2.0310^{-1} \pm 0.59\%$	$1.3310^{-1} \pm 0.94\%$	$9.4010^{-2} \pm 1.13\%$
7	$1.6510^{-1} \pm 0.72\%$	$2.2310^{-1} \pm 0.55\%$	$1.4510^{-1} \pm 0.88\%$	$1.0210^{-1} \pm 1.05\%$
8	$1.8110^{-1} \pm 0.66\%$	$2.4410^{-1} \pm 0.51\%$	$1.5710^{-1} \pm 0.82\%$	$1.1010^{-1} \pm 0.98\%$
9	$1.9810^{-1} \pm 0.62\%$	$2.6610^{-1} \pm 0.47\%$	$1.7010^{-1} \pm 0.77\%$	$1.1910^{-1} \pm 0.92\%$
10	$2.1510^{-1} \pm 0.57\%$	$2.8810^{-1} \pm 0.44\%$	$1.8410^{-1} \pm 0.72\%$	$1.2810^{-1} \pm 0.86\%$
11	$2.3410^{-1} \pm 0.54\%$	$3.1210^{-1} \pm 0.41\%$	$1.9810^{-1} \pm 0.68\%$	$1.3810^{-1} \pm 0.81\%$
12	$2.5310^{-1} \pm 0.50\%$	$3.3810^{-1} \pm 0.39\%$	$2.1310^{-1} \pm 0.64\%$	$1.4810^{-1} \pm 0.76\%$
13	$2.7410^{-1} \pm 0.47\%$	$3.6510^{-1} \pm 0.36\%$	$2.2910^{-1} \pm 0.61\%$	$1.5910^{-1} \pm 0.71\%$
14	$2.9510^{-1} \pm 0.44\%$	$3.9310^{-1} \pm 0.34\%$	$2.4610^{-1} \pm 0.58\%$	$1.7110^{-1} \pm 0.67\%$
15	$3.1810^{-1} \pm 0.42\%$	$4.2310^{-1} \pm 0.33\%$	$2.6310^{-1} \pm 0.55\%$	$1.8310^{-1} \pm 0.63\%$

Table A.17: MSE and respective 95% confidence interval for the LP predictor with N=15.

h[ms]	Environment road	stadium1	stadium2	walk
1	$3.4110^{-2} \pm 3.34\%$	$4.5610^{-2} \pm 3.27\%$	$3.9010^{-2} \pm 3.63\%$	$3.4210^{-2} \pm 4.34\%$
2	$8.0310^{-2} \pm 1.56\%$	$1.0510^{-1} \pm 1.62\%$	$8.8610^{-2} \pm 1.82\%$	$7.4610^{-2} \pm 2.25\%$
3	$1.1510^{-1} \pm 1.12\%$	$1.4710^{-1} \pm 1.21\%$	$1.2110^{-1} \pm 1.39\%$	$1.0510^{-1} \pm 1.70\%$
4	$1.4010^{-1} \pm 0.94\%$	$1.7610^{-1} \pm 1.03\%$	$1.4210^{-1} \pm 1.20\%$	$1.2910^{-1} \pm 1.37\%$
5	$1.6010^{-1} \pm 0.83\%$	$2.0210^{-1} \pm 0.92\%$	$1.5810^{-1} \pm 1.09\%$	$1.5110^{-1} \pm 1.17\%$
6	$1.7910^{-1} \pm 0.75\%$	$2.2810^{-1} \pm 0.83\%$	$1.7310^{-1} \pm 1.01\%$	$1.7210^{-1} \pm 1.08\%$
7	$1.9710^{-1} \pm 0.69\%$	$2.5710^{-1} \pm 0.75\%$	$1.8910^{-1} \pm 0.94\%$	$1.9410^{-1} \pm 1.00\%$
8	$2.1510^{-1} \pm 0.64\%$	$2.8610^{-1} \pm 0.69\%$	$2.0510^{-1} \pm 0.88\%$	$2.1710^{-1} \pm 0.94\%$
9	$2.3510^{-1} \pm 0.60\%$	$3.1810^{-1} \pm 0.64\%$	$2.2310^{-1} \pm 0.83\%$	$2.4010^{-1} \pm 0.88\%$
10	$2.5610^{-1} \pm 0.55\%$	$3.5110^{-1} \pm 0.60\%$	$2.4210^{-1} \pm 0.78\%$	$2.6510^{-1} \pm 0.83\%$
11	$2.7810^{-1} \pm 0.52\%$	$3.8710^{-1} \pm 0.56\%$	$2.6310^{-1} \pm 0.73\%$	$2.9210^{-1} \pm 0.73\%$
12	$3.0110^{-1} \pm 0.49\%$	$4.2510^{-1} \pm 0.53\%$	$2.8610^{-1} \pm 0.69\%$	$3.1810^{-1} \pm 0.70\%$
13	$3.2610^{-1} \pm 0.46\%$	$4.6510^{-1} \pm 0.50\%$	$3.0910^{-1} \pm 0.65\%$	$3.4610^{-1} \pm 0.63\%$
14	$3.5210^{-1} \pm 0.43\%$	$5.0810^{-1} \pm 0.47\%$	$3.3210^{-1} \pm 0.62\%$	$3.7410^{-1} \pm 0.59\%$
15	$3.7910^{-1} \pm 0.41\%$	$5.5310^{-1} \pm 0.45\%$	$3.5710^{-1} \pm 0.59\%$	$4.0410^{-1} \pm 0.58\%$

Table A.18: MSE and respective 95% confidence interval for the LP predictor with N=15.

h[ms]	Environment archi	carpark	maths	mensa
1	$2.5210^{-2} \pm 3.90\%$	$3.7210^{-2} \pm 2.77\%$	$2.8910^{-2} \pm 3.55\%$	$2.1110^{-2} \pm 4.51\%$
2	$5.9110^{-2} \pm 1.82\%$	$8.6610^{-2} \pm 1.30\%$	$6.4710^{-2} \pm 1.77\%$	$4.6410^{-2} \pm 2.18\%$
3	$8.4010^{-2} \pm 1.31\%$	$1.2110^{-1} \pm 0.95\%$	$8.6810^{-2} \pm 1.35\%$	$6.1710^{-2} \pm 1.66\%$
4	$1.0110^{-1} \pm 1.10\%$	$1.4410^{-1} \pm 0.81\%$	$9.9210^{-2} \pm 1.20\%$	$7.0210^{-2} \pm 1.46\%$
5	$1.1510^{-1} \pm 0.98\%$	$1.6010^{-1} \pm 0.73\%$	$1.0710^{-1} \pm 1.12\%$	$7.5810^{-2} \pm 1.36\%$
6	$1.2610^{-1} \pm 0.90\%$	$1.7310^{-1} \pm 0.68\%$	$1.1410^{-1} \pm 1.06\%$	$8.0510^{-2} \pm 1.29\%$
7	$1.3610^{-1} \pm 0.84\%$	$1.8510^{-1} \pm 0.64\%$	$1.2010^{-1} \pm 1.01\%$	$8.4910^{-2} \pm 1.23\%$
8	$1.4610^{-1} \pm 0.79\%$	$1.9710^{-1} \pm 0.61\%$	$1.2710^{-1} \pm 0.97\%$	$8.9210^{-2} \pm 1.17\%$
9	$1.5510^{-1} \pm 0.75\%$	$2.0910^{-1} \pm 0.58\%$	$1.3410^{-1} \pm 0.93\%$	$9.3710^{-2} \pm 1.12\%$
10	$1.6510^{-1} \pm 0.71\%$	$2.2110^{-1} \pm 0.55\%$	$1.4110^{-1} \pm 0.89\%$	$9.8510^{-2} \pm 1.08\%$
11	$1.7510^{-1} \pm 0.68\%$	$2.3410^{-1} \pm 0.52\%$	$1.4910^{-1} \pm 0.85\%$	$1.0410^{-1} \pm 1.03\%$
12	$1.8610^{-1} \pm 0.64\%$	$2.4810^{-1} \pm 0.50\%$	$1.5710^{-1} \pm 0.81\%$	$1.0910^{-1} \pm 0.98\%$
13	$1.9710^{-1} \pm 0.61\%$	$2.6310^{-1} \pm 0.48\%$	$1.6510^{-1} \pm 0.78\%$	$1.1510^{-1} \pm 0.94\%$
14	$2.0910^{-1} \pm 0.58\%$	$2.7810^{-1} \pm 0.45\%$	$1.7310^{-1} \pm 0.75\%$	$1.2110^{-1} \pm 0.90\%$
15	$2.2110^{-1} \pm 0.55\%$	$2.9310^{-1} \pm 0.43\%$	$1.8210^{-1} \pm 0.72\%$	$1.2710^{-1} \pm 0.86\%$

Table A.19: MSE and respective 95% confidence interval for the LP predictor with N=20.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$3.3010^{-2} \pm 3.46\%$	$4.4210^{-2} \pm 3.38\%$	$3.7810^{-2} \pm 3.75\%$	$3.3510^{-2} \pm 4.46\%$
2	$7.5910^{-2} \pm 1.65\%$	$1.0010^{-1} \pm 1.69\%$	$8.4210^{-2} \pm 1.91\%$	$7.2010^{-2} \pm 2.10\%$
3	$1.0610^{-1} \pm 1.21\%$	$1.3810^{-1} \pm 1.28\%$	$1.1310^{-1} \pm 1.48\%$	$1.0010^{-1} \pm 1.65\%$
4	$1.2610^{-1} \pm 1.03\%$	$1.6110^{-1} \pm 1.10\%$	$1.2910^{-1} \pm 1.30\%$	$1.2210^{-1} \pm 1.44\%$
5	$1.4110^{-1} \pm 0.93\%$	$1.8110^{-1} \pm 0.99\%$	$1.4010^{-1} \pm 1.21\%$	$1.4010^{-1} \pm 1.24\%$
6	$1.5310^{-1} \pm 0.86\%$	$2.0110^{-1} \pm 0.91\%$	$1.5010^{-1} \pm 1.13\%$	$1.5810^{-1} \pm 1.16\%$
7	$1.6410^{-1} \pm 0.81\%$	$2.2010^{-1} \pm 0.84\%$	$1.5910^{-1} \pm 1.07\%$	$1.7710^{-1} \pm 1.09\%$
8	$1.7510^{-1} \pm 0.76\%$	$2.4110^{-1} \pm 0.78\%$	$1.6810^{-1} \pm 1.02\%$	$1.9510^{-1} \pm 1.02\%$
9	$1.8610^{-1} \pm 0.72\%$	$2.6310^{-1} \pm 0.73\%$	$1.7810^{-1} \pm 0.97\%$	$2.1510^{-1} \pm 0.89\%$
10	$1.9810^{-1} \pm 0.68\%$	$2.8610^{-1} \pm 0.68\%$	$1.8910^{-1} \pm 0.92\%$	$2.3510^{-1} \pm 0.85\%$
11	$2.1010^{-1} \pm 0.65\%$	$3.1010^{-1} \pm 0.64\%$	$2.0110^{-1} \pm 0.88\%$	$2.5610^{-1} \pm 0.84\%$
12	$2.2310^{-1} \pm 0.61\%$	$3.3510^{-1} \pm 0.61\%$	$2.1410^{-1} \pm 0.84\%$	$2.7810^{-1} \pm 0.77\%$
13	$2.3710^{-1} \pm 0.58\%$	$3.6210^{-1} \pm 0.58\%$	$2.2710^{-1} \pm 0.80\%$	$3.0010^{-1} \pm 0.72\%$
14	$2.5210^{-1} \pm 0.56\%$	$3.9010^{-1} \pm 0.55\%$	$2.4110^{-1} \pm 0.76\%$	$3.2210^{-1} \pm 0.71\%$
15	$2.6710^{-1} \pm 0.53\%$	$4.2010^{-1} \pm 0.52\%$	$2.5410^{-1} \pm 0.73\%$	$3.4610^{-1} \pm 0.68\%$

Table A.20: MSE and respective 95% confidence interval for the LP predictor with N=20.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$3.3010^{-2} \pm 3.46\%$	$4.4210^{-2} \pm 3.38\%$	$3.7810^{-2} \pm 3.75\%$	$3.3510^{-2} \pm 4.46\%$
2	$7.5910^{-2} \pm 1.65\%$	$1.0010^{-1} \pm 1.69\%$	$8.4210^{-2} \pm 1.91\%$	$7.2010^{-2} \pm 2.10\%$
3	$1.0610^{-1} \pm 1.21\%$	$1.3810^{-1} \pm 1.28\%$	$1.1310^{-1} \pm 1.48\%$	$1.0010^{-1} \pm 1.65\%$
4	$1.2610^{-1} \pm 1.03\%$	$1.6110^{-1} \pm 1.10\%$	$1.2910^{-1} \pm 1.30\%$	$1.2210^{-1} \pm 1.44\%$
5	$1.4110^{-1} \pm 0.93\%$	$1.8110^{-1} \pm 0.99\%$	$1.4010^{-1} \pm 1.21\%$	$1.4010^{-1} \pm 1.24\%$
6	$1.5310^{-1} \pm 0.86\%$	$2.0110^{-1} \pm 0.91\%$	$1.5010^{-1} \pm 1.13\%$	$1.5810^{-1} \pm 1.16\%$
7	$1.6410^{-1} \pm 0.81\%$	$2.2010^{-1} \pm 0.84\%$	$1.5910^{-1} \pm 1.07\%$	$1.7710^{-1} \pm 1.09\%$
8	$1.7510^{-1} \pm 0.76\%$	$2.4110^{-1} \pm 0.78\%$	$1.6810^{-1} \pm 1.02\%$	$1.9510^{-1} \pm 1.02\%$
9	$1.8610^{-1} \pm 0.72\%$	$2.6310^{-1} \pm 0.73\%$	$1.7810^{-1} \pm 0.97\%$	$2.1510^{-1} \pm 0.89\%$
10	$1.9810^{-1} \pm 0.68\%$	$2.8610^{-1} \pm 0.68\%$	$1.8910^{-1} \pm 0.92\%$	$2.3510^{-1} \pm 0.85\%$
11	$2.1010^{-1} \pm 0.65\%$	$3.1010^{-1} \pm 0.64\%$	$2.0110^{-1} \pm 0.88\%$	$2.5610^{-1} \pm 0.84\%$
12	$2.2310^{-1} \pm 0.61\%$	$3.3510^{-1} \pm 0.61\%$	$2.1410^{-1} \pm 0.84\%$	$2.7810^{-1} \pm 0.77\%$
13	$2.3710^{-1} \pm 0.58\%$	$3.6210^{-1} \pm 0.58\%$	$2.2710^{-1} \pm 0.80\%$	$3.0010^{-1} \pm 0.72\%$
14	$2.5210^{-1} \pm 0.56\%$	$3.9010^{-1} \pm 0.55\%$	$2.4110^{-1} \pm 0.76\%$	$3.2210^{-1} \pm 0.71\%$
15	$2.6710^{-1} \pm 0.53\%$	$4.2010^{-1} \pm 0.52\%$	$2.5410^{-1} \pm 0.73\%$	$3.4610^{-1} \pm 0.68\%$

Table A.21: MSE and respective 95% confidence interval for the LP predictor with N=30.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$3.2010^{-2} \pm 3.56\%$	$4.3110^{-2} \pm 3.47\%$	$3.6910^{-2} \pm 3.85\%$	$3.3010^{-2} \pm 4.54\%$
2	$7.2510^{-2} \pm 1.72\%$	$9.6410^{-2} \pm 1.76\%$	$8.0910^{-2} \pm 1.99\%$	$7.0210^{-2} \pm 2.15\%$
3	$9.9410^{-2} \pm 1.28\%$	$1.3010^{-1} \pm 1.34\%$	$1.0610^{-1} \pm 1.55\%$	$9.6910^{-2} \pm 1.70\%$
4	$1.1610^{-1} \pm 1.11\%$	$1.4910^{-1} \pm 1.17\%$	$1.1910^{-1} \pm 1.39\%$	$1.1710^{-1} \pm 1.50\%$
5	$1.2610^{-1} \pm 1.02\%$	$1.6410^{-1} \pm 1.07\%$	$1.2710^{-1} \pm 1.30\%$	$1.3310^{-1} \pm 1.38\%$
6	$1.3410^{-1} \pm 0.96\%$	$1.7810^{-1} \pm 0.99\%$	$1.3210^{-1} \pm 1.24\%$	$1.4910^{-1} \pm 1.29\%$
7	$1.4010^{-1} \pm 0.92\%$	$1.9110^{-1} \pm 0.93\%$	$1.3710^{-1} \pm 1.20\%$	$1.6510^{-1} \pm 1.15\%$
8	$1.4610^{-1} \pm 0.89\%$	$2.0510^{-1} \pm 0.87\%$	$1.4210^{-1} \pm 1.15\%$	$1.8210^{-1} \pm 1.09\%$
9	$1.5110^{-1} \pm 0.86\%$	$2.1910^{-1} \pm 0.83\%$	$1.4710^{-1} \pm 1.11\%$	$1.9810^{-1} \pm 0.95\%$
10	$1.5710^{-1} \pm 0.83\%$	$2.3310^{-1} \pm 0.79\%$	$1.5310^{-1} \pm 1.08\%$	$2.1610^{-1} \pm 0.95\%$
11	$1.6310^{-1} \pm 0.80\%$	$2.4710^{-1} \pm 0.75\%$	$1.5910^{-1} \pm 1.04\%$	$2.3310^{-1} \pm 0.88\%$
12	$1.6910^{-1} \pm 0.77\%$	$2.6210^{-1} \pm 0.72\%$	$1.6610^{-1} \pm 1.00\%$	$2.5110^{-1} \pm 0.84\%$
13	$1.7510^{-1} \pm 0.74\%$	$2.7610^{-1} \pm 0.69\%$	$1.7310^{-1} \pm 0.96\%$	$2.7010^{-1} \pm 0.84\%$
14	$1.8210^{-1} \pm 0.72\%$	$2.9210^{-1} \pm 0.66\%$	$1.8010^{-1} \pm 0.93\%$	$2.8810^{-1} \pm 0.73\%$
15	$1.8910^{-1} \pm 0.70\%$	$3.0710^{-1} \pm 0.64\%$	$1.8610^{-1} \pm 0.90\%$	$3.0610^{-1} \pm 0.71\%$

Table A.22: MSE and respective 95% confidence interval for the LP predictor with N=30.

A.4 Modified Covariance — MC

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$1.9910^{-1} \pm 0.56\%$	$2.7410^{-1} \pm 0.40\%$	$1.6610^{-1} \pm 0.68\%$	$1.4910^{-1} \pm 0.63\%$
2	$2.04 \pm 0.29\%$	$1.26 \pm 0.25\%$	$6.2910^{-1} \pm 0.38\%$	$7.7510^{-1} \pm 0.32\%$
3	$3.0010^{2} \pm 0.28\%$	$1.8810^{1} \pm 0.25\%$	$5.89 \pm 0.31\%$	$8.64 \pm 0.27\%$
4	$2.6910^{5} \pm 0.28\%$	$7.9710^{2} \pm 0.25\%$	$1.7510^{2} \pm 0.32\%$	$3.3610^{2} \pm 0.27\%$
5	$1.7010^{8} \pm 0.27\%$	$3.5810^{4} \pm 0.25\%$	$6.1510^{3} \pm 0.31\%$	$1.1410^{4} \pm 0.26\%$
6	$8.5810^{10} \pm 0.27\%$	$1.5910^{6} \pm 0.24\%$	$2.0610^{5} \pm 0.31\%$	$3.1610^{5} \pm 0.26\%$
7	$1.8510^{14} \pm 0.26\%$	$1.8410^{8} \pm 0.24\%$	$2.1210^{7} \pm 0.31\%$	$2.7210^{7} \pm 0.26\%$
8	$1.5710^{17} \pm 0.26\%$	$1.4010^{10} \pm 0.24\%$	$1.3310^{9} \pm 0.30\%$	$1.5710^{9} \pm 0.25\%$
9	$1.0510^{20} \pm 0.26\%$	$8.5810^{11} \pm 0.24\%$	$5.9110^{10} \pm 0.30\%$	$5.3610^{10} \pm 0.25\%$
10	$3.7010^{23} \pm 0.25\%$	$1.3410^{14} \pm 0.23\%$	$7.2910^{12} \pm 0.30\%$	$5.9810^{12} \pm 0.24\%$
11	$5.8610^{26} \pm 0.25\%$	$1.2410^{16} \pm 0.23\%$	$5.8010^{14} \pm 0.30\%$	$4.3210^{14} \pm 0.24\%$
12	$5.1710^{29} \pm 0.25\%$	$7.9710^{17} \pm 0.23\%$	$3.3110^{16} \pm 0.30\%$	$1.6810^{16} \pm 0.24\%$
13	$2.1110^{33} \pm 0.25\%$	$1.2910^{20} \pm 0.23\%$	$4.3710^{18} \pm 0.29\%$	$1.9510^{18} \pm 0.24\%$
14	$3.0010^{36} \pm 0.25\%$	$1.3610^{22} \pm 0.23\%$	$3.6810^{20} \pm 0.29\%$	$1.5810^{20} \pm 0.24\%$
15	$2.0610^{39} \pm 0.25\%$	$9.5610^{23} \pm 0.23\%$	$2.2910^{22} \pm 0.29\%$	$6.6510^{21} \pm 0.23\%$

Table A.23: MSE and respective 95% confidence interval for the MC predictor with P=5.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$2.3810^{-1} \pm 0.50\%$	$1.9510^{-1} \pm 0.81\%$	$1.8810^{-1} \pm 0.83\%$	$1.1510^{-1} \pm 1.08\%$
2	$1.40 \pm 0.29\%$	$8.1210^{-1} \pm 0.46\%$	$8.0910^{-1} \pm 0.47\%$	$3.8010^{-1} \pm 0.58\%$
3	$4.2210^{1} \pm 0.28\%$	$9.88 \pm 0.39\%$	$1.3010^{1} \pm 0.40\%$	$3.30 \pm 0.40\%$
4	$5.8310^{3} \pm 0.28\%$	$4.6410^{2} \pm 0.39\%$	$1.0110^{3} \pm 0.40\%$	$1.0610^{2} \pm 0.40\%$
5	$7.5410^{5} \pm 0.27\%$	$2.2210^{4} \pm 0.39\%$	$7.7210^{4} \pm 0.40\%$	$3.8210^{3} \pm 0.39\%$
6	$8.0910^{7} \pm 0.27\%$	$9.9310^{5} \pm 0.39\%$	$4.3610^{6} \pm 0.39\%$	$1.5910^{5} \pm 0.39\%$
7	$2.5410^{10} \pm 0.27\%$	$1.1710^{8} \pm 0.38\%$	$8.4410^{8} \pm 0.39\%$	$1.5110^{7} \pm 0.39\%$
8	$6.3610^{12} \pm 0.26\%$	$1.1810^{10} \pm 0.38\%$	$1.3610^{11} \pm 0.39\%$	$1.1310^{9} \pm 0.38\%$
9	$1.5010^{15} \pm 0.26\%$	$5.8710^{11} \pm 0.38\%$	$9.9010^{12} \pm 0.38\%$	$5.7810^{10} \pm 0.38\%$
10	$7.6010^{17} \pm 0.26\%$	$1.1210^{14} \pm 0.37\%$	$2.5310^{15} \pm 0.38\%$	$7.6410^{12} \pm 0.38\%$
11	$2.1810^{20} \pm 0.26\%$	$1.0510^{16} \pm 0.37\%$	$4.4410^{17} \pm 0.38\%$	$7.0810^{14} \pm 0.37\%$
12	$3.7610^{22} \pm 0.25\%$	$5.5110^{17} \pm 0.37\%$	$4.3710^{19} \pm 0.38\%$	$4.0610^{16} \pm 0.37\%$
13	$2.0810^{25} \pm 0.25\%$	$9.2010^{19} \pm 0.37\%$	$1.1510^{22} \pm 0.38\%$	$6.1210^{18} \pm 0.37\%$
14	$7.3210^{27} \pm 0.25\%$	$9.9010^{21} \pm 0.37\%$	$2.4410^{24} \pm 0.38\%$	$6.1410^{20} \pm 0.37\%$
15	$1.3810^{30} \pm 0.25\%$	$5.9810^{23} \pm 0.37\%$	$2.2010^{26} \pm 0.37\%$	$4.1910^{22} \pm 0.37\%$

Table A.24: MSE and respective 95% confidence interval for the MC predictor with P=5.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$1.9310^{-1} \pm 0.55\%$	$2.3610^{-1} \pm 0.42\%$	$1.5510^{-1} \pm 0.69\%$	$1.3310^{-1} \pm 0.66\%$
2	$3.4910^{-1} \pm 0.38\%$	$3.7110^{-1} \pm 0.31\%$	$2.4610^{-1} \pm 0.50\%$	$2.1010^{-1} \pm 0.48\%$
3	$7.1410^{-1} \pm 0.30\%$	$5.2010^{-1} \pm 0.27\%$	$3.6010^{-1} \pm 0.42\%$	$3.0110^{-1} \pm 0.40\%$
4	$2.93 \pm 0.27\%$	$8.5610^{-1} \pm 0.24\%$	$7.0010^{-1} \pm 0.35\%$	$5.1310^{-1} \pm 0.33\%$
5	$3.7610^{1} \pm 0.27\%$	$2.52 \pm 0.24\%$	$3.00 \pm 0.31\%$	$1.60 \pm 0.27\%$
6	$5.2210^{2} \pm 0.27\%$	$8.96 \pm 0.24\%$	$1.5310^{1} \pm 0.31\%$	$5.92 \pm 0.26\%$
7	$1.1210^{4} \pm 0.27\%$	$3.6510^{1} \pm 0.25\%$	$8.3510^{1} \pm 0.31\%$	$2.1310^{1} \pm 0.26\%$
8	$1.5110^{5} \pm 0.27\%$	$1.4110^{2} \pm 0.25\%$	$4.2910^{2} \pm 0.31\%$	$7.1810^{1} \pm 0.26\%$
9	$9.6210^{6} \pm 0.27\%$	$7.9410^{2} \pm 0.24\%$	$4.3010^{3} \pm 0.31\%$	$3.2510^{2} \pm 0.26\%$
10	$2.2210^{8} \pm 0.26\%$	$4.3110^{3} \pm 0.24\%$	$3.1710^{4} \pm 0.31\%$	$1.3910^{3} \pm 0.26\%$
11	$7.4210^{9} \pm 0.26\%$	$2.6210^{4} \pm 0.24\%$	$3.5410^{5} \pm 0.31\%$	$7.2810^{3} \pm 0.26\%$
12	$9.9310^{10} \pm 0.26\%$	$1.4210^{5} \pm 0.24\%$	$2.5010^{6} \pm 0.30\%$	$3.2310^{4} \pm 0.26\%$
13	$2.1310^{13} \pm 0.26\%$	$9.6810^{5} \pm 0.24\%$	$3.0510^{7} \pm 0.30\%$	$1.6610^{5} \pm 0.25\%$
14	$4.4310^{14} \pm 0.26\%$	$5.4110^{6} \pm 0.24\%$	$2.8510^{8} \pm 0.30\%$	$7.5710^{5} \pm 0.25\%$
15	$7.2210^{15} \pm 0.25\%$	$3.2010^{7} \pm 0.24\%$	$2.0210^{9} \pm 0.30\%$	$3.5410^{6} \pm 0.25\%$

Table A.25: MSE and respective 95% confidence interval for the MC predictor with P=10.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$2.3310^{-1} \pm 0.50\%$	$1.8010^{-1} \pm 0.82\%$	$1.7810^{-1} \pm 0.83\%$	$1.1010^{-1} \pm 1.07\%$
2	$4.2010^{-1} \pm 0.35\%$	$2.9510^{-1} \pm 0.60\%$	$2.8910^{-1} \pm 0.62\%$	$1.7910^{-1} \pm 0.78\%$
3	$8.2810^{-1} \pm 0.29\%$	$4.2310^{-1} \pm 0.51\%$	$4.4110^{-1} \pm 0.52\%$	$2.5610^{-1} \pm 0.64\%$
4	$3.01 \pm 0.27\%$	$7.0910^{-1} \pm 0.44\%$	$9.1610^{-1} \pm 0.43\%$	$4.5610^{-1} \pm 0.52\%$
5	$3.9910^{1} \pm 0.28\%$	$2.16 \pm 0.38\%$	$4.58 \pm 0.39\%$	$1.68 \pm 0.41\%$
6	$5.8310^{2} \pm 0.28\%$	$7.70 \pm 0.38\%$	$3.1210^{1} \pm 0.39\%$	$8.41 \pm 0.39\%$
7	$1.4210^{4} \pm 0.27\%$	$3.1310^{1} \pm 0.38\%$	$2.8010^{2} \pm 0.39\%$	$5.3110^{1} \pm 0.39\%$
8	$2.2210^{5} \pm 0.27\%$	$1.2110^{2} \pm 0.38\%$	$2.0610^{3} \pm 0.39\%$	$3.0110^{2} \pm 0.39\%$
9	$1.2310^{7} \pm 0.27\%$	$7.2710^{2} \pm 0.38\%$	$3.0710^{4} \pm 0.39\%$	$3.4710^{3} \pm 0.39\%$
10	$3.5810^{8} \pm 0.27\%$	$3.7110^{3} \pm 0.38\%$	$2.9810^{5} \pm 0.39\%$	$3.1810^{4} \pm 0.38\%$
11	$1.3610^{10} \pm 0.26\%$	$2.3110^{4} \pm 0.38\%$	$5.3010^{6} \pm 0.39\%$	$3.7810^{5} \pm 0.38\%$
12	$2.2810^{11} \pm 0.26\%$	$1.2110^{5} \pm 0.38\%$	$6.2110^{7} \pm 0.38\%$	$3.2610^{6} \pm 0.38\%$
13	$2.9310^{13} \pm 0.26\%$	$7.8410^{5} \pm 0.37\%$	$1.1910^{9} \pm 0.38\%$	$5.5010^{7} \pm 0.38\%$
14	$9.0910^{14} \pm 0.26\%$	$4.5910^{6} \pm 0.37\%$	$1.6610^{10} \pm 0.38\%$	$6.2810^{8} \pm 0.37\%$
15	$1.4510^{16} \pm 0.26\%$	$2.6710^{7} \pm 0.37\%$	$1.3610^{11} \pm 0.38\%$	$5.7010^{9} \pm 0.37\%$

Table A.26: MSE and respective 95% confidence interval for the MC predictor with P=10.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$1.4810^{-1} \pm 0.63\%$	$1.9610^{-1} \pm 0.47\%$	$1.3410^{-1} \pm 0.74\%$	$1.0510^{-1} \pm 0.76\%$
2	$2.2010^{-1} \pm 0.47\%$	$2.7910^{-1} \pm 0.36\%$	$1.9010^{-1} \pm 0.57\%$	$1.4610^{-1} \pm 0.59\%$
3	$2.7110^{-1} \pm 0.41\%$	$3.2610^{-1} \pm 0.32\%$	$2.2310^{-1} \pm 0.52\%$	$1.6610^{-1} \pm 0.54\%$
4	$3.3110^{-1} \pm 0.37\%$	$3.6610^{-1} \pm 0.30\%$	$2.6210^{-1} \pm 0.48\%$	$1.8710^{-1} \pm 0.50\%$
5	$4.4510^{-1} \pm 0.33\%$	$4.1810^{-1} \pm 0.29\%$	$3.4710^{-1} \pm 0.43\%$	$2.2210^{-1} \pm 0.46\%$
6	$7.1710^{-1} \pm 0.30\%$	$5.1210^{-1} \pm 0.27\%$	$5.8710^{-1} \pm 0.38\%$	$2.9310^{-1} \pm 0.41\%$
7	$1.65 \pm 0.27\%$	$7.2510^{-1} \pm 0.25\%$	$1.54 \pm 0.33\%$	$4.5110^{-1} \pm 0.35\%$
8	$4.46 \pm 0.27\%$	$1.15 \pm 0.24\%$	$5.11 \pm 0.32\%$	$8.0410^{-1} \pm 0.30\%$
9	$1.3010^{1} \pm 0.27\%$	$1.99 \pm 0.24\%$	$2.0110^{1} \pm 0.32\%$	$1.50 \pm 0.28\%$
10	$3.5510^{1} \pm 0.27\%$	$3.41 \pm 0.24\%$	$6.1710^{1} \pm 0.32\%$	$2.73 \pm 0.27\%$
11	$1.0210^{2} \pm 0.27\%$	$6.52 \pm 0.24\%$	$2.2410^{2} \pm 0.32\%$	$5.02 \pm 0.26\%$
12	$2.9210^{2} \pm 0.27\%$	$1.2810^{1} \pm 0.24\%$	$6.9910^{2} \pm 0.31\%$	$9.54 \pm 0.26\%$
13	$1.1810^{3} \pm 0.27\%$	$2.9010^{1} \pm 0.24\%$	$3.8910^{3} \pm 0.31\%$	$2.0210^{1} \pm 0.26\%$
14	$3.9110^{3} \pm 0.27\%$	$6.5310^{1} \pm 0.24\%$	$1.4510^{4} \pm 0.31\%$	$4.3510^{1} \pm 0.26\%$
15	$1.4310^{4} \pm 0.27\%$	$1.5410^{2} \pm 0.24\%$	$7.9210^{4} \pm 0.31\%$	$1.0110^{2} \pm 0.26\%$

Table A.27: MSE and respective 95% confidence interval for the MC predictor with P=15.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$1.9210^{-1} \pm 0.55\%$	$1.5410^{-1} \pm 0.88\%$	$1.4710^{-1} \pm 0.91\%$	$9.7310^{-2} \pm 1.14\%$
2	$2.8810^{-1} \pm 0.41\%$	$2.2910^{-1} \pm 0.67\%$	$2.1310^{-1} \pm 0.70\%$	$1.4410^{-1} \pm 0.87\%$
3	$3.6610^{-1} \pm 0.36\%$	$2.7610^{-1} \pm 0.60\%$	$2.5610^{-1} \pm 0.63\%$	$1.7510^{-1} \pm 0.77\%$
4	$4.7410^{-1} \pm 0.33\%$	$3.2210^{-1} \pm 0.55\%$	$2.9710^{-1} \pm 0.59\%$	$2.0710^{-1} \pm 0.70\%$
5	$7.6910^{-1} \pm 0.29\%$	$3.9210^{-1} \pm 0.51\%$	$3.7210^{-1} \pm 0.54\%$	$2.6410^{-1} \pm 0.63\%$
6	$1.86 \pm 0.28\%$	$5.1310^{-1} \pm 0.46\%$	$5.7010^{-1} \pm 0.47\%$	$3.9710^{-1} \pm 0.54\%$
7	$8.32 \pm 0.27\%$	$8.1910^{-1} \pm 0.41\%$	$1.15 \pm 0.42\%$	$8.7510^{-1} \pm 0.44\%$
8	$4.1410^{1} \pm 0.28\%$	$1.44 \pm 0.38\%$	$2.86 \pm 0.39\%$	$2.37 \pm 0.40\%$
9	$2.4410^{2} \pm 0.28\%$	$2.77 \pm 0.37\%$	$9.48 \pm 0.39\%$	$7.68 \pm 0.39\%$
10	$1.1010^{3} \pm 0.28\%$	$5.33 \pm 0.37\%$	$2.5010^{1} \pm 0.39\%$	$2.1310^{1} \pm 0.39\%$
11	$8.3310^{3} \pm 0.27\%$	$1.1710^{1} \pm 0.37\%$	$8.3710^{1} \pm 0.39\%$	$8.2310^{1} \pm 0.39\%$
12	$4.2910^{4} \pm 0.27\%$	$2.5110^{1} \pm 0.37\%$	$2.7410^{2} \pm 0.39\%$	$2.6810^{2} \pm 0.38\%$
13	$5.6610^{5} \pm 0.27\%$	$6.3710^{1} \pm 0.37\%$	$1.2710^{3} \pm 0.39\%$	$1.4810^{3} \pm 0.38\%$
14	$3.9810^{6} \pm 0.27\%$	$1.6310^{2} \pm 0.37\%$	$4.8610^{3} \pm 0.39\%$	$5.7610^{3} \pm 0.38\%$
15	$3.5710^{7} \pm 0.27\%$	$4.4610^{2} \pm 0.38\%$	$2.1810^{4} \pm 0.39\%$	$3.0610^{4} \pm 0.38\%$

Table A.28: MSE and respective 95% confidence interval for the MC predictor with P=15.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$1.3510^{-1} \pm 0.66\%$	$1.8410^{-1} \pm 0.49\%$	$1.2910^{-1} \pm 0.75\%$	$9.6410^{-2} \pm 0.80\%$
2	$1.9310^{-1} \pm 0.50\%$	$2.5410^{-1} \pm 0.38\%$	$1.7610^{-1} \pm 0.60\%$	$1.2810^{-1} \pm 0.63\%$
3	$2.2610^{-1} \pm 0.44\%$	$2.8910^{-1} \pm 0.34\%$	$2.0010^{-1} \pm 0.55\%$	$1.4210^{-1} \pm 0.59\%$
4	$2.4910^{-1} \pm 0.42\%$	$3.0910^{-1} \pm 0.33\%$	$2.1810^{-1} \pm 0.53\%$	$1.4810^{-1} \pm 0.57\%$
5	$2.7510^{-1} \pm 0.40\%$	$3.2810^{-1} \pm 0.32\%$	$2.5110^{-1} \pm 0.50\%$	$1.5710^{-1} \pm 0.55\%$
6	$3.0910^{-1} \pm 0.38\%$	$3.4710^{-1} \pm 0.31\%$	$3.2110^{-1} \pm 0.45\%$	$1.6810^{-1} \pm 0.53\%$
7	$3.7110^{-1} \pm 0.35\%$	$3.7810^{-1} \pm 0.30\%$	$5.4010^{-1} \pm 0.39\%$	$1.8710^{-1} \pm 0.50\%$
8	$4.8710^{-1} \pm 0.32\%$	$4.2210^{-1} \pm 0.29\%$	$1.39 \pm 0.34\%$	$2.1810^{-1} \pm 0.47\%$
9	$7.3610^{-1} \pm 0.29\%$	$4.9910^{-1} \pm 0.27\%$	$6.08 \pm 0.32\%$	$2.6810^{-1} \pm 0.42\%$
10	$1.28 \pm 0.28\%$	$6.2410^{-1} \pm 0.26\%$	$3.3910^{1} \pm 0.32\%$	$3.5710^{-1} \pm 0.38\%$
11	$2.40 \pm 0.27\%$	$8.1410^{-1} \pm 0.24\%$	$1.9810^{2} \pm 0.32\%$	$4.9810^{-1} \pm 0.34\%$
12	$4.21 \pm 0.27\%$	$1.06 \pm 0.24\%$	$6.2510^{2} \pm 0.32\%$	$6.8010^{-1} \pm 0.31\%$
13	$7.72 \pm 0.27\%$	$1.45 \pm 0.23\%$	$3.3610^{3} \pm 0.32\%$	$9.3710^{-1} \pm 0.29\%$
14	$1.4210^{1} \pm 0.27\%$	$1.99 \pm 0.23\%$	$1.3610^{4} \pm 0.32\%$	$1.30 \pm 0.28\%$
15	$2.9010^{1} \pm 0.27\%$	$2.91 \pm 0.23\%$	$1.2210^{5} \pm 0.32\%$	$1.83 \pm 0.27\%$

Table A.29: MSE and respective 95% confidence interval for the MC predictor with P=20.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$1.8410^{-1} \pm 0.56\%$	$1.4510^{-1} \pm 0.90\%$	$1.3810^{-1} \pm 0.93\%$	$9.6310^{-2} \pm 1.14\%$
2	$2.6410^{-1} \pm 0.42\%$	$2.1010^{-1} \pm 0.69\%$	$1.9310^{-1} \pm 0.74\%$	$1.3910^{-1} \pm 0.88\%$
3	$3.1810^{-1} \pm 0.38\%$	$2.4510^{-1} \pm 0.63\%$	$2.2110^{-1} \pm 0.67\%$	$1.6510^{-1} \pm 0.79\%$
4	$3.6810^{-1} \pm 0.35\%$	$2.7010^{-1} \pm 0.59\%$	$2.3810^{-1} \pm 0.65\%$	$1.8610^{-1} \pm 0.74\%$
5	$4.5510^{-1} \pm 0.33\%$	$3.0210^{-1} \pm 0.56\%$	$2.6210^{-1} \pm 0.62\%$	$2.1310^{-1} \pm 0.69\%$
6	$6.5010^{-1} \pm 0.31\%$	$3.3910^{-1} \pm 0.53\%$	$2.9110^{-1} \pm 0.59\%$	$2.5810^{-1} \pm 0.63\%$
7	$1.33 \pm 0.28\%$	$3.9610^{-1} \pm 0.49\%$	$3.4310^{-1} \pm 0.55\%$	$3.4510^{-1} \pm 0.56\%$
8	$3.90 \pm 0.28\%$	$4.8010^{-1} \pm 0.46\%$	$4.3910^{-1} \pm 0.50\%$	$5.8910^{-1} \pm 0.48\%$
9	$1.8010^{1} \pm 0.28\%$	$6.2510^{-1} \pm 0.43\%$	$6.4010^{-1} \pm 0.46\%$	$1.40 \pm 0.42\%$
10	$1.0710^{2} \pm 0.28\%$	$8.9310^{-1} \pm 0.40\%$	$1.11 \pm 0.42\%$	$4.45 \pm 0.39\%$
11	$6.5310^{2} \pm 0.28\%$	$1.31 \pm 0.38\%$	$2.15 \pm 0.39\%$	$1.7310^{1} \pm 0.39\%$
12	$2.9510^{3} \pm 0.28\%$	$1.91 \pm 0.37\%$	$4.10 \pm 0.39\%$	$4.7010^{1} \pm 0.39\%$
13	$1.9010^{4} \pm 0.28\%$	$3.03 \pm 0.36\%$	$7.62 \pm 0.38\%$	$1.6410^{2} \pm 0.39\%$
14	$8.8610^{4} \pm 0.27\%$	$4.71 \pm 0.36\%$	$1.4910^{1} \pm 0.38\%$	$4.9710^{2} \pm 0.38\%$
15	$7.6310^{5} \pm 0.27\%$	$8.02 \pm 0.36\%$	$3.4010^{1} \pm 0.38\%$	$2.7210^{3} \pm 0.38\%$

Table A.30: MSE and respective 95% confidence interval for the MC predictor with P=20.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$1.2410^{-1} \pm 0.69\%$	$1.7410^{-1} \pm 0.50\%$	$1.3510^{-1} \pm 0.73\%$	$8.8910^{-2} \pm 0.84\%$
2	$1.7410^{-1} \pm 0.53\%$	$2.3610^{-1} \pm 0.39\%$	$1.8510^{-1} \pm 0.58\%$	$1.1610^{-1} \pm 0.67\%$
3	$1.9910^{-1} \pm 0.47\%$	$2.6410^{-1} \pm 0.36\%$	$2.1410^{-1} \pm 0.54\%$	$1.2610^{-1} \pm 0.63\%$
4	$2.1110^{-1} \pm 0.45\%$	$2.7610^{-1} \pm 0.35\%$	$2.4610^{-1} \pm 0.51\%$	$1.2810^{-1} \pm 0.62\%$
5	$2.2110^{-1} \pm 0.44\%$	$2.8310^{-1} \pm 0.34\%$	$3.8510^{-1} \pm 0.44\%$	$1.3010^{-1} \pm 0.62\%$
6	$2.2910^{-1} \pm 0.43\%$	$2.8910^{-1} \pm 0.34\%$	$1.15 \pm 0.36\%$	$1.3110^{-1} \pm 0.62\%$
7	$2.3810^{-1} \pm 0.42\%$	$2.9610^{-1} \pm 0.34\%$	$7.02 \pm 0.33\%$	$1.3410^{-1} \pm 0.61\%$
8	$2.5010^{-1} \pm 0.41\%$	$3.0310^{-1} \pm 0.33\%$	$3.9210^{1} \pm 0.33\%$	$1.3710^{-1} \pm 0.60\%$
9	$2.6510^{-1} \pm 0.40\%$	$3.1410^{-1} \pm 0.33\%$	$2.4910^{2} \pm 0.33\%$	$1.4210^{-1} \pm 0.59\%$
10	$2.8610^{-1} \pm 0.39\%$	$3.2710^{-1} \pm 0.32\%$	$1.1510^{3} \pm 0.33\%$	$1.4910^{-1} \pm 0.57\%$
11	$3.1810^{-1} \pm 0.37\%$	$3.4310^{-1} \pm 0.31\%$	$7.2210^{3} \pm 0.32\%$	$1.5810^{-1} \pm 0.56\%$
12	$3.6210^{-1} \pm 0.35\%$	$3.6410^{-1} \pm 0.31\%$	$2.9310^{4} \pm 0.32\%$	$1.7110^{-1} \pm 0.53\%$
13	$4.3310^{-1} \pm 0.33\%$	$3.9410^{-1} \pm 0.30\%$	$3.1610^{5} \pm 0.32\%$	$1.8710^{-1} \pm 0.51\%$
14	$5.4010^{-1} \pm 0.31\%$	$4.3210^{-1} \pm 0.29\%$	$4.7110^{6} \pm 0.32\%$	$2.0910^{-1} \pm 0.48\%$
15	$7.1510^{-1} \pm 0.29\%$	$4.8310^{-1} \pm 0.27\%$	$1.8210^{8} \pm 0.32\%$	$2.3610^{-1} \pm 0.45\%$

Table A.31: MSE and respective 95% confidence interval for the MC predictor with P=30.

	Environment			
h[ms]	road	stadium1	stadium2	walk
1	$1.8110^{-1} \pm 0.56\%$	$1.3810^{-1} \pm 0.92\%$	$1.3310^{-1} \pm 0.95\%$	$1.0310^{-1} \pm 1.09\%$
2	$2.5510^{-1} \pm 0.43\%$	$1.9510^{-1} \pm 0.72\%$	$1.8410^{-1} \pm 0.75\%$	$1.4910^{-1} \pm 0.84\%$
3	$2.9810^{-1} \pm 0.39\%$	$2.2310^{-1} \pm 0.66\%$	$2.0510^{-1} \pm 0.69\%$	$1.7610^{-1} \pm 0.76\%$
4	$3.2910^{-1} \pm 0.37\%$	$2.3810^{-1} \pm 0.63\%$	$2.1410^{-1} \pm 0.68\%$	$1.9710^{-1} \pm 0.71\%$
5	$3.7310^{-1} \pm 0.35\%$	$2.5210^{-1} \pm 0.61\%$	$2.2210^{-1} \pm 0.66\%$	$2.2110^{-1} \pm 0.67\%$
6	$4.5610^{-1} \pm 0.33\%$	$2.6510^{-1} \pm 0.59\%$	$2.2910^{-1} \pm 0.65\%$	$2.6310^{-1} \pm 0.63\%$
7	$7.1810^{-1} \pm 0.31\%$	$2.8310^{-1} \pm 0.57\%$	$2.4010^{-1} \pm 0.63\%$	$3.4810^{-1} \pm 0.56\%$
8	$1.62 \pm 0.29\%$	$2.9810^{-1} \pm 0.55\%$	$2.5410^{-1} \pm 0.61\%$	$5.9410^{-1} \pm 0.49\%$
9	$5.67 \pm 0.28\%$	$3.2010^{-1} \pm 0.53\%$	$2.7410^{-1} \pm 0.59\%$	$1.50 \pm 0.42\%$
10	$2.1910^{1} \pm 0.28\%$	$3.4010^{-1} \pm 0.52\%$	$3.0010^{-1} \pm 0.57\%$	$4.92 \pm 0.40\%$
11	$8.8610^{1} \pm 0.28\%$	$3.7210^{-1} \pm 0.50\%$	$3.4010^{-1} \pm 0.54\%$	$2.0810^{1} \pm 0.39\%$
12	$3.5010^{2} \pm 0.28\%$	$4.1210^{-1} \pm 0.48\%$	$4.0210^{-1} \pm 0.51\%$	$9.6710^{1} \pm 0.39\%$
13	$1.9810^{3} \pm 0.28\%$	$4.6610^{-1} \pm 0.46\%$	$4.9110^{-1} \pm 0.48\%$	$5.9110^{2} \pm 0.39\%$
14	$1.2010^{4} \pm 0.28\%$	$5.3910^{-1} \pm 0.44\%$	$6.4010^{-1} \pm 0.44\%$	$3.4810^{3} \pm 0.39\%$
15	$1.7710^{5} \pm 0.28\%$	$6.5010^{-1} \pm 0.42\%$	$8.6610^{-1} \pm 0.42\%$	$3.3310^{4} \pm 0.39\%$

Table A.32: MSE and respective 95% confidence interval for the MC predictor with P=30.

	Environment			
h[ms]	archi	carpark	maths	mensa
1	$1.2410^{-1} \pm 0.69\%$	$1.7410^{-1} \pm 0.50\%$	$1.3510^{-1} \pm 0.73\%$	$8.8910^{-2} \pm 0.84\%$
2	$1.7410^{-1} \pm 0.53\%$	$2.3610^{-1} \pm 0.39\%$	$1.8510^{-1} \pm 0.58\%$	$1.1610^{-1} \pm 0.67\%$
3	$1.9910^{-1} \pm 0.47\%$	$2.6410^{-1} \pm 0.36\%$	$2.1410^{-1} \pm 0.54\%$	$1.2610^{-1} \pm 0.63\%$
4	$2.1110^{-1} \pm 0.45\%$	$2.7610^{-1} \pm 0.35\%$	$2.4610^{-1} \pm 0.51\%$	$1.2810^{-1} \pm 0.62\%$
5	$2.2110^{-1} \pm 0.44\%$	$2.8310^{-1} \pm 0.34\%$	$3.8510^{-1} \pm 0.44\%$	$1.3010^{-1} \pm 0.62\%$
6	$2.2910^{-1} \pm 0.43\%$	$2.8910^{-1} \pm 0.34\%$	$1.15 \pm 0.36\%$	$1.3110^{-1} \pm 0.62\%$
7	$2.3810^{-1} \pm 0.42\%$	$2.9610^{-1} \pm 0.34\%$	$7.02 \pm 0.33\%$	$1.3410^{-1} \pm 0.61\%$
8	$2.5010^{-1} \pm 0.41\%$	$3.0310^{-1} \pm 0.33\%$	$3.9210^{1} \pm 0.33\%$	$1.3710^{-1} \pm 0.60\%$
9	$2.6510^{-1} \pm 0.40\%$	$3.1410^{-1} \pm 0.33\%$	$2.4910^{2} \pm 0.33\%$	$1.4210^{-1} \pm 0.59\%$
10	$2.8610^{-1} \pm 0.39\%$	$3.2710^{-1} \pm 0.32\%$	$1.1510^{3} \pm 0.33\%$	$1.4910^{-1} \pm 0.57\%$
11	$3.1810^{-1} \pm 0.37\%$	$3.4310^{-1} \pm 0.31\%$	$7.2210^{3} \pm 0.32\%$	$1.5810^{-1} \pm 0.56\%$
12	$3.6210^{-1} \pm 0.35\%$	$3.6410^{-1} \pm 0.31\%$	$2.9310^{4} \pm 0.32\%$	$1.7110^{-1} \pm 0.53\%$
13	$4.3310^{-1} \pm 0.33\%$	$3.9410^{-1} \pm 0.30\%$	$3.1610^{5} \pm 0.32\%$	$1.8710^{-1} \pm 0.51\%$
14	$5.4010^{-1} \pm 0.31\%$	$4.3210^{-1} \pm 0.29\%$	$4.7110^{6} \pm 0.32\%$	$2.0910^{-1} \pm 0.48\%$
15	$7.1510^{-1} \pm 0.29\%$	$4.8310^{-1} \pm 0.27\%$	$1.8210^{8} \pm 0.32\%$	$2.3610^{-1} \pm 0.45\%$

Table A.33: MSE and respective 95% confidence interval for the MC predictor with P=40.

h[ms]	Environment road	stadium1	stadium2	walk
1	$1.8110^{-1} \pm 0.56\%$	$1.3810^{-1} \pm 0.92\%$	$1.3310^{-1} \pm 0.95\%$	$1.0310^{-1} \pm 1.09\%$
2	$2.5510^{-1} \pm 0.43\%$	$1.9510^{-1} \pm 0.72\%$	$1.8410^{-1} \pm 0.75\%$	$1.4910^{-1} \pm 0.84\%$
3	$2.9810^{-1} \pm 0.39\%$	$2.2310^{-1} \pm 0.66\%$	$2.0510^{-1} \pm 0.69\%$	$1.7610^{-1} \pm 0.76\%$
4	$3.2910^{-1} \pm 0.37\%$	$2.3810^{-1} \pm 0.63\%$	$2.1410^{-1} \pm 0.68\%$	$1.9710^{-1} \pm 0.71\%$
5	$3.7310^{-1} \pm 0.35\%$	$2.5210^{-1} \pm 0.61\%$	$2.2210^{-1} \pm 0.66\%$	$2.2110^{-1} \pm 0.67\%$
6	$4.5610^{-1} \pm 0.33\%$	$2.6510^{-1} \pm 0.59\%$	$2.2910^{-1} \pm 0.65\%$	$2.6310^{-1} \pm 0.63\%$
7	$7.1810^{-1} \pm 0.31\%$	$2.8310^{-1} \pm 0.57\%$	$2.4010^{-1} \pm 0.63\%$	$3.4810^{-1} \pm 0.56\%$
8	$1.62 \pm 0.29\%$	$2.9810^{-1} \pm 0.55\%$	$2.5410^{-1} \pm 0.61\%$	$5.9410^{-1} \pm 0.49\%$
9	$5.67 \pm 0.28\%$	$3.2010^{-1} \pm 0.53\%$	$2.7410^{-1} \pm 0.59\%$	$1.50 \pm 0.42\%$
10	$2.1910^{1} \pm 0.28\%$	$3.4010^{-1} \pm 0.52\%$	$3.0010^{-1} \pm 0.57\%$	$4.92 \pm 0.40\%$
11	$8.8610^{1} \pm 0.28\%$	$3.7210^{-1} \pm 0.50\%$	$3.4010^{-1} \pm 0.54\%$	$2.0810^{1} \pm 0.39\%$
12	$3.5010^{2} \pm 0.28\%$	$4.1210^{-1} \pm 0.48\%$	$4.0210^{-1} \pm 0.51\%$	$9.6710^{1} \pm 0.39\%$
13	$1.9810^{3} \pm 0.28\%$	$4.6610^{-1} \pm 0.46\%$	$4.9110^{-1} \pm 0.48\%$	$5.9110^{2} \pm 0.39\%$
14	$1.2010^{4} \pm 0.28\%$	$5.3910^{-1} \pm 0.44\%$	$6.4010^{-1} \pm 0.44\%$	$3.4810^{3} \pm 0.39\%$
15	$1.7710^{5} \pm 0.28\%$	$6.5010^{-1} \pm 0.42\%$	$8.6610^{-1} \pm 0.42\%$	$3.3310^{4} \pm 0.39\%$

Table A.34: MSE and respective 95% confidence interval for the MC predictor with P=40.

Appendix A

Further Results for Measured Channels

A.1 One Step — OS

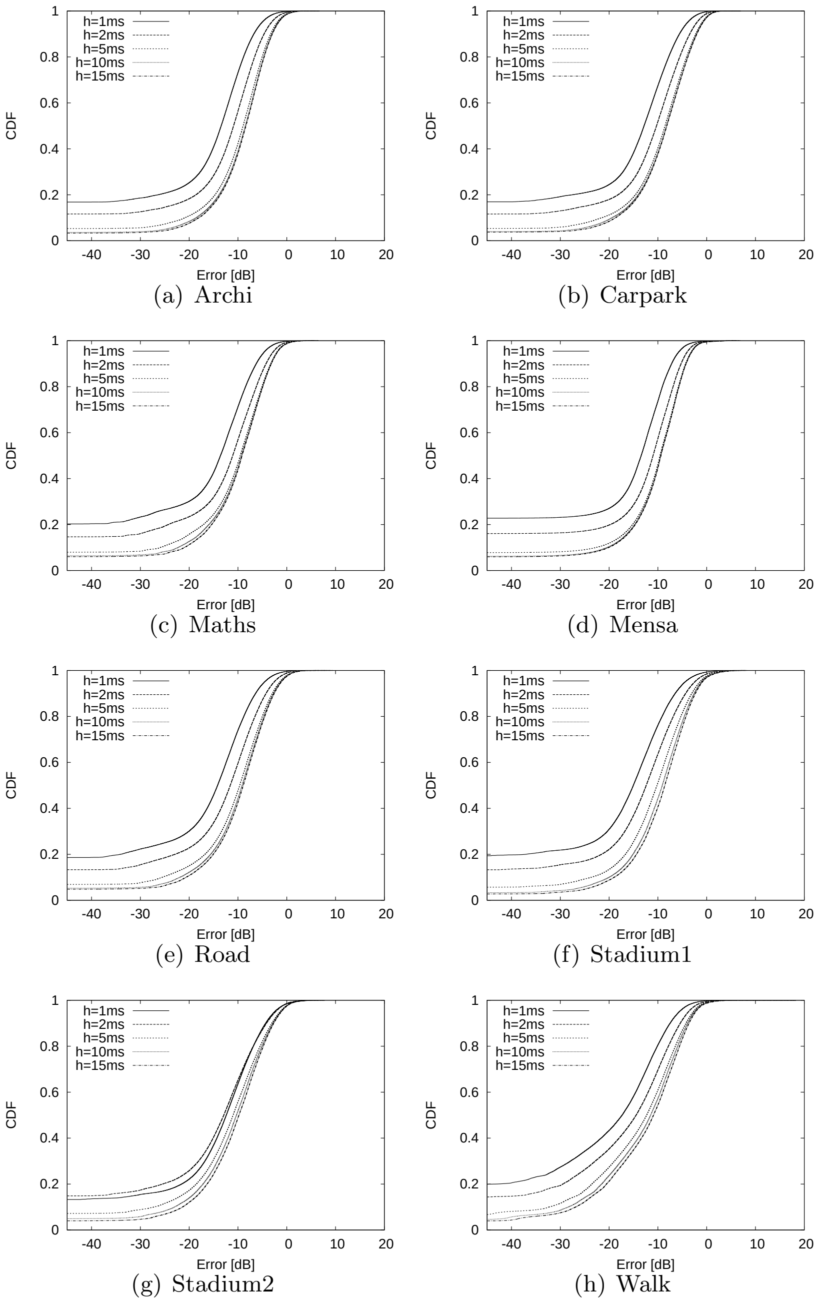


Figure A.1: CDF of normalised prediction errors for the OS predictor.

A.2 Moving Average — MA

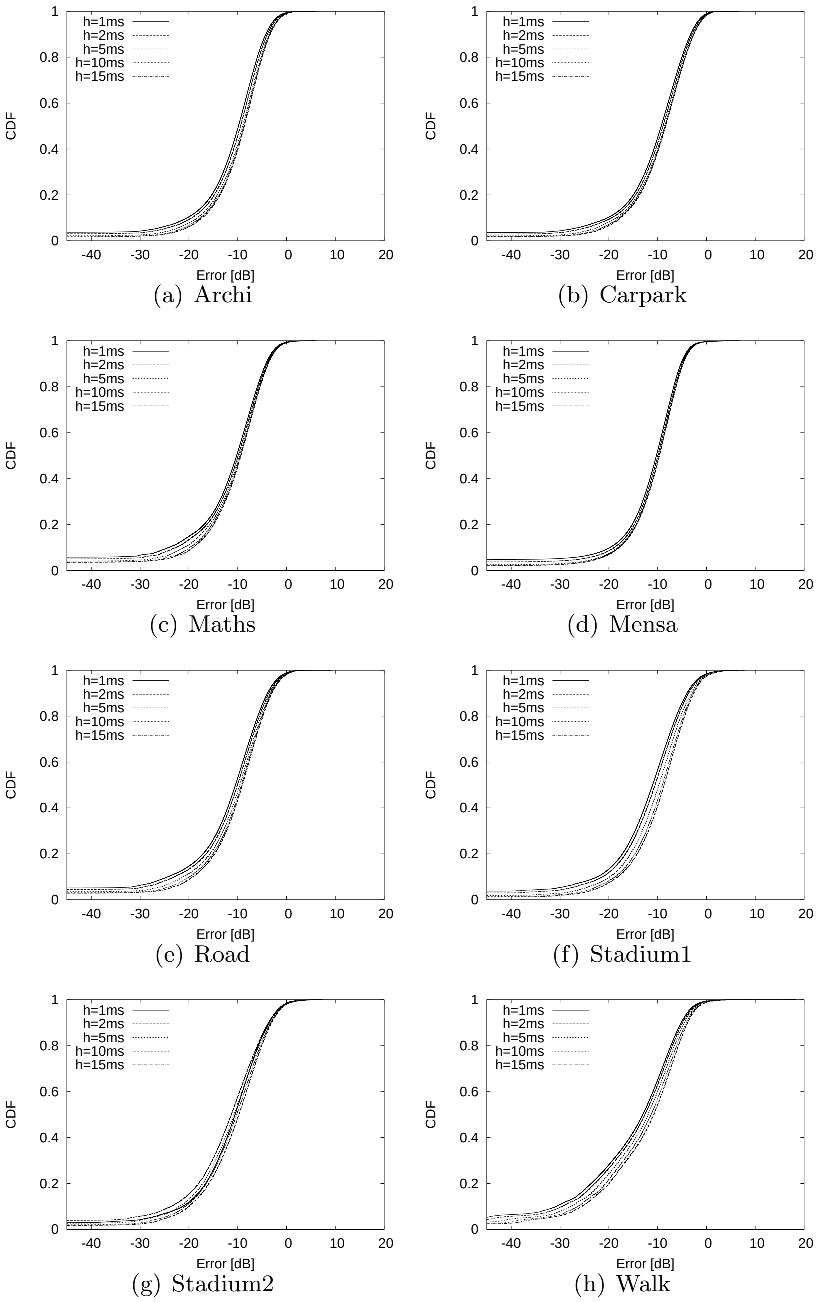
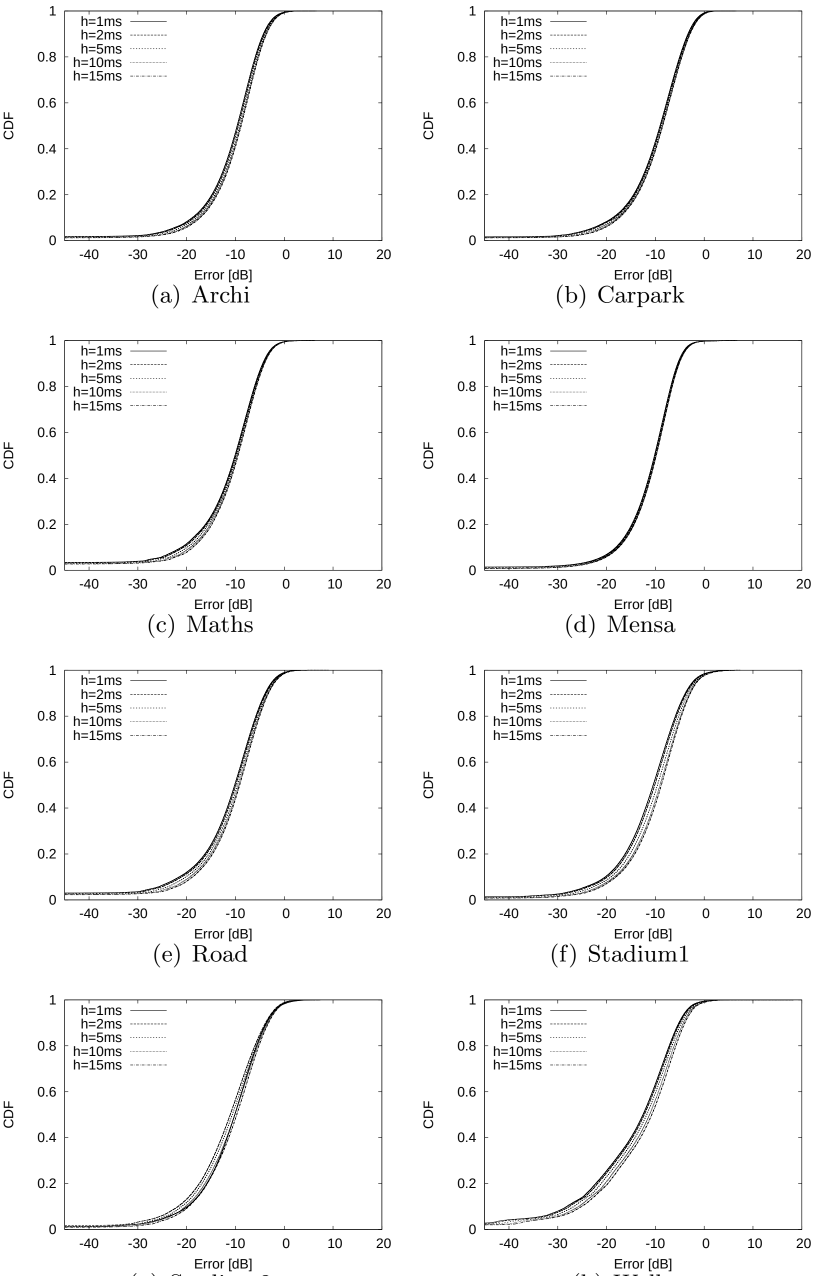


Figure A.2: CDF of normalised prediction errors for the MA prediction algorithm with N=5.



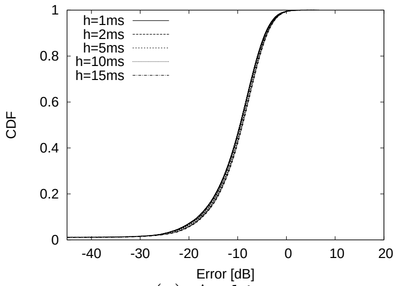
(a) Archi (b) Carpark

(c) Maths (d) Mensa

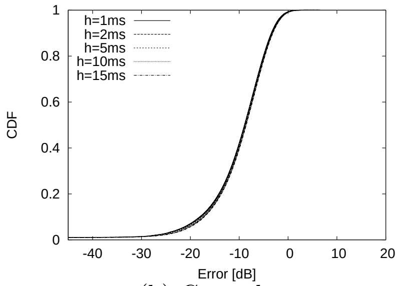
(e) Road (f) Stadium1

(g) Stadium2 (h) Walk

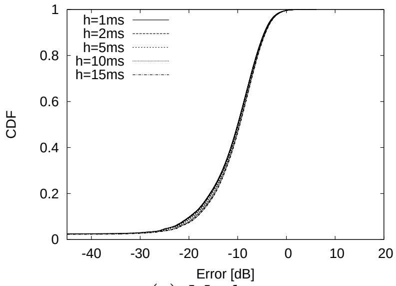
Figure A.3: CDF of normalised prediction errors for the MA prediction algorithm with N=10.



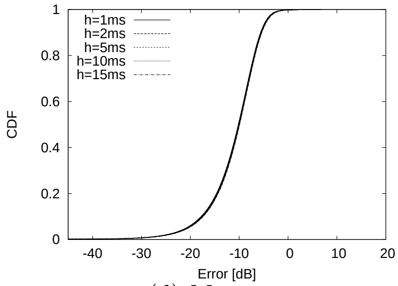
(a) Archi



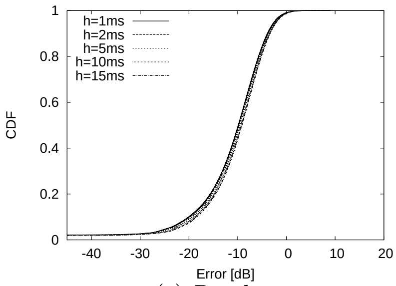
(b) Carpark



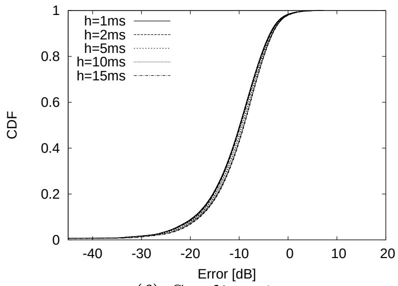
(c) Maths



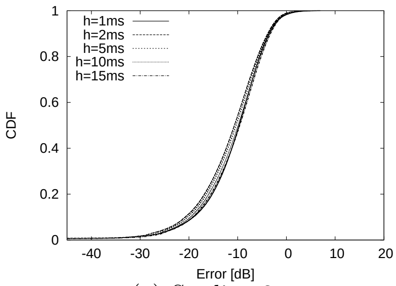
(d) Mensa



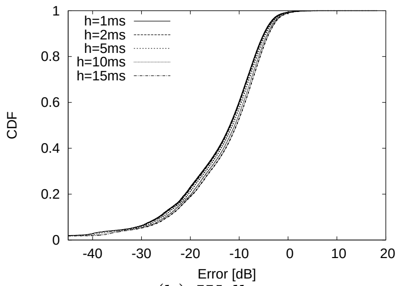
(e) Road



(f) Stadium1

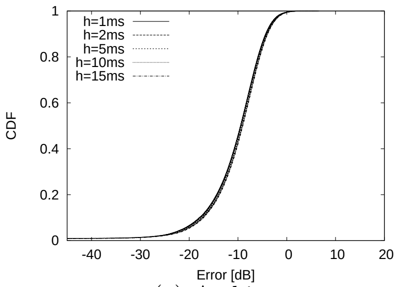


(g) Stadium2

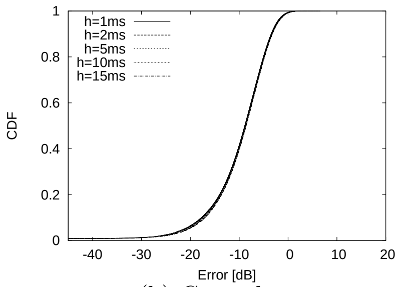


(h) Walk

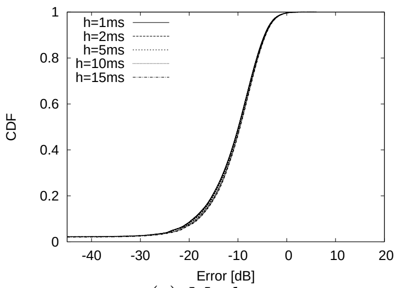
Figure A.4: CDF of normalised prediction errors for the MA prediction algorithm with N=20.



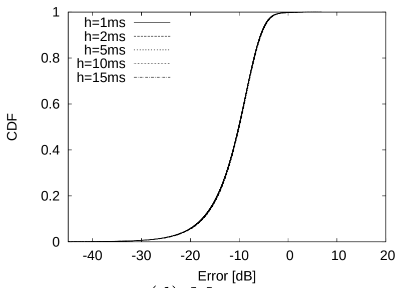
(a) Archi



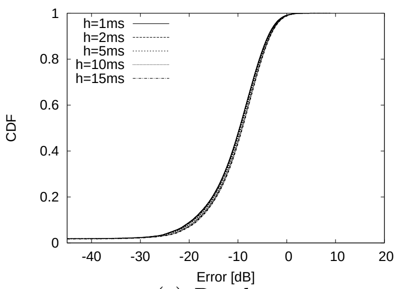
(b) Carpark



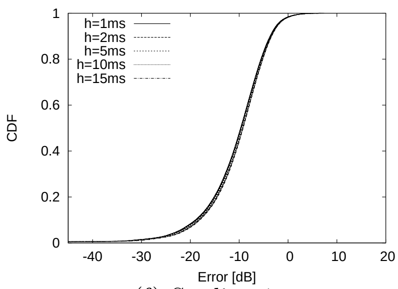
(c) Maths



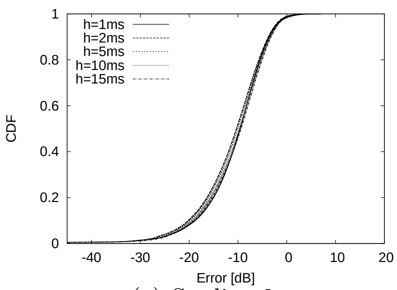
(d) Mensa



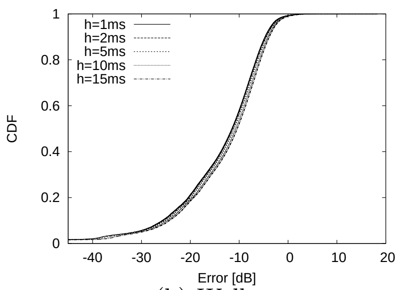
(e) Road



(f) Stadium1



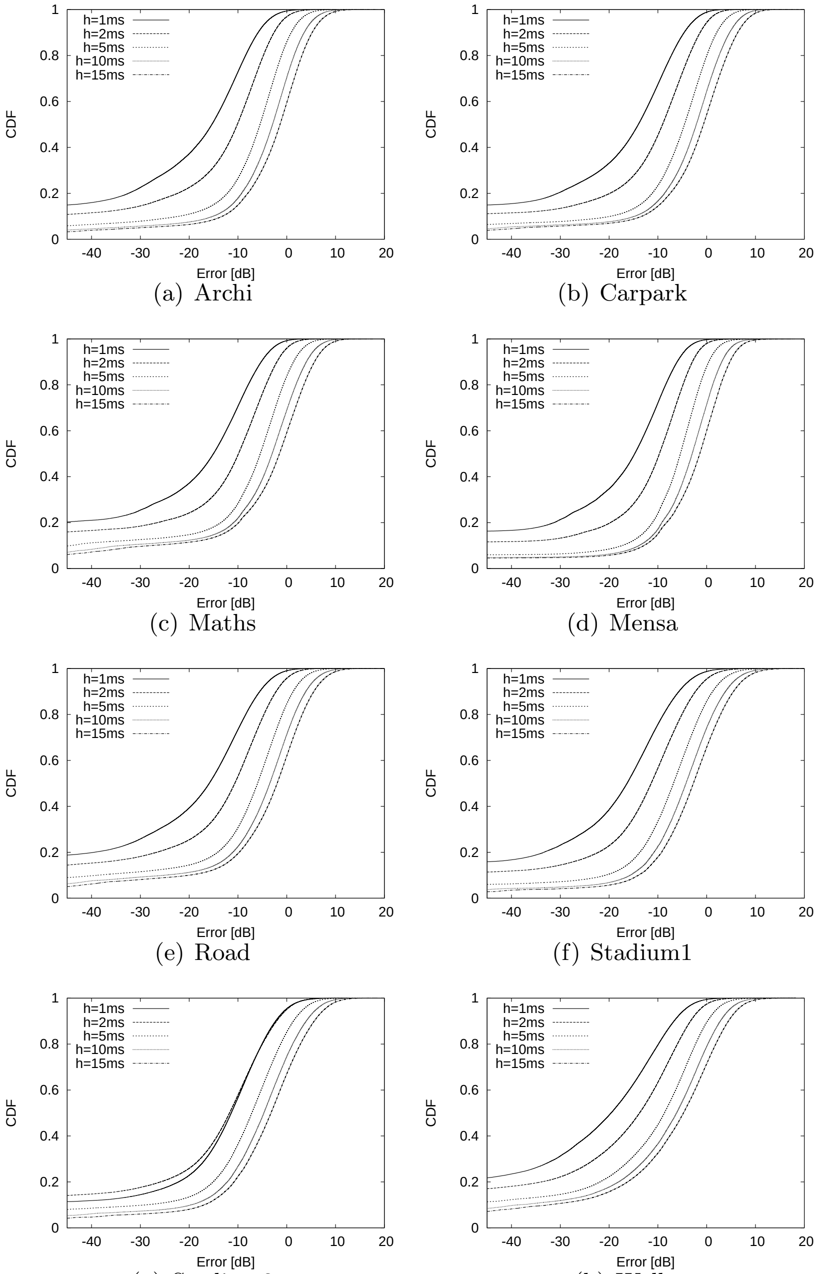
(g) Stadium2



(h) Walk

Figure A.5: CDF of normalised prediction errors for the MA prediction algorithm with N=30.

A.3 Linear Prediction



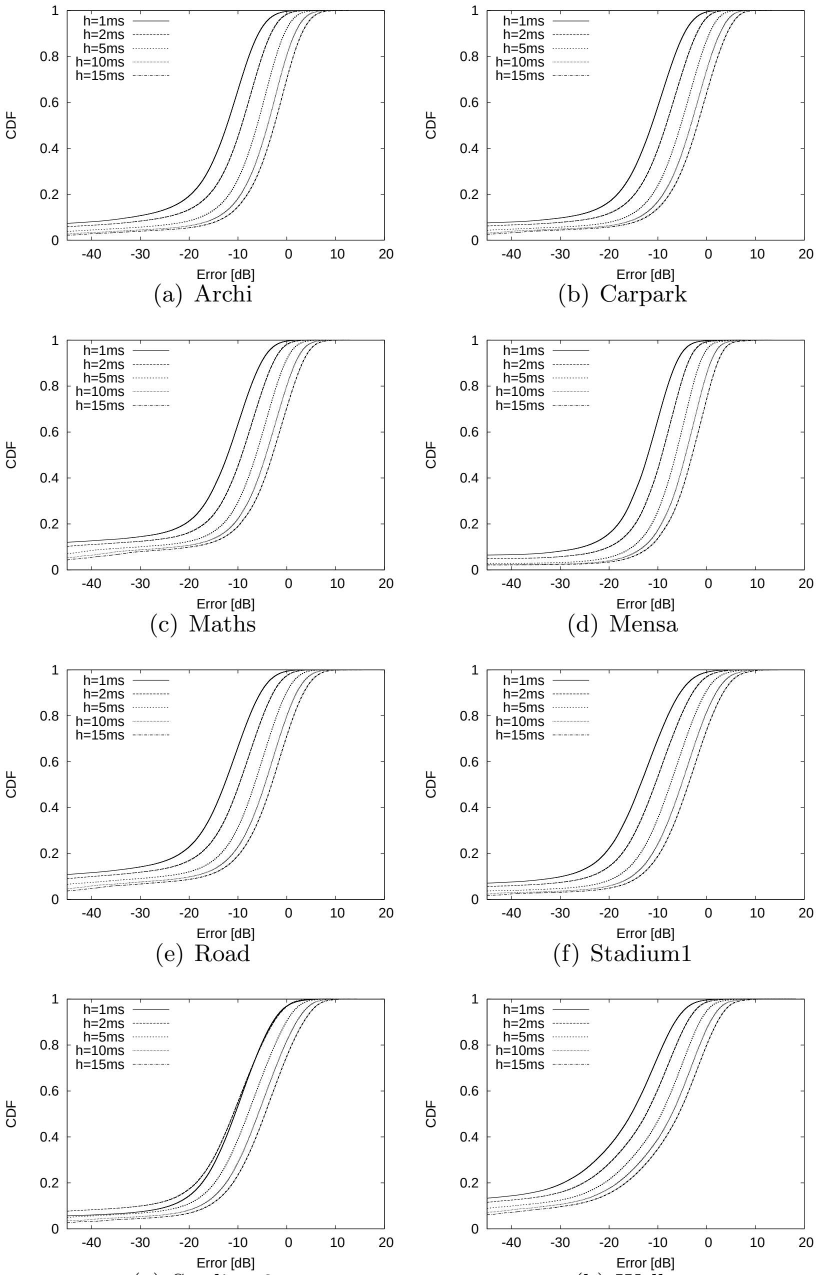
(a) Archi (b) Carpark

(c) Maths (d) Mensa

(e) Road (f) Stadium1

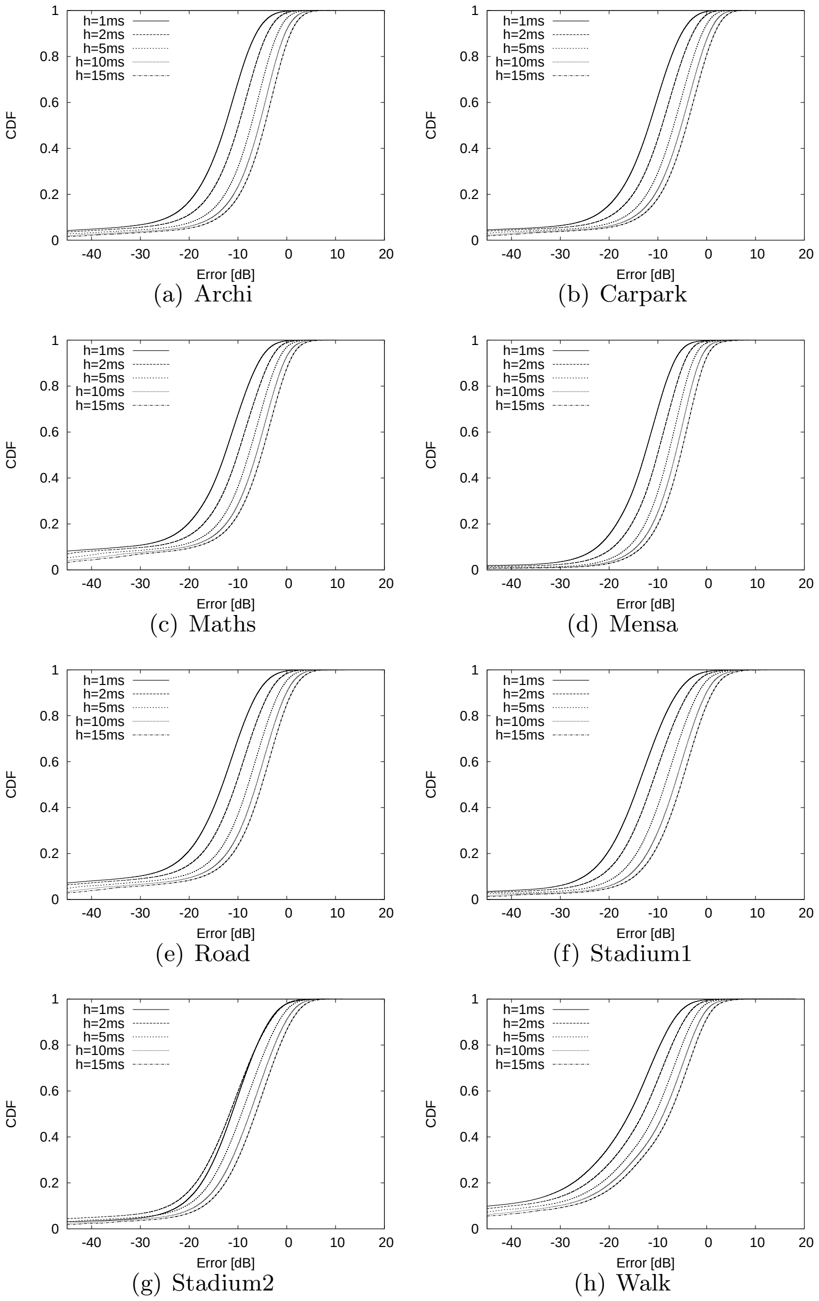
(g) Stadium2 (h) Walk

Figure A.6: CDF of normalised prediction errors for the LP prediction algorithm using N=2 samples.



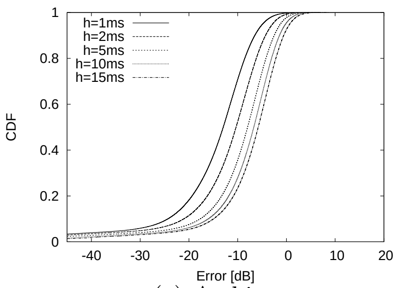
(a) Archi (b) Carpark
(c) Maths (d) Mensa
(e) Road (f) Stadium1
(g) Stadium2 (h) Walk

Figure A.7: CDF of normalised prediction errors for the LP prediction algorithm using N=5 samples.

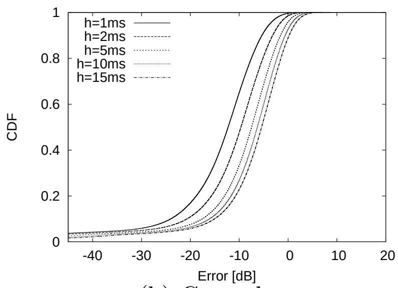


(a) Archi (b) Carpark (c) Maths (d) Mensa (e) Road (f) Stadium1 (g) Stadium2 (h) Walk

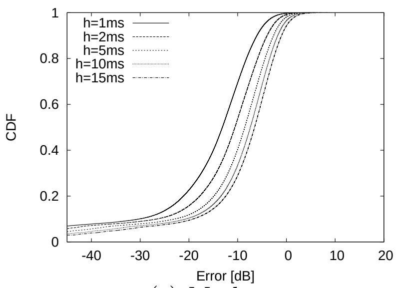
Figure A.8: CDF of normalised prediction errors for the LP prediction algorithm using N=10 samples.



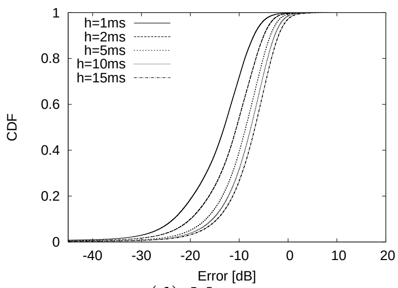
(a) Archi



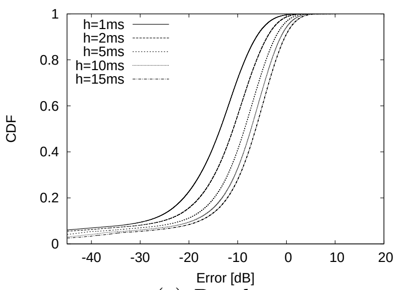
(b) Carpark



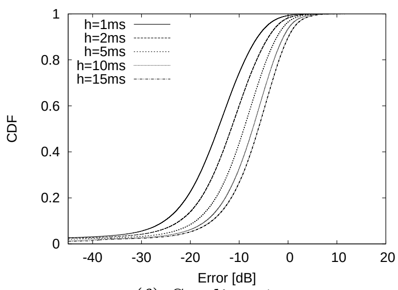
(c) Maths



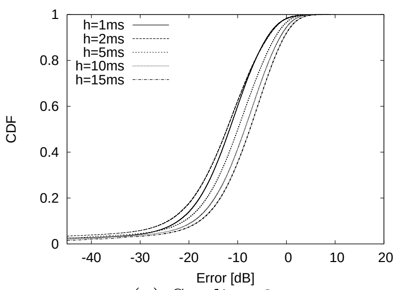
(d) Mensa



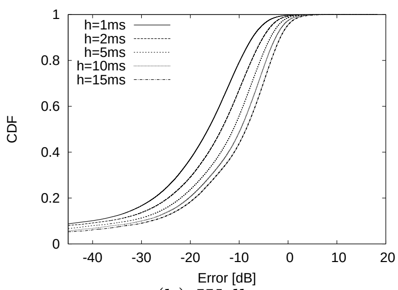
(e) Road



(f) Stadium1

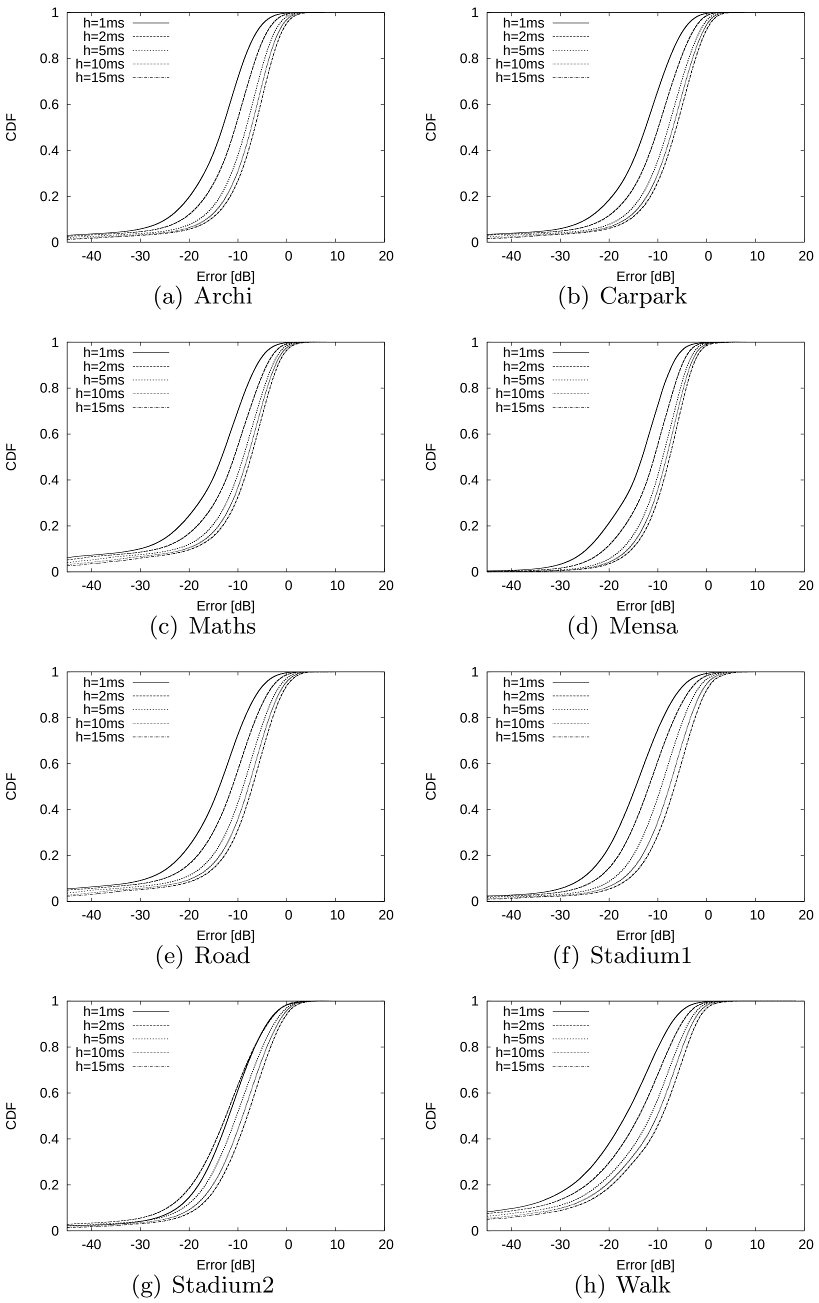


(g) Stadium2



(h) Walk

Figure A.9: CDF of normalised prediction errors for the LP prediction algorithm using N=15 samples.



(a) Archi (b) Carpark (c) Maths (d) Mensa (e) Road (f) Stadium1 (g) Stadium2 (h) Walk

Figure A.10: CDF of normalised prediction errors for the LP prediction algorithm using N=20 samples.

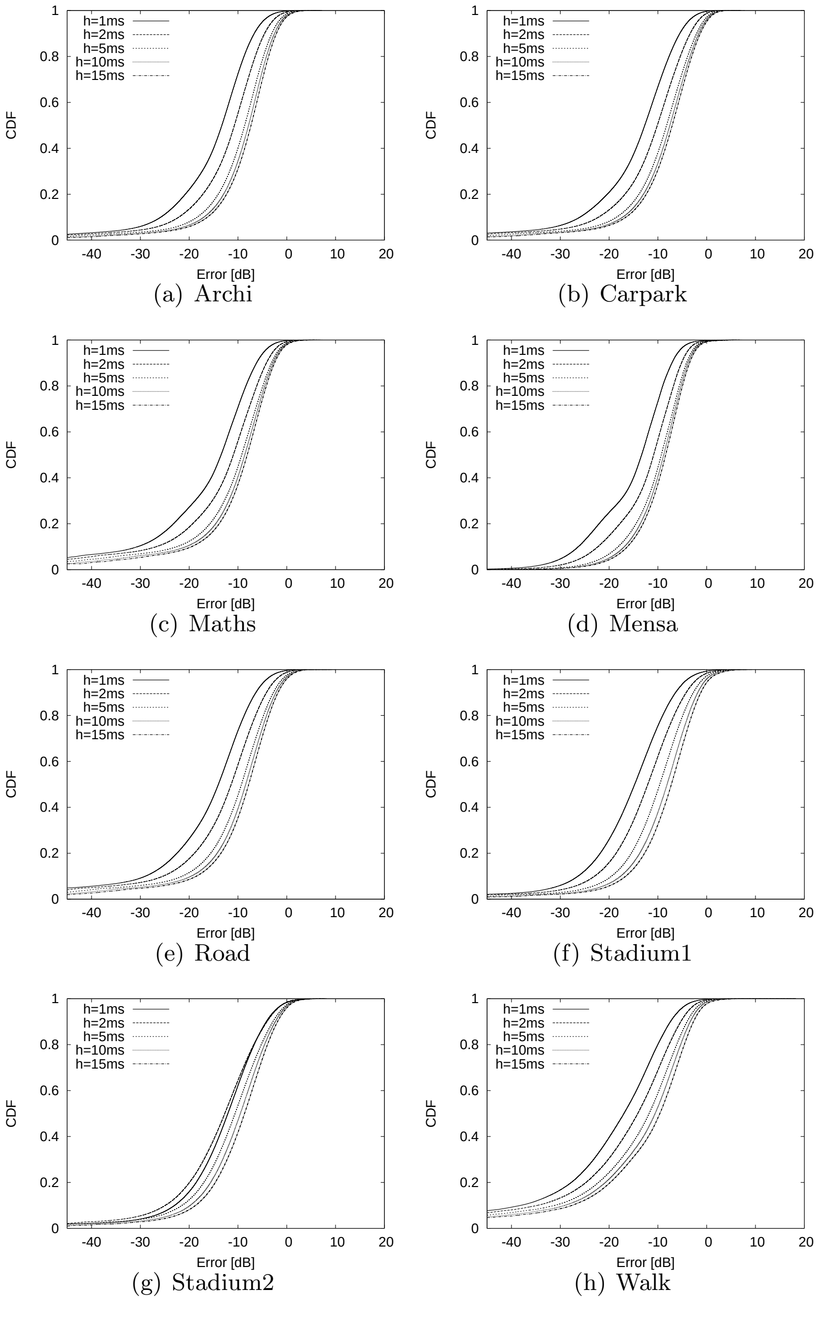
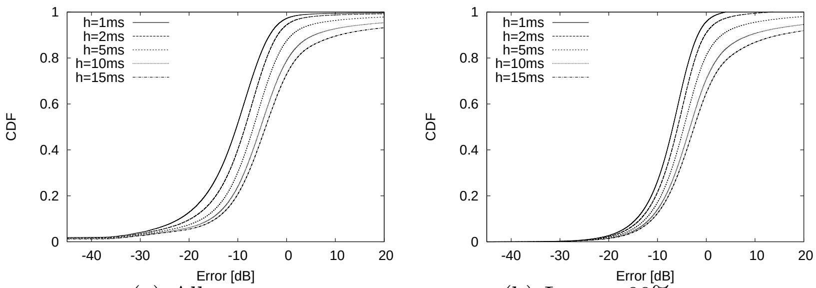


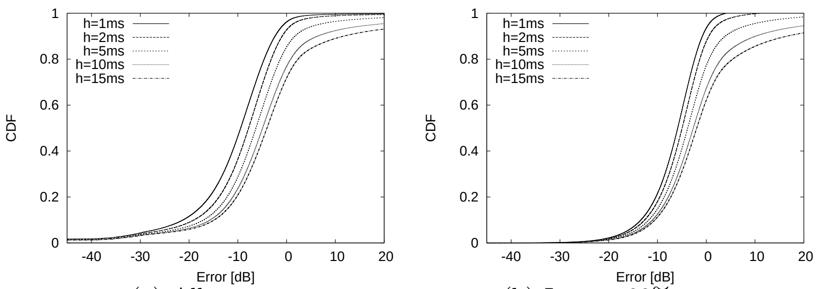
Figure A.11: CDF of normalised prediction errors for the LP prediction algorithm using N=30 samples.

A.4 Modified Covariance — MC



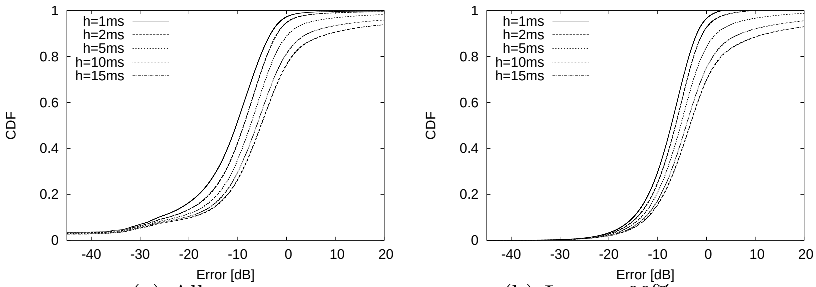
(a) All errors (b) Lowest 99% errors

Figure A.12: CDF of normalised prediction errors for the MC predictor with AR model order P=5 before and after removing outliers in the environment Archi.



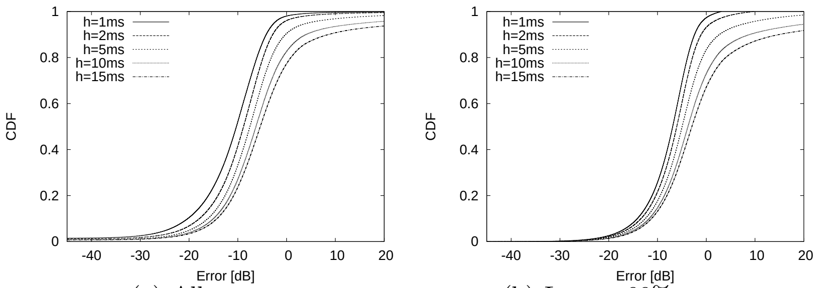
(a) All errors (b) Lowest 99% errors

Figure A.13: CDF of normalised prediction errors for the MC predictor with AR model order P=5 before and after removing outliers in the environment Carpark.



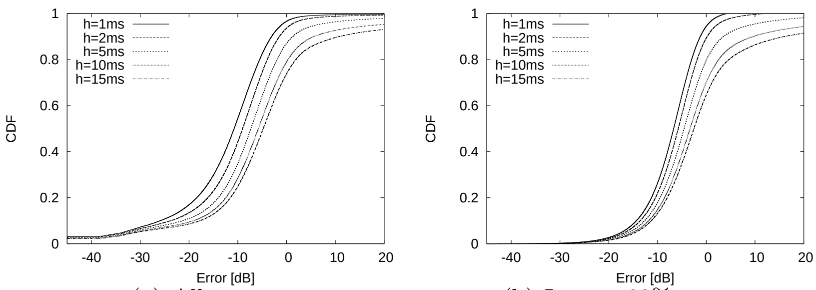
(a) All errors (b) Lowest 99% errors

Figure A.14: CDF of normalised prediction errors for the MC predictor with AR model order P=5 before and after removing outliers in the environment Maths.



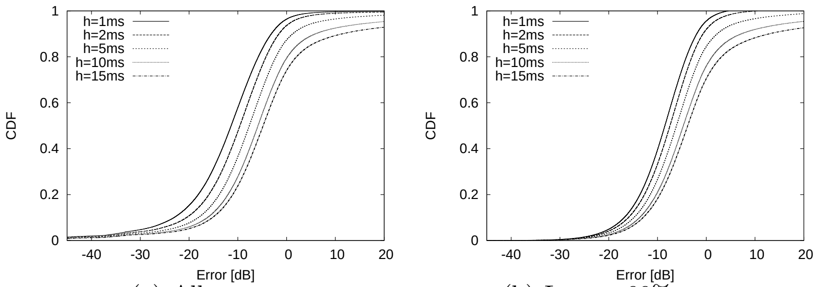
(a) All errors (b) Lowest 99% errors

Figure A.15: CDF of normalised prediction errors for the MC predictor with AR model order P=5 before and after removing outliers in the environment Mensa.



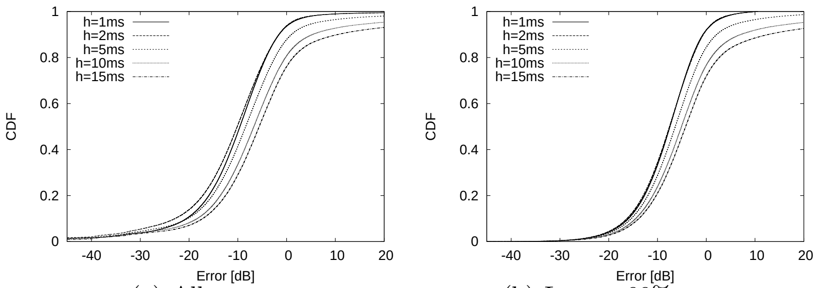
(a) All errors (b) Lowest 99% errors

Figure A.16: CDF of normalised prediction errors for the MC predictor with AR model order P=5 before and after removing outliers in the environment Road.



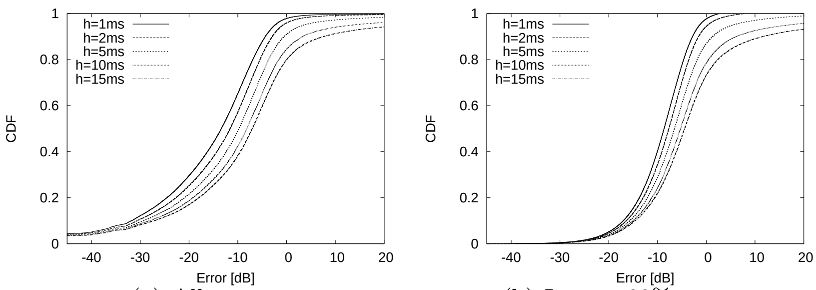
(a) All errors (b) Lowest 99% errors

Figure A.17: CDF of normalised prediction errors for the MC predictor with AR model order P=5 before and after removing outliers in the environment Stadium1.



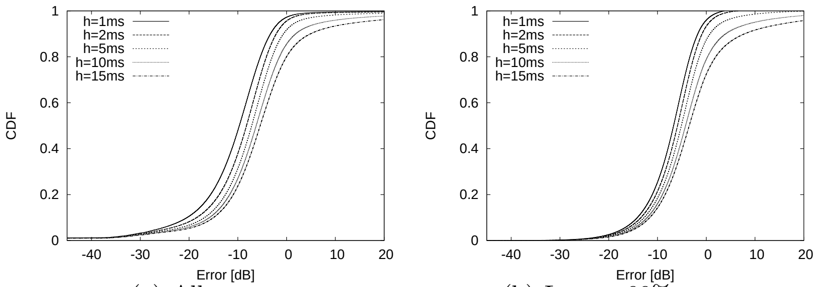
(a) All errors (b) Lowest 99% errors

Figure A.18: CDF of normalised prediction errors for the MC predictor with AR model order P=5 before and after removing outliers in the environment Stadium2.



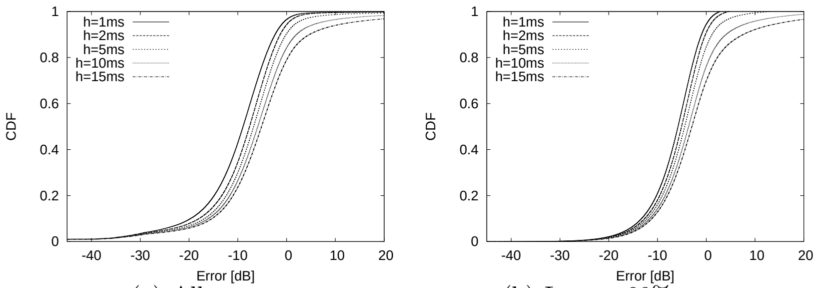
(a) All errors (b) Lowest 99% errors

Figure A.19: CDF of normalised prediction errors for the MC predictor with AR model order P=5 before and after removing outliers in the environment Walk.



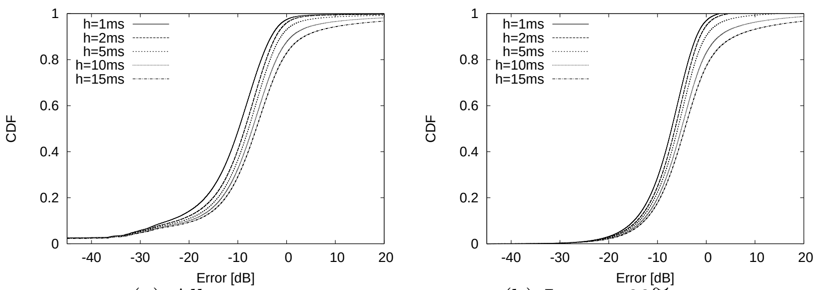
(a) All errors (b) Lowest 99% errors

Figure A.20: CDF of normalised prediction errors for the MC predictor with AR model order P=10 before and after removing outliers in the environment Archi.



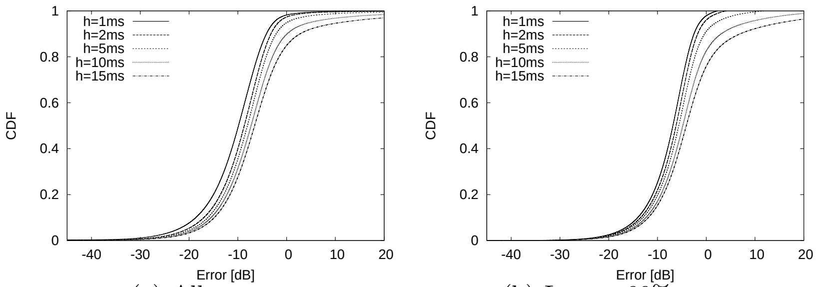
(a) All errors (b) Lowest 99% errors

Figure A.21: CDF of normalised prediction errors for the MC predictor with AR model order P=10 before and after removing outliers in the environment Carpark.



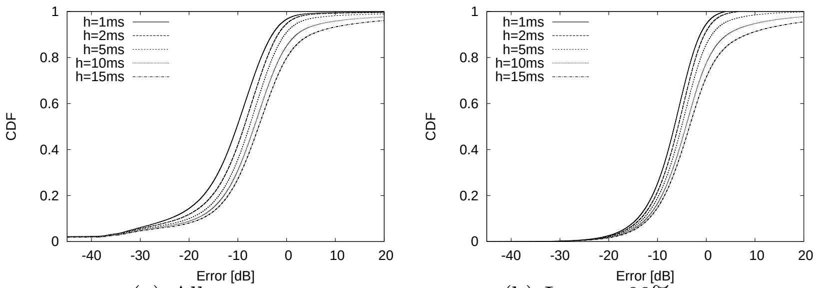
(a) All errors (b) Lowest 99% errors

Figure A.22: CDF of normalised prediction errors for the MC predictor with AR model order P=10 before and after removing outliers in the environment Maths.



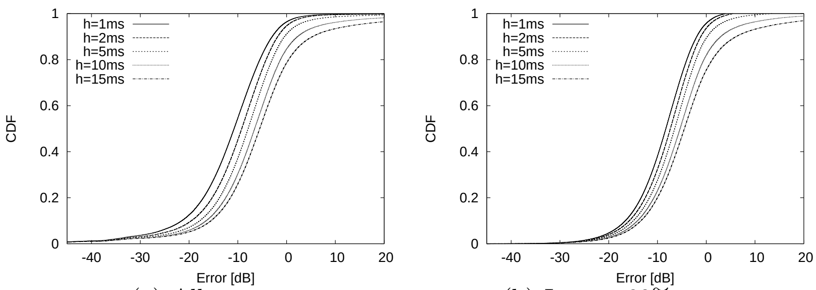
(a) All errors (b) Lowest 99% errors

Figure A.23: CDF of normalised prediction errors for the MC predictor with AR model order P=10 before and after removing outliers in the environment Mensa.



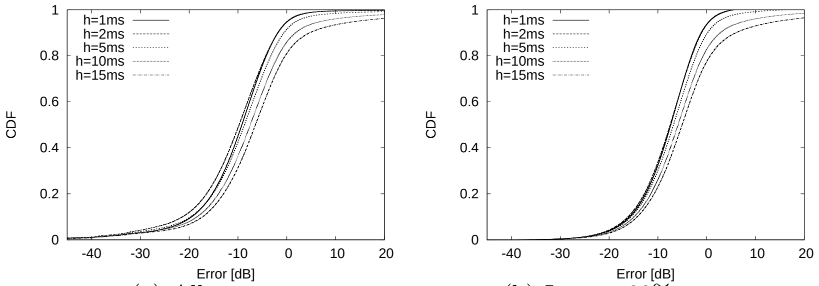
(a) All errors (b) Lowest 99% errors

Figure A.24: CDF of normalised prediction errors for the MC predictor with AR model order P=10 before and after removing outliers in the environment Road.



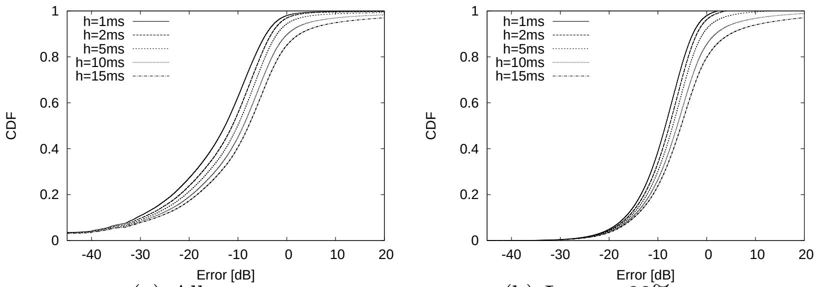
(a) All errors (b) Lowest 99% errors

Figure A.25: CDF of normalised prediction errors for the MC predictor with AR model order P=10 before and after removing outliers in the environment Stadium1.



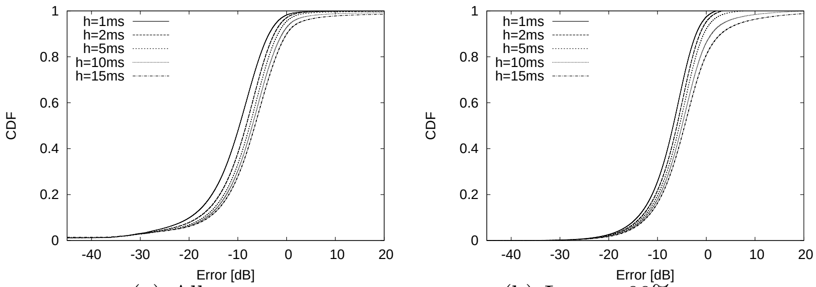
(a) All errors (b) Lowest 99% errors

Figure A.26: CDF of normalised prediction errors for the MC predictor with AR model order P=10 before and after removing outliers in the environment Stadium2.



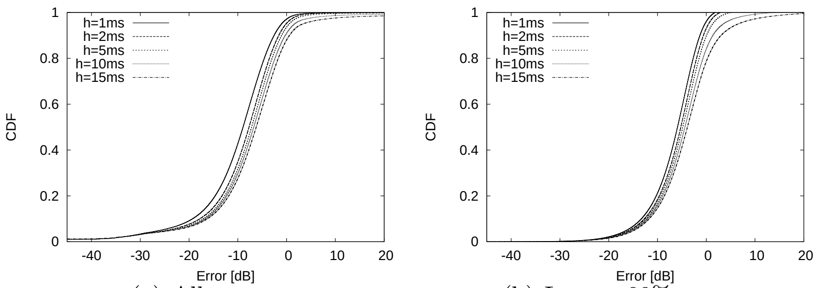
(a) All errors (b) Lowest 99% errors

Figure A.27: CDF of normalised prediction errors for the MC predictor with AR model order P=10 before and after removing outliers in the environment Walk.



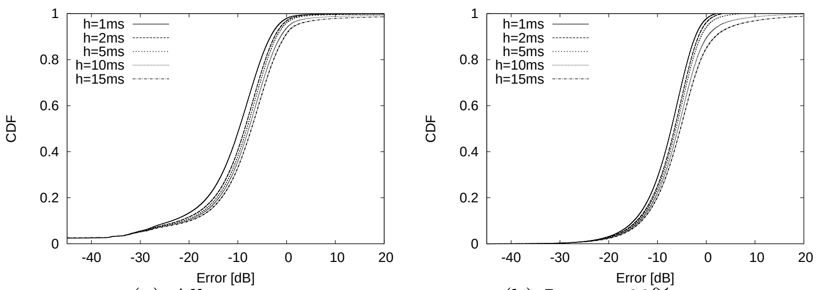
(a) All errors (b) Lowest 99% errors

Figure A.28: CDF of normalised prediction errors for the MC predictor with AR model order P=15 before and after removing outliers in the environment Archi.



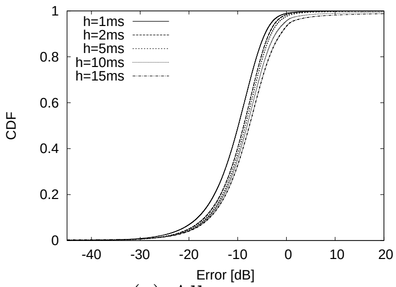
(a) All errors (b) Lowest 99% errors

Figure A.29: CDF of normalised prediction errors for the MC predictor with AR model order P=15 before and after removing outliers in the environment Carpark.

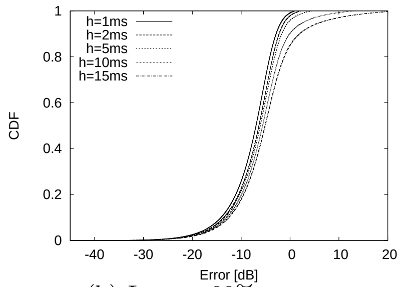


(a) All errors (b) Lowest 99% errors

Figure A.30: CDF of normalised prediction errors for the MC predictor with AR model order P=15 before and after removing outliers in the environment Maths.

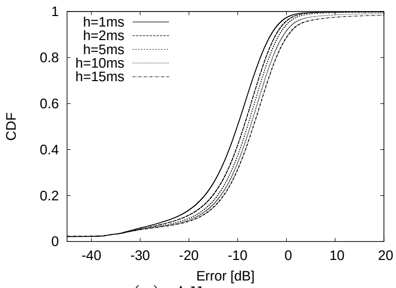


(a) All errors

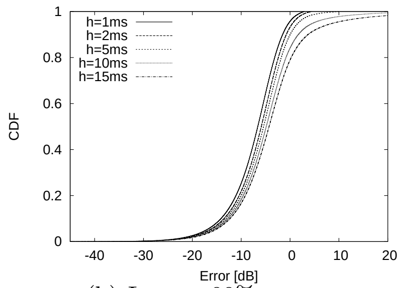


(b) Lowest 99% errors

Figure A.31: CDF of normalised prediction errors for the MC predictor with AR model order P=15 before and after removing outliers in the environment Mensa.

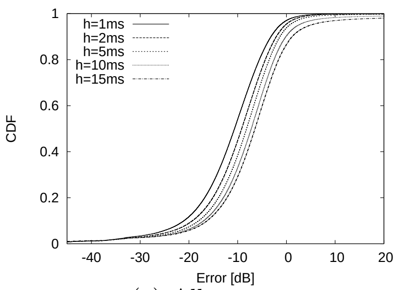


(a) All errors

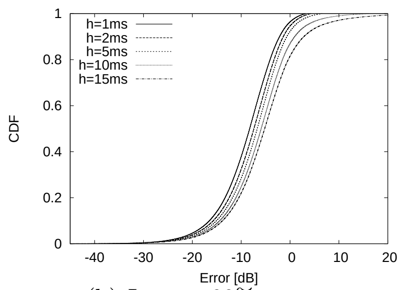


(b) Lowest 99% errors

Figure A.32: CDF of normalised prediction errors for the MC predictor with AR model order P=15 before and after removing outliers in the environment Road.

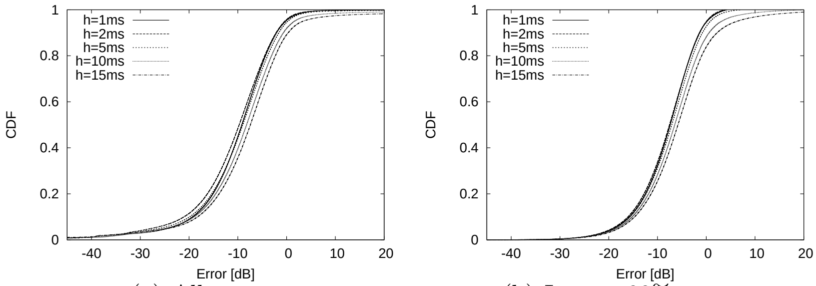


(a) All errors



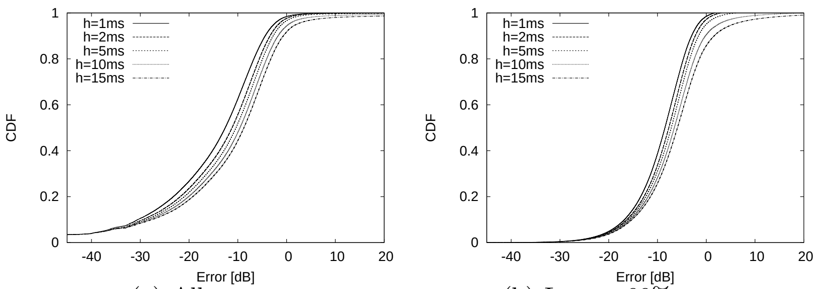
(b) Lowest 99% errors

Figure A.33: CDF of normalised prediction errors for the MC predictor with AR model order P=15 before and after removing outliers in the environment Stadium1.



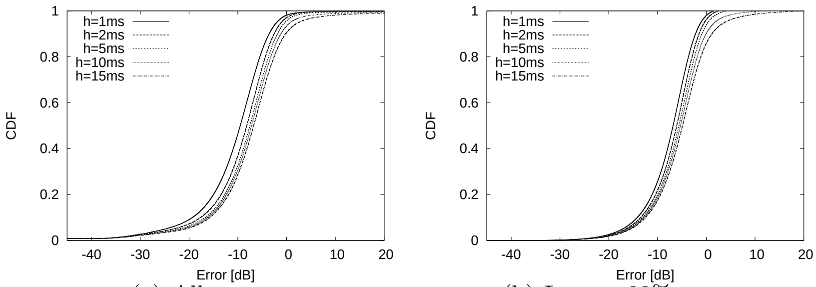
(a) All errors (b) Lowest 99% errors

Figure A.34: CDF of normalised prediction errors for the MC predictor with AR model order P=15 before and after removing outliers in the environment Stadium2.



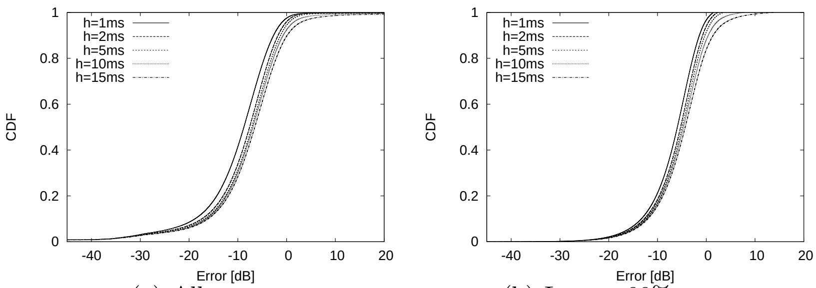
(a) All errors (b) Lowest 99% errors

Figure A.35: CDF of normalised prediction errors for the MC predictor with AR model order P=15 before and after removing outliers in the environment Walk.



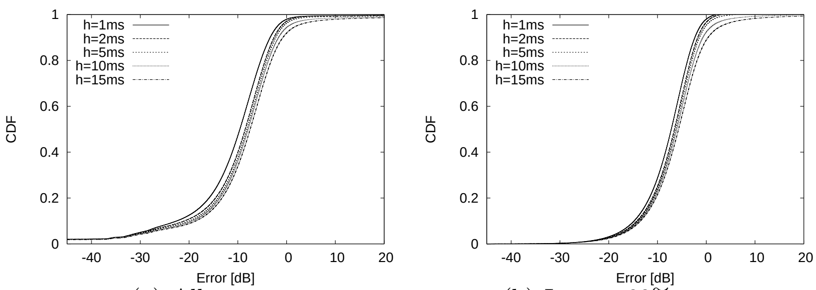
(a) All errors (b) Lowest 99% errors

Figure A.36: CDF of normalised prediction errors for the MC predictor with AR model order P=20 before and after removing outliers in the environment Archi.



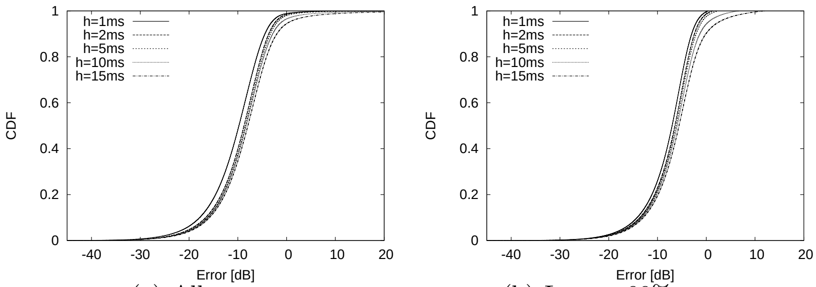
(a) All errors (b) Lowest 99% errors

Figure A.37: CDF of normalised prediction errors for the MC predictor with AR model order P=20 before and after removing outliers in the environment Carpark.



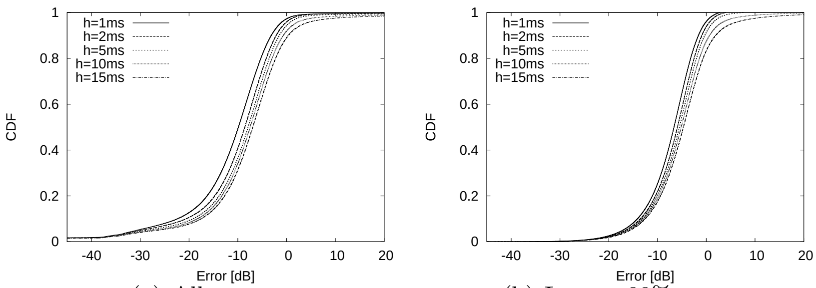
(a) All errors (b) Lowest 99% errors

Figure A.38: CDF of normalised prediction errors for the MC predictor with AR model order P=20 before and after removing outliers in the environment Maths.



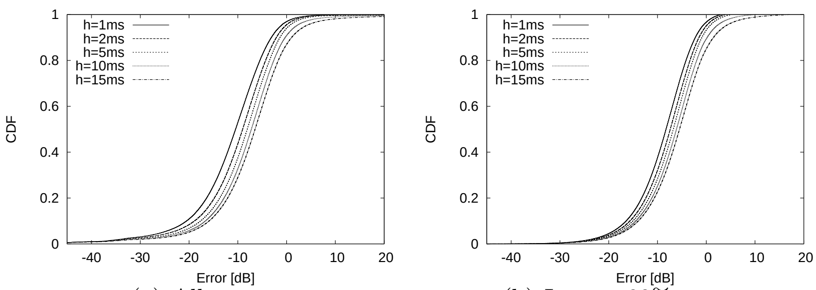
(a) All errors (b) Lowest 99% errors

Figure A.39: CDF of normalised prediction errors for the MC predictor with AR model order P=20 before and after removing outliers in the environment Mensa.



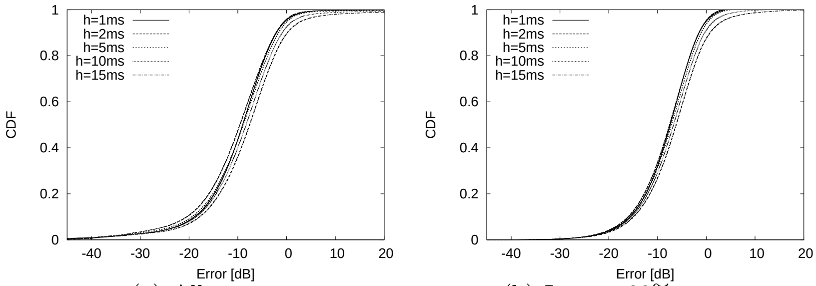
(a) All errors (b) Lowest 99% errors

Figure A.40: CDF of normalised prediction errors for the MC predictor with AR model order P=20 before and after removing outliers in the environment Road.



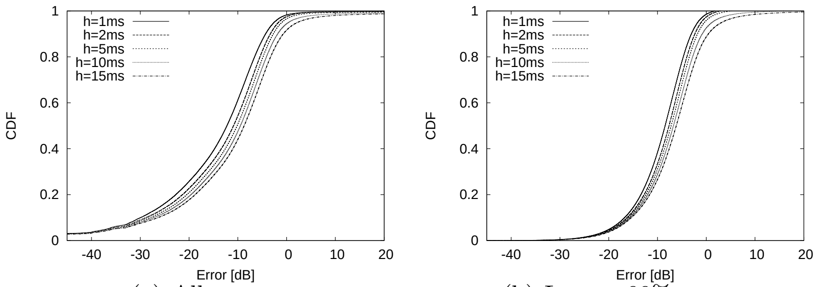
(a) All errors (b) Lowest 99% errors

Figure A.41: CDF of normalised prediction errors for the MC predictor with AR model order P=20 before and after removing outliers in the environment Stadium1.



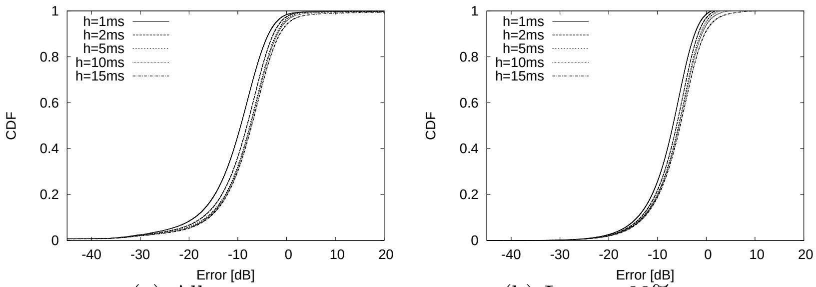
(a) All errors (b) Lowest 99% errors

Figure A.42: CDF of normalised prediction errors for the MC predictor with AR model order P=20 before and after removing outliers in the environment Stadium2.



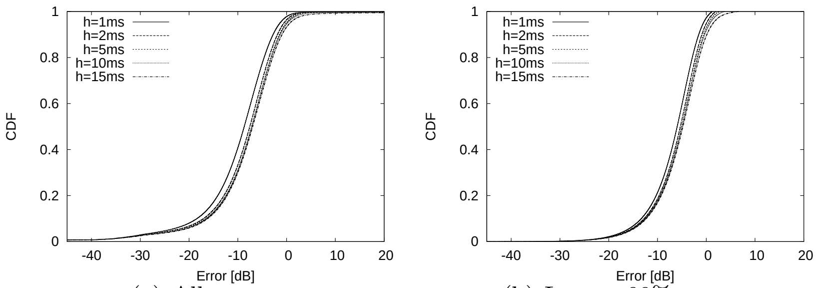
(a) All errors (b) Lowest 99% errors

Figure A.43: CDF of normalised prediction errors for the MC predictor with AR model order P=20 before and after removing outliers in the environment Walk.



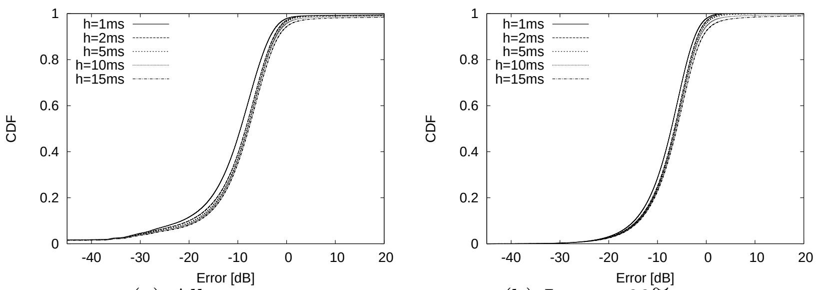
(a) All errors (b) Lowest 99% errors

Figure A.44: CDF of normalised prediction errors for the MC predictor with AR model order P=30 before and after removing outliers in the environment Archi.



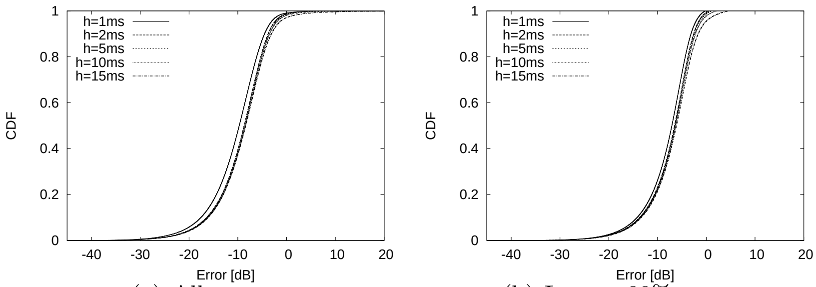
(a) All errors (b) Lowest 99% errors

Figure A.45: CDF of normalised prediction errors for the MC predictor with AR model order P=30 before and after removing outliers in the environment Carpark.



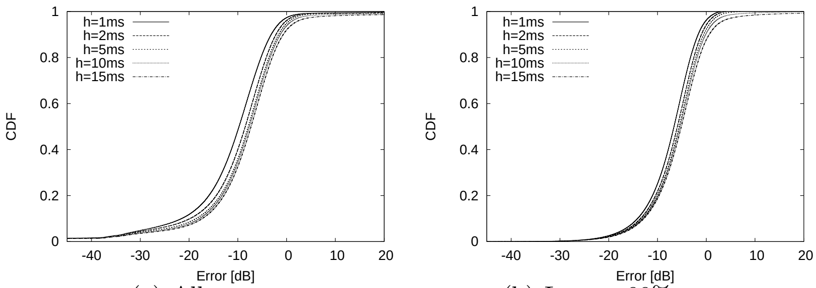
(a) All errors (b) Lowest 99% errors

Figure A.46: CDF of normalised prediction errors for the MC predictor with AR model order P=30 before and after removing outliers in the environment Maths.



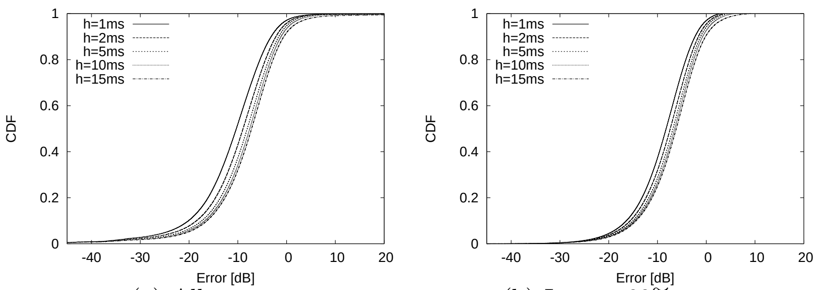
(a) All errors (b) Lowest 99% errors

Figure A.47: CDF of normalised prediction errors for the MC predictor with AR model order P=30 before and after removing outliers in the environment Mensa.



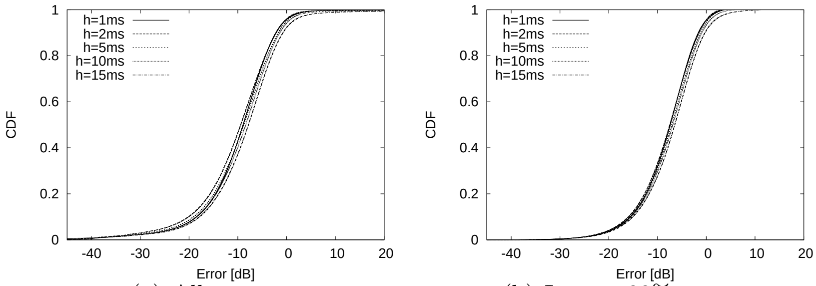
(a) All errors (b) Lowest 99% errors

Figure A.48: CDF of normalised prediction errors for the MC predictor with AR model order P=30 before and after removing outliers in the environment Road.



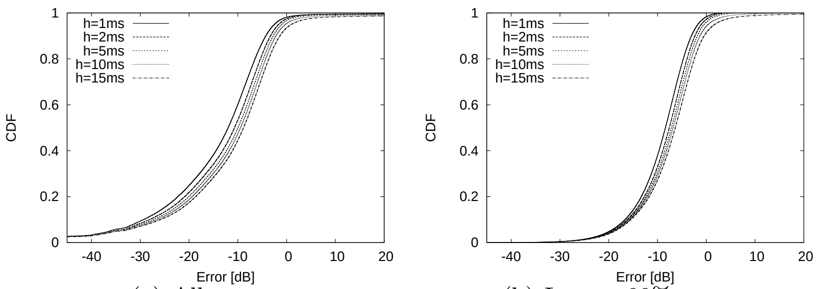
(a) All errors (b) Lowest 99% errors

Figure A.49: CDF of normalised prediction errors for the MC predictor with AR model order P=30 before and after removing outliers in the environment Stadium1.



(a) All errors (b) Lowest 99% errors

Figure A.50: CDF of normalised prediction errors for the MC predictor with AR model order P=30 before and after removing outliers in the environment Stadium2.



(a) All errors (b) Lowest 99% errors

Figure A.51: CDF of normalised prediction errors for the MC predictor with AR model order P=30 before and after removing outliers in the environment Walk.