4C3-1

Comparison of Phantoms for Browsing Position by a NLOS Outdoor MIMO Propagation Test

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1. Introduction

In recent years, MIMO radio propagation techniques for cellular systems are of considerable practical concern since MIMO may provide a high capacity [1, 3]. Thus, various investigations of MIMO channels using human phantoms have been carried out to evaluate MIMO performance [3] in realistic environments. However, there have been few works to examine the effectiveness of the human phantoms on evaluating the handset MIMO antennas. It has been reported that radiation patterns of a handset antenna with a realistic phantom [4] in a browsing position are in good agreement with those of the human operator. In reference [4], the investigations have been made for only the confirmation of the validities with respect to the radiation patterns but no examination has been done to estimate the MIMO performance of the handset array.

This paper presents electromagnetic effects of the human phantoms in a browsing position on the MIMO channel capacities by urban outdoor MIMO experiments at 2.4 GHz. The propagation experiment was performed in a non line-of-sight (NLOS) situation. Three types of phantoms including the realistic phantom [4] were used for the propagation tests. A handset antenna array, comprising two monopoles and two planer inverted-F antennas (PIFAs), was held by the hand of the phantom in a browsing position. The effectiveness of the phantoms on the handset MIMO evaluation will be discussed by a comparison between the results measured with the phantoms.

2. Experimental Setup

Fig. 1 illustrates the outdoor MIMO propagation test. In the experiment, the handset MIMO antenna held by a human phantom was moved on a car trailer. The MIMO channels were collected by a sounder [5], [6] inside the car. The space in between samples was approximately 1.7 cm, corresponding to 0.14 wavelengths at 2.4 GHz. The handset MIMO was 1.52 m in height from the ground. The antenna array of the base station was mounted on a lift to be positioned at height of 14.5 m. The array of the base station consists of eight elements located linearly. The array was divided into two sub-arrays. Each sub-array has four elements with spacing between the elements of one wavelength or two wavelengths at 2.4 GHz. In this paper, propagation characteristics of the sub-array with spacing of two wavelengths were evaluated. Each antenna element has a peak gain of 16.5 dBi and half-power beamwidths of 6 degrees in the vertical plane and 85 degrees in the horizontal plane. A vertically polarized wave at 2.4 GHz was transmitted and power to each element was 34 dBm. Fig. 2 depicts the test route in an urban area of Aalborg in Denmark. The route was selected to obtain non line-of-sight (NLOS) situations where the heights of most surrounding building are more than 15 m. The length of the route is about 140 m on the long side of the rectangle route and 100 m on the short side. The propagation characteristics were measured along four sub-routes in straight lines.

Fig. 3 illustrates the configuration of the handset MIMO antenna [3] used for our experiment. The handset array consists of two monopoles and two PIFAs. This array enables us to examine up to 8-by-4 MIMO reception characteristics. Figs. 4(a) and 4(b) show the realistic and generic human phantoms. The generic phantom is a simplified model by elliptical pillars and rectangular parallelepipeds. Fig. 4(c) depicts a commercial phantom [7], which has a head and

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shoulders but no arms and no abdomen. The phantoms simulate a human operator in a browsing position. In the experiment, the handset was held by the right hand of the phantom. The distance D between the handset and the chest of the phantom was set at 20 cm, and the handset was inclined at angle of 40 degrees from the vertical. In the experiments using the commercial phantom, the generic hand was used for holding the handset. In this paper, we will evaluate MIMO characteristics of the generic and commercial phantoms in comparison with results of the realistic phantom, which were verified by experiments [4].

3. Outdoor Propagation Experiment

In this paper, we evaluated the result along the route labelled II. Fig. 5 provides a plot of the variations of the average channel gains of a dipole with a vertical polarization and a slot dipole with a horizontal polarization in free space when a signal was radiated from only one of the base station antennas Tx1. In our investigation, the data was averaged by 100 samples. From Fig. 5, the cross polarization discrimination (XPD) of the test site was 9.3 dB. Fig. 6 shows the cumulative distributions of the channel gains of the dipole and slot dipole. Fig. 6 indicates that the channel gains of each antenna were in good agreement with the Rayleigh distribution.

Fig. 7 shows the variations in the average channel gains of the handset MIMO with the three phantoms. Table 1 gives the average values of instantaneous variation in channel gain normalized by the average value of the dipole. It is found from Table 1 that the average channel gains of the generic and commercial phantoms are lower than those of the realistic phantom. The hand of the generic phantom causes a large electromagnetic effect on the handset antennas since the generic hand phantom with a flat surface has a large area in contact with the handset. Moreover, the average channel gains of the commercial phantom are greater than those of the generic phantom since the commercial phantom does not have the arms and abdomen.

Fig. 8 shows the cumulative distributions of the channel capacities with the phantoms. Table 2 lists the medians of the channel capacities. It is observed from Fig. 8 and Table 2 that the MIMO channel capacity of the generic phantom exhibits the lowest values since the generic phantom has the smallest average channel gains among the phantoms. From this, the generic phantom can be utilized in an excessive investigation or the worst possible estimation for handset MIMO antennas.

4. Conclusion

Comparison among the three types of phantoms in browsing position was made by outdoor radio propagation experiments for a handset MIMO antenna at 2.4 GHz in an urban area of a city, which resulted in non line-of-sight (NLOS) situations. The generic phantom shows the lowest MIMO channel capacity among the phantoms. We concluded that the generic phantom can be utilized in an excessive investigation or the worst possible estimation for handset MIMO antennas.

References

[1] M. C. Mtumbuka, and D. J. Edwards, “Investigation of tri-polarised MIMO technique,” IEEE ELECTRONICS LETTERS Vol. 41 No. 3, pp. 137 - 138, Feb. 2005.

[2] H. T. Hui, “Practical dual-helical antenna array for diversity/MIMO receiving antennas on mobile handsets,” IEE Proc.-Microw. Antennas Propag., Vol. 152, No. 5, pp. 367 - 372,October 2005.

[3] K. Ogawa, H. Iwai, A. Yamamoto, and J. Takada, “Channel capacity of a handset MIMO antenna influenced by the effects of 3D angular spectrum, polarization, and operator,” APS 2006, Albuquerque, USA, pp. 153 - 156, July 2006.

[4] H. Iwai, K. Ogawa, and N. Hatakenaka, “A Development of a Realistic Human Phantom in a PDA Position for EM Evaluation of Handset Antennas,” IEICE Transaction, vol. J89-B, No. 5, pp. 784-793, 2006.

[5] J. Ø. Nielsen, and J. B. Andersen, “Indoor MIMO channel measurement and modeling,” WPMC’05, Aalborg, Denmark, pp. 479–483, Sep. 2005.

[6] J. Ø. Nielsen, J. B. Andersen, P. C. F. Eggers, G. F. Pedersen, K. Olesen, E. H. Sørensen, and H. Suda, “Measurements of Indoor 16×32 Wideband MIMO Channels at 5.8 GHz,” ISSSTA 2004, Sydney, Australia, pp. 864 - 868, Aug. 2004.
[7] Schmid & Partner, http://www.speag.com/ Generic torso Phantom, v.3.6.

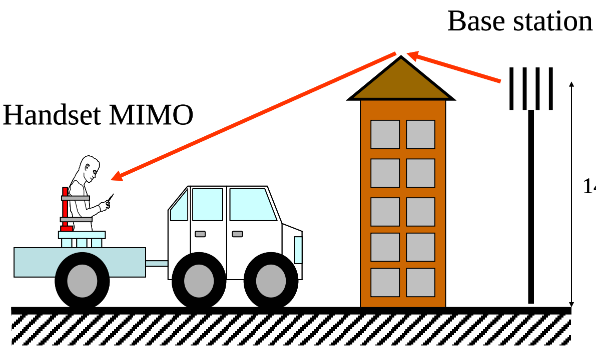


Figure 1: Outdoor MIMO propagation test.

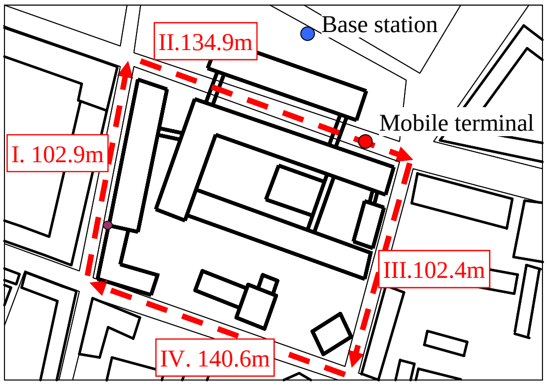


Figure 2: Test route in an urban area.

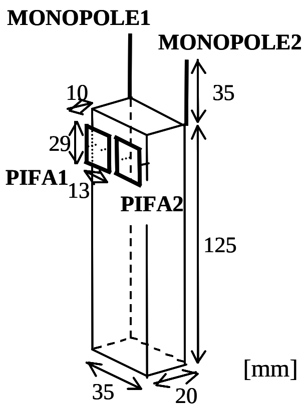
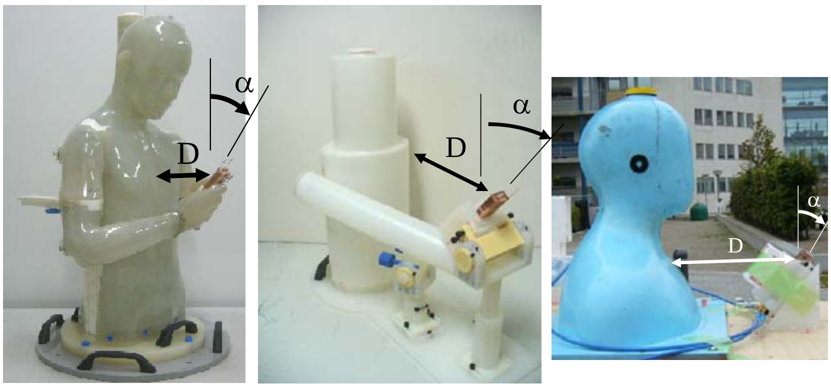


Figure 3: Handset MIMO.



(a) Realistic phantom (b) Generic phantom (c) Commercial phantom

Figure 4: Human phantoms.

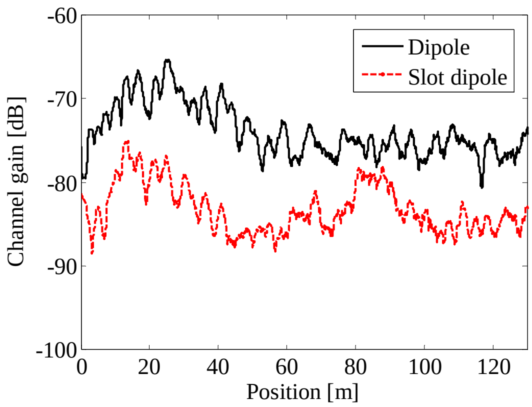


Figure 5: Variations of the average channel gains of a dipole and a slot dipole.

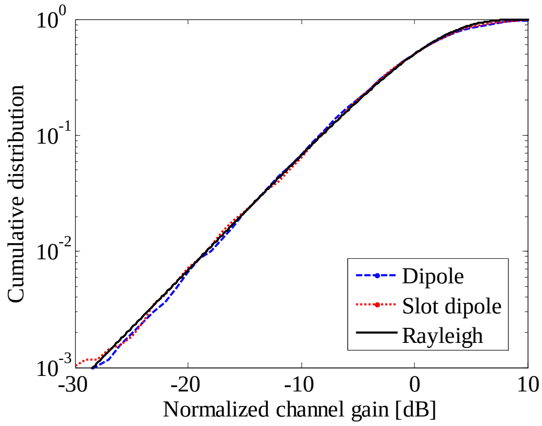
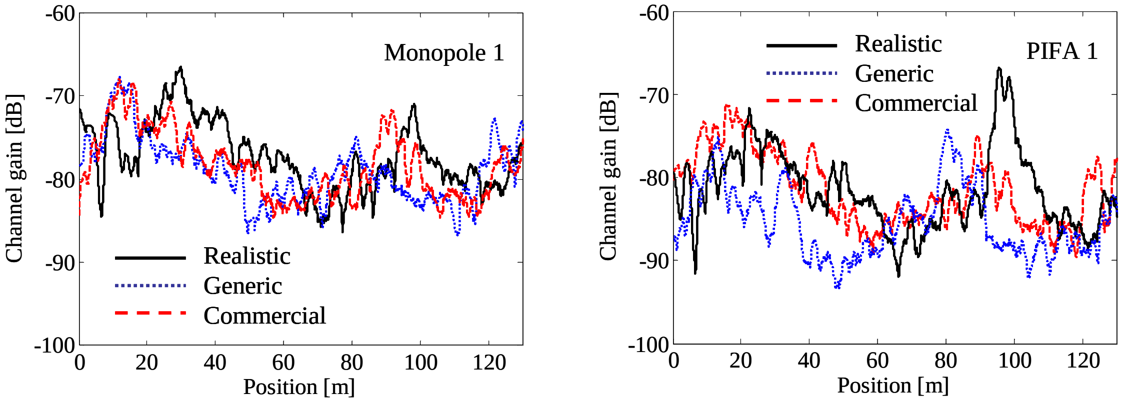


Figure 6: Cumulative distributions of the channel gains of the dipole and the slot dipole.

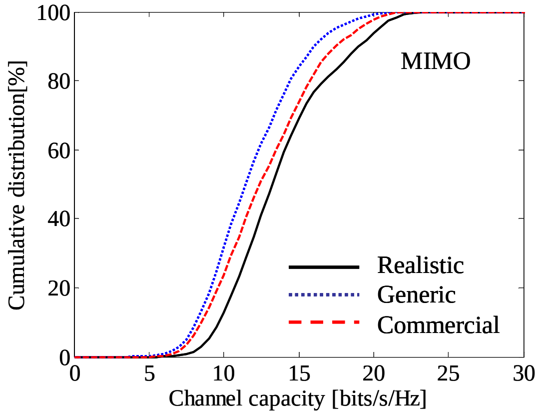
Table 1: Average values of instantaneous variation in channel gain in dB normalized by the average value of the dipole.

	Monopole 1	Monopole 2	PIFA 1	PIFA 2
Realistic	-2.8	-1.4	-6.0	-7.1
Generic	-4.3	-2.8	-10.7	-10.6
Commercial	-4.2	-2.0	-7.0	-7.5

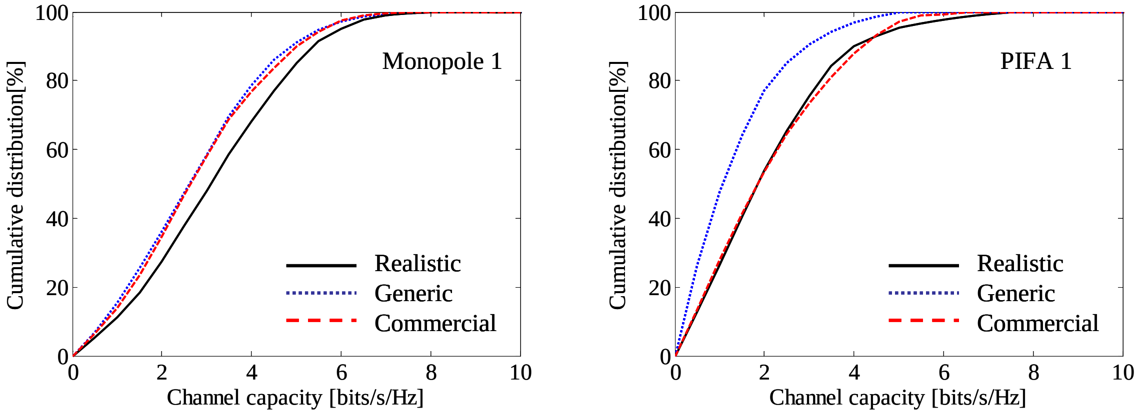


(a) Monopole 1 (b) PIFA 1

Figure 7: Comparison of the average channel gains.



(a) MIMO



(b) Monopole 1 (c) PIFA 1

Figure 8: Comparison of the channel capacities.

Table 2: Medians of the channel capacities in bits/s/Hz.

	MIMO	Monopole 1	PIFA 1
Realistic	13.7	3.2	2.1
Generic	11.8	2.7	1.3
Commercial	12.8	2.8	2.1