

Research Article

Stiefel Manifold and TCQ based on Unit Memory Coding for MIMO System

Vijey Thayanathan and Ahmed Alzahrani

Department of Computer Science, Faculty of Computing and Information Technology,
King Abdulaziz University, Jeddah 21589, Saudi Arabia

Abstract: The Multi Input and Multi Output (MIMO) systems have been analyzed with a number of quantization techniques. In this short communication, few problems like performance and accuracy are investigated through a quantization technique based on Stiefel Manifold (SM). In order to improve these problems, suitable Trellis Coded Quantization (TCQ) based on Unit Memory (UM) coding is studied and applied to SM of MIMO components as a novel approach. Anticipated results are the bit error performance which is an overall improvement of feedback connected between transmitter and receiver of MIMO. As a conclusion, this research not only reduces the quantization problems on SM but also improve the performance and accuracy of limited-rate feedback used in MIMO system.

Keywords: Feedback, MIMO system, stiefel manifolds, TCQ, UM coding

INTRODUCTION

The scope of this research is a design of suitable quantization helped to increase the rates and performance of MIMO. Quantization and coded quantization are used in digital signal processing to enhance the overall quality of receiver and digital channel (Duman and Ghrayeb, 2007). In this study, the specific approach of quantization is considered with a number of transmitter (N_t) and receiver (N_r) antennas. In order to improve the techniques of quantization process, SM is introduced with MIMO channel development (Krishnamachari and Varanasi, 2012).

The techniques of TCQ have been used many applications for more than three decades. The investigation about the manifold with TCQ based on the Unit or Partial Unit Memory (UM/PUM) coding is the novel technique. Rank and complexity reduction through the dimensions is the example of the properties (Thayanathan *et al.*, 1998). Here, UM (4.2) is considered for this challenge as an example.

In Dai *et al.* (2008), necessary information of quantization on Grassmann manifold is studied to develop quantization on SM. Here, quantization can be assumed as a representation of source that feedback link uses to increase the rate. According to Krishnamachari and Varanasi (2011), quantization depends on the key quantities of dimensions and volume of the SM ($Vol(V_{p,k}^C)$). Here, p (orthonormal vectors) and k are columns and rows of the rectangular matrix and C is complex field. Feedback is maintained through the correct and coded quantization techniques obtained

from the mapping of points on SM and UM/PUM coding schemes. The quality of TCQ and its optimization methods are given in Wang and Fisher (1994), which can be employed to analyze the noisy channel of MIMO system.

Limited-rate feedback is a challenging problem because efficient quantization is required to minimize the overhead incurred by the feedback channel (Choi *et al.*, 2013). In this research, optimized TCQ design based on SM and UM (4.2) is applied to feedback channel that bit error rate is better than conventional TCQ, which improve the overall MIMO system.

PROPOSED SYSTEM

In this section, MIMO with limited-rate feedback is introduced to propose for increasing the quality and quantity factors of existing MIMO systems (Krishnamachari and Varanasi, 2012; Dai *et al.*, 2008). In this scheme, SM $V_{4,2}^C$ is used for trellis design influenced with UM (4.2). Let our aim be to design a TCQ/ (P) UM scheme that for 2^{r+1} quantisation levels provides quantisation rate of r and free distance ($d_{free} \geq 2$). Following the basic idea of TCQ, we partition 2^{r+1} quantization levels into 2^{q_1} subsets with 2^{q_2} quantisation levels within each subset, where q_1 and q_2 should be chosen according to the following condition (1):

$$\text{Quantization rate } (r) = q_1 + q_2 - 1 \quad (1)$$

Corresponding Author: Vijey Thayanathan, Department of Computer Science, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah 21589, Saudi Arabia

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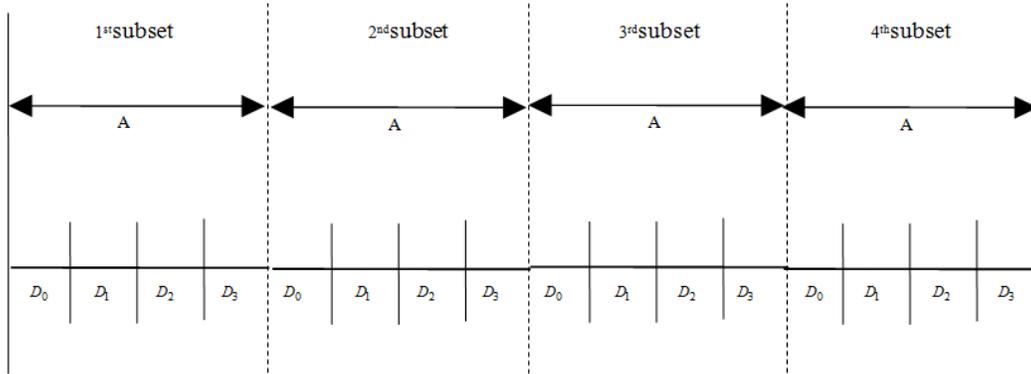


Fig. 1: Selected subset of manifold

We denote each partition subset by q_1 binary bits and the i -th quantisation level within the j -th subset as $D_i + A(j - 1)$. Figure 1 shows four subsets, where i ($i = 0, 1, \dots, 2^{q_2} - 1$) is considered. The letter 'A' is the width of the subset. Figure 1 illustrates the partitioning of the case of $r = 3$ bits/index (feedback-index or element), when $q_1 = q_2 = 2$.

RESULTS AND ANALYSIS

Preliminary results show the obvious improvement when TCQ/UM design is used in MIMO channels matrix where the SM could be employed to minimize the dimensions and rank, which are the basic parameters needed to solve the problems related to quantization.

Here, three different quantization techniques are compared; the scalar quantization as in Thayanathan *et al.* (1998), conventional TCQ and proposed TCQ/ (P) UM are plotted. Assume that SM used here has minimum dimension and rank.

CONCLUSION

As a proposed scheme, the TCQ based on (P) UM and SM have been studied for feedback and quantization of MIMO system. When SM is employed to this proposed scheme, overall MIMO system will be improved. Proposed scheme achieved 1dB improvement, which is better than conventional TCQ used in low bit rate applications. The full investigation of coded MIMO scheme with different dimension of SM and TCQ will be progressing in my continuous research on this area of research and will be published in our extended study.

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REFERENCES

- Choi, J., D.J. Love and U. Madhow, 2013. Limited feedback in massive MIMO systems-exploiting channel correlations via noncoherent trellis-coded quantization. Proceedings of Conference on Information Sciences and Systems.
- Dai, W., Y. Liu and B. Rider, 2008. Quantization bounds on Grassmann manifolds and applications to MIMO communications. IEEE T. Inf. Theory, 54(3): 1108-1123.
- Duman, T.M. and A. Ghayeb, 2007. Coding for MIMO Communication Systems. John Wiley and Sons Ltd., UK.
- Krishnamachari, R.T. and M.K. Varanasi, 2011. MIMO performance under covariance matrix feedback. Proceeding of the IEEE International Symposium on Information Theory, St. Petersburg, Russia, pp: 543 -547.
- Krishnamachari, R.T. and M.K. Varanasi, 2012. MIMO Systems with Quantized Covariance Feedback. IEEE Transactions on Signal Processing, (Accepted for Publication). Retrieved from: <http://ecee.colorado.edu/~varanasi/publicat.htm>.
- Thayanathan, V., B. Honary and G. Markarian, 1998. Trellis coded quantisation technique based on partial unit memory codes. Proceeding of the IEEE International Symposium on Information Theory MIT, August 16th-21st.
- Wang, M. and T.R. Fisher, 1994. Trellis coded quantisation designed for noisy channels. IEEE T. Inform. Theory, 40(6): 1792-1802.