International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:3, No:6, 2009

Using PFA in Feature Analysis and Selection for H.264 Adaptation

Nora A. Naguib, Ahmed E. Hussein, Hesham A. Keshk, and Mohamed I. El-Adawy

Abstract—Classification of video sequences based on their contents is a vital process for adaptation techniques. It helps decide which adaptation technique best fits the resource reduction requested by the client.

In this paper we used the principal feature analysis algorithm to select a reduced subset of video features. The main idea is to select only one feature from each class based on the similarities between the features within that class. Our results showed that using this feature reduction technique the source video features can be completely omitted from future classification of video sequences.

Keywords—Adaptation, feature selection, H.264, Principal Feature Analysis (PFA)

I. Introduction

VIDEO adaptation is one of the emerging techniques in video communications. It is concerned mainly with changing the bit rate, complexity, and quality of a video to meet the needs of the receiving client. [1]

There exists a large number of video adaptation scheme that would change a precoded video stream into another that exhibits less bit rate or complexity and therefore quality.

Currently, the main problem in video adaptation is the management of the process itself [2]. More specifically, the problem lies in on how to determine,

1) The amount of adaptation required to meet the client side requirements.
2) The adaptation scheme(s) that is to be used to achieve this amount.

This problem is tackled by classifying the videos based on their content and finding main groups of videos that are to behave the same way within the adaptation engine. This classification reflects the main aspects of adaptation. (i.e. source video complexity, resources required, coded domain complexity) [2]-[4]

In this paper we examine the possibility of reducing video features on each of these aspects by the selection of a subset of features that minimizes the mutual information between the selected features.

We run the principal feature analysis algorithm on the feature on each aspect separately. This results in a reduced subset of features in each of them. Furthermore we have used the same algorithm to check if there is mutual information between both the source domain and the coded domain feature. The results showed that we can depend mainly on coded domain features since we found that there is a strong correlation between the coded and the source video features.

Using only the coded video features enable us to use the precoded video sequence without the need of any associated information.

A.E.H is with King.Saud.University,SA. e-mail:ahyoussef(at)ksu.edu.sa

The rest of this paper is organized as follows: Section II introduces the extracted features definition and the PFA algorithm. In section III, we present our results. Finally, in section IV give the conclusion and future work.

II. Methodology

Our system relies mainly on the idea of finding key features that would characterize the differences between the different video sequences. Those video sequences usually reach the transcoding server in a precoded form. The adaptation server should distinguish the class of that video sequence through only the information in hand.

A. H.264 Coding Set up

We used test video sequences in [5].Those video sequences are single shot video segments. Therefore, video sequence is encoded with only the first frame as I-frame and the rest of the frames as P-frames.

We are using the C++ implementation of the H.264 video coding algorithm in [6], [7] Version JM 13.0.

To simplify our work we have used the baseline profile. This profile contains the following features:

- **I slices:** Intra-coding, only spatial prediction is allowed.
- **P slices:** Inter-coding, forward temporal prediction.
- **CAVLC:** Context Adaptive variable length codes

Configuration parameters for the coding algorithm:

- Baseline Profile
- QP=28
- To be coded in IPPP.

B. Extracted Features

All of the features definitions described in this section are calculated on per frame basis, In order to calculate a single value for each sequence we computed the average. Only for the Source Domain Features we compared both the average value against the first frame (I-frame) value.

1) Source Domain Features:

- **Variance:** Average variance of the luminance pixels
- **Pelact:** Standard deviation of the luminance pixels
- **Pelspread:**Standard deviation of Pelact
- **Edgeact:** Magnitude of pixel gradient
- **Edgespread:** standard deviation of EdgeAct

2) Resources Required:

- **bitcount:** Bitcount for coding for macroblock accumelated on the whole frame.
- **bitcount Y:** Bitcount used for coding only the Y component of the frame
- **ME time:** Time consumed in motion estimation
- **SNRY:** Signal to Noise ration calculated on Y frame
- **SNRU:** Signal to Noise ration calculated on U frame
- **SNRV:** Signal to Noise ration calculated on V frame
- **Time:** Time consumed in coding

3) Coded Domain features:

- **MV magn:** Motion verctors magnitude (Calculated for only non static Macroblocks)
- **MV magn var:** Motion vectores variance (Calculated for only non static Macroblocks)
- **sub MV:** Percentage of MVs that require subpixel interpolation (either half pixel or quarter pixel)
- **non zero MV:** Percentage of non static Macroblocks
- **ave energy I:** Average Energy of AC coffecient in I-frames
- **ave energy P:** Average Energy of AC coffecient in P-frames
- **MV accel:** Motion vectors acceleration
- **MV dir:** Motion vector change of direction

C. Feature analysis and selection

Using Principal component analysis (PCA) would only help in changing the axis on which the features are projected into the axes with the highest covariance between the features. Therefore PCA is not suitable for our system as our main purpose is to omit some of the features and to inspect if source video features are important for differentiating between the video sequences or not.

Principal Feature analysis [8] provides a way to do this. By classifying the features in the high variance axes and by that finding the most dominant feature groups Therefore we can choose only one feature from each dominant group and use it.

This process is run on each of the three feature domains separately first. Then, this is followed by running the feature selection algorithm on the selected feature from both the source and the coded domains. This trail is used to examine the possibility of the complete removal of source based features so as to be able to extract the required features for adaptation through only the precoded video in realtime.

The PFA algorithm is as follows:

1) Calculate the PCA for the covariance matrix of the feature set
2) Choose the desired retained variability after the reduction: sum of the first q eignvalues divided by sum of all eignvalues, The retained variablitily describes the amount of information loss in the process.
3) Cluster the row vectors of the Eigenvector matrix into p clusters where p is greater than or equal to q. The clustering algorithm is k-mean algorithm

TABLE I
SOURCE DOMAIN FEATURES

Cluster Index	Feature	Distance from center
2	Ave Variance (I-frame)	0.063633
2	Ave Variance (Averanged)	0.063633
3	Pelact (I-frame)	0.0015095
3	Pelact (Averaged)	0.0019788
3	Pelspread (I-frame)	0.00086648
3	Pelspread (Averaged)	0.0013133
1	Edgeact (I-frame)	0.0045721
1	Edgeact (Averaged)	0.0045721
3	Edgespread (I-frame)	0.012588
3	Edgespread (Averaged)	0.0014647

TABLE II
RESOURCE FEATURES

Cluster Index	Feature	Distance from center
3	Bitcount	0.18841
3	Bitcount Y	1.1781
2	ME Time	0.0012094
1	SNR V	0.02584
1	SNR V	0.025837
1	SNR Y	0.02599
2	Time	0.0012094

III. RESULTS

In this section we present the results of each trail of the algorithm as follows

1) Running the algorithm on the source domain features
2) Running the algorithm on the Resources features
3) Running the algorithm on the coded domain features
4) Running the algorithm on the selected features from both the coded domain and the source domain

In Table I, the trail for the source domain features. The PFA algorithm highlighted that calculating any of the features by averaging all the per frame values or selecting only that of the first I frame is statistically indistinguishable. The four source features to be selected are: Ave variance, Pelspread (I-frame), and Edgeact. The retained variability of this trail was 99.3974 %.

In Table II, the trail for the resources. We can find from the analysis that the ME time can be used instead for the encoding time without any loss of information and that the SNR can calculated on any of the frame components YUV without any difference. The retained variability of this trail was 99.77155 %.

In Table III, the trail for the coded domain features. The four selected features are MV magn, sub MV, Ave energy I, and Ave energy P.

The forth and final trail is where we compare both the source and coded domain features. This trail results are illustrated in Table IV. The retained variability for this trail is 99.9966 %

IV. CONCLUSION

In this paper, we have demonstrated the use of the PFA in the analysis and selection of a smaller and more concise

TABLE III
CODED DOMAIN FEATURES

Cluster Index	Feature	Distance from center
1	MV magn	0
1	MV magn var	0
2	Sub MV	0
2	Non zero MV	0
3	Ave energy I	0
4	Ave energy P	0
1	MV accel	0
1	MV dir	0

TABLE IV
FINAL TRAIL

Cluster Index	Feature	Distance from center
2	MV magn	0.0016
2	Sub MV	0.0018
3	Ave energy I	0
1	Ave energy P	0
2	Ave variance	0.0481
2	PelSpread	0
2	EdgeSpread	0.0096

subset of features that would be suitable for video content classification to be used in H.264 adaptation. Our future work consists of using the set of selected features in the adaptation scheme for the H.264.

REFERENCES

[1] Vidyut Samanta, Ricardo Oliveira, Advait Dixit, Parixit Aghera, Petros Zerfos, Songwu Lu, ”Impact of Video Encoding Parameters on Dynamic Video Transcoding”, in IEEE COMSWARE, Delhi, India, January 2006.
[2] Yong Wang, Jae-Gon Kim, Shih-Fu Chang, Hyung-Myung Kim,”Utility-Based Video Adaptation for Universal Multimedia Access (UMA) and Content-Based Utility Function Prediction for Real-Time Video Transcoding”, Multimedia, IEEE Transactions on, Volume 9, Issue 2, Feb. 2007
[3] Dimitrios Miras, ”On Quality Aware Adaptation of Internet Video”, University of London, PhD dissertation, May 2004
[4] Catalina Crespi de Arriba, ”Subjective Video Quality Evaluation and Estimation for H.264 Codec and QVGA Resolution Sequences”, PhD dissertation, 2007
[5] Test sequences: www.cipr.rpi.edu
[6] H.264 C++ implementation: http://iphome.hhi.de/suehring/tml/ Version: JM13
[7] ITU-T (Prepublished Recommendation) H.264 (05/2003): Advanced Video Coding for Generic Audiovisual Services
[8] Yijuan Lu, Ira Cohen, Xiang Sean Zhou, Qi Tian, ”Feature selection using principal feature analysis”, Proceedings of the 15th international conference on Multimedia, Augsburg, Germany, September 24-29, 2007. ACM 2007, ISBN 978-1-59593-702-5, Pages 301-304