Selective Motion Vector Redundancies for Improved Error Resilience in HEVC

J. Carreira[1,4⋆], E. Ekmekcioglu[3], A. Kondoz[3], P. Assuncao[1,2], S. Faria[1,2], V. De Silva[4]
[1]Instituto de Telecomunicações, [2]Instituto Politécnico de Leiria/ESTG, PT;
[3]Institute for Digital Technologies, Loughborough University in London; [4]Apical Ltd, Leicestershire, UK
⋆jfmcarreira@gmail.com

Introduction

New coding tools introduced in the HEVC standard bring further compression efficiency, but also complexity increasing and error robustness decreasing.
In this work, a novel method to improve the error resilience of HEVC coded video is proposed. In order to reduce the error propagation due to incorrect MV prediction when frame losses occur, redundant motion information is proposed to be used.

Proposed error resilience method

- The HEVC standard highly increases the spatial and temporal dependencies between consecutive motion vectors (MV);
- In case of frame loss, wrong motion vector predictions lead to severe quality degradation;
- The proposed method is based on breaking the MV dependencies, by selecting and encoding redundant MVs that can be independently decoded.

Proposed Motion Vector selection scheme

Initial MV selection — - select the temporally dependent MVs, which affect the error propagation in case of frame loss.

↓

Analysis of spatial dependencies — - analysis of the number of dependent MVs; - the temporal predicted MVs are assumed as independent.

↓

Prioritisation of the motion information — - to previously the selected MVs, a prioritisation is applied based on the number of dependent MVs.

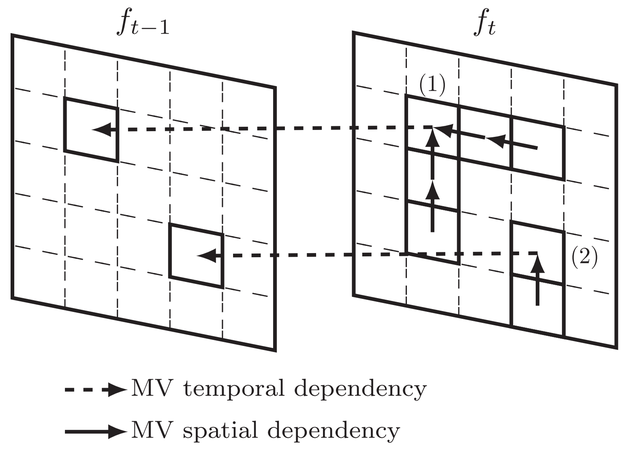
↓

Selection a sub-set of the relevant MVs — - based on the prioritisation scheme a sub-set of relevant MVs is selected.

↓

Coding the redundant motion information — - the selected MV information is compressed using arithmetic coding in order to reduce the overhead.

Examples of motion vector dependencies in HEVC



- In the proposed method the analysis is performed for each frame isolated, in order to reduce the coding delay;
- The selected MVs are transmitted through the SEI messages supported by the HEVC;

Experimental evaluation

Test conditions

Table 1: Test sequences

Sequence	Resolution	Description
Basketball Drill	832 × 480 30 fps	High motion with several basket ball players
Book Arrival	1024 × 768 30 fps	Low translational motion with two moving persons
Kendo	1024 × 768 30 fps	Moderate motion with two moving persons, and moving camera
Race Horses	832 × 480 30 fps	Moderate motion with several horse riders
Tennis	1920 × 1080 24 fps	High motion with one moving person in the scene

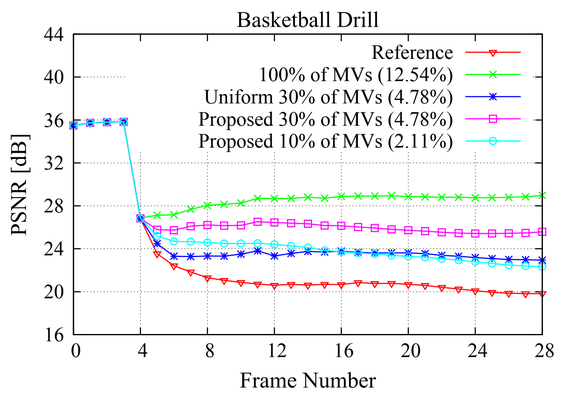
- IDR period of 32 frames;
- GOP size of 1 (*i.e.*, I-P-P...)
- Uniform selection of MVs is used for comparison.

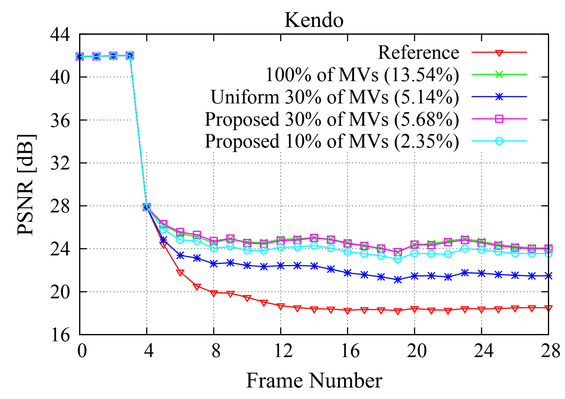
Table 2: Bjontegaard's average Δ bitrate.

Sequence	Percentage of used redundant MVs			
	100%	30%	20%	10%
Book Arrival	11.26	4.19	3.15	2.08
Kendo	16.14	5.90	4.36	2.76
Basketball Drill	14.30	4.98	3.58	2.13
Race Horses	8.71	3.03	2.14	1.23
Tennis	8.43	2.86	2.02	1.14

- 100% stands for no selection - all the temporally dependent MV ar redundantly encoded;
- Tests included the selection of 10%, 20% and 30% of the redundant MVs using the proposed method;

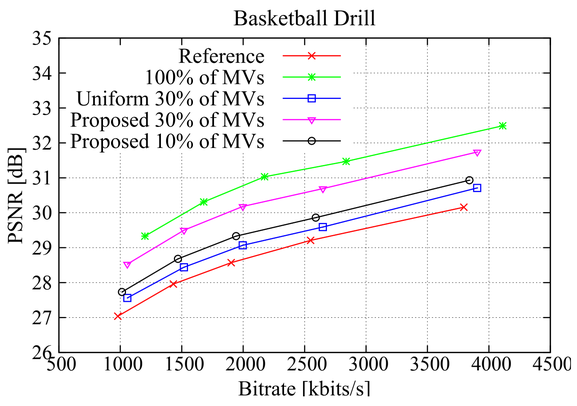
Error propagation (frame 4 is lost)

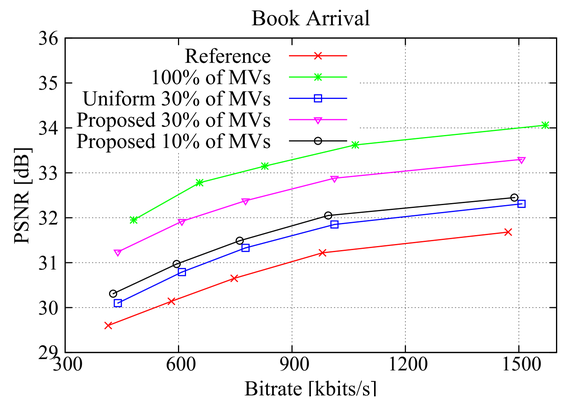


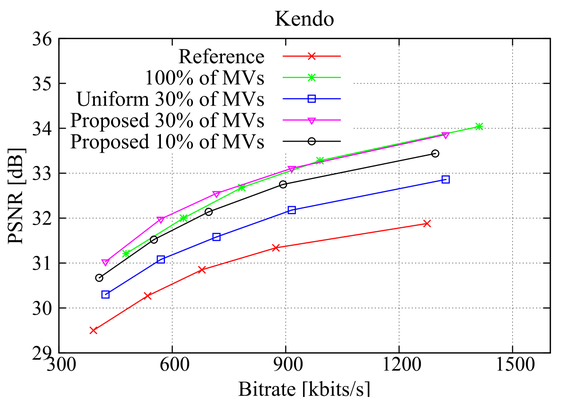


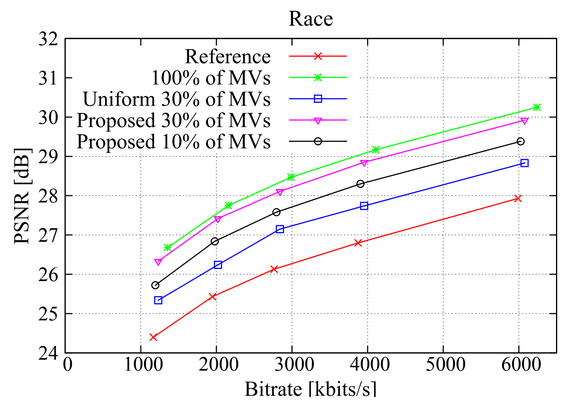
- With the proposed method the amount of MV redundancy decreases by approximately 3 times in comparison with the 100% case;
- An average gain of 4 dB is obtained compared to the reference HEVC (Basketball Drill sequence).

Average quality results for random frame loss (5% of loss)









- The proposed method clearly outperforms the uniform selection;
- For Kendo and Race sequences the proposed selection scheme with 30% of MV redundancy is able to provide similar robustness to the 100% case.

Conclusions

- In this work a selection method for redundant MV coding in HEVC was proposed to identify the most relevant motion information in terms of error propagation prevention;
- The results show that the relevance of MVs for error resilience is correlated with their spatial dependencies;
- The proposed method is able to increase the HEVC robustness, using a reduced amount of redundant MVs (increase of bitrate);
- The results indicate that further research should be carried out to define a dynamic threshold for choosing the amount of redundant MVs, such that only the most useful ones are encoded according to the video content.

This work was supported by the FCT, Portugal (PhD grant SFRH/BD/86368/2012), and the ROMEO project (grant number: 287896), which was funded by the EC FP7 ICT collaborative research programme.