OCTAGONAL-AXIS RASTER PATTERN FOR IMPROVED TEST ZONE SEARCH MOTION ESTIMATION

Paulo Gonçalves, Marcelo Porto, Bruno Zatt, Luciano Agostini, Guilherme Correa
Federal University of Pelotas (UFPel), Pelotas, Brazil

Contact:
phrgoncalves@inf.ufpel.edu.br

INTRODUCTION

- HEVC bit rates are 40-50% smaller than in H.264 [1], but the encoding process is up to 500% more complex [2]
  - Much larger number of partitions evaluated in Motion Estimation (ME)
- **Test Zone Search** (TZS) is a fast ME algorithm
  - Great coding efficiency, close to Full Search
  - Used in the reference HEVC encoder
  - Still, most of HEVC encoding complexity is due to ME
- **This paper proposes OARP:** a novel search pattern for Raster Search step on TZS
  - Based on an analysis of the best match distributions along the ME search area
- Average TZS time reduction of **60.91%** was achieved, with a negligible BD-rate increase (**0.037%**)

THE TEST ZONE SEARCH ALGORITHM

- TZS has four different steps: Motion Vector Prediction, First Search, Raster Search and Refinement
  - **Raster Search** step finds only **0.4%** of the best block matchings on average [3]
  - **Raster Search** is the only step that **fully exploits** the search area
- The average processing time distribution (rightmost column in Fig.1) of TZS algorithm in different PU sizes indicates:
  - Prediction: 3%
  - First Search: 13%
  - Raster Search: 75%
  - Refinement: 9%

- Video sequences:
  - *NebutaFestival;*
  - *Traffic*;
  - *BQTerrace;*
  - *Cactus;*
  - *ParkScene.*
- Quantization Parameters: 22, 27, 32, 37;
- *Main* profile, *Random Access* configuration;
- Search Range: 256;
- HEVC encoder: HM software (v16.14).

Box 1: Analysis conditions

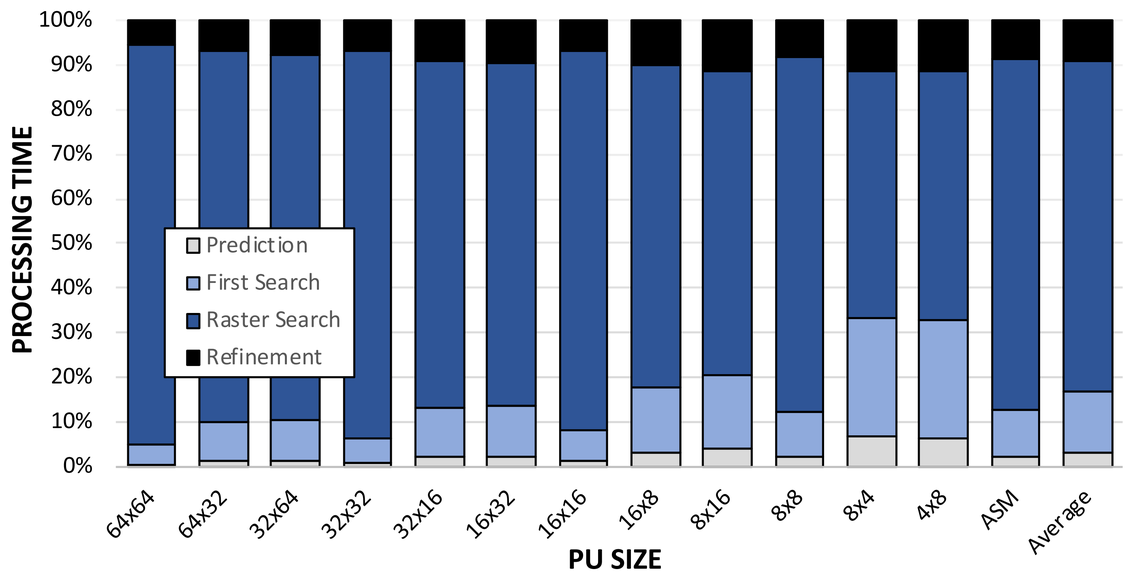

Fig. 1: Distribution of TZS processing time across its four steps for different PU sizes.

- **Raster Search** is by far the most complex step of TZS for any PU size, since it has the major portion of time in TZS algorithm as seen in the rightmost column in Fig. 1
- Raster Search is an **indispensable step** in TZS since it is performed when the previous steps cannot predict correctly the region with the best block matching
- By analyzing block matching statistics in Raster Search, **intelligent approaches** can be proposed to reduce the number of search points

BLOCK MATCHING DISTRIBUTION IN RASTER

- **Fig. 2(a)-(c)** shows a distribution analysis of best block matching positions after each execution of Raster Search
  - **Fig. 2(a)** and **(b)** are corner cases that represent the two most uncommon distributions among all videos analyzed
  - **Fig. 2(c)** shows the average distribution for all videos
- **Fig. 2(d)** presents the **Octagonal-Axis Raster Search**
  - Exploits the observed characteristics in heatmaps
  - Reduces in **75%** the number of search points in the original Raster Search
  - Covers **62.3%** of the total best block matchings

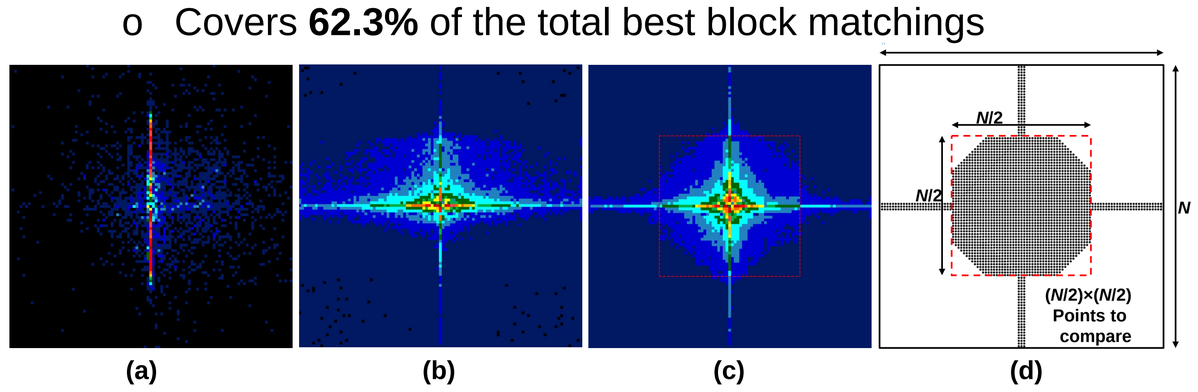

Fig. 2: Heatmap of the block matching distribution within the [-256,+256] search area for (a) *BQTerrace,* and (b) *YachtRide* sequences; (c) average block matching distribution for the whole set video sequences tested; (e) proposed Octagonal-Axis Raster Pattern (OARP).

EXPERIMENTS AND RESULTS

- **Compression efficiency** and **Computational complexity** was computed in terms of Bjøntegaard Delta rate (BD-rate) and processing time, respectively
- The same conditions in **Box 1** were used to evaluate the proposed pattern, **except for the video sequences**

Table I: Experimental results for OARP

Video Sequences	BD-rate (%)	Total TR (%)	TZS TR (%)
PeopleOnStreet	-0.251	18.99	60.65
SteamLocomotiveTrain	+0.051	21.30	61.40
BasketballDrive	-0.029	20.93	59.55
Kimono	-0.072	13.58	53.19
CampfireParty	+0.095	30.04	68.16
ToddlerFountain	-0.030	16.08	56.96
CatRobot	+0.025	22.88	61.71
DaylightRoad	+0.508	28.78	65.66
Average	**+0.037**	**21.57**	**60.91**

- **Table I**: **OARP** leads to an average complexity reduction of **60.91%** for TZS and **21.57%** for the whole encoding process, with a BD-rate increase of **0.037%**

CONCLUSION

- The proposed search pattern, named Octagonal-Axis Raster Pattern (OARP), was designed to efficiently exploit the search area in the Raster Search step of TZS
- A decrease of **60.91%** in TZS complexity was achieved, with a negligible BD-rate increase of **0.037%**
- When implemented in the HEVC reference software, an average total encoding time reduction of 21.6% is achieved
- OARP is compatible with other fast Motion Estimation algorithms that employ Raster Search, and can be jointly implemented with other complexity reduction strategies

REFERENCES

[1] G. J. Sullivan, J. Ohm, H. Woo-Jin, and T. Wiegand, "Overview of the High Efficiency Video Coding (HEVC) Standard," IEEE Transactions on Circuits and Systems for Video Technology, vol. 22, pp. 1649-1668, 2012.

[2] G. Correa, P. Assuncao, L. Agostini, and L. A. da Silva Cruz, "Performance and Computational Complexity Assessment of High Efficiency Video Encoders," IEEE Transactions on Circuits and Systems for Video Technology, vol. 22, pp. 1899-1909, 2012.

[3] P. Goncalves, G. Correa, M. Porto, B. Zatt, L. Agostini, "Multiple Early-Termination Scheme for TZSearch Algorithm based on Data Mining and Decision Trees," IEEE 19th International Workshop on Multimedia Signal Processing, 2017.