Exercise 1: Investigate the Effect of DC Prediction

Our current image codec include a DC prediction. That means all samples of a current block are predicted by the average of the surrounding already coded samples, and only the difference between the original samples of the block and the prediction signal is coded using transform coding.

Investigate the effect of the implemented prediction:

- Replace the DC prediction with a method by which all samples of a block are set equal to the midgray value (128 for 8-bit pictures).
- Run simulations for all test images with and without DC prediction.
- Repeat the experiment for different block sizes.
- What do you observe?
Exercise 2: Implement and Test Different Predictors

Try the following alternative prediction methods:

- **Horizontal prediction**: All samples of a row (of the current block) are predicted using the already reconstructed sample to the left of the row.

- **Vertical prediction**: All samples of a column (of the current block) are predicted using the already reconstructed sample above the column.

- **Planar prediction**: All samples of a block are predicted using the planar prediction mode of HEVC.

Implement the above listed prediction methods (as alternatives to the DC prediction) using separate functions. You may want to try additional prediction modes.

- Test the coding efficiency of the different prediction modes.
- Run simulations for different block sizes.
- What do you observe?
Exercise 3a: Block-Adaptive Intra Prediction

The goal of the exercise is to enable an adaptive selection of the best prediction mode for the current block. In order to enable this functionality, we need the following:

- Different predictors (DC, horizontal, vertical, planar).
- A syntax element that is transmitted for each block and signals the chosen prediction mode to the decoder.
- An algorithm in the encoder that chooses the best prediction mode for each block.

In the last exercise, you have already implemented different prediction functions. Hence, we need to implement the following missing parts:

- Extend the entropy encoding/decoding for a block in a way that at the beginning of a block, a syntax element is coded that signals the chosen prediction mode to the decoder. – Choose a suitable code for this syntax element.
- In the encoder, choose the best prediction mode for each block:
  - Test all prediction modes. For each mode, calculate the Lagrangian cost $J = D + \lambda R$. It is suggested to modify the function `compressBlock(..)` in a way that it return the Lagrangian cost $J$.
  - Choose the prediction mode that minimizes the Lagrangian cost $J$. 
Exercise 3b: Test Block-Adaptive Intra Prediction

Test the following versions (with different amounts of prediction methods):

- Only DC prediction (our original version).
- Only horizontal prediction (as in a previous exercise).
- Only vertical prediction (as in a previous exercise).
- Only planar prediction (as in a previous exercise).
- Block-adaptive decision between horizontal and vertical prediction.
- Block-adaptive decision between DC, horizontal, and vertical prediction.
- Block-adaptive decision between DC, planar, horizontal, and vertical prediction.

Repeat the experiment for different block sizes (4, 8, 16, 32). What do you observe?

- Does a block-adaptive prediction improve coding efficiency relative to the single best predictor?
- Does the improvement change with the selected block size?
- What impact does it have on the encoder run time?
- How could we further improve coding efficiency?