Displaced frame difference signal coding using DCT and symmetry graph transform

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Outline

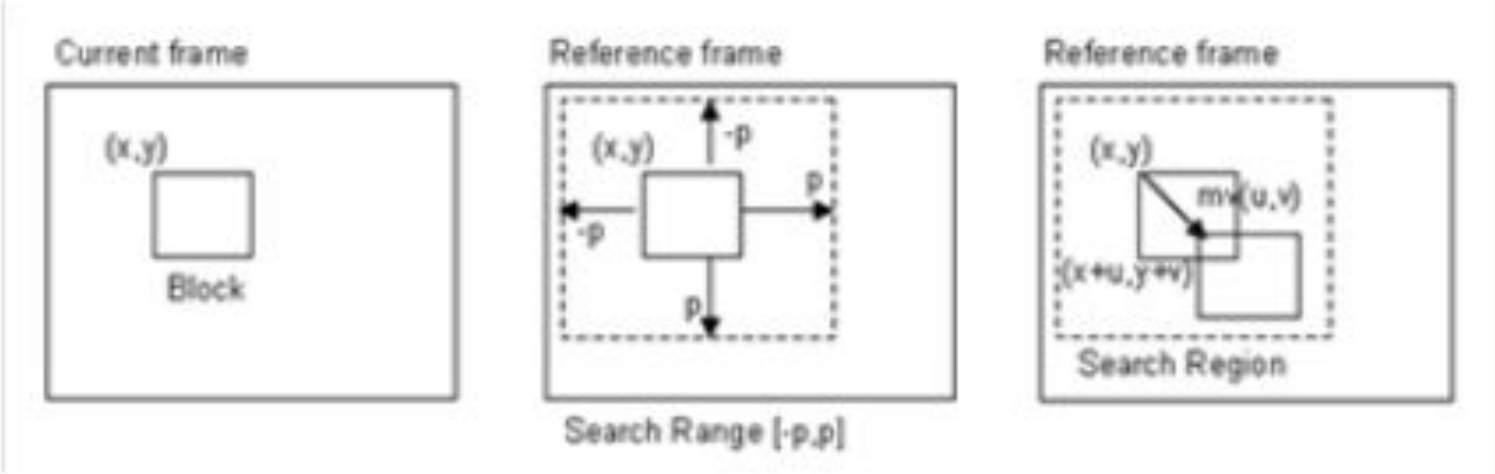
- ★ Introduction
- ★ Transform coding
- ★ Results and comparison
- ★ Result analysis

Introduction

- ★ The main idea of this project is to identify which one of the transform coding GFT or DCT is able to sparsify the signal
- ★ For this project I used one of the video compression methods called motion estimation & will obtain the motion field, the display frame difference(DFD)
- ★ I used the residual image(DFD) which is usually coded using a transform based technique
- ★ Try to analyze which one of the two transforms has the better performance

Motion compensation

- ★ The most common ME technique is called Block Matching Algorithm (BMA)
- ★ where the current frame is divided into Macro blocks (MBs).
- ★ In BMA each MB in the current frame will be compared with the corresponding MBs in the Search Area (SA) of the reference frame to find the best match MB in the reference frame



Motion compensation

- ★ Once the best match block for the block in the current frame is located at the reference frame
- ★ The motion vector is calculated as the displacement between these two macro blocks.
- ★ By determining the motion vectors (using motion estimation), we can be able to apply a transformation and synthesis the next image (motion compensation) to finally achieve the main goal of this technique which is video compression.

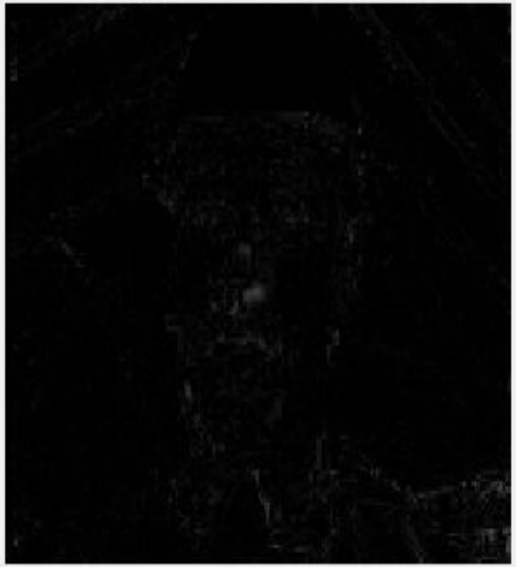
Motion compensation

Motion compensation

original frame 2

predicted frame 2 by MV

Displaced frame difference



Cont.

- ★ DFD is generated by the process of motion compensation method, but it does not fully exploit the underlying redundancies.
- ★ To reduce this redundancies we further implement the Transform coding
- ★ Transform coding aims at mapping the image into a set of coefficients and the resulting coefficients are then quantized and coded
    - ➢ Partition the residual image into 8x8 blocks.
    - ➢ using a DCT or GFT based coding scheme for each block.
    - ➢ Order the Coefficients in descending order.
    - ➢ Quantization(Remove the smallest coefficients)
    - ➢ Reconstruct and Compare the result of DCT & GFT mean square error.

Cont.

- The transform coding used for this project are
  - Set of GFTs
  - DCT

Graph fourier transform

★ Given a signal x with N samples, we denote the graph by $\mathcal{G}(\mathcal{N}, \mathcal{E})$, where $\mathcal{N}$ = {1,....,N} and $\mathcal{E}$ represent the set of nodes and the set of edges, respectively. A graph Laplacian matrix is defined as

$$L = D - A$$

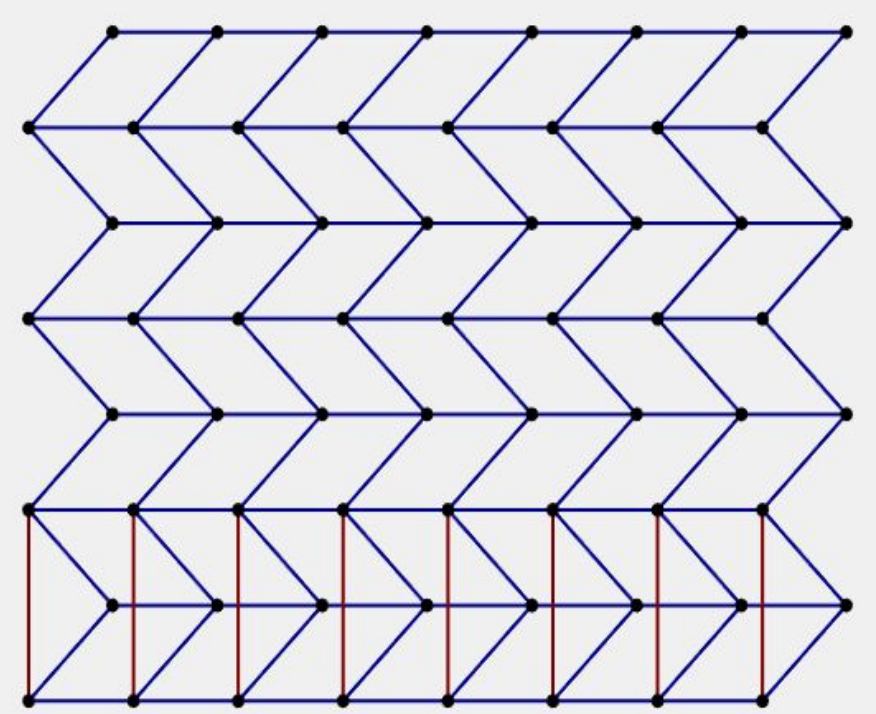
- Where D and A are the degree and adjacency matrices of $\mathcal{G}$.

★ Let U be the matrix of eigenvectors of L,

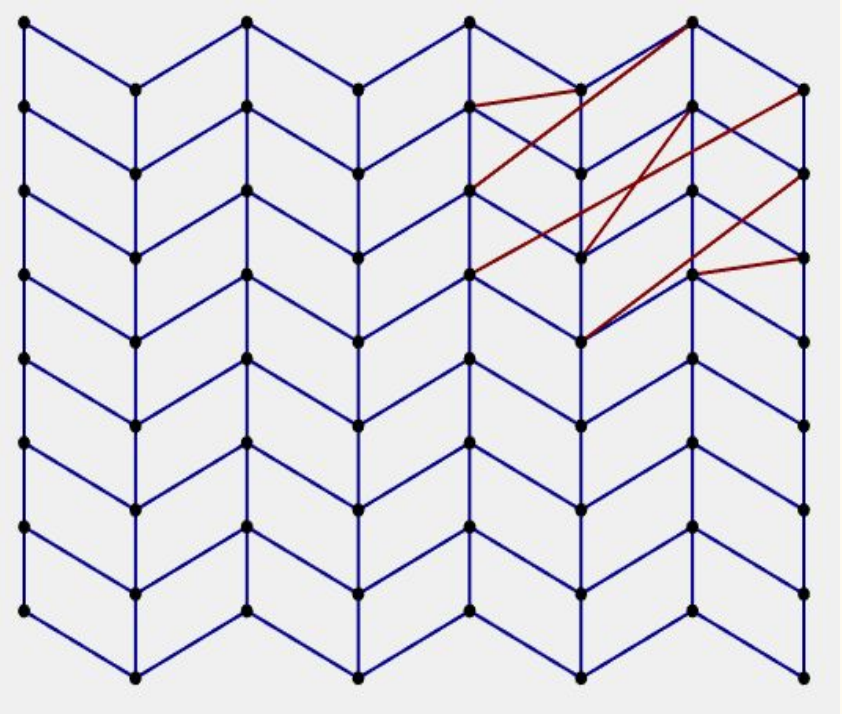
★ GFT is defined using the eigen-decomposition of the graph Laplacian matrix.

Two of the forty graph designed for each 8 × 8 residual blocks which lead to 40 different GFT's

First graph



The fourteen graph



Graph fourier transform(GFT)

- Graph-based compression methods use a graph representation of the signal through its GFT
- The GFT interprets a signal as being defined on a graph, and calculates the eigenvector decomposition of the corresponding graph Laplacian
- A graph can be computed for each image blocks, making the GFT a more flexible framework for transform design.
- an image can be represented by a graph, where the nodes are the image pixels and the edge weights capture the similarity between adjacent pixels.

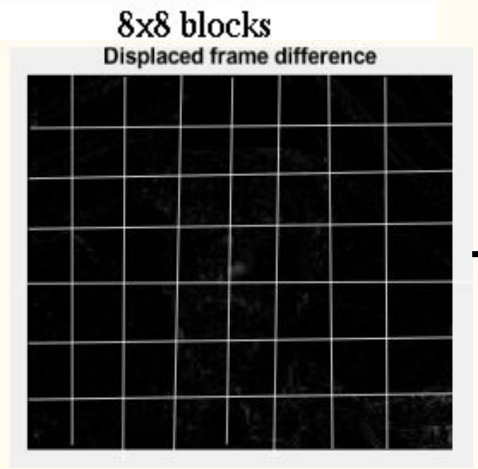
Steps used for GFT

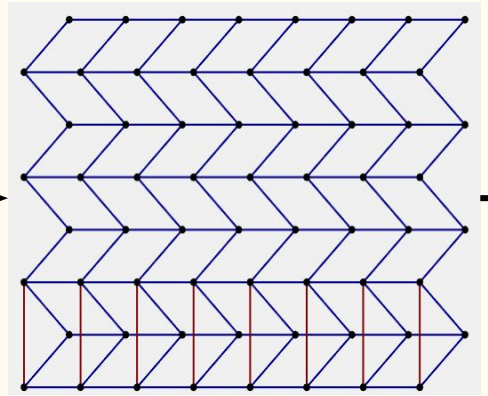
- ★ Partition the residual into 8x8 blocks on a regular grid.
- ★ For each block the 40's GFT is tested
- ★ Remove the smallest coefficient from each residual blocks
- ★ Find the winner graph from each block by using the graph that returns the minimum MSE
- ★ Take only the winner graph from each block
- ★ Apply the inverse GFT by using the the winner graph from each block

How to find the winner graph

- For each block compute the mean square error
- MSE is the mean square error between the original and the reconstructed
- From each block find the winner graph by using MSE
- The coding mode that, after quantization, produces the largest number of zeros is selected as the winner graph

How the GFT works





Quantization & Find the winner graph

Inverse GFT by using the winner graph

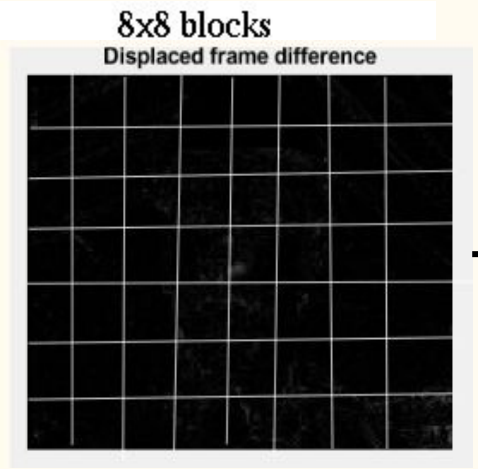
Discrete Cosine Transform (DCT)

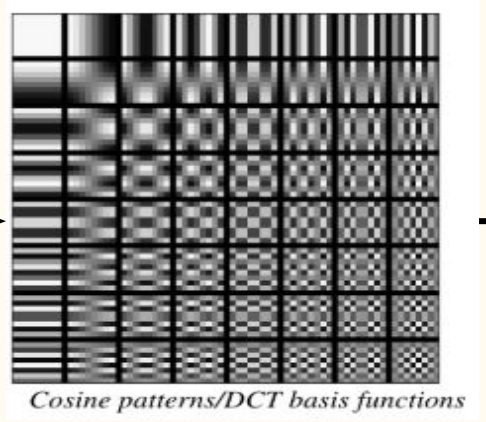
- ★ Partition the image into blocks of 8x8 pixels.
- ★ The DCT transform is then performed on each block
- ★ Using JPEG standard quantization table, then we get quantized coefficients

Steps used for DCT

- ★ Partition the DFD image into 8x8 blocks on.
- ★ Apply a DCT based coding scheme for each block
- ★ Order the Coefficients in descending order
- ★ Remove the smallest coefficient
- ★ Compute the DCT inverse using the most significant coefficient

How the DCT works





Quantization

Inverse DCT

The difference in the encoder & decoder

Fro DCT

- When i use the DCT the encoder sends N coefficients to the decoder and the decoder knows that it has to apply the inverse DCT

For GFT

- If i apply GFT each block has been obtained from different graph
- The encoder should send for each block also the index(the winner graph) that indicate the graph I used for the block otherwise the decoder doesn't know which graph to use for each block.

DCT coefficient for 2 & 8

DCT coefficient for 6 & 16

Reconstructed image DCT coef

Reconstructed image DCT coef

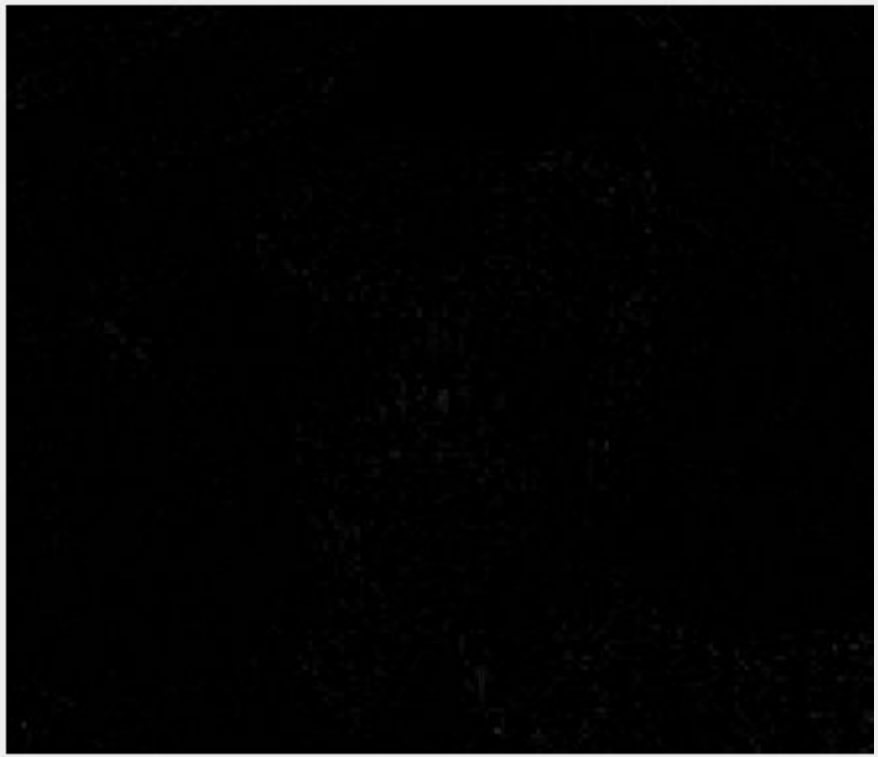
GFT coefficient for 2 & 8

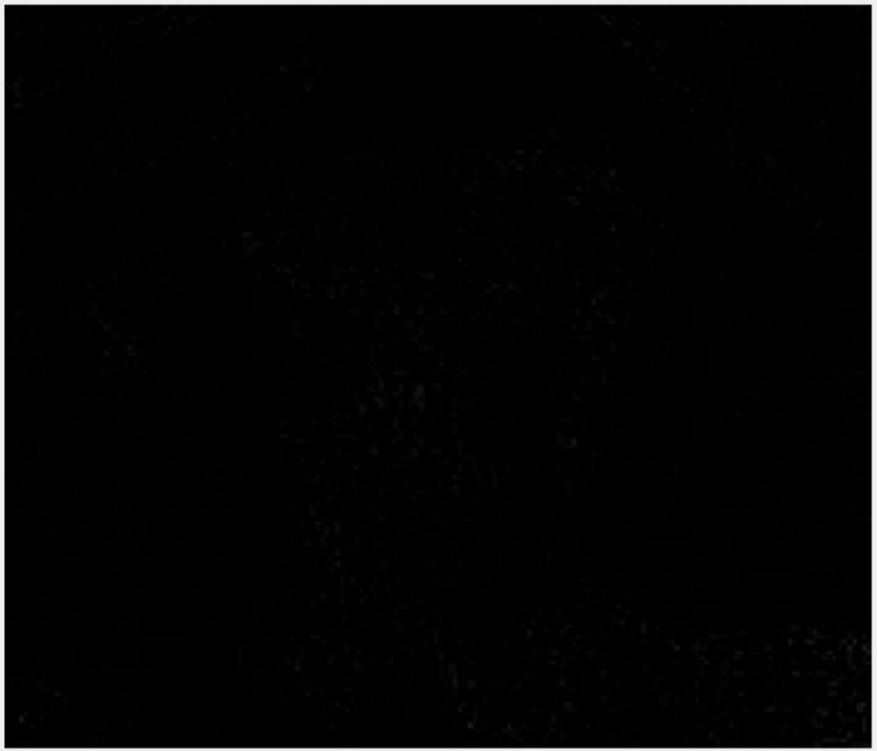
Reconstructed image usiing most significant GFT coeffs for each block

Reconstructed image usiing most significant GFT coeffs for each block

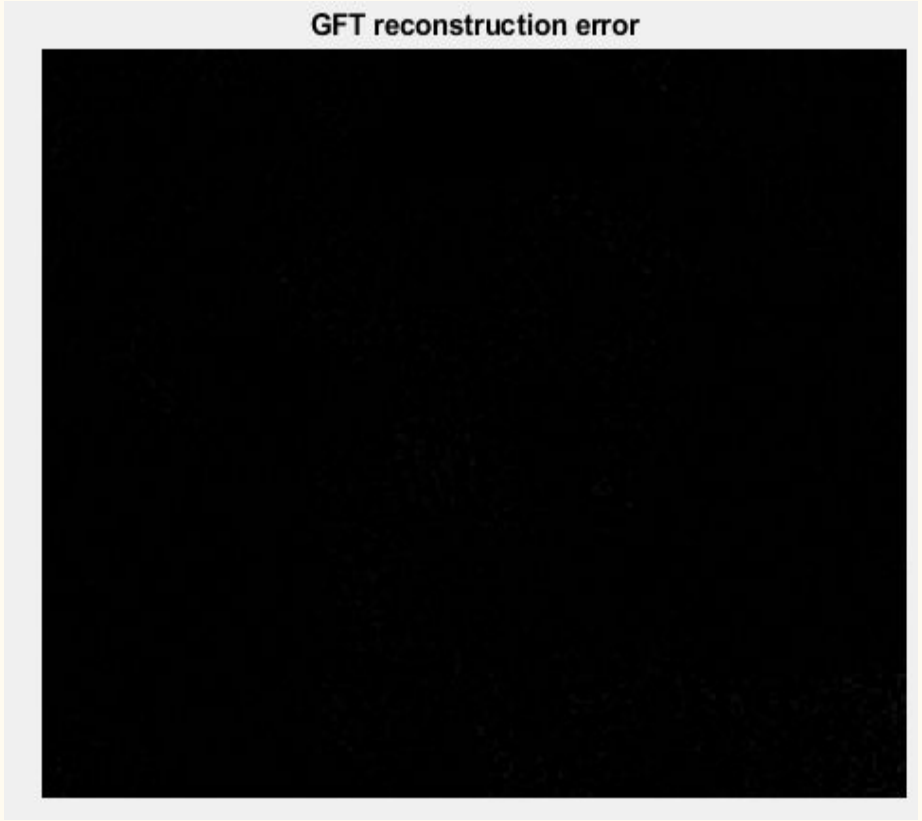
GFT coefficient for 6 & 16

GFT coefficient for 6 & 8 reconstruction error

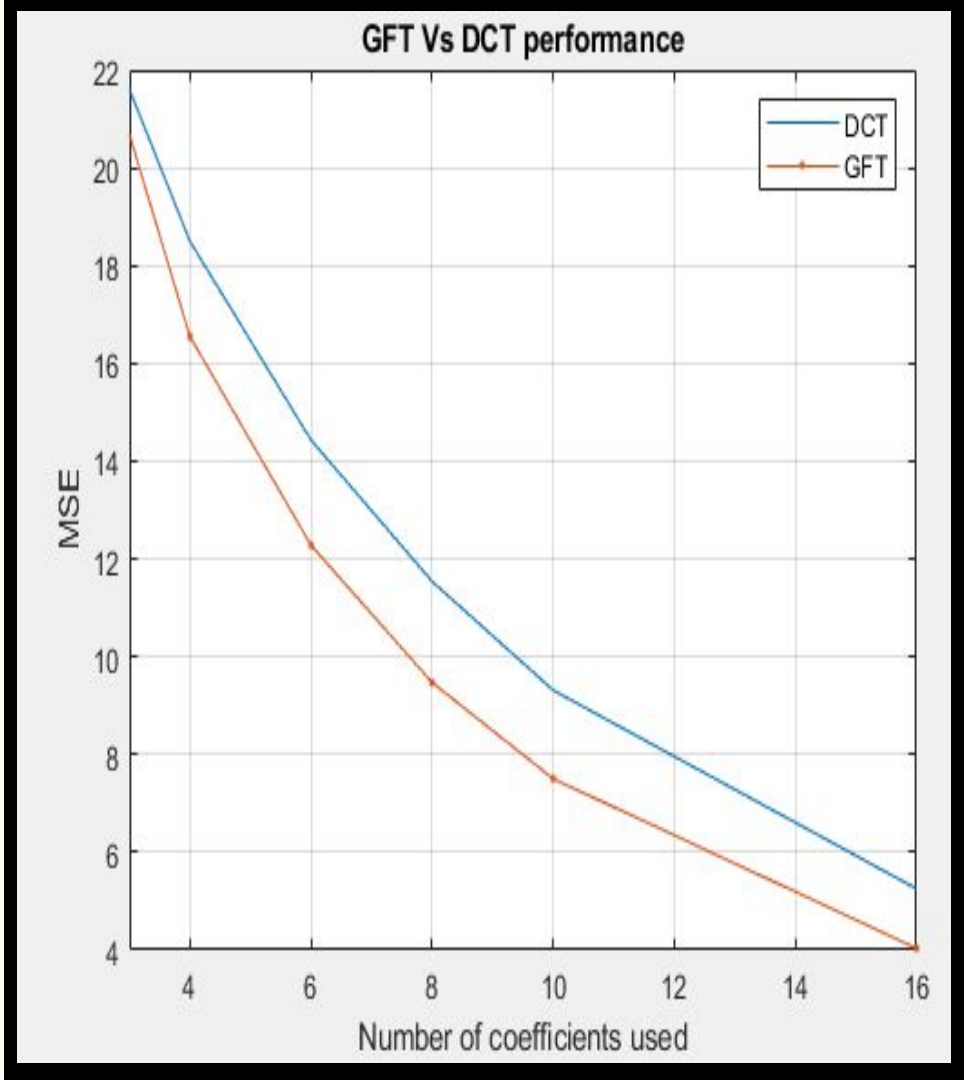




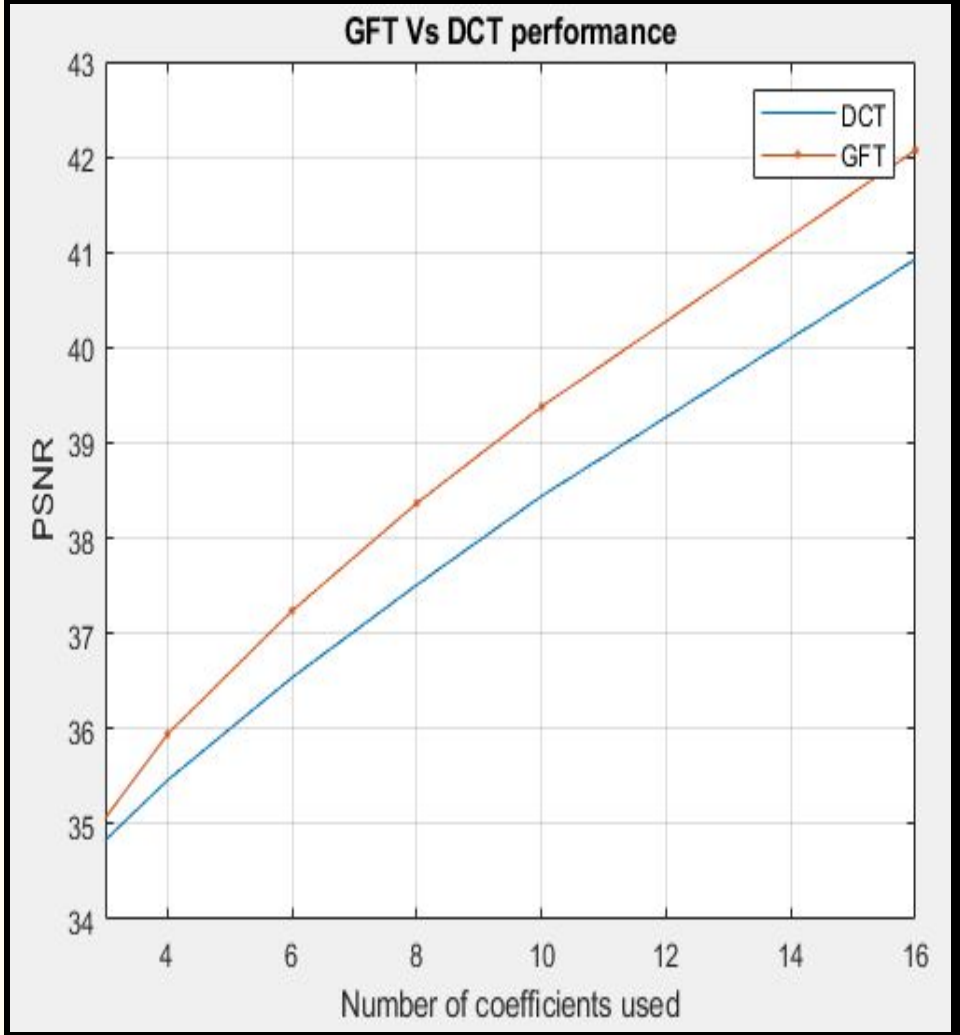
GFT coefficient for 10 & 16 reconstruction error



The performance between GFT and DCT



The performance between GFT and DCT



Result analysis

- ★ The DFD coding scheme proposed in this project key observation is to improve the performance of any transform based DFD coder.
- ★ The results show that we can use only a few of transform coefficients to reconstruct the original image with accepted visual quality
- ★ It clearly shows performance of GFT is better than DCT for various coefficients.
- ★ when more transform coefficients are conserved, a good representation of image is reconstructed.
- ★ The key idea is to predict locations of high DFD concentration which occupy small portions of the image and use this predicted information to improve the quality of the decoded image.