Progressive Imaging: A Transform Space Approach

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Introduction

- Modern medical imaging techniques can produce large amounts of image data
- Transmission of these large datasets can be problematic, especially in interactive applications
- Progressive transmission addresses this concern by reconstructing an image when only part of the data is received, then refining the reconstruction as new information becomes available
- If receivers can recognize the presence or absence of features of interest, they can decide to continue or abort transmission before all the data is received
- The goal of progressive transmission is to allow reconstruction of the most detailed image with as little data as possible
- The general outline of progressive transmission of an image $A = (a_{IJK})$ is:
  - decompose $A = \sum_{i=1}^{n} \tilde{A}_i, \ \tilde{A}_i \ and \ \tilde{A}_j \ disjoint.$
  - order $\{A_i\}_{i=1}^{n} = \{\tilde{A}_{i_j}\}_{j=1}^{n}$
  - transmit $A_1, A_2, A_3, ...$
  - $A_1;\ A_1, A_2;\ A_1, A_2, A_3;$ ... used for successive approximations of A

Mathematical Background

Direct Progressive Transmission

- Individual Best Remaining Region (IBRR) ordering strategy:

  If $A_1, A_2, ..., A_s$ are transmitted, the next, A_{s+1}, is one of the unsent slices, A_j for which $max_{A_j} \ ||R(A_1, A_2, ..., A_s)|_{j^{th} \ slicing} - A_j||$ is minimized; R is a (partial) reconstruction

Transform Space Progressive Transmission

Algorithm:

1. Compute $(\mathcal{T}(A)_{IJK})$
2. Determine decreasing order of elements $|\mathcal{T}(A)_{IJK}|$; retain first d% of them
3. Zero remaining (100-d)% of the elements of $(\mathcal{T}(A)_{IJK})$
4. Apply $\mathcal{T}^{-1}$ to modified matrix

This produces an approximate image to A, incorporating d% of the elements of $(\mathcal{T}(A)_{IJK})$

For the illustration below, we have used $\mathcal{T} = \mathcal{F}$

Data and Methods

- The Fourier $(\mathcal{F}(A))$ method was used with a 3D MRI head data set and compared with the use of IBRR direct optimal strategy with decomposition by slices

Figure 1: Two views of the MRI head test data set (50 slices, each 256x256 pixels).

Results

Progressive Imaging: Direct (IBRR)

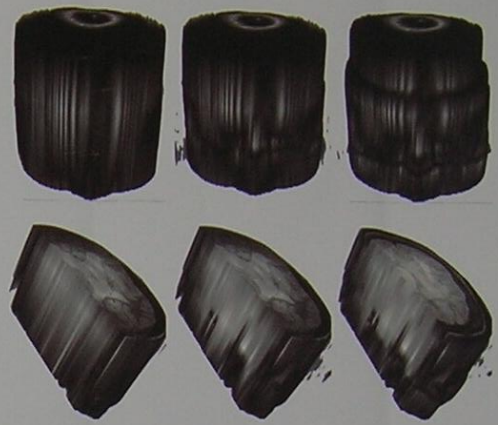

Figure 2: IBRR direct scheme for a slice decomposition of the image in Fig. 1. (a) 8% of data transmitted, (b) 12% transmitted and (c) 20% transmitted.

Progressive Imaging: Transform Space Algorithm

Figure 3: Fourier transform strategy for decomposition of the image in Fig. 1. (a) 8% of data transmitted, (b) 12% transmitted and (c) 20% transmitted.

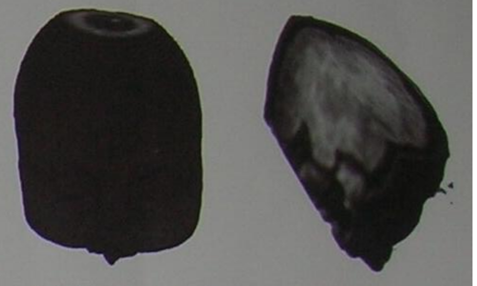

Figure 4: The Fourier transform scheme shows some detail even with only 1% of the data transmitted.

Conclusions

- The transform space approach to progressive transmission, illustrated here with the Fourier transform:
  - is easy to implement
  - reproduces good internal detail when compared to the IBRR approach
  - permits fast decomposition and reconstruction

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