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Proof of Concept Interpolation Technique

A NEW TECHNIQUE FOR COMMUNICATION OF IMAGERY PRODUCTS AND FILE SERVER ECONOMY

May 1996

Purpose

- Significantly increase the capability to rapidly disseminate digital imagery products using existing tactical communications assets

- The Proof of Concept indicates the Interpolation Technique:

  Provides usable products with lower transmission times

  Allows an increased number of usable products to be stored on existing servers

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Approach

- Determine the minimum amount of data needed to present usable image products to workstation displays and printers
- Use classic image processing techniques combined with standard compression ratios
- *Intended only for the transmission of Products to Users in the field!*

Present Method JPEG 3:1

Product Generation and Transmission

Product Generation

2K x 2K Image
JPEG 3:1
Loaded on file server

Transmission Method

De-compress
Delivered

Transmission Time

Transmission Method	JPEG 3:1
2.4 Kbs Phone	1 hr, 17 min
9.6 Kbs Link	19.4 min
56 Kbs DDN	3.3 min
64 Kbs ISDN	2.9 min
1,544 Kbs T-1	7.2 sec
45,000 Kbs T-3	.25 sec

Interpolation Technique #1

Product Generation and Transmission

Product Generation

Original 2K x 2K Image

Down Interpolation 4:1 (13 sec)
(2K x 2K > 512 x 512)
Width Interpolation 3:1 (2.1 sec)
(512 x 512 > 170 x 512)
JPEG Compression 12:1 (3 sec)

Transmission Method

De-compressed JPEG 12:1(170 x 512)
Width Interpolation (512 x 512)
Up Interpolation 4:1
✓ Nearest Neighbor
✓ Smoothing
Delivered

Transmission Time vs JPEG 3:1

Transmission Method	JPEG 3:1	Interpolation Technique
2.4 Kbs Phone	1 hr, 17 min	49 sec
9.6 Kbs Link	19.4 min	12 sec
56 Kbs DDN	3.3 min	2 sec
64 Kbs ISDN	2.9 min	2 sec
1,544 Kbs T-1	7.2 sec	.1 sec
45,000 Kbs T-3	.25 sec	.01 sec

Effective compression ratio 283.9:1
RMS = 22.7

Interpolation Technique #2

Product Generation and Transmission

Product Generation

Original 2K x 2K Image

Down Interpolation 4:1 (13 sec)
(2K x 2K > 512 x 512)
Width Interpolation 2:1 (2.8 sec)
(512 x 512 > 256 x 512)
JPEG Compression 12:1 (3 sec)

Transmission Method

De-compressed JPEG 12:1(256 x 512)
Width Interpolation (512 x 512)
Up Interpolation 4:1
✓ Nearest Neighbor
✓ Smoothing
Delivered

Transmission Time vs JPEG 3:1

Transmission Method	JPEG 3:1	Interpolation Technique
• 2.4 Kbs Phone	1 hr, 17 min	1.1 min
• 9.6 Kbs Link	19.4 min	18 sec
• 56 Kbs DDN	3.3 min	3 sec
• 64 Kbs ISDN	2.9 min	3 sec
• 1,544 Kbs T-1	7.2 sec	.1 sec
• 45,000 Kbs T-3	.25 sec	.01 sec

Effective compression ratio198.8:1
RMS = 20.1

Interpolation Technique #3

Product Generation and Transmission

Product Generation

Original 2K x 2K Image

Down Interpolation 4:1 (13 sec)
(2K x 2K > 512 x 512)
JPEG Compression 16:1 (4 sec)

Transmission Method

De-compressed JPEG 16:1(512 x 512)
Up Interpolation 4:1
✓ Nearest Neighbor
✓ Smoothing
Delivered

Transmission Time vs JPEG 3:1

Transmission Method	JPEG 3:1	Interpolation Technique
2.4 Kbs Phone	1 hr, 17 min	53 sec
9.6 Kbs Link	19.4 min	13 sec
56 Kbs DDN	3.3 min	2 sec
64 Kbs ISDN	2.9 min	2 sec
1,544 Kbs T-1	7.2 sec	.1 sec
45000 Kbs T-3	.25 sec	.01 sec

Effective compression ratio 206.5:1
RMS = 17.9

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Interpolation Technique #4

Product Generation and Transmission

Product Generation

Original 2K x 2K Image

Down Interpolation 4:1 (13 sec)
(2K x 2K > 512 x 512)
JPEG Compression 8:1 (2 sec)

Transmission Method

De-compressed JPEG 8:1(512 x 512)
Up Interpolation 4:1
✓ Nearest Neighbor
✓ Smoothing
Delivered

Transmission Time vs JPEG 3:1

Transmission Method	JPEG 3:1	Interpolation Technique
• 2.4 Kbs Phone	1 hr, 17 min	1.8 min
• 9.6 Kbs Link	19.4 min	33 sec
• 56 Kbs DDN	3.3 min	5 sec
• 64 Kbs ISDN	2.9 min	4 sec
• 1,544 Kbs T-1	7.2 sec	.2 sec
• 45000 Kbs T-3	.25 sec	.01 sec

Effective compression ratio 106.9:1
RMS = 16.9

Interpolation Technique #5

Product Generation and Transmission

Product Generation

Original 2K x 2K Image

Down Interpolation 2:1
(2K x 2K > 512 x 512)
JPEG Compression 15:1 (2 sec)

Transmission Method

De-compressed JPEG 15:1(512 x 512)
Up Interpolation 2:1
✓ Nearest Neighbor
✓ Smoothing
Delivered

Transmission Time vs JPEG 3:1

Transmission Method	JPEG 3:1	Interpolation Technique
• 2.4 Kbs Phone	1 hr, 17 min	4.53 min
• 9.6 Kbs Link	19.4 min	1.13 min
• 56 Kbs DDN	3.3 min	12 sec
• 64 Kbs ISDN	2.9 min	11 sec
• 1,544 Kbs T-1	7.2 sec	.4 sec
• 45000 Kbs T-3	.25 sec	.01 sec

Effective compression ratio 47.7:1
RMS = 10.5

Interpolation Technique Summary

Transmission Times and File Server Storage (no overhead)

Summary of Results

	2K x 2K	JPEG 3:1	Technique #1	Technique #2	Technique #3	Technique #4	Technique #5
File Size (bytes)	4,194,304	978,316	14,773	21,103	20,315	39,222	88,000
RMS	0	2.2	22.7	20.1	17.9	16.9	10.5
Comp. Ratio	1.0	4.3	283.9	198.8	206.5	106.9	47.7
Method	**Transmission Time (seconds)**						
2.4 Kbs Phone	13,981	3,261	49	70	68	131	293
9.6 Kbs Link	3,495	815	12	18	17	33	73
56 Kbs DDN	599	140	2	3	3	6	13
64 Kbs ISDN	524	122	2	3	3	5	11
1,544 Kbs T-1	21.7	5.1	.1	.1	.1	.2	.5
45,000 Kbs T-3	0.75	0.17	.003	.004	.004	.007	.016
File Server Images	10,729	45,997	3,046,098	2,132,398	2,215,112	1,147,315	511,364

File Server Storage Economy

- Present capacity on a 45 gigabyte File Server

  33,000 2K x 2K images (JPEG 3:1 compressed)

- Increased capacity using Interpolation Techniques before loading on a 45 gigabyte File Server

  1.4 to 3.0 million 2K x 2K images

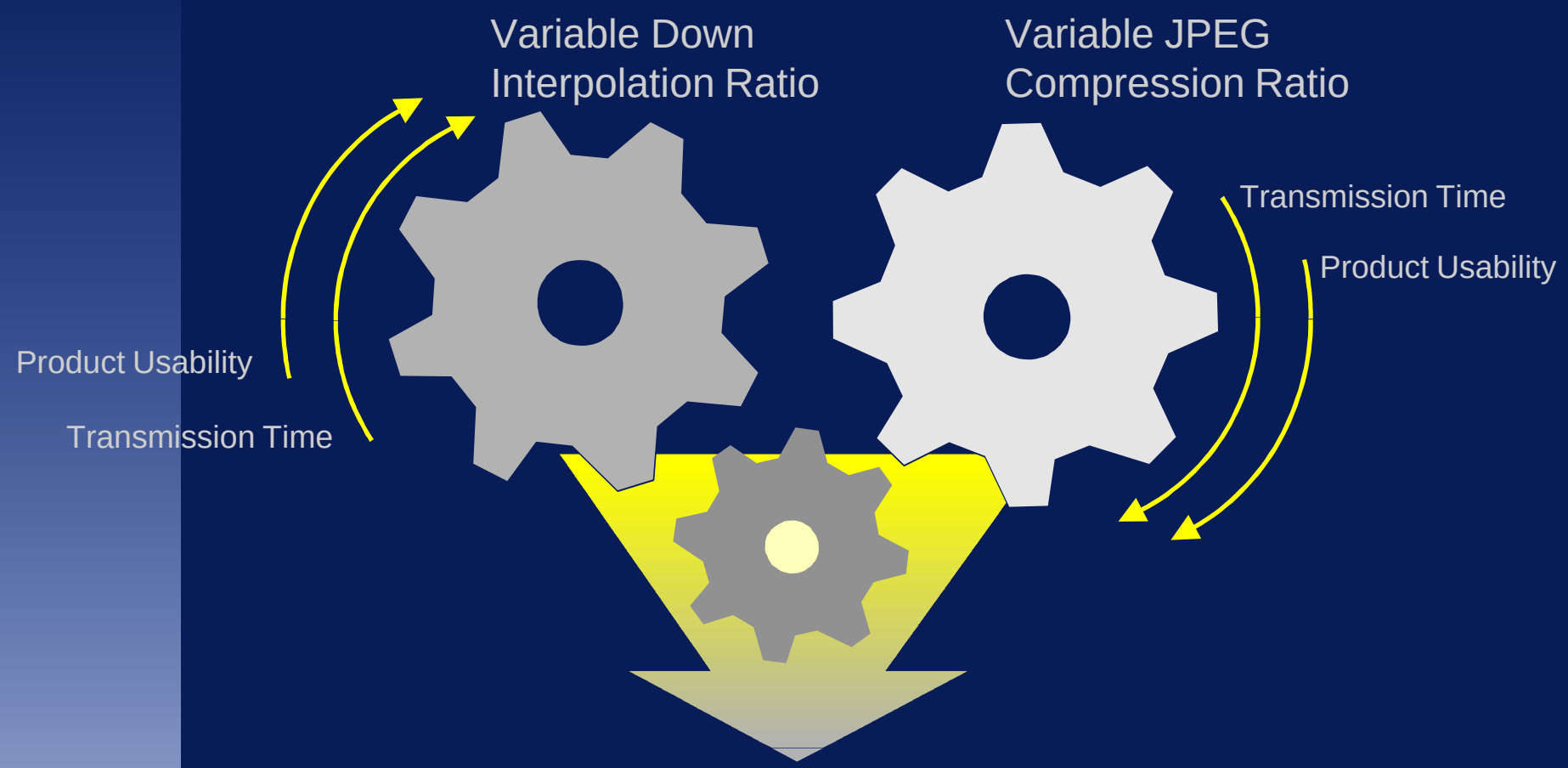
JAC/JIC Products in Your Laptop

- Develop a *MOBILE ARCHIVE* using a standard laptop computer
- 2K x 2K images stored on a 2 gigabyte laptop drive:

Interpolation Technique	Number of Images
None (JPEG 3:1)	1,400
1	135,000
2	94,000
3	98,000
4	62,000

Time -vs- Usability Dial

Select either maximum product usability, minimum transmission time ao the best combination of both



Acceptable tradeoff between product usability and transmission time

Potential Development Areas

- Time -vs- Usability Dial
- “Region of Interest” - to define a block of data for transmission without loss
- Application of a common sharpening filter to improve overall image appearance
- Explore other image formats

  Video/Digital products: *Unmanned Aerial Vehicles*

  Tactical reconnaissance: *digitized photo prints*
  Image Display and Exploitation System products
  Target Material Work Station
  Other national digitized film products