NEESgrid Imaging Overview
- White Paper –
-
This is a Very Early DRAFT
its content will change a lot .

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Table of Contents

1 Scope of This Document

This document is intended to define some common imaging terminology and related consequences of image processing and manipulation which are associated with data that might be collected by a NEESgrid site. This document is intented to be a living document and will be updated as needed as an archive of information relative to the NEESgrid project. It is not mean't to be a comprehensive review of imaging but rather a collection of salient points as they relate to the issues associated with NEESgrid. Much of the information herein is copied directly from various sources on the WWW, these will be documented in the references, right now this is just a draft.

2 Background

Imaging, in the context of this document, should be regarded as any process in which a two dimensional representation of data is used to describe an object. Most frequently this will be associated with a intensity modulated two dimensional data recorded either by a still or a video camera, and might be either in analog or digital content, however other imaging modalities are not precluded.

3 Overview of Basic Terms, Definitions, Concepts

In the context of imaging using still and video equipment there are a number of terms and definitions which are frequently encountered. The list below is a discussion of some of these in a semi-organized manner.

3.1 Resolution

Resolution of any image is the number of pixels (individual points of intensity) contained in it, expressed in terms of the number of pixels on the horizontal axis and the number on the vertical axis (X,Y) . The sharpness of the image on a display depends on the resolution and the size of the monitor, as well as the number of real pixels in that image. . The same pixel resolution will be sharper on a smaller display and gradually lose sharpness on larger monitors because the same number of pixels are being spread out over a larger size.

The human eye has a a resolution of ~ 0.1 mm. The typical pixel size of a computer monitor ranges between 0.2 – 0.35 mm per pixel. this is sometimes called the pitch of the monitor. Your eye can easily detect this difference, with the better monitors obviously having a smaller pitch.

Images are displayed on conventional monitors are typically at 72-100 dpi or about 0.25 – 0.35 mm, i.e. matching the resolution of the monitor.

A typical laser or inkject printer today produce dots at 300-600 dpi or at 0.04 - 0.08 mm.

A 24” television has a resolution of about ~0.5 mm, with the added complication that the pixels on a TV are rectangular in contrast to that of a computer monitor which are “square”.

Add a discussion of large screen displays here. Should be also put in the context of Acesss Grid.

3.2 Image Size

The size of an image is simply the number of pixels in the image multipled by the number of intensity bits which each pixel represents. Intensity levels are described in terms of the numerical range which that intensity can represent when expressed as a binary number in units of powers of 2. Thus, the intensity range of 0-255 can be represented digitally as 2^0 –1 (=00000000) through 2^8 –1 (= 11111111) that is an eight bit binary number . Typical color cameras measure intensity in each of the three primary colors , Red, Green, and Blue giving rise to the nomenclature of a 24 bit (8bit x 3) images. High intensity resolution cameras can be obtained having 10, 12, 14 and 16 bit (1024, 4096, 16384, 65536) resolution. Most of these high (intensity) resoultion cameras are monochrome.. These higher resolution devices are infrequentnly used in video work, but have application in still scientific measurement cameras, for example , they are used often used in quantitative microscopy. Intensity resoultion in an image is frequently referred to as the bit depth of the pixels in the image.

For comparison the intensity resolution in grey scale for the unaided human eye ranges is nominal 32-64 levels. (~ 5-6 bits).depending upon the individual. For color imaging the eyes resolution is greater ~ ?? levels (find out what a good value this this!!) .

The following are some typical numbers which one can associate with various size images. Here we use the word resolution in terms of it’s spatial extent (X,Y) rather than the intensity resolution. Intensity resolution when specified will be always given as the bit depth of at each pixel.

3.2.1 High resolution image

1280 x 960 pixels x 24 bits
= 1,228,800 pixels @ 24 bit (this is a 1.2 Mpixel image !)
=29.491 Mbits
= 3.686 Mbytes @ 24 bit or in grey scale 1.228 Mbytes @ 8 bit

3.2.2 Standard resolution image

640 x 480 pixels x 24 bits
= 307,200 pixels @ 24 bit
=7.3728 Mbits
= 921.6 kbytes @ 24 bit or in grey scale 307.2 kbytes @ 8 bit

3.2.3 Medium resolution image

320 x 240 x 24 bits
= 76,800 pixels @ 24 bit

=1.8432 Mbits
= 230.4 kbytes @ 24 bit or in grey scale 76.8 kbytes @ 8 bit

3.2.4 Low resolution image

1 Image ~ 160 x 120 x 24 bits
= 19,200 pixels @ 24 bit
= 460.8 kbits
= 57.6 kbytes @ 24 bit or in grey scale 19.2kbytes @ 8bit

4 Image File Formats and Compression Schemes.

Data once recorded must be stored for use in the NEESgrid Collaboratory. In order to do this the information must ultimately be placed into a file with some format. In this section we outline the varoius formats and compression schemes.

Lossless Data Format

These are file formats which do not mathematically change in any way the numerical data within an image. A losslessly stored image can be stored and reread and the exact original intensity at each pixel will be recovered from which the data was derived. . Some files formats can compress data without loss, examples of this are TIFF, JPEG-LS and PNG.

If any quantitative measurements of a image are to be anticipated, a master copy of the original data set should always be archived in a true lossless format.

If a format does not specifically state it is lossless, then you can be assured that in its compression alogrithms your data will be modified. See example of loss of resolution due to compression schemes later in this document.

Raw Data

A raw data format is a sequential pixel by pixel storage of the absolute intensity of each point of an image. Raw data formats having no compression. Raw data may be stored a number of different ways, either as binary or as a series of ascii numbers. The format of raw data files depends upon the program being used.

TIFF (Tagged Image File Format)

TIFF is one of the most popular and flexible of the current public domain raster file formats. There are no provisions in TIFF for storing vector graphics, text annotation. TIFF is based on file-offsets, so that it is not easily "streamable" in the way JPEG JFIF streams are. TIFF was developed by Aldus and

Microsoft Corp, and the specification was owned by Aldus, which in turn merged with Adobe Systems, Incorporated. Consequently, Adobe Systems now holds the Copyright for the TIFF specification.
The current specification of TIFF can be found at
(http://partners.adobe.com/asn/developer/pdfs/tn/TIFF6.pdf)

PNG (Portable Network Graphics)

The Portable Network Graphics (PNG) format was designed to replace the older and simpler GIF format and, to some extent, the much more complex TIFF format. It's principle target is WWW based graphics, however, PNG's compression is fully lossless--and since it supports up to 48-bit truecolor or 16-bit grayscale--saving, restoring and re-saving an image will not degrade its quality, unlike standard JPEG.
http://www.libpng.org/pub/png/

GIF (Graphics Interchange Format)

JPEG (Joint Photographic Experts Group)

The best known standard from JPEG is IS 10918-1 (ITU-T T.81), which is the first of a multi-part set of standards for still image compression. A basic version of the many features of this standard, in association with a file format placed into the public domain by C-Cube Microsystems (JFIF) is what most people think of as JPEG. http://www.jpeg.org

JPEG is designed for compressing either full-color or gray-scale images of natural, real-world scenes. It works well on photographs, naturalistic artwork, and similar material; not so well on lettering, simple cartoons, or line drawings. Standard JPEG is lossy compression, designed for "static" images it can routinely achieve 10:1 -> 20:1 compression of color with little loss in "perception" by the unaided eye, however, the compression can be varied to preserve the maximum amount of the original image, resulting in a very low, compression ratio. JPEG stores full color information: 24 bits/pixel (16 million colors). While JPEG is a compression scheme it is not a true file format , JFIF is the file format. The orginal JPEG specification includes a lossless compression scheme, but it has been infrequently implemented in commerical software.

JPEG-2000

The JPEG 2000 initiative is intended to provide a new image coding system using state of the art compression techniques, based on the use of wavelet technology. Its architecture should lend itself to a wide range of uses from portable digital cameras through to its use in advanced pre-press, medical imaging and motion. JPEG-2000 is not a lossless compression scheme but it is claimed to be better than standard JPEG. http://www.elsevier.com/gej-ng/10/22/18/62/27/33/abstract.html

JPEG-LS

Lossless JPEG compression. This is a newly defined standard. It is being embraced by the different areas of the scientific community for continuous-tone images, ISO-14495-1/ITU-T.87. The standard is based on the LOCO-I algorithm (LOw COmplexity LOssless COmpression for Images) developed at Hewlett-Packard Laboratories. (http://www.hpl.hp.com/loco/). It does not achieve high compression ratio's values reported are low ~ 1.1/1 to 2/1. but it has a true lossless mode.

SJPEG

Streaming JPEG, not a real standard per se. In the context of video, it simply means that each frame of a video is processed by a JPEG encoder, the compression can be chozen by the user.

MJPEG

Motion JPEG, this is the same as SJPEG. Most high end video editing systems use this format for data storage.

MPEG (Moving Pictures Experts Group)

MPEG is the recognized standard for motion picture compression. It uses many of the same techniques as JPEG, but adds inter-frame compression to exploit the similarities that usually exist between successive frames. Because of this, MPEG typically compresses a video sequence by about a factor of three more than "M-JPEG" methods. The disadvantages of MPEG are (1) it requires far more computation to generate the compressed sequence (since detecting visual similarities is hard for a computer), and (2) it's difficult to edit an MPEG sequence on a frame-by-frame basis (since each frame is intimately tied to the ones around it). This latter problem has made "M-JPEG" methods rather popular for video editing products. The quality of the MPEG is preset and has been defined by the visual perception of a human, it is intended specifically for the entertainment community for viewing time synced AV, it was never intended for use on data which is to be employed in any scientific measurements.

The basic scheme is to predict motion from frame to frame in the temporal direction, and then to use DCT's (discrete cosine transforms) to organize the redundancy in the spatial directions. The DCT's are done on 8x8 blocks, and the motion prediction is done in the luminance (Y) channel on 16x16 blocks. In other words, given the 16x16 block in the current frame that you are trying to code, you look for a close match to that block in a previous or future frame (there are backward prediction modes where later frames are sent first to allow interpolating between frames).

http://mpeg.telecomitalialab.com/

MPEG-1

Designed for Video on CD's
Designed for Hardware compression/ Software Decompression
Image size 352 x 240 (rectangular)

Image size 320 x 240 (square)

MPEG encoders have Aspect ratios in the headers
Warning not all decodes (ie.an image display program) do square pixel decoding
Real Player and Microsoft Media Players do not, QuickTime (QT) does .

The MPEG-1 codec targets a bandwidth of 1-1.5 Mbps offering VHS quality video at CIF (352x288) resolution and 30 frames per second. MPEG-1 requires hardware for real-time encoding. While decoding can be done in software, most implementations consume a large fraction of a high-end processor. MPEG-1 does not offer resolution scalability and the video quality is highly susceptible to packet losses, due to the dependencies present in the P (predicted) and B (bi-directionally predicted) frames. The B-frames also introduce latency in the encode process, since encoding frame N needs access to frame N+k, making it less suitable for video conferencing.

MPEG-2

MPEG 2 extends MPEG 1 by including support for higher resolution video and increased audio capabilities. The targeted bit rate for MPEG 2 is 4-15Mbits/s, providing broadcast quality full-screen video. The MPEG 2 draft standard does cater for scalability. Three (3) types of scalability; Signal-to-Noise Ratio (SNR), Spatial and Temporal, and one extension (that can be used to implement scalability) Data Partitioning, have been defined. Compared with MPEG-1, it requires even more expensive hardware to encode and decode. It is also prone to poor video quality in the presence of losses, for the same reasons as MPEG-1. Both MPEG-1 and MPEG-2 are well suited to the purposes for which they were developed. For example, MPEG-1 works very well for playback from CD-ROM, and MPEG-2 is great for (movies) archiving applications and for TV broadcast applications. In the case of satellite broadcasts, MPEG-2 allows >5 digital channels to be encoded using the same bandwidth as used by a single analog channel today, without sacrificing video quality. Given this major advantage, the large encoding costs are really not a factor. However, for existing computer and Internet infrastructures, MPEG-based solutions are expensive and require bandwidth; they were not designed with the Internet in mind.

In MPEG2 high resolution components are less preserved than low resolution Because the high resolution details are considered less important to they eye in the entertainment community. "i.e. they are interested in visual quality not quantitative measurements".

MPEG-4

The intention of MPEG 4 is to provide a compression scheme suitable for video conferencing, i.e. data rates less 64Kbits/s. MPEG4 will be based on the segmentation of audiovisual scenes into AVOs or "audio/visual objects" which can be multiplexed for transmission over heterogeneous networks. The MPEG-4 framework currently being developed focuses on a language called MSDL (MPEG-4 Syntactic Description Language). MSDL allows applications to construct new codecs by composing more primitive components and providing the ability to dynamically download these components over the Internet. This philosophy is similar to that for the multimedia APIs being developed for Sun Microsystems Java, where it will be possible to dynamically download codec components. This trend is also seen in products from major vendors such as Microsoft and Netscape, where they allow for multiple audio and video codecs to be plugged into their real-time streaming solutions.

Video Image formats

NTSC (National Television Standards Committee)
An NTSC (analog) TV image has 525 horizontal lines per frame, however, due to overscan the number typically seen by a viewer is only 482 . These lines are scanned from left to right, and from top to bottom. Every other line is skipped. Thus it takes two screen scans to complete a frame: one scan for the odd-numbered horizontal lines, and another scan for the even-numbered lines. Each half-frame screen scan takes approximately 1/60 of a second; a complete frame is scanned every 1/30 second. This alternate-line scanning system is known as interlacing.

NTSC Analog Aspect Ratio = 4:3
Note: TV’s have “rectangular pixels” in contrast to
computer monitors which have square pixels. !!

There is a digital equivalent of NTSC which CCD based digital Video Cameras operate under.

Digital Equivalent of NTSC = 720 x 486 (Full Frame), however some cameras crop
this to provide a smaller image comparable to the underscan area of a TV set.
this to be equivalent to ~ 640 x 480.

PAL (Phase Alternation Line)
A color television signaling standard with 625 scan lines and 25 interlaced frames/second. Used in Europe/Asia/Australia
Digital Equivalent of PAL = 768 X 576(Full Frame)

SECAM (Sequential Couleur Avec Memoire)
A color television signaling standard with 625 scan lines and 25 interlaced frames/second. Used in France, the Newly Independent States (NIS) of the former Soviet Union, and parts of the Middle East.

H.261
targeted at teleconferencing applications mainly for use over ISDN lines
encoding alogrithm is similar to MPEG but incompatible with it. .
supports 2 resolutions QCIF, CIF
QCIF=quarter common intermediate format
CIF = FCIF = common intermediate format
optimized for picture quality vs motion.
i.e. static images are better than moving ones.
~ approximately a constant bit rate encoding rather than constant quality.

H.263

targeted at low bit rate communications,
replaces H.261 in many apps
supports 5 resolutions: QCIF, CIF, SQCIF, 4CIF, 16CIF
Most implementations of H.263 in hardware operated at SQCIF, QCIF, or CIF.

H.323

H.323 is a standard that specifies the components, protocols and procedures that provide multimedia communication services of near real-time audio, video, and data communications over packet networks, including Internet protocol (IP) based networks. Basically it completely specifies how connections are made, data is exchanged etc… Most important to this document is the video component of H323 is the H.261 or H.263 standard (above) while the audio standard is G. 722, G.723.1 or G.728. Polycomm units use the H.323 protocol to communicate with each other.

Image Format Comparison Information

Format	Resolution	Aspect Ratio
SQCIF	128 x 96	4/3=1.333
QCIF	176 x 144	1.222
CIF	352 x 288	1.222
4CIF	704 x 576	1.222
16CIF	1408 x 1152	1.222

Notice that nearly all CIF based formats have different aspect ratios than video camera's, if this is not compensated for then a distortion will be introduced into any image stored in that format. Note that all versions of MPEG are based upon CIF defined formats!!!

Format	Bandwidth(kcps)	Max FPS	Resolutions Supported
H.261	384 – 2000	30	QCIF, CIF
H.263	28.8 -768	30	SQCIF, QCIF, CIF, 4CIF, 16CIF
MPEG-1	400 – 2000	30	QCIF, CIF, 4CIF
MPEG-2	1500 – 6000	30	4CIF, 16 CIF
MPEG-4	28.8 – 500	30	QCIF, CIF
JPEG	N/A	N/A	Any. Different compressions algorithms are available, when compressed the data is nolonger losseless
TIFF	N/A	N/A	Any. This is a mathematically lossless format
PNG	N/A	N/A	Any. This is a mathematically lossless format

NTSC/PAL/ SCEAM Resolutions Compared

	Vertical Lines	**Active Lines**	**Vertical Resolution**	**Horizontal Resolution**	**Aspect Ratio**	**Frame Rate**
NTSC	525	484	340	330	4/3=1.33	29.94
PAL	625	575	290	425	4/3=1.33	25
SECAM	625	575	290	465	4/3=1.33	25
D-NTSC	486	486	486	720	1.48	29.94
D-NTSC*	480	480	480	640	4/3=1.33	29.94
D-PAL	576	576	576	768	4/3	25

*typically used for display purposes to keep aspect ratio correct
Note: some D-NTSC formats have a different aspect ratio, this must be kept track of.

NTSC & HDTV Resolution

Standards	**Format**	**Vertical**	**Horizontal**	**Aspect Ratio**	**I/P***
NTSC	VHS Videocassette	525 lines	275 lines	4/3	Interlace
NTSC	Broadcast	525 lines	330 lines	4/3	Interlace
NTSC	12" Laserdisc**	525 lines	425 lines	4/3	Interlace
NTSC	DVD***	525 lines	486 lines	4/3	Interlace
HDTV	Broadcast	480 Pixels	720 Pixels	4/3	Progressive
HDTV	HD-DVD****	1080 Pixels	1920 Pixels	16/9	Interlace

Microsoft NETMEETING Video

Size	**Format**	**Resolution**	**Aspect Ratio**
Large	CIF	352 x 288	1.22
Medium	QCIF	176 x 144	1.22
Small	SQCIF	128 x 96	1.22

5 Comparision of Compression Techniques on a Digital Video Images

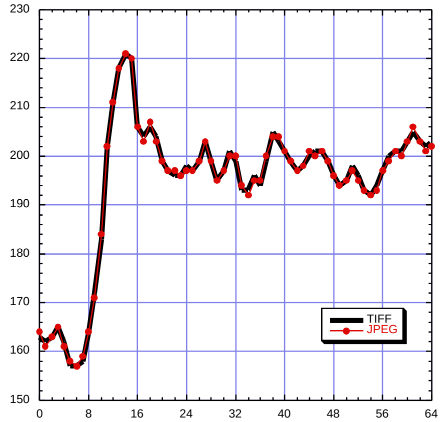
Purpose of this test was to measure the resolution of an actual crack from a video sequence after various compression techniques have been applied to the data.

Raw Data, captured on a Canon ZR 20 Digital Video Camera @ 640x480 RGB 24 bit
Data transferred by Firewire Interface to Mac G4.
Software processed to different compression schemes

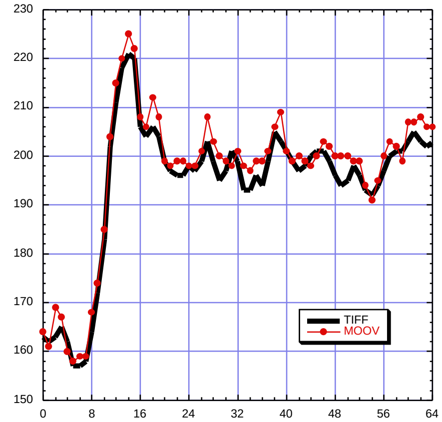
a.) Lossless (TIFF)
b.) JPEG
c.) MOV
d.) MPEG-1
e.) DVD = MPEG2 ?? (need to confirm that DVD format is equal to MPEG2)
f.) Video
g.) H263

Figure 1: Uncompressed Raw Data (TIFF) Crack to be measured at the border of the brick/mortar interface. at center of the field of view.

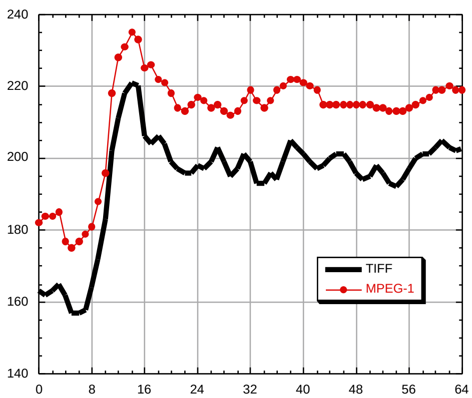
Region of Interest after compression : Left->Right TIFF, JPEG, MOV,MPEG1, DVD?MPEG2, Video, H263. Note your eye has a hard time seeing difference in the first 3 images.



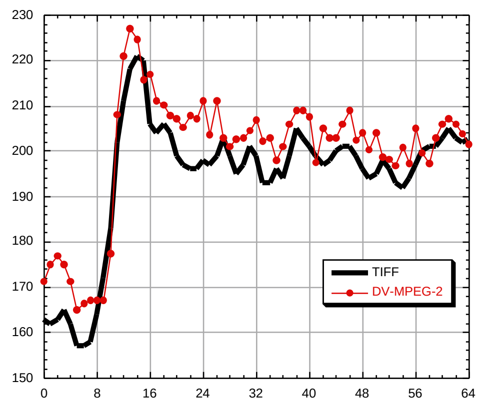
Compare TIFF/JPEG



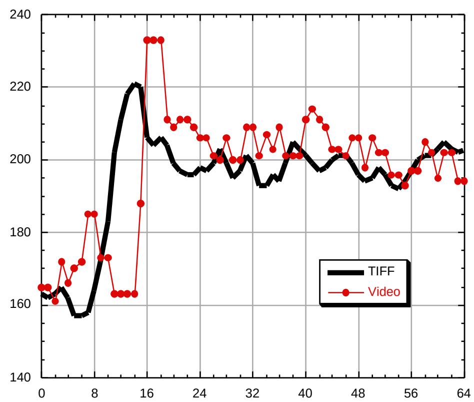
Compare TIFF/MOV



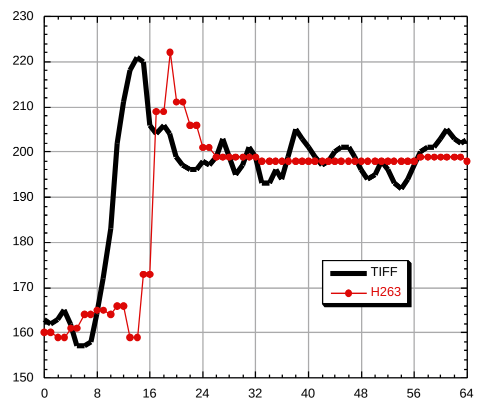
Compare TIFF/MPEG1



Compare TIFF/DVD=MPEG2?



Compare TIFF/Video



Compare TIFF/H263

Figure 2. Graphs comparing quantitiative measurements of a line scan through the same position through the data in each image referenced to the uncompressed (TIFF) image. Plots are inverted to more easily show differences (i.e. the peak in each figure correpond to the darkest part of the crack).

This does not change the quantitative measurement of spatial resolution loss from the different compression schemes. .

Things to do..

Need to repeat this measurement on a variety of different images!!!

6 Image Acquisition Hardware : “Cameras”

7.1 Still Cameras

7.1.1 Film

7.1.2 Digital

7.2 Video Cameras

7.2.1 Analog

7.2.2 Digital Video

7.2.3 High Speed

7.2.4 High Resolution

7 References

Yep, I’ve not put anything in here yet this is still a draft and not ready for distribution.…