Score Scanning Workshop

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June 22, 2004

Workshop schedule

- Digitization
  - Technical overview
  - Setting specifications
  - Planning
  - Workflow
- Delivery
- Metadata

Digitization

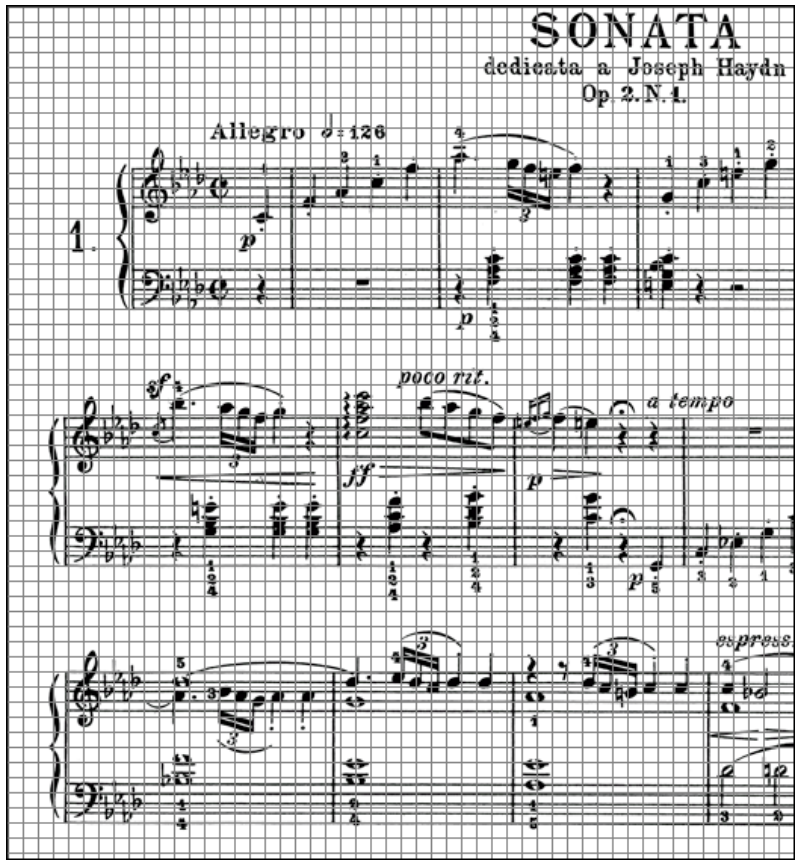
- Technical overview
- Setting specifications
- Planning
- Workflow

Technical overview

- Analog to digital conversion
- Resolution
- Bit depth
- Color representation
- Reflectivity and polarity
- Compression

Analog to digital conversion

- Image is converted to a series of pixels laid out in a grid
- Each pixel has a specific color, represented by a sequence of 1s and 0s
- Pixel-based images are called “raster” images or “bitmaps”



Resolution (1)

- Often referred to as “dpi” or “ppi”
- RATIO of number of pixels captured per inch of original photo size
  - 8x10 print scanned at 300ppi = 2400 x 3000 pixels
  - 35mm slide (24x36mm!) scanned at 300ppi ≈ 212 x 318 pixels

Resolution (2)

- “Spatial resolution” refers to pixel dimensions of image, e.g., 3000 x 2400 pixels
- Flatbed and film scanners have a fixed focus, so they know how big the original is; digital cameras don’t

Resolution (3)

- Optical vs. interpolated
  - Optical is the number of sensors in the scanning array – what the scanner actually “sees”
  - Interpolated is a higher resolution - the number of pixels the software can make up based on what the scanner actually saw
  - Don’t set a scanner to use higher than its optical resolution

Bit depth

- Refers to number of bits (binary digits, places for zeroes and ones) devoted to storing color information about each pixel

- 1 bit (1) = 2^1 = 2 shades (black & white)
- 2 bit (01) = 2^2 = 4 shades
- 4 bit (0010) = 2^4 = 16 shades
- 8 bit (11010001) = 2^8 = 256 shades

Color representation

- RGB
  - Scanners generally have sensors for Red, Green, and Blue
  - Each of these “channels” is stored separately in the digital file
  - 8 bits for each of 3 channels = 24 bit color
- CMYK (Cyan, Magenta, Yellow and Black) is used for high-end “pre-press” printing purposes

Reflectivity and polarity

	Positive	**Negative**
Reflective	Paper Photographic prints	
Transmissive	Slide film	Negative film

Compression

- Makes files smaller for storage
- Files must be decompressed for viewing
- Lossless
- Lossy
  - “visually lossless”

Technical questions?

- Analog to digital conversion
- Resolution
- Bit depth
- Color representation
- Reflectivity and polarity
- Compression

Digitization

- Technical overview
- Setting specifications
- Planning
- Workflow

Setting specifications

- Capture once, use many
- Determine purpose
- Resolution
- Bit depth & color
- Image processing
- Master file formats
- Microfilm

Capture once, use many

- Create master image when scanning
  - Capture all “important” information
  - Meets all foreseeable needs
  - For long-term storage and later use
- Create derivatives for specific uses later
  - Web delivery
  - Printing
  - Publication

Determine purpose

- Define what “important” information is
  - Not always “what people can see”
- Materials of artifactual value
  - Manuscript
  - Rare
  - Annotations from collector
- Materials whose musical content is primary consideration
  - Mass-printed editions
  - Previously microfilmed materials

Determining resolution (1)

- Higher is not always better
- Scan at highest resolution necessary to achieve your stated purpose, no higher

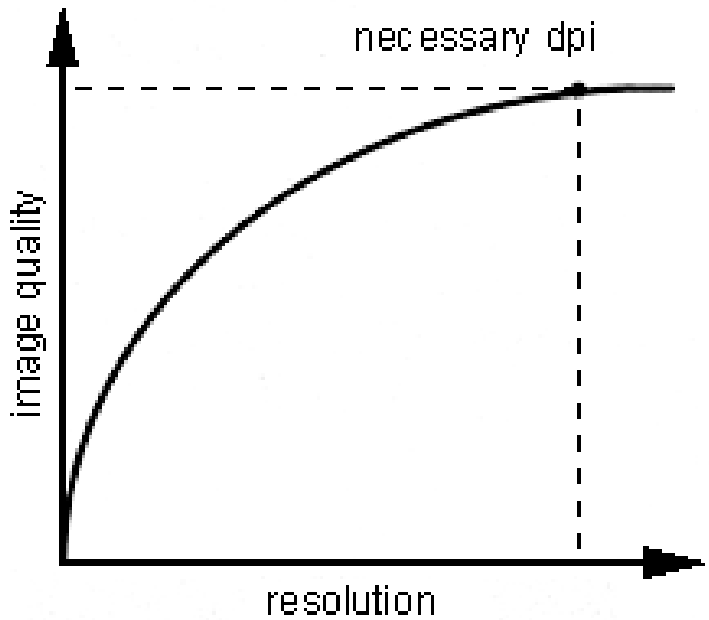
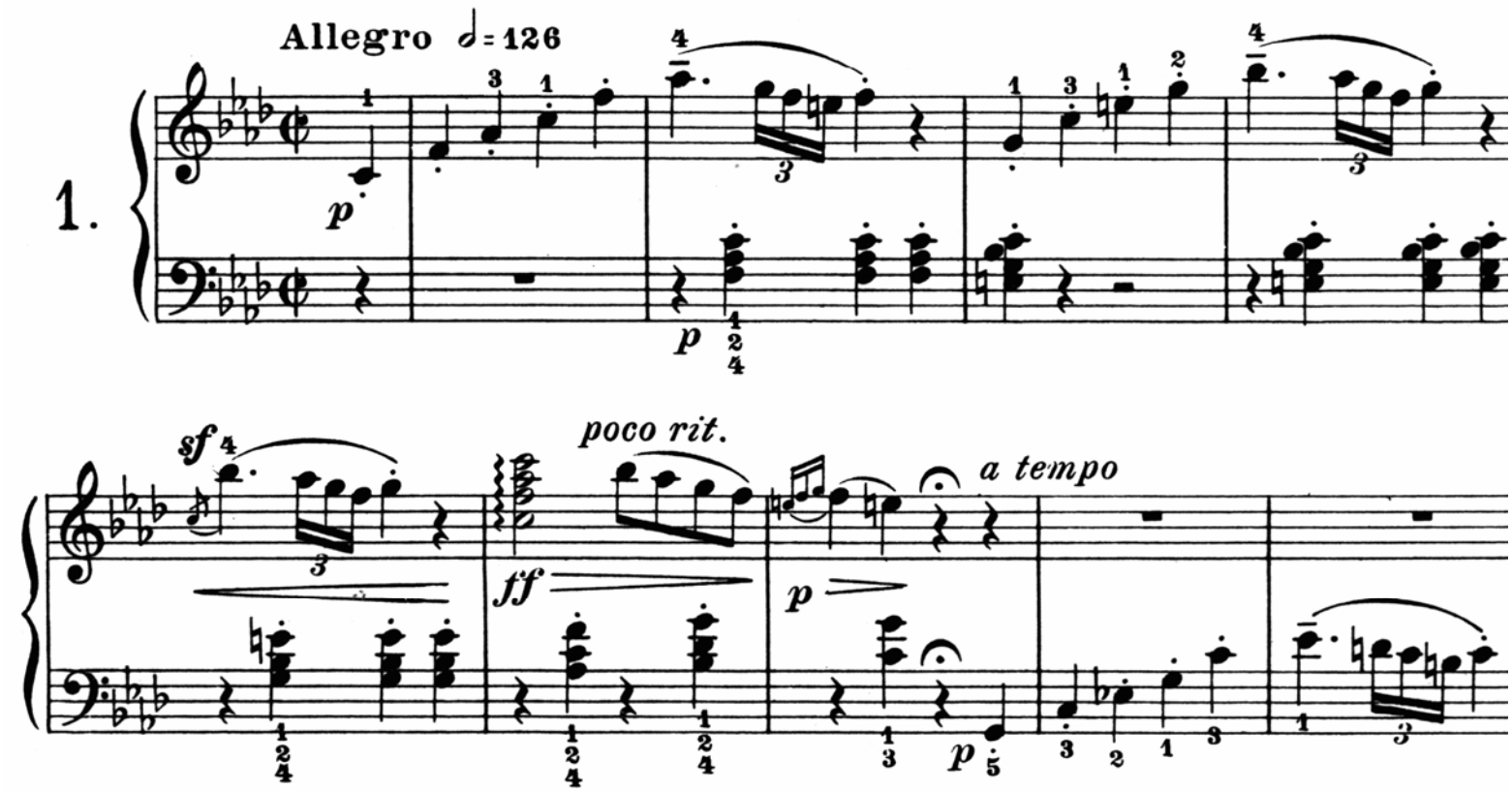


chart from Cornell's online digital imaging tutorial:
<http://www.library.cornell.edu/preservation/tutorial/conversion/conversion-03.html>

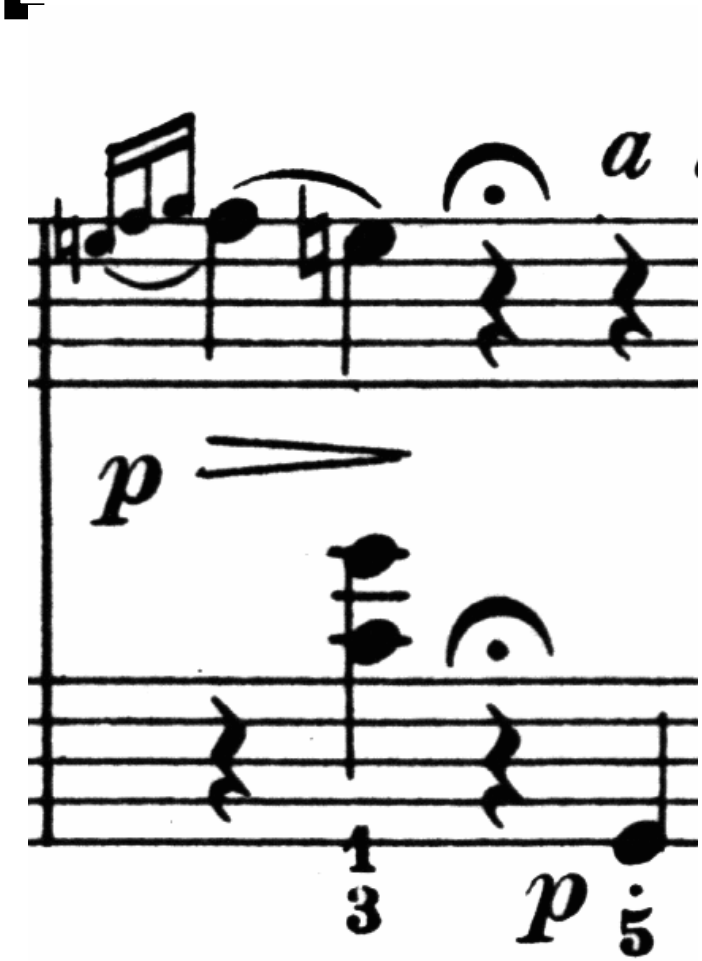
Determining resolution (2)

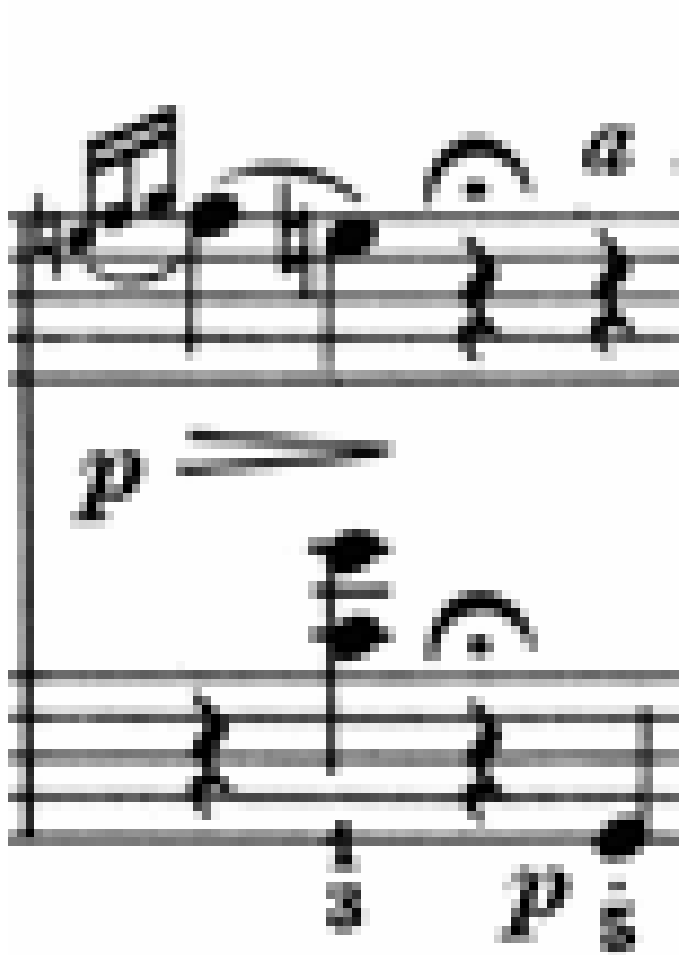
- For music, size of notation should generally determine resolution
- Can calculate necessary resolution from size of smallest detail
  - Capture smallest detail with 2 pixels (Kenney)
  - Spaces between beams generally smallest detail in musical notation
  - ppi = 2px / (size of smallest detail in mm x .03937)
- Rules of thumb can also apply

Resolution comparison (1)



Resolution comparison (2)





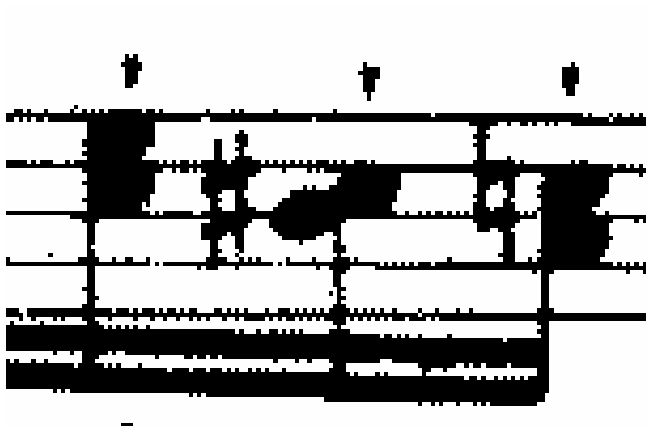
Compare for yourself

- resolution/color/
- resolution/gray_big/
- resolution/gray_small/
- resolution/manuscript/

Bit depth & color (1)

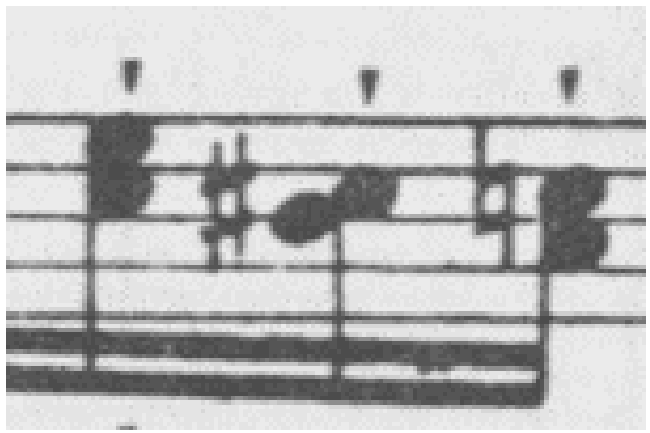
- Artifact
  - 24-bit color
- Content
  - 8-bit grayscale (usually not 1-bit bitonal)
  - Contrast

Bit depth & color (2)

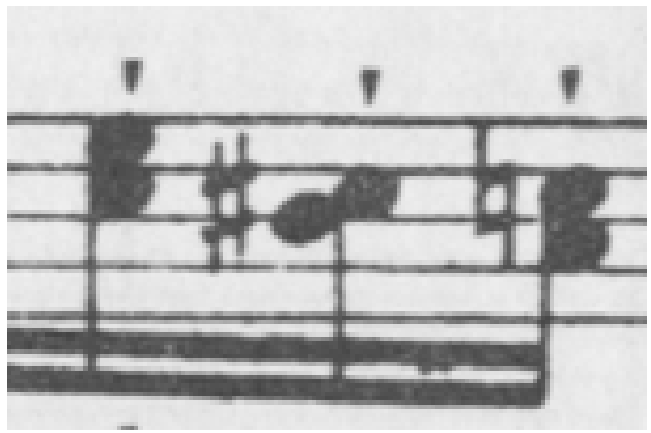


1 bit (black & white)

2 bit (4 colors)



4 bit (16 colors)



8 bit (256 colors)

Compare for yourself

- bitdepth/artifact
- bitdepth/content
- bitdepth/questionable
- bitdepth/contrast

Image processing

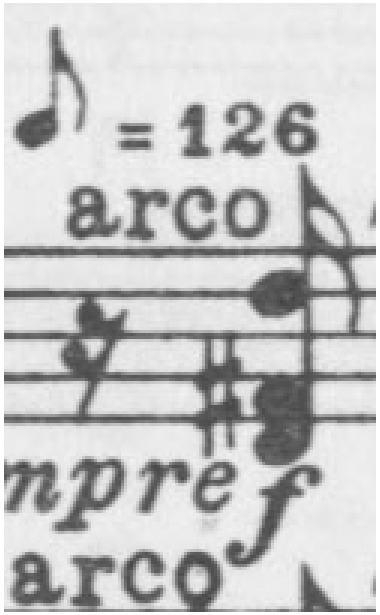
- Generally avoided for master images
- “Clean-up” sometimes OK
- Color balance, cropping, etc., can and usually should be done when creating derivatives
- Descreening sometimes done, but for musical materials high enough scan resolution makes it not generally necessary

Master file formats

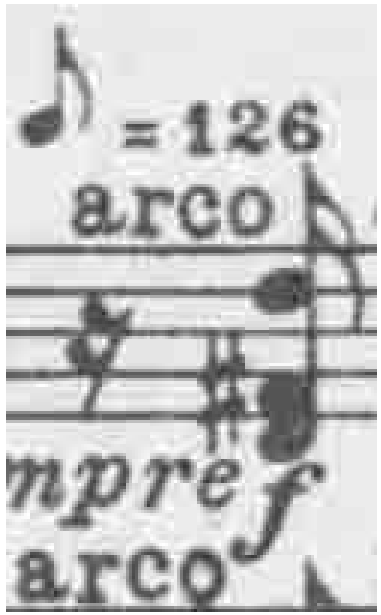
- TIFF (uncompressed)
  - Virtually unanimously recommended by digital imaging best practices
  - “De facto” standard
- JPEG2000
  - ISO/IEC IS 15444-1 | ITU-T T.800
  - Not patent-free
  - Up-and-coming but not quite there yet
  - Supports embedded metadata
  - Uses wavelet-based compression

Why not JPEG?

- Lossy-compressed every time they are saved



low compression, high quality



high compression, low quality

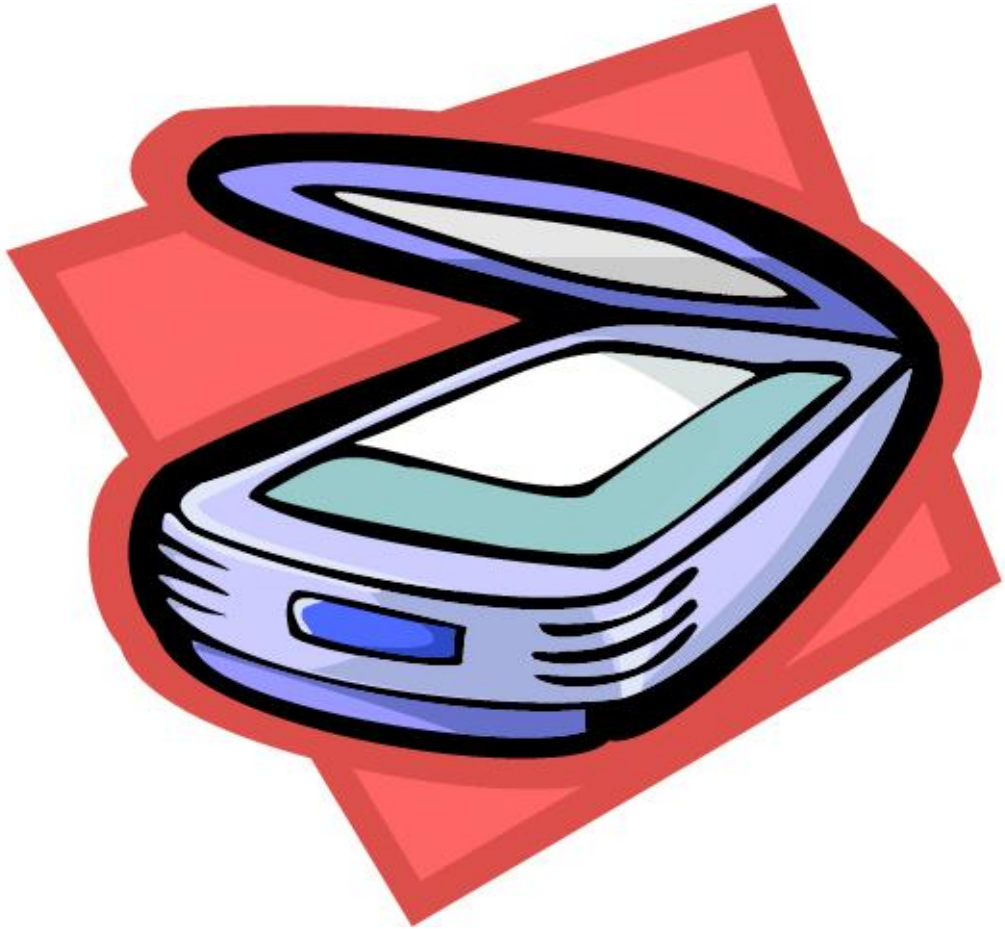
A word about microfilm

- Can be positive or negative
- Resolution depends on reduction of original
- The “600 dpi” myth
- Most is “high-contrast” severely limiting tonal depth possible in digital images
- LC and others chose bitonal scanning of musical materials from microfilm

Specifications questions?

- Capture once, use many
- Determine purpose
- Resolution
- Bit depth & color
- Image processing
- Master file formats
- Microfilm

Let's practice!



Digitization

- Technical overview
- Setting specifications
- Planning
- Workflow

Planning

- Digitization in context
- Choosing equipment
- Filenaming
- Documentation
- Testing
- Other considerations

Digitization in context

- Collection development policies still apply
- Can be one of the easier parts of digital projects but still requires careful planning
- You don’t want to have to re-do digitization later – do it right the first time!
- If it’s done poorly your whole project will suffer

Choosing equipment

- Scanner
  - Scan area
  - Optical resolution
  - Dynamic range (from Kenney & Rieger, *Moving Theory into Practice*, p. 38)
    - newsprint: 0.9
    - printed material: 1.5
    - photographic prints: 1.4 – 2.0
    - negative films: 2.8
    - high grade transparencies: 3.0 – 4.0
- Monitor: use CRT, not LCD

Filenaming

- Can often make use of existing ID numbers
- More human-readable if parts (ID, copy, page) are delimited
- BUT…
  - ISO9660 standard for CD recording requires 8.3 filenames

Documentation

- Document everything

But really…

- Document everything!
- Scanner model
- Scanning software & version
- Software settings
- Exhaustive, step-by-step procedures
  - Digitization
  - Quality control
- Rationale for all decisions & specs
- High-level overview for sharing

Testing

- Don’t blindly follow any specific recommendation – make sure it works for you
- For both digitization and quality control
- Useful to divide materials into homogeneous groups, with different specifications for each

Other considerations

- Scan from earliest generation practical
- Can use color bars or rulers for future reference
- Train scanner operators in correct handling of materials

Planning questions?

- Digitization in context
- Choosing equipment
- Documentation
- Testing
- Other considerations

Digitization

- Technical overview
- Setting specifications
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- Workflow

Workflow

- Color management
- Quality review
- Storage
- Imaging software
- Outsourcing

Color management (1)

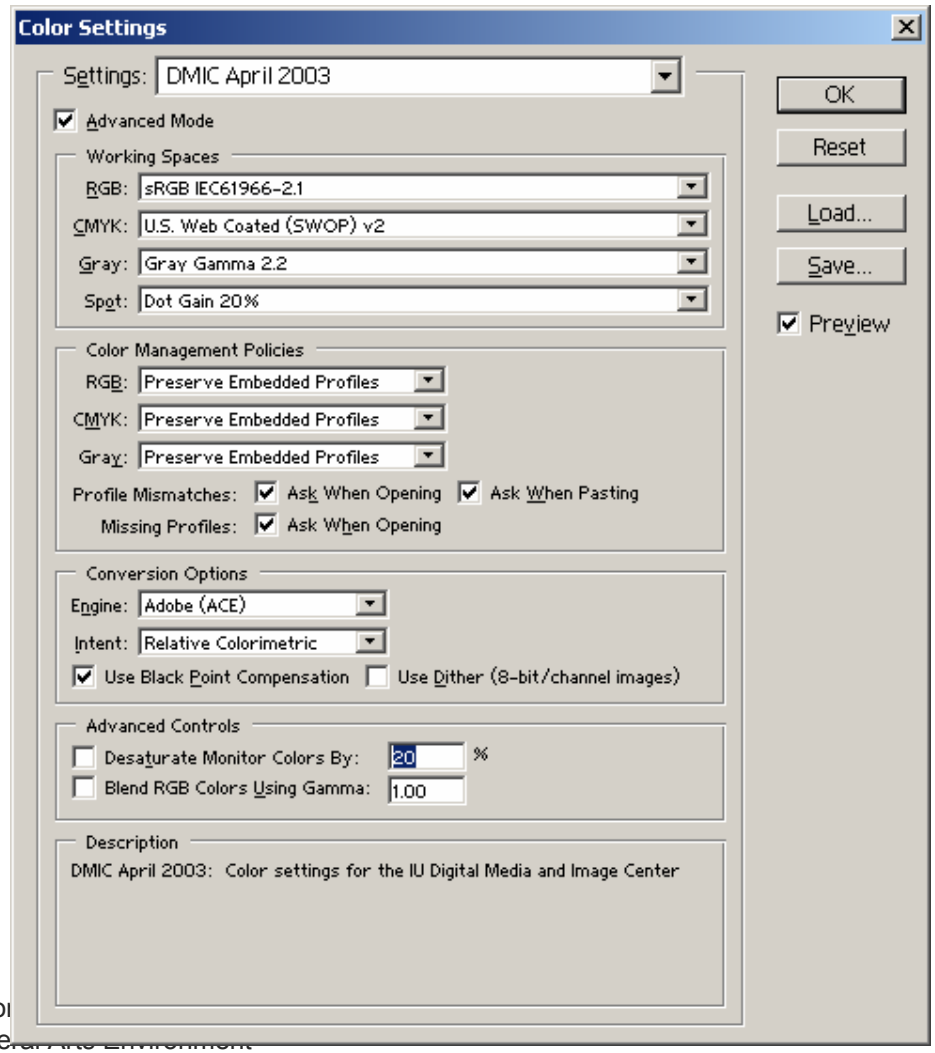
- Ensure the color captured and displayed on any device is “accurate”
- “Device-independent” color
- ISO 3664 describes standard graphic viewing conditions

Color management (2)

- All devices should be characterized with ICC profiles
  - monitors
  - scanners
  - printers
- Creating your own preferable to using “canned” profiles
- Profiling software from Monaco Systems; also included in high-end software

Color management (3)

- Many suggest embedding ICC profiles in master images
- Set up Photoshop to use that profile and to warn you when profiles are missing or different



Quality review

- A consistent quality review process is *absolutely* essential
- Objective
- Subjective

Objective image review (1)

- Pixel dimensions
- Resolution & unit
- Bit depth
- Compression
- Byte order
- Structure of filename
- Embedded color profile

Objective image review (2)

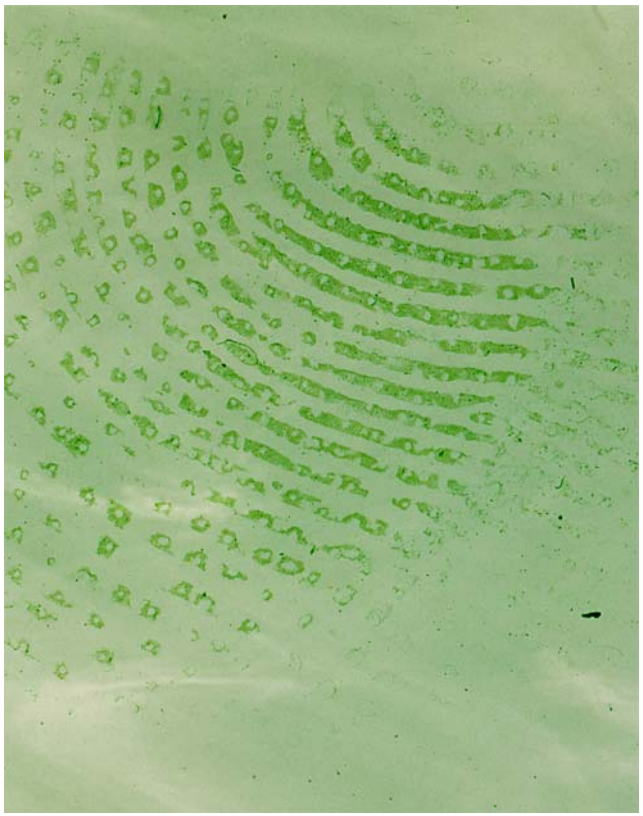
- A significant amount of information stored in TIFF “Image File Directory”
  - Check in graphical image software
  - Check with command-line tools
- Checks can be automated
  - Tiffdump/Tiffinfo (Libtiff), ImageMagick
  - Perl or other scripting/programming language

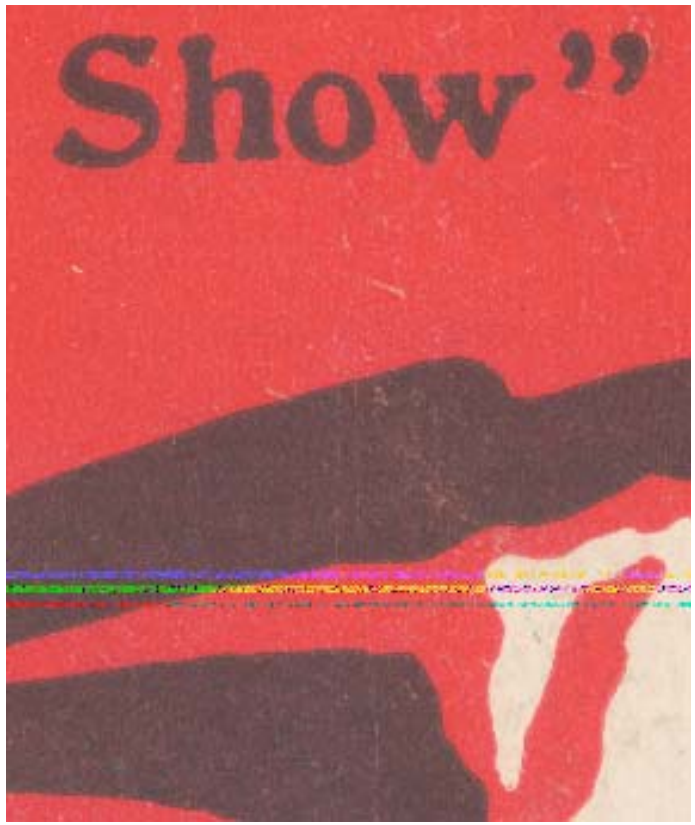
Subjective image review (1)

- Filename matches the image
- Scanning artifacts
- Cropping
- Orientation
- Skew & border
- Physical matter obscuring image

- Let’s look at examples!

Subjective image review (2)





Storage (1)

- File size calculations (uncompressed)
  - (height (in) x width (in) x bit depth x dpi^2) / 8
  - 1 Kilobyte (KB) = 1,024 bytes
- A long-term view is essential
- Multiple copies always a good idea

Storage (2)

- Hard disk
- Other optical
  - CD(-R/-RW/+R/+RW)
  - DVD(-R/-RW/+R/+RW)
- Tape

Imaging software

- Adobe Photoshop
- IfranView
- GIMP
- ImageMagick
- LibTiff
- Silverfast

A word about outsourcing

- Still requires management and knowledge
- Faster production possible
- No equipment investment required
- Different funding model

Workflow questions?

- Color management
- Quality review
- Storage
- Imaging software
- Outsourcing

Delivery

- Web delivery files
- Printing files
- Derivative creation
- Delivery systems
- Some online collections
- Other ways to share
- Other issues

Choosing Web file formats

- Viewable by target users
- File sizes appropriate for network delivery
- Support for multi-page items

Web delivery file formats

File format	Commonly viewable via the Web	File size	Multi-page support
JPEG	√	√	
GIF	√	√	
PNG	√	√	
TIFF		depends	√
PDF	√ -		√
DjVu		√	√
JPEG2000		√	√

Web delivery image specs

- Bit depth
  - Often decided by file format choice
  - Generally follows from master file bit depth
- Pixel dimensions
  - Adequately show notation
  - Fit image in window
  - Thumbnails not so useful for music

Dimensions

	200dpi	150dpi	100dpi
5.5” x 7.5” miniature score	1100 px x 1500 px will not fit horizontally on many common screen resolutions	825 px x 1125 px adequate for most purposes, but still requires horizontal scrolling for smaller screen resolutions	550 px x 750 px will fit horizontally on all common screen resolutions
9” x 12” score or sheet music	1800 px x 2400 px will not fit horizontally on any common screen resolution	1350 px x 1800 px requires horizontal scrolling for most common screen resolutions	900 px x 1200 px will fit horizontally on all but the smallest common screen resolutions

Printing file specs

- Everyone wants printable versions!
- Pixel dimensions
  - Exactly as big as the page
  - Scalable formats nice
- Bit depth
  - For content-focused materials, bitonal is best
  - For artifact-focused materials, stay with 24-bit color

Printing file formats (1)

File format	Advantages	Disadvantages
JPEG	**Wide support**	**No multi-page support** **Difficult to size properly for multiple printer types** **JPEG compression not good for printing technology** **Doesn't handle bitonal images**
GIF	**Wide support**	**No multi-page support** **Difficult to size properly for multiple printer types**
PNG	**Wide support**	**No multi-page support** **Difficult to size properly for multiple printer types**

Printing file formats (2)

File format	Advantages	Disadvantages
TIFF	**Very flexible** **Can provide any level of quality wanted**	**Multi-page images not supported in all software** **Difficult to size properly for multiple printer types**
PDF	**Multi-page support** **Scalable sizing for output page size** **Serves as a wrapper for any sort of image file** **Can handle multiple bit depths**	**Extremely large file sizes when made from page images** **Software common but not pervasive**
DjVu	**Multi-page support** **Scalable sizing for output page size**	**Software not pervasive**
JPEG2000	**Multi-page support** **Scalable sizing for output page size** **Can package metadata with images**	**Software not pervasive**

Derivative creation

- Create when scanning
  - Adds time to workflow
  - Can lead to inconsistent quality
- Batch creation
  - Photoshop “batch actions”
  - Irfanview “batch conversion”
  - ImageMagick and other scriptable software

Systems

- ContentDM
- Greenstone
- DLXS/XPAT
- ILS modules
  - ENCompass (Endeavor)
  - Hyperion (Sirsi)
  - MetaSource (III)

Some online collections

- Music for the Nation
- Indiana University Sheet Music
- University of Chicago Chopin Early Editions

Other ways to share

- Union catalogs
- OAI Sheet Music Harvester
- RLG Cultural Materials

Other issues

- Persistent URLs
- Symbolic notation
  - A digitized image is like a photograph
  - Conversion from image to notation format is necessary
    - OMR exists but isn't very effective
    - "Re-keying" commonly used
    - Not very much research in this area

Delivery questions?

- Web delivery files
- Printing files
- Derivative creation
- Delivery systems
- Some online collections
- Other ways to share
- Other issues

Metadata

- Descriptive metadata
- Technical metadata
- Structural metadata
- There are others too…

Descriptive metadata

- Infinite options
  - MARC
  - Dublin Core
  - Custom databases
- Create as much as you can afford

Technical metadata

- Essential!
- For fixing quality problems
- For long-term maintenance of files
- NISO draft standard Z39.87: Technical Metadata for Digital Still Images
- Some embedded in TIFF image, some recorded elsewhere

Structural metadata

- For creating a logical structure between digital objects
  - Multiple copies of same bibliographic item
  - Multiple pages within item
  - Multiple sizes of each page

Metadata questions?

- Descriptive metadata
- Technical metadata
- Structural metadata
- Others?

More information

- These presentation slides & other workshop materials: http://www.dlib.indiana.edu/~jenlrile/presentations/musictech/
- A plug for my article: http://www.dlib.indiana.edu/~jenlrile/oclc/oss.pdf
- jenlrile@indiana.edu