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# Presentation on Evaluating the Creation and Preservation Challenges of Photogrammetry-based 3D Models

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# Evaluating the Creation and Preservation Challenges of Photogrammetry-based 3D Models

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# Photogrammetry

- Allows for the creation of 3D objects from 2D photography.
- Rides the rising tide of ongoing software and hardware advances in computational digital imaging.
- Similar in its outputs to 3D scanning.

# Photogrammetry Use in Cultural Heritage

- Allows for the recording and analysis of surfaces and volume that intuitively mimic human stereo vision.

- Non-destructive manipulation of virtual surrogate objects.

- Condition assessments over time.

- Analog surrogates can be created through the 3D printing from 3D datasets.
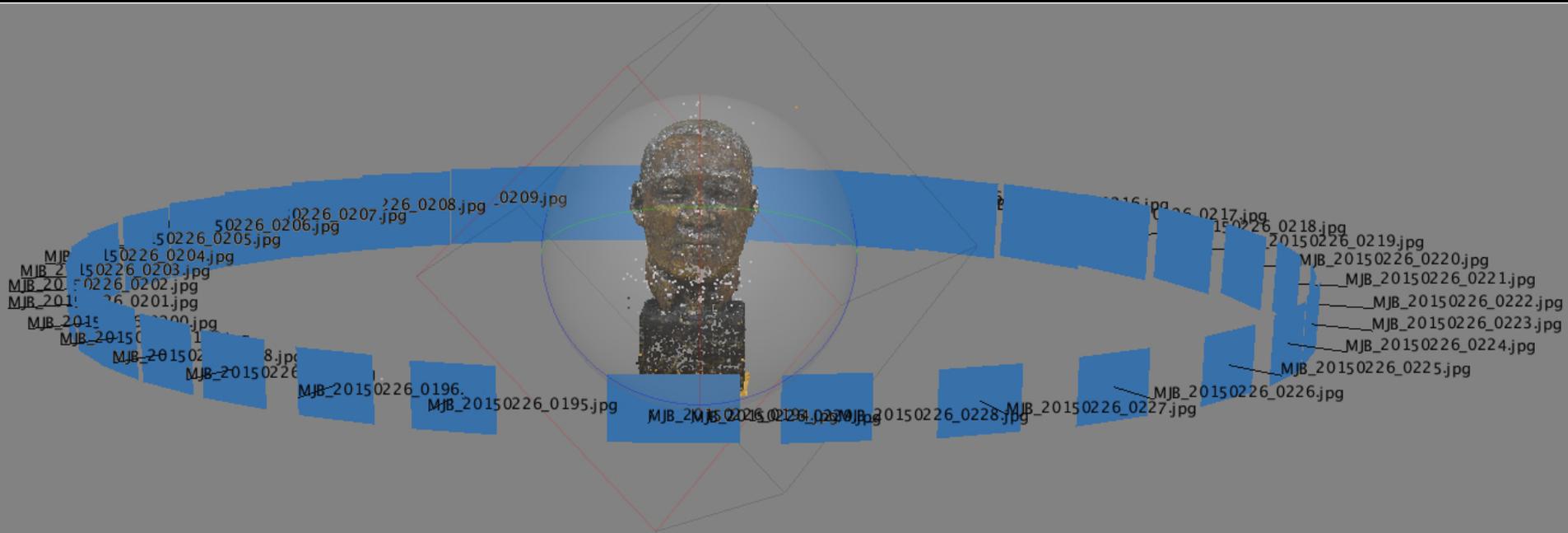
# Basic 3D Model Reconstruction

- Agisoft PhotoScan.

- Can use common DSLR cameras and standard lenses to capture 2D source images.

- PhotoScan then uses these images to build an initial point cloud...
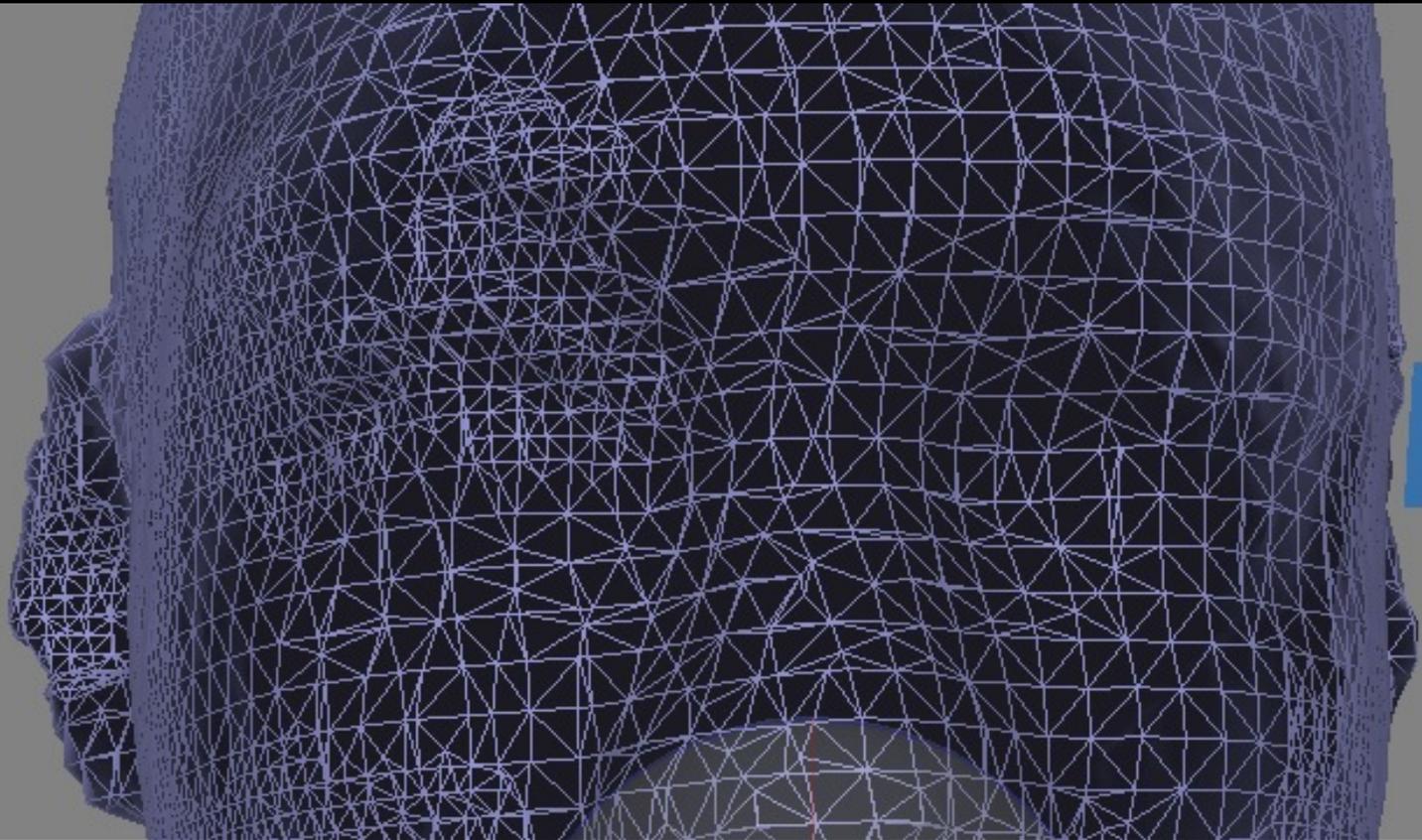
# Original Object

# Point cloud from 2D images

# Basic 3D Model Reconstruction

- PhotoScan then creates a 3D geometric mesh from the point cloud data…

Geometric Mesh

# Basic 3D Model Reconstruction

- finally a textured 3D model is mapped onto the mesh…

# Textured 3D Model

# 3D Model Exports

- PhotoScan v.1.1 allows for the saving and exporting of various stages of model reconstruction in a variety of formats.

- These include <u>point cloud data </u>in OBJ, PLY, XYZ text file format, ASPRS LAS, ASTM E57, U3D, potree, PhotoScan OC3, and PDF.

- <u>Textured 3D models</u>: OBJ, 3DS file format, VRML, COLLADA, PLY, STL, Autodesk FBX, Autodesk DXF, U3D, and PDF.

# 3D Model Exports (cont.)

- Finally, PhotoScan native "project files" which are wrapped and saved to the Postscript-based PSZ compressed format can also be archived.

- These PSZ project files can contain a list of the following…

# 3D Model Exports (cont.)

1. Loaded 2D source images
2. Masks applied to the photos
3. Depth maps for cameras
4. A dense point cloud model
5. A reconstructed 3D polygonal model with user edits
6. Mesh and texture reconstructions

# Preservation Decision Point

- With this array of format options naturally arrives the question of what should be archived for long-term digital preservation?

# Lessons from CAD/BIM

- Much of the 3D project digital archiving literature to date has mainly centered on the curating of CAD and Building Information Models (BIM) from the architecture, engineering, and construction industries.

- Open standards initiatives, including IFC, STEP, and IGES have been introduced in an attempt to mitigate the acute problems of comprehensive 3D project archiving and coherent model exchange that currently exist.

# Lessons from CAD/BIM (cont.)

- However, as Smith* notes, even when models can be output into an open standard, the result incurs loss since "native 3D CAD file formats cannot be interpreted accurately in any but the original version of the original software product used to create the model."

*Smith, MacKenzie. "Curating Architectural 3D CAD Models." International Journal of Digital Curation 4, no. 1 (2009): 98–106. doi:doi:10.2218/ijdc.v4i1.81.

# General Lessons Learned from CAD/ BIM...

1. When possible, normalize data into open standards.*

2. However, native (often proprietary) formats should <u>also</u> be archived as well.

*PhotoScan doesn't support IFC, STEP, or IGES.*

# Thinking More Specifically About Photogrammetry Data

1. Original <u>2D raster image sets</u> should be archived, uncropped and not resized, in both a raw (e.g. DNG) and RGB-rendered (e.g. TIF) versions.

2. <u>Final registered point cloud data</u> should at a minimum also be archived in an ASCII format with text file extension along with at least one 3D graphics format like the openly documented and well supported OBJ.

# Thinking More Specifically About Photogrammetry Data (cont.)

3. 3D models should be similarly archived as OBJ, and VRML ISO/IEC 14772 or VRML's successor, X3D ISO/IEC 19776.
4. STL models should also be considered for basic, non-colored 3D printing purposes.
5. X3D for 3D color printing (if a high priority).
6. Additionally archive a format that is easily manipulated and perceived in generic viewers: e.g. PDF

# Thinking More Specifically About Photogrammetry Data (cont.)

7. Finally, preserve the photogrammetry software's <u>native format</u>: e.g. PhotoScan PSZ* wrapper

*Though .PSZ files can be uncompressed into its individual parts by freeware such as 7-Zip, only PhotoScan coherently understands both the wrapper and the encoding of the encapsulated bitstreams.*

Now, with a better sense of the pieces…

*How Do You Organize All of this Data?*

# Bundling Options...

1. <u>ZIP</u> (good)

2. <u>BagIt</u> (better)...

Bagger 2.1.3

File   Window   Help

Create New Bag   Open Existing Bag   Create Bag In Place   Validate Bag   Is Bag Complete   Close Bag   Save Bag   Save Bag As...

## Bagger

Payload

- data
  - MLK_Model_Data
    - MLK_OBJ_Model
      - MLK.jpg
      - MLK.mtl
      - MLK.obj
    - MLK_VRML_Model
      - MLK.jpg
      - MLK.wrl
  - MLK_Point_Cloud_Data
    - MLK.obj
    - MLK.txt
  - Source_Images_DNG
  - Source_Images_TIF
  - MLK.pdf
  - MLK.psz

## Bag Info

File name:   /Users/michaelbennett/Desktop/MLK_3D_Project
Profile:   <no profile>
Holey Bag?:   false

Bag version:   0.96
Serialize Type?:   none

Bag-Info

☑ Standard [                    ] : [                    ] Add

Internal-Sender-Identifier   Michael J. Bennett                                ✕
Payload-Oxum   2767567789.72                                ✕
Internal-Sender-Description   Digital Production Librarian, University of Connecticut   ✕
Bag-Size   2.6 GB                                ✕
Bagging-Date   2015-05-17                                ✕
External-Description   MLK_Project                                ✕

Tag Files

- MLK_3D_Project
  - bag-info.txt
  - bagit.txt
  - .DS_Store
  - tagmanifest-md5.txt
  - MLK.stl
  - manifest-md5.txt

## Console

Complete: ⊖       Valid: ⊖       Profile Compliant: ⊖

*What to Save, and How to Save It?*

One Possible Hierarchical View…
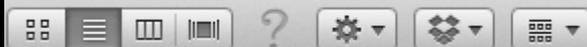
Name

▼ 📁 data
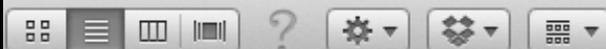   ▼ 📁 MLK_3D_Project
      📕 MLK.pdf
      📄 MLK.psz
     ▼ 📁 MLK_Model_Data
        📄 MLK.stl
       ▼ 📁 MLK_OBJ_Model
          🖼 MLK.jpg
          📄 MLK.mtl
          📄 MLK.obj
       ▼ 📁 MLK_VRML_Model
          📄 MLK.wrl
          🖼 MLK.jpg
     ▼ 📁 MLK_Point_Cloud_Data
        📄 MLK.txt
        📄 MLK.obj
     ▶ 📁 Source_Images_DNG
     ▶ 📁 Source_Images_TIF
  📄 bag-info.txt
  📄 bagit.txt
  📄 manifest-md5.txt
  📄 tagmanifest-md5.txt

# A Caveat…

*The BagIt specification <u>does not require</u> nor prohibit the customized inclusion of detailed manifest information on the relationships among bag components <u>or define</u> how such information should be created.*

# So…

*Without some implicit hierarchical folder organization, it is difficult to recognize important file dependencies.*

MLK_3D_Project_Bag

| Name |
| --- |
| ▼ 📁 data |
|    ▼ 📁 MLK_3D_Project |
|       📕 MLK.pdf |
|       📄 MLK.psz |
|       ▼ 📁 MLK_Model_Data |
|          📄 MLK.stl |
|          ▼ 📁 MLK_OBJ_Model |
|             🖼 MLK.jpg |
|             📄 MLK.mtl |
|             📦 MLK.obj |
|          ▼ 📁 MLK_VRML_Model |
|             📄 MLK.wrl |
|             🖼 MLK.jpg |
|       ▼ 📁 MLK_Point_Cloud_Data |
|          📄 MLK.txt |
|          📦 MLK.obj |
|       ▶ 📁 Source_Images_DNG |
|       ▶ 📁 Source_Images_TIF |
|   📄 bag-info.txt |
|   📄 bagit.txt |
|   📄 manifest-md5.txt |
|   📄 tagmanifest-md5.txt |
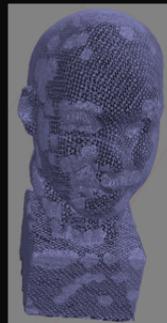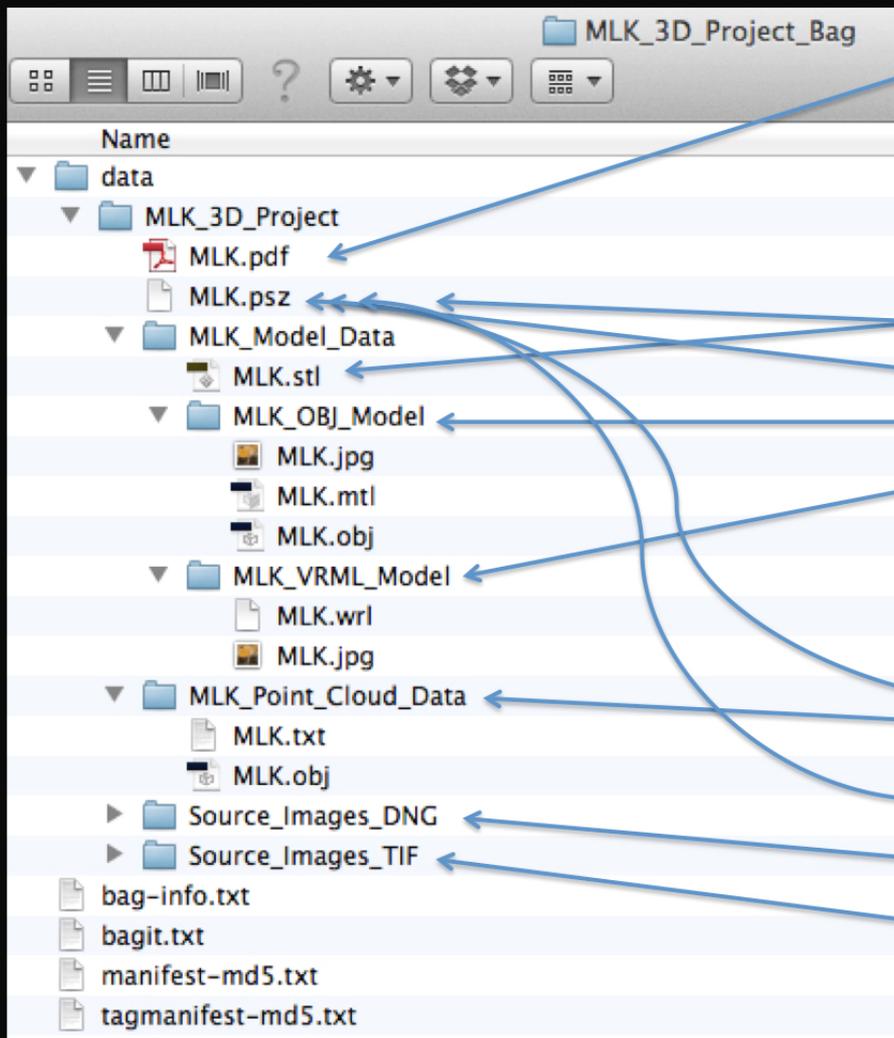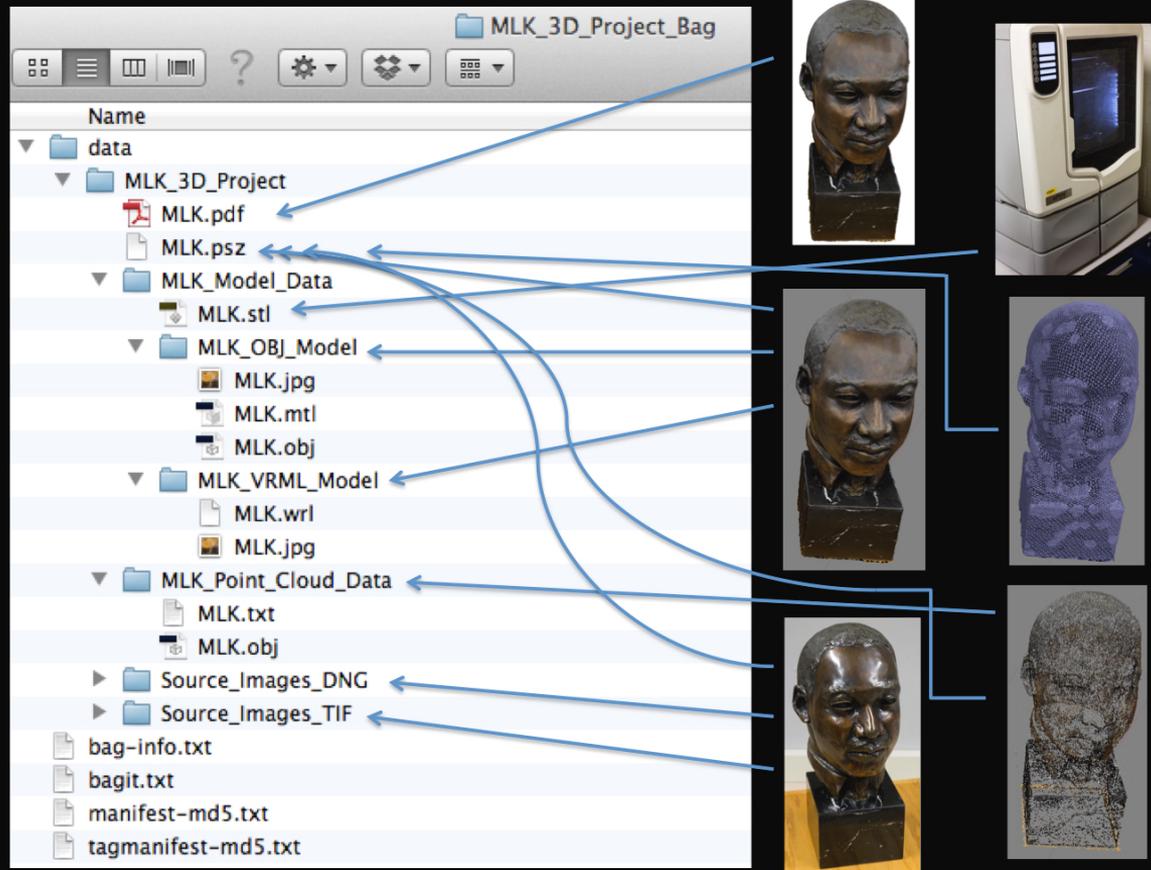
*1 Analog Object = 78 Total Files = 2.76 GB*

# Bundling Options…

1. <u>ZIP</u> (good)

2. <u>BagIt</u> (better)

3. <u>Document Container File</u> (best?)…

# Document Container File...

- Based upon a constrained form of ZIP, ISO/IEC 21320-1

- Still in proposal stage

- Anticipated to mandate the description of relationships among component files "either through a generic relationship representation or the use of prescribed application-specific naming conventions."*

*Document Container File: Core (based on ZIP 6.3.3). Accessed March 2, 2015. http://www.digitalpreservation.gov/formats/fdd/fdd000361.shtml.

# Digital Repository Options

- Finally, digital repositories can also directly play an organizational role in the preservation of 3D datasets.

- Platforms like Fedora host their own structural metadata schemas that more explicitly define how associated files or *datastreams* should be related to one another.

- In practice, bundling formats can act as complementary transfer carriers to repositories of conforming data that are either ingested as-is or are further normalized to a repository's given 3D object content model.

# Thank You

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