Quality Management of 3D Cultural Heritage Replicas with CIDOC-CRM

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3D models are increasingly used in Cultural Heritage, thanks to the diffusion of technologies like laser scanning and photogrammetry that make 3D models widely available methodology.

Nowadays it is being adopted for mass acquisition of artifacts and monuments, and 3D datasets are stored in an increasing number of openly accessible digital libraries.

E.g.: Europeana started to populate with 3D models of European art and to create tools for the creation of collections of digital replicas of cultural objects.
How can we verify the quality of a 3D model and its reliability?

• Documentation is crucial to assess trustworthiness and suitability for purpose and thus enable re-use.

  CIDOC-CRM can help to this purpose?

• This research proposes to use CIDOC-CRM and its extension CRMdig to document the planning and execution of 3D models of cultural artifacts in order to manage the quality of the replicas.
Laser Scanner Project Workflow

- Aim Definition
- Location Survey
- Repository Creation
- Technology Definition
- 3D Data Post-Processing
- 3D Data Registration
- Field Operation
Aim Definition

- Aim Definition: define the purpose of the digitization
  - modeling for cultural documentation
  - production of virtual models for dissemination
  - creation of 3D models for virtual restoration
  - 3D printed replicas for dissemination (e.g. museum exhibitions) and for research purposes
- The definition of the aim is strictly connected to the Technology Definition
Location Survey

- Location Survey concerns the inspection of
  - Environmental conditions
    - Lighting, temperature, presence of dust (indoor and outdoor) ...
  - Object feature and size related to the surrounding scene
    - Location of monument or museum object (e.g. space available for scanning)

- This stage will support
  - In defining best time to collect the data
  - In identifying the presence of high reflective surfaces, obstructions and obstacles that may voids artifacts
Repository Creation

- Repository design and creation: design the repository according to the project needs
  - The project may use an existing repository, if the work concerns models added to a previously existing one
- Define correct file formats in order to save space and to guarantee interoperability
Repository Creation

- **Repository Creation**
  - E65_Creation
  - Repository_Type: E55_Type

- **Laser_Scanning_Project**
  - D28_Digital_Documentation_Project

- **D13_Digital_Information_Carrier**
  - P94_has_created
  - L19_stores

- **D15_Repository_Object**
  - Digital_Model
  - P2_has_type

- **Object_Type**
  - Format_Type
  - Purpose_Type
  - E55_Type
Technology Definition

- The Technology Definition step concerns
  - Device features according to the location survey outcomes
    - Environment
    - Object material
    - Object shape
    - Object size
Field Operations

- The Field Operation step defines
  - Device features according to the location survey outcomes and to the object/scene to be scanned (FOV, level of detail)
  - Number of scan position (orientation angle)
  - Number and position of targets

- Total station and GPS
- Internal/external camera
- Set-up of lighting system (e.g., caves, museums)
Scanner Settings

- 3D_Scanner_Definition
- E7_Activity
- P20_has_specific_purpose

- 3D_Data_Capture
- D7_Digital_Machine_Event
- L12_happened_on_device

- 3D_Scanner_Settings
- D1_Digital_Object
- P43_has_dimension

- 3D_Scanner_Settings_Values
- E54_Dimension
- P91_has_unit

- 3D_Scanner_Setting_Type
- E55_Type

- 3D_Scanner_Setting_Unit
- E58_Measurement_Unit

- 3D_Scanner_Setting_Value
- E60_Number
Field Operations

- Total Station
- Marker
- Laser Scanner
Field Operations
The 3D Data Registration consists of merging multiple scans with each other in correct, relative 3D geometry within a single coordinate system. It includes:

- Scanner position
- Ground Control Points (GCPs) or identifiable features
- Pre-registration cleaning: remove noisy data, which could affect the final result.
3D Data Registration
Pre-Registration Cleaning

L3_used_parameters → P43_has_dimension

L21_used_as_Derivation_source → L22_created_derivative

D15_Repository_Object

D3_Formal_Derivation

Model Cleaning Parameters:
- Cleaning vertices and faces on the boundary

Cleaning Parameters Values:
- E54_Dimension

Cleaning Setting Type:
- E56_Type
  - Boundary

Cleaning Setting Unit:
- E58_Measurement Unit
  - faces or vertices

Cleaning Setting Value:
- E60_Number
  - 2

L3_used_parameters

P2_has_type

P91_has_unit

P90_has_value

P0_has_value
3D Dataset Post-Processing

- The Post-Processing step includes
  - Polygonal mesh generation
  - Cleaning processes
  - Resampling and decimation
3D Dataset Post-Processing

- Post-processing_Type
  - E5_Type
  - P2_has_type
- 3D_Data_Post-processing
  - D3_Formal_Derivation
    - L23_used_software_or_firmware
    - P9_consists_of
      - Laser_Scanning_Project
      - D28_Digital_Documentation_Process
    - L22_created_derivative
      - L21_used_as_derivation_source
        - Model
          - D15_Repository_Object
    - Post-processing_Software
      - D1_Digital_Object
        - PP_Software_Parameters
          - P43_has_dimension
            - PP_Software_Parameter_Type
              - E55_Type
            - PP_Software_Parameter_Unit
              - E58_Measurement_Unit
            - PP_Software_Parameter_Value
              - E60_Number
  - D3_Formal_Derivation
    - P2_has_type
      - Laser_Scanning_Project
      - D28_Digital_Documentation_Process
    - P9_consists_of
      - Model
      - D15_Repository_Object
Conclusions and Future Works

• This research illustrates how CRM may support Quality Management of 3D Cultural Heritage documentation
• It is being extended to other methodologies like photogrammetry/SfM, videogrammetry
• It may need refinements and revisions dictated by practice
• Implementation will need tools to simplify the input
• The procedure is being tested within a 3D digital library project
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Thank you for your attention.