Software Pipeline for 3D Heritage Digitization - The Case of Faro Focus Scans

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Biographies

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3D digitization of heritage objects

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- The 3D digitization has gained importance and became a widely utilized method for documenting of cultural heritage objects.
- Wide actions are undertaken to digitize the collection of both well-known facilities and smaller museums.
- The process of processing raw 3D data to obtain a model (digital twin) is time and resource consuming. It is generally conducted based on proprietary and device dedicated software, yet the steps are similar regardless of the 3D scanner used.
- The case of architectural objects digitization using Terrestrial Laser Scanning (Faro Focus) has been taken into account.

Obtaining a 3D model with TLS

- Data gathering
- **Data processing - point clouds (Faro Scene)**
  - Raw scans processing
  - Scans registration (aligning)
  - Data cleanup
  - Registered point clouds export

Obtaining a 3D model with TLS

- **Data processing - textured 3D mesh (Reality Capture)**
  - Registered point clouds import
  - Triangle mesh generation (and simplification)
  - Texture generation
  - Textured 3D mesh export
  - Data processing - point clouds (Faro Scene)

The above steps have to be conducted in a sequence for a single object. Different hardware resources are utilized during respectful steps.

The problem

- During the sequence of 3D model generation steps, the utilization of computer resources is sub-optimal – different resources used by different tasks.
- The proprietary software units are not designed for parallelization of tasks when processing scans of multiple objects. Implementation of it by one software vendor would affect only one software unit and not the whole pipeline.
- The need to transfer data between software units causes additional lags when processing objects one-by-one.

Proposed approach

- The sequence of tasks for one object can be conducted in synchronization with another sequence (or sequences) for other object(s) conducted at the same time by another instance of the software.
- To avoid resource exhaustion, the next task of the additional object is started only when the current task of the first object uses heavily different resources.

Materials and methods

The proposed approach was tested during 3D digitization of wooden churches in Romania. The scan data of facades of 3 churches were used:

- (C1) The orthodox church from Creaca: 13 scans - 10,338 x 4,267 pt.
- (C2) The orthodox church from Targusor: 10 scans - 10,342 x 4,267 pt.
- (C3) The orthodox church from Petrindu in the open-air museum in Cluj-Napoca: 15 scans - 10,172 x 4,267 pt.

Materials and methods

The software tasks were executed sequentially for scans of the 3 wooden churches in 2 approaches

- Executing tasks for the next church after finishing ALL the tasks of the prior one [sequential]
- Executing tasks for the next church during the tasks of the prior one whenever the needed resources are available (not highly utilized by the current task of the prior object) [parallel]

Materials and methods

The identification of used resources has been conducted for all tasks with the following thresholds

- Low – up to 30%
- Medium – 31% to 70%
- High – from 71%

The rule was set that the task of the next object having high demand for resource X can only be started when the demand of current task of the prior object for the same resource is low.

Results

The table presents resources usage and execution times for respective tasks during the sequential and parallel approach.

The total time for all 3 objects computations

- Sequential – 54h 45m
- Parallel – 42h 15m

Results

Values from the table are an average of 3 series conducted on a computer with specifications

- Intel i9 processor (8 cores)
- 64 GB RAM
- nVidia RTX 2080m graphics
- SSD M2 disk drive

Results

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No.	Task name	Comp. type	Op. eng. [%]	Load of CPU/GPU/SDD [%]	Exec. time for C1/C2/C3 [h]
1	Opening and colorization of individual scans	seq	L	M/L/M	1.5/ 1.3/ 2.0
		par	L	M/L/M	1.5/ 1.5 /2.0
2	Registration of scans in relation to each other	seq	L	H/L/M	1.0/ 0.5/ 1.0
		par	L	H/L/M	1.0/ 1.0/ 1.0
3	Scans cleaning	seq	H	L/M/L	0.3/ 0.1/ 1.0
		par	H	L/M/L	0.3/ 0.1/ 1.0
4	Data export from Faro Scene	seq	L	L/L/L	8.0/ 5.5/ 9.0
		par	L	L/L/L	8.0/ 5.5/ 9.0

Results

No.	Task name	Comp. type	Op. eng. [%]	Load of CPU/GPU/SDD [%]	Exec. time for C1/C2/C3 [h]
5	Data import to Reality Capture	seq	L	H/L/H	0.5/ 0.3/ 0.5
		par	L	H/L/H	0.8/ 0.5/ 0.5
6	Generation of a 3D mesh based on scans	seq	L	H/L/M	3.3/ 3.0/ 3.5
		par	L	H/L/M	4.0/ 3.5/ 3.5
7	Mesh texturing	seq	L	M/H/M	4.0/ 4.0/ 4.0
		par	L	M/H/M	4.0/ 4.3/ 4.0
8	Export of the final model	seq	L	H/L/H	0.3/ 0.3/ 0.3
		par	L	H/L/H	0.3/ 0.3/ 0.3

Results

(C1) 3D model of the orthodox church from Creaca

Results

(C2) 3D model of the orthodox church from Targusor

Results

(C3) 3D model of the orthodox church from Petrindu

Conclusions

- Although increasing the individual time of acquiring respectful 3D models, the proposed optimization allowed to decrease noticeably the total time of acquiring all 3D models of objects from TLS scans.
- So far, the decision to start an additional task is done manually. A dedicated software can be prepared to minimize the expert involvement.
- The optimization by tasks parallelization can be achieved even when using a set of proprietary software not designed for parallel tasks execution.