Surface reconstruction of 3D scanned data from cave Domica (Slovakia)

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Collaborators

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Previous experiences to port scientific tasks to computational grids

- Image processing (tracking position of many microparticles in thin fluid layers)
  - Phys. Rev. E 70, 031504 (2004)
  - Phys. Rev. E 78, 061401 (2008)
- Computer simulations of avalanche phenomena
  - Phys. Rev. E 82, 061116 (2010)
  - Phys. Rev. E 73, 066125 (2006)

Motivation and goals

- to explore previous experiences with grid computing in a new application domain,
- to try how easy or difficult is to fulfill user demands to solve parametric tasks,
- to produce “a software solution-product” with a potential to be sold,
- to utilize existing partial software solutions.

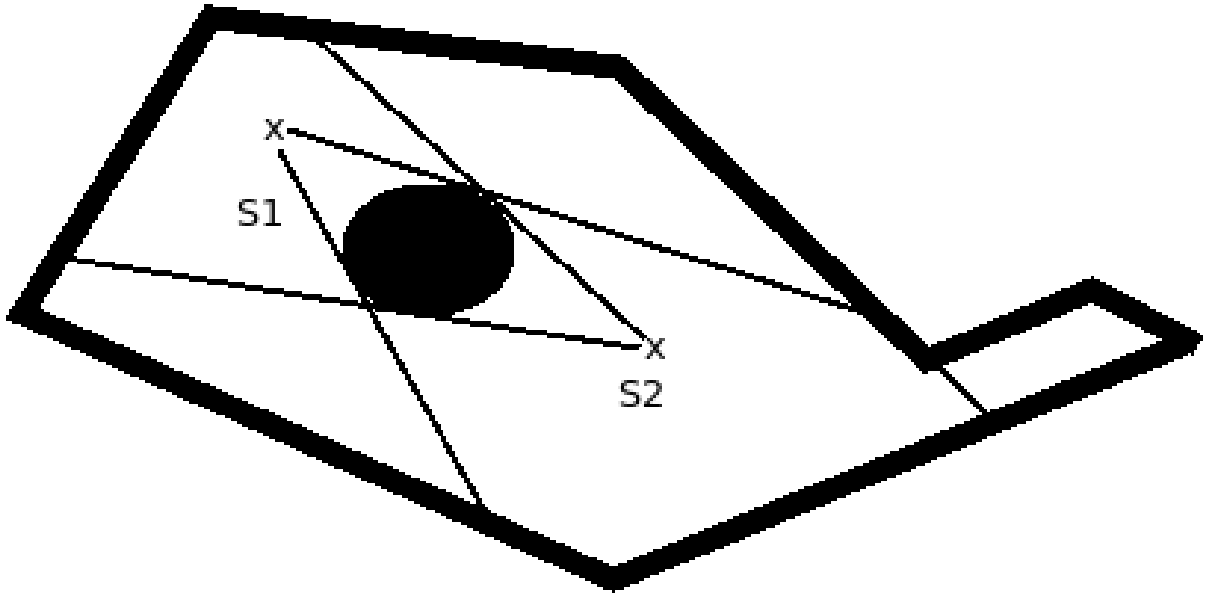
Cave Domica

- crosses a border between Slovakia and Hungary http://www.ssj.sk/en/jaskyna/7-domica-cave,
- belongs in UNESCO world heritage,
- is attractive for:
  - scientists,
  - tourists (floating on a small boat in underground river),
  - students (easy access).

Method and Data

- Terrestrial laser scanning method LIDAR was applied to scan a relief of the cave.
- LIDAR scanners produce output data sets of points z,y,z (+color).
- Many positions of LIDAR scanner are needed to minimize shadow volumes (next slide).
- A few formats exist to store data.

LIDAR scanning of closed spaces- principle

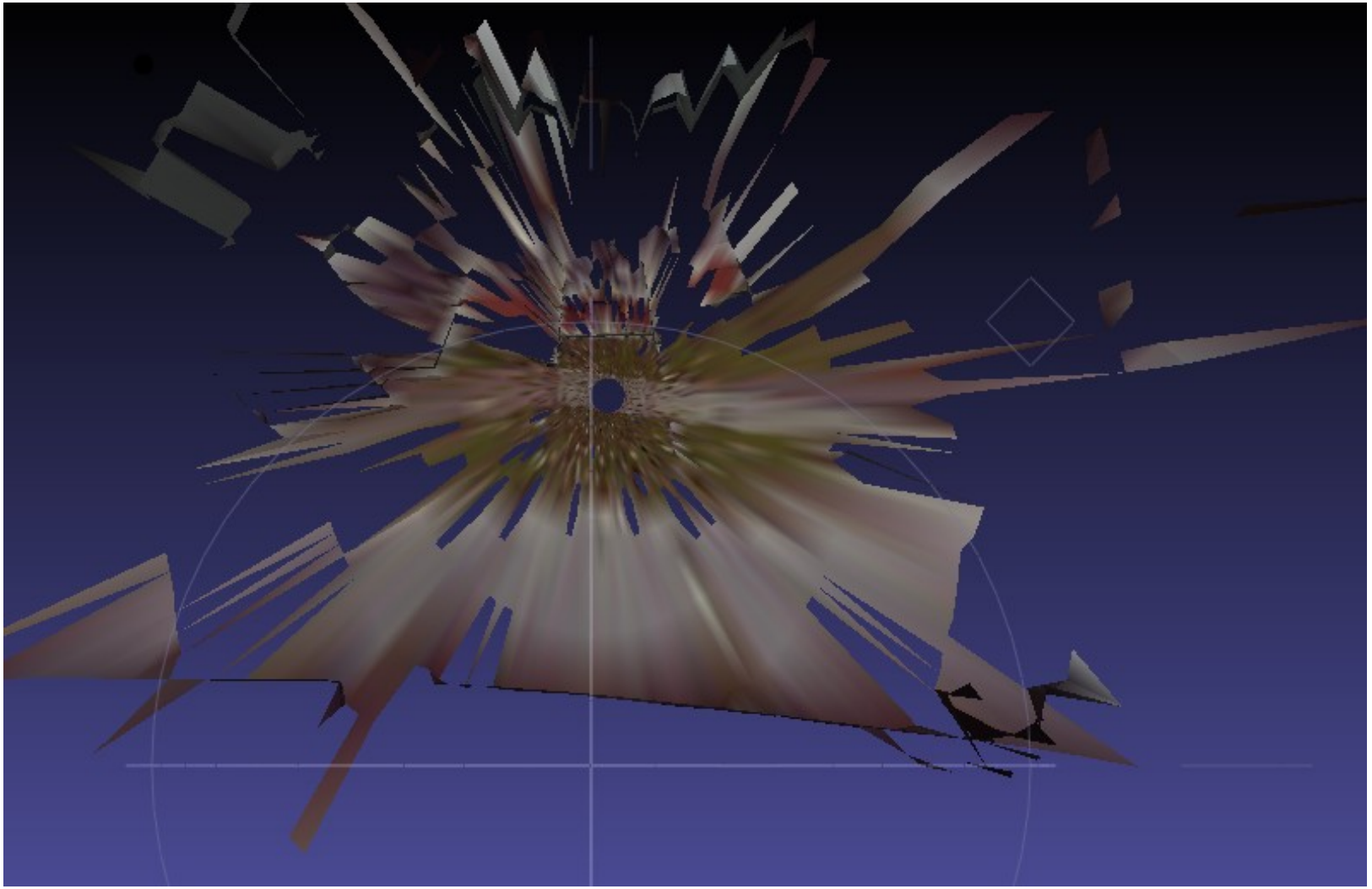


- Several positions of LIDAR scanner are needed to avoid shadow volumes. This approach increase data redundancy

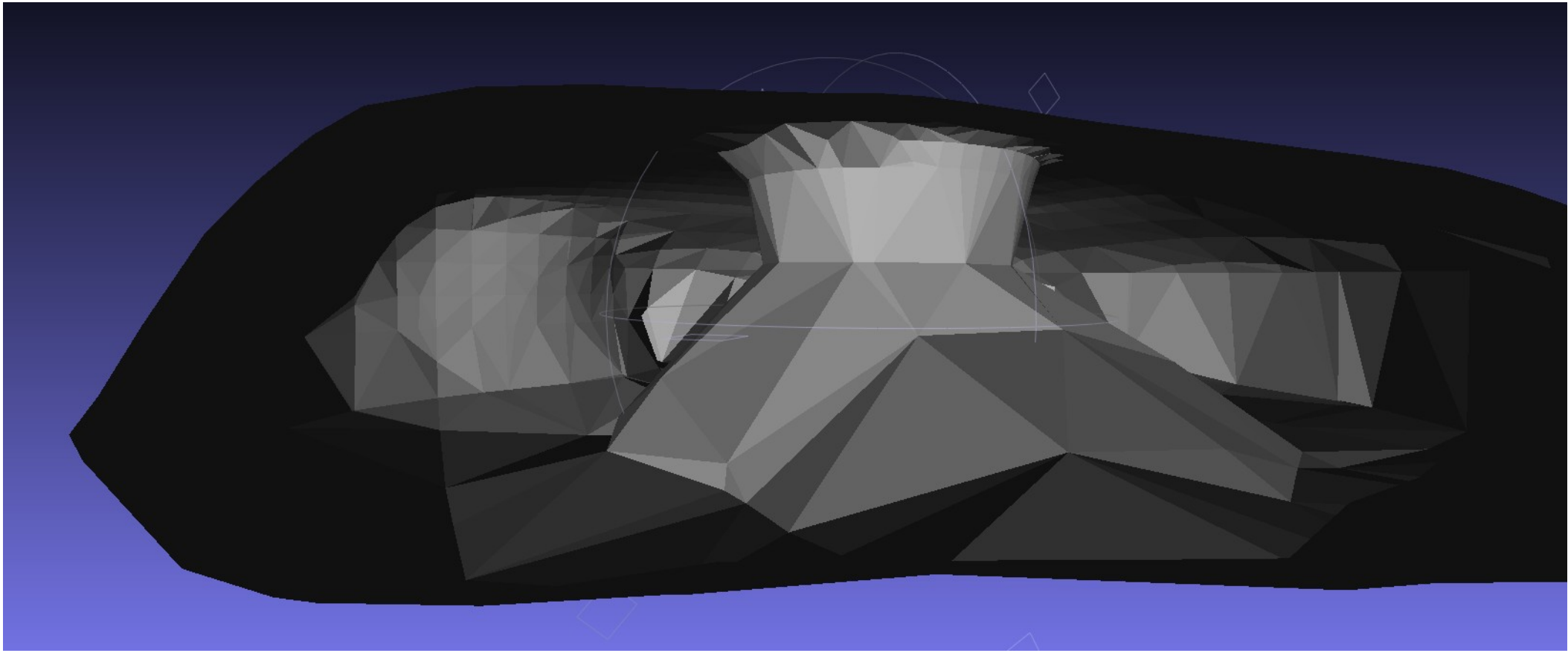
DATA-processing

- input data – a set of points (x,y,z) for each position of LIDAR scanner
- data processing is realized in a simple chain of several steps:
  - reduction of redundant point,
  - surface reconstruction from a cloud of points to triangular surfaces, Poisson method of surface reconstruction.
- Big data sets (MB/GB), time consuming operations (several hours or days)

cloud of points - an input for the surface reconstruction



The output of surface reconstruction in Meslab when a command:
meshlabserver -i domica_10x10.ptxDomica001.ptx -o domica001.ply -s poisson.mlx
was typed to perform a surface reconstruction.



Porting of the task to ARC based computational grid

- A parametric task: a volume of the cave is divided on subvolumes, and the same Meshlab operations are applied on each subvolume.
- Installation of a new RTE "APPS/GEO/MESHLAB-1.3.3" -installed on EGI production site arc-ce.grid.upjs.sk
- Development of scripts:
  - run_meshlab.sh, a script to run Meshlab command on a local/remote server,
  - poisson.mlx, a description of filters needed for surface reconstruction,
  - create_xrls.sh, it creates a task description script: domica.xrls,
  - domica.xrls, the task description script.
- ARC command to run:
  - arcsub -S org.org.glue.emies domica.xrls -c arc-ce.grid.upjs.sk

Script run_meshlab.sh

```
#!/bin/sh
MESHLABSERVER -i domica_10x10.ptxDomica$1.ptx -o
domica$1.ply -s poisson.mlx
exit $exitcode
```

Script poisson.mlx

```
<!DOCTYPE FilterScript>
<FilterScript>
 <filter name="Surface Reconstruction: Poisson">
  <Param type="RichInt" value="12" name="OctDepth"/>
  <Param type="RichInt" value="12" name="SolverDivide"/>
  <Param type="RichFloat" value="3" name="SamplesPerNode"/>
  <Param type="RichFloat" value="3" name="Offset"/>
 </filter>
</FilterScript>
```

```
#create_XRLS.sh

#!/bin/sh
echo +
for i in $(seq -w 300)
do
echo \(
echo \&
echo \(executable=run_meshlab.sh\)
echo \(arguments=\"$i\"\)
echo      \(jobname=meshlab_job$i\)
echo      \(inputfiles =
echo      \(\"domica_10x10.ptxDomica$i.ptx\" \"\"\)
echo      \(\"poisson.mlx\" \"\"\)
echo      \)
echo      \(outputfiles =
echo      \(\"domica$i.ply\" \"\"\)
echo      \)
echo      \(stdout=std.out\)
echo      \(stderr=std.err\)
echo      \(gmlog=gridlog\)
echo      \(\&\(runtimeenvironment\>=APPS\/GEO\/MESHLAB-1.3.3\)\)
echo \)

done
```

Deployment on a production EGI cluster

- The initial OS SL6 was changed due to issue to run (compile) Meshlab
  - we have to changed OS on the cluster Ununtu 14.04 the same Meshlab issue as above
  - we have to downgrade OS Ubuntu 14.04 on Ubuntu 12.04 the same Meshlab issue as above
- The cluster remained in the production mode during all changes
- We found A-rex issue:
  - Bug 3473] A-rex crashes after input/output jobs handling however arsub with -S org.org.glue.emies produces correct results.

Remarks

- A software solution was delivered despite issues to install Meshlab.
- Commercial value ?
- We profited from the abstraction in ARC i.e. xRLS job description feature witch hides details of CE batch system.
- We reused the same design pattern which was developed for quit different application in many years ago, however tasks have a common feature (parametric tasks).
- We think that the current ARC has a limited functionality to be easy reconfigured to fulfill user demands

Proposals

- to introduce abstract layer(s) to describe user demands similar approach was proposed in software development [1] (iPython). A user will define demands once. All additional steps to map demands to available resources or to produce a new resources should be automatic [2]:
  - to use a concept of reconfiguration and adaptability of abstract functional blocks, for example FPGA design, i.e. to map functionality into “structure” (appropriate reconnection of functional blocks)
  - to propose a new methods how to handle information about available resources, i.e. a new scalable information model.
  - functional blocks are private or public

References

[1] T. C. Schulthess, Programming revisited, Nature Physics 11, 369 (2015).

[2] J. Cernak et al, Reconfigurable and adaptable computational resources on the abstract level, Proceeding of the Work in Progress Session, 23rd EUROMICRO Internatonal Conference on Parallel, Distributed and Network-based Processing, PDP 2015, Turku 4-6 March 2015

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