Real-time 3D Reconstruction and Navigation Using Laser Range Finders

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INTRODUCTION / STATE OF THE ART

Over the last years, real environment 3D modeling has become of extreme importance. Several commercial products have emerged, with a field of application ranging from the engineering areas like Civil Engineering; Maritime Engineering; Geographical Engineering; Mechanical Engineering; Mining Engineering, to Geology, Architecture, Archeology and Forensics [1][3]. While generating the 3D models, it is usual to join information obtained from different locations of the laser range finders and also with digital photographs [2]. Actually, several nation wide companies work directly with 3D data acquisition.

The 3D reconstruction process is divided in the data acquisition and data processing. Data is obtained through laser range finders in the form of point clouds and transferred to a computer. Several scans are generated from different locations and registered between them. The registration can be optimized by the use Global Positioning Systems (GPS), markers placed over the environment, through geometrical extraction in the acquired model or aided by reflectance images and digital images [3]. It is common to register digital photographs with the point clouds [2][4]. LIDAR systems (**Li**ght **D**etection **a**nd **R**aging) allow data acquisition while moving. Those systems have an Inertial System for motion detection associated to a GPS navigation system. LIDAR systems do automatic registration of points.

After the data acquisition, comes the data processing. The processing starts by eliminating noise from data, common on laser measuring errors, like duplicated points. The point clouds are triangulated, integrated on a single model. Textures are extracted from the digital photographs taken from the environment. The order these steps take place are determined by the software tool used [7][8]. Many tools have simplification mechanisms to decrease point clouds and triangulated models, thus requiring less computing resources [5]. Information visualization and processing are done after the acquisition phase. The triangulation and integration of the different point clouds are made during these stages, making possible to detect holes and occlusions in the model. The holes and occlusions in the model can be filled using known algorithms, but for uncovered regions of considerable size, it is necessary new scans at the location modeled.

present the 3D acquisition and preliminary results of *Anta Pintada* de Antelas, em Oliveira de Frades using a 3D laser scanner prototype developed at the Mechanical Department of University of Aveiro.

Figure 1 present the 3D acquisition and preliminary results of *Anta Pintada* de Antelas, em Oliveira de Frades using a 3D laser scanner prototype developed at the Mechanical Department of University of Aveiro.

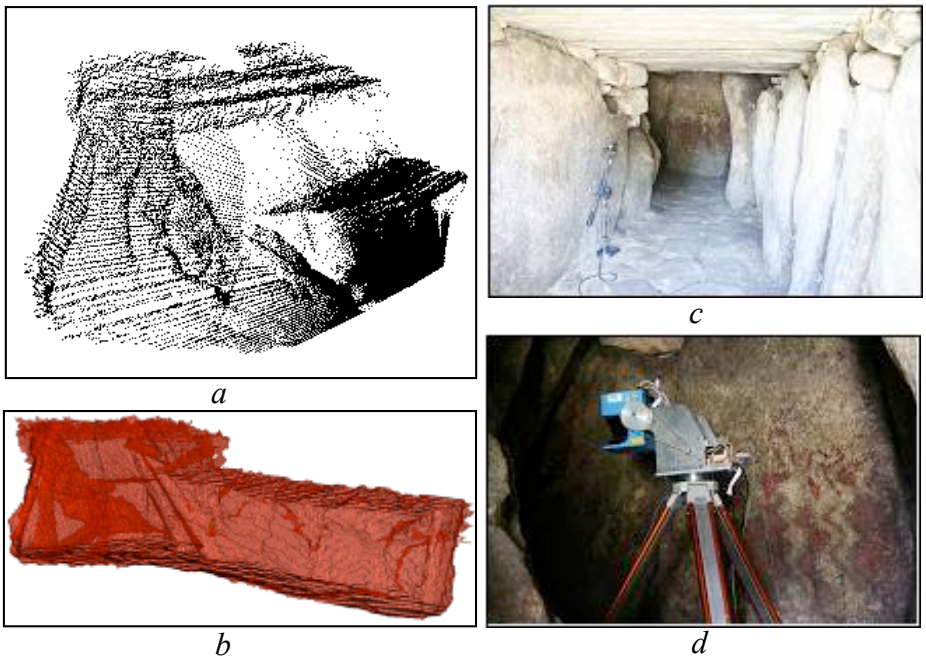

Figure 1: Acquisition of *Anta Pintada* de Antelas: (a) cloud of points; (b) Geometric model; (c,d) – Digital photographs of the acquisition..

1. Work Plan and methods

The work will be a collaboration of IEETA/Department of Electronics, Telecommunications and Informatics and Department of Mechanical Engineering based on early previous work developed in these institutions. There is the possibility of future application in other projects at Universidade de Aveiro.

The main expected tasks are:

- 3D acquisition of data on motion, with a system capable of detecting movements and estimating its position. Automatic registration of points and generation of a single point cloud. The several steps are:
  - Analyze different forms of motion detection and use the most appropriate one(s);
  - Merge information from the motion sensors with the information from the laser sensors;
  - Integration of new points with the already acquired ones;
  - Minimize errors from measurements.
- On-site fast prototyping with real-time ability of data visualization, with functionalities like zoom, browse. Fast prototyping of acquired data can give a rough idea of how the model looks like. The final result is an autonomous application with those functionalities, with no specific hardware needs;
- Improve and upgrade existing 3D reconstruction tools, to include the work described on previous points. Using already existing tools, the knowledge created can quickly be used in the real-world, making them usable in other areas;
- Development of others tools for the specific purpose of robot navigation (environment exploration, obstacles avoidance) and other relevant areas like Civil Engineering, Archeology or even Acoustic Modeling;

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