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DIGITAL COGNITIVE 3D-TECHNOLOGIES

Victor Alexandrov[1], Daria Kourneva[2], Alexey Aksenov[1]

[1]Saint-Petersburg Institute for Informatics and Automation of RAS
14th line V.O., 39
199178 St.-Petersburg, Russia
[2] Peter the Great St.Petersburg Polytechnic University
Institute of Computing and Control
Control Systems and Technologies department
e-mail address of lead author: alexandr@iias.spb.su

Abstract

The paper considers the creation of a full digital copy of the physical objects by using Artec Spider 3D scanner.

INTRODUCTION

Digital programmed technology development has led to ability of three-dimensional objects digitization and direct visual 3D modelling which involves creative cognitive capabilities of the mind. In contrast to the technology of "cutting off excess" that is often used in sculpturing.

This demonstrates a clear innovative digital technology leap in cognitive programming and 3D computer modelling. Cognitive programming in contrast to traditional programming methods relying on specific formal languages is based on the development of applications and services interface. Cognitive programming conveys unformalized creative process to digital protocols and formats. Thus, cognitive programming - is a digital simulation of the creative process (the world of the imagination - fantasies) [1, 2].

COGNITIVE PROGRAMMING

Digital 3D technology and cognitive programming offer unique ability to reconstruct complex spatial forms, objects, engineering structures and mechanisms. The realization of these abilities given by the technology of digital control of the material particles in 3D environment by rapid prototyping tools which determine the properties of the reproduced object [3].

Structural components of digital 3D cognitive programming technology of complex spatial forms are shown in figure 1. Each of these components has its own technological tools, hardware and software.

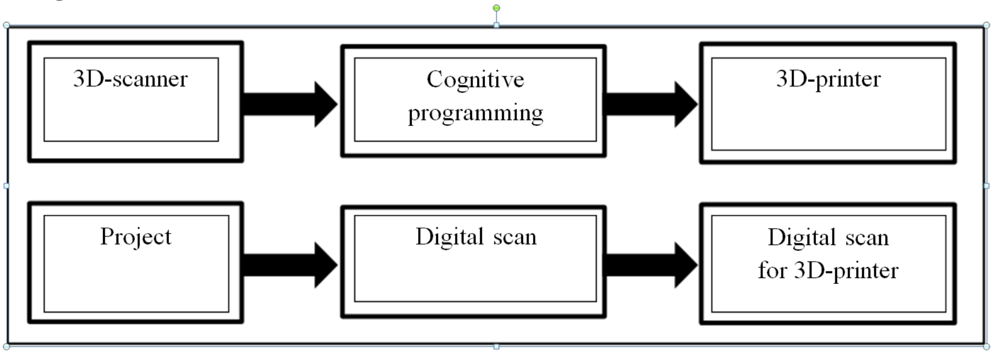


Figure 1 Structural components of digital 3D technology cognitive programming

The essence of cognitive programmable technology is a combination of knowledge and cognitive creativity with capabilities of technology.

3D-scanning is the first step to represent the physical object in digital form. Thus, depending on the capabilities and definition of 3D scanners, the problem reproduction accuracy emerges.

3D-SCANNING

3D-scanning - is a systematic process for determining the coordinates of points belonging to the surface of physical objects for subsequent obtaining of spatial mathematical model.

Three-dimensional scanning technology can be divided into two types: contact (imply the presence of a mechanical device - "dipstick") and contactless (laser, ultrasonic, magnetic).

Despite the variety of 3D-scanner types their common goal is digital representation of physical objects which is useful in following industries:

- ❖ Medicine
- ❖ Construction and Architecture
- ❖ Car and shipbuilding
- ❖ Museology and Restoration
- ❖ Entertainment Industry

- ❖ Souvenirs and advertising items
- ❖ Fashion and Jewellery
- ❖ Engineering Analysis
- ❖ Digital Archiving

A striking example is the application of 3D scanning to restore the missing part of the toucan beak. In mid-March 2015 its beak was scanned by a 3D-scanner Artec Spider and submitted for revision and prosthesis creation to 3D-modelers (Figure 2).

Figure 2 Scanning toucan beak.

3D-scanner Artec Spider is designed to scan objects of different size. It is capable of 7.5 of one megapixel frames per second processing and produces high resolution (0.1 mm) and high precision (0.05 mm) 3D scans. This model is a lightweight portable hand-held scanner with compact dimensions. And it does not require the special markers placement on a scanned object.

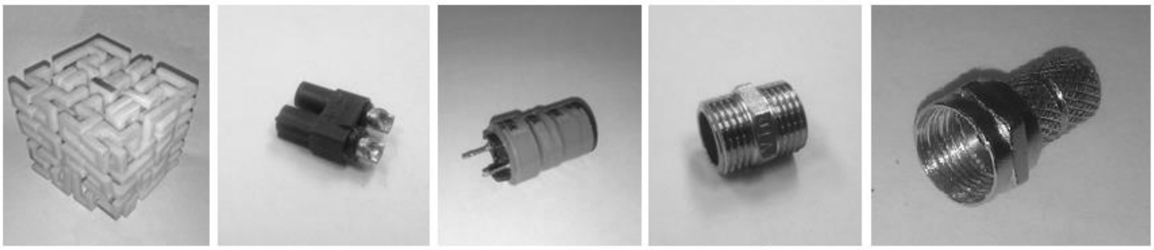
Types of source material data

Classification of the source data used for experiments:

- ❖ existence of internal structure:
  - – existence of internal structure (Figure. 3, a)
  - – lack of internal structure (Figure. 3, b)
- ❖ the nature of the surface:
  - – smooth (Figure. 3, c)
  - – complex surface (small parts of a size greater than the resolution of the scanner, Figure. 3, d)

– noisy surface (small parts with a size smaller than the resolution of the scanner, Figure. 3, e)

– defects in the surface scanning



a *b* *c* *d* *e*

Figure 3 Classification of samples

THREE DIMENSIONAL OBJECT RECOGNITION

The process of scanning 3D-object includes a number of consecutive actions, which affect the final result. The scanner software (SS) reconstructs and post-processes the point cloud from a set of images obtained from multiple digital cameras of 3D-scanner therefore it makes sense to consider the hardware and software parts as the one technical system "3D-scanner – SS".

The effect of SS is primarily appears in the change (distortion) of objects shape (Fig. 4) when it tries to compensate for errors during scanning process which entails degradation of 3D-scan.

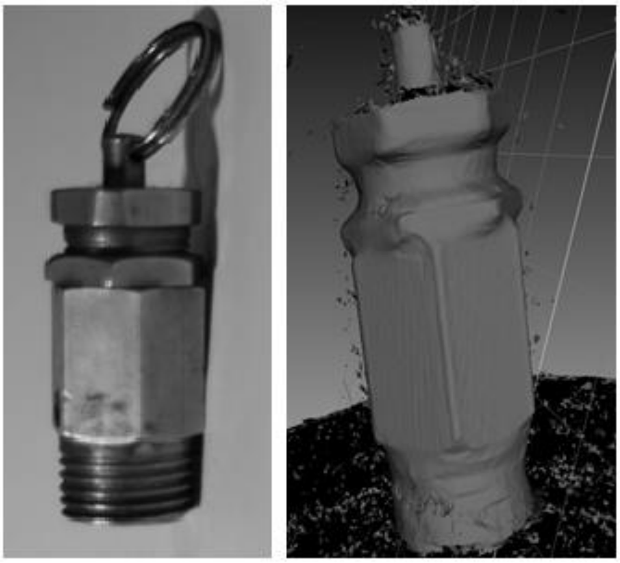


Figure 4 Left: the photo of the original object. Right: the scanned object.

The lack of ambient light, lightning glare introduces the errors leading to surface defects which cannot be compensated by the SS.

There are types of surfaces (primarily transparent and mirror) that cannot be scanned due to the optical principle of 3D-scanner operation.

In this regard, the selected object for the experiment was a smooth non-transparent clay statuette without internal structure (Fig. 5).

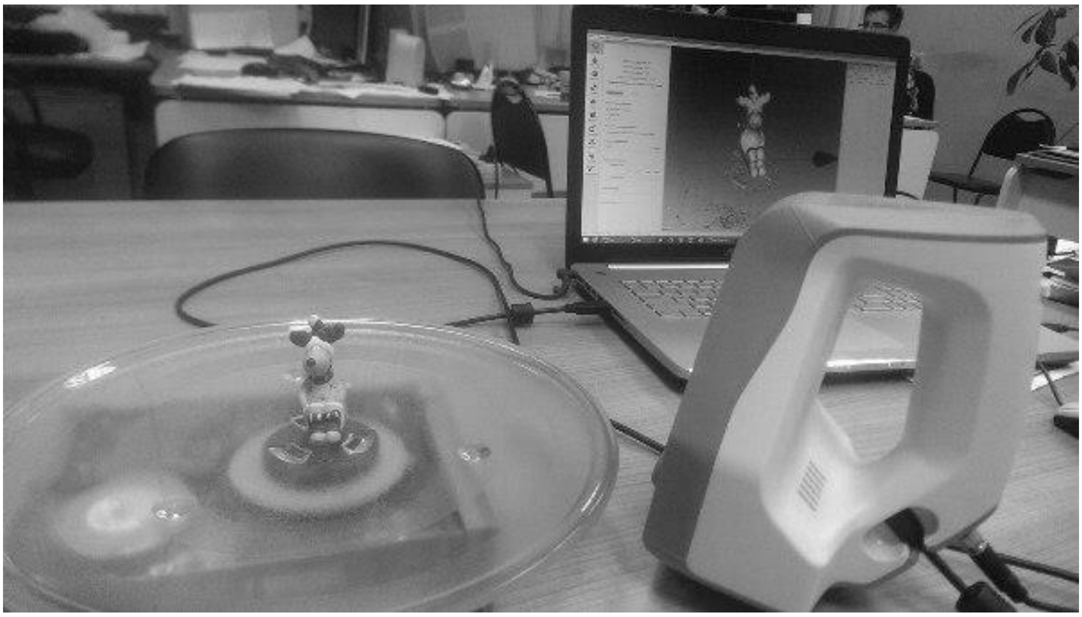
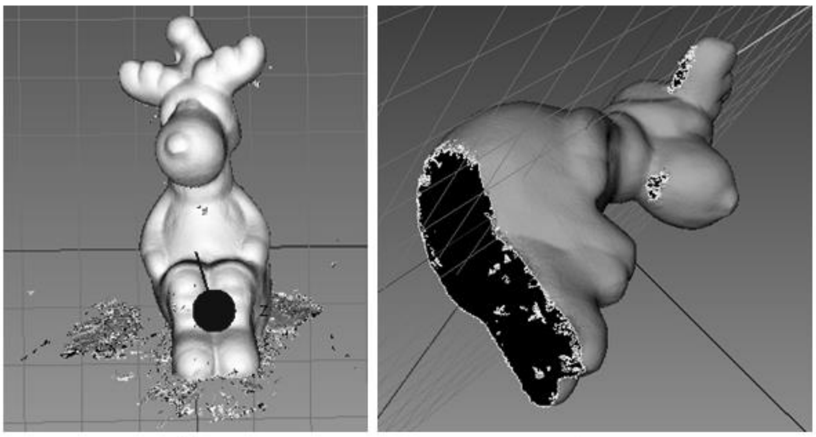


Figure 5 Scanning smooth clay figurines which has no internal structure.

After the scanning process a number of artefacts (Fig. 6, a), and "hole" (Fig. 6, b) were found in the 3D-model. These defects were introduced by uneven object tracking caused by surface smoothness. Such errors are also possible during scanning of symmetrical objects. In this case, the imperfect SS makes frame alignment errors leading to multiple repetitions of object's fragments in resulting model.



a *b*

Figure 6 3D-model of the scanned object

During the research it was found that a further attempt to improve the 3D-scan through the use of automatic surface smoothing and artefact removing has resulted in a loss of precision and fine details. The results of manual processing of a statuette 3D model in Artec scanning SDK are shown on Fig. 7.

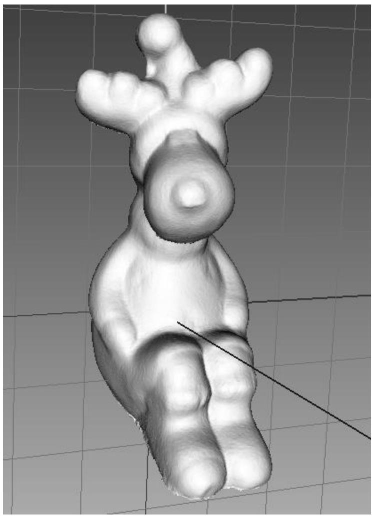


Figure 7 - The final form of 3D-model.

During the experiments it was determined that the actual resolving power of the Artec Spider scanner equals to 1 mm along the vertical axis and 0.5 mm along the horizontal axis.

CONCLUSIONS

Digital scan - is a potentially new paradigm. It expands the 3D design capabilities and replaces the projective design principle with a direct object point manipulation in the three-dimensional space. Work becomes easier in areas where the projective approach is difficult (for example, medical research, virtual sculpting, landscape design, etc.)

Analysis of current research has revealed an almost complete absence of ready multipurpose solutions for digital 3D scan optimization and automated processing for further replication on 3D- printing devices.

Experiments has shown that the system “3D - scanner - SS" does not work as specified making relevant the research of its technical capabilities and making suggestions for its improvement.

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