DIGITALIZATION OF OBJECTS

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Abstract

Computer supported technologies such as CAD, CAM, CAE and others, require efficient coordinate measuring technique to achieve matching of numerical models and the actual component. In systems where, in the short term, is necessary to provide high accuracy and the amount of data, the speed and flexibility of systems for 3D scanning is emphasized. These systems have a large range of sizes of items that can measure (from a few millimetres to several tens of meters) which gives them a huge advantage over other systems. This also enables them digitization of moving objects. It's "question of day" to use it in kinesiology.

Key words*: techniques, digitalization, objects, technology, sport, kinesiology*

Introduction

3D digitalization is a term for a three-dimensional representation of real objects in the form of three-dimensional models of virtual world. 3D digitizer has a wide range of applications due to the size of the object. Limiting size of the objects that can be digitally processed is in range of few millimetres to several tens of meters or more (depending on manufacturer and purpose). 3D digitizer is used in the manufacturing industry for: 1. 3 d coordinate measuring, 2. Quality assurance and control, 3. Development of products and tools - design and engineering reversible, 4. Copying objects, 5. Optimizing processing with particulate 6. Repairs, reconstruction and development of spare parts, 7. Analysis and Planning, 8. Archiving, visualization and presentation. System is ideal for various applications such as moving images design and CG (computer generated) of 3d model, crime scene investigation and archeological archiving or sports actions.

3 d coordinate measuring

Various measurement tasks can be accurately, quickly and easily performed with optical measuring procedures. For objects size of 10 millimeters to a few tens of meters it is measured as follows: 1. dimensions, 2. three-dimensional shape, 3. distance, 4. angles, 5. spatial position, 6. three-dimensional shifts, 7. deviations of shape and position (circularity, parallelism, etc.)

Quality assurance and quality control

3D digitizer is used to determine three-dimensional shape of entire objects or particular parts of particular importance. This measurement result is ideal for controlling the shape of product or optimization of tools and production parameters.

Figure 1. Camera sample
Source: www.wikipedia.org

Depending on the method of analysis and outcomes there are: Control of dimension, shape and position (longitude, distance, diameter, circularity, parallelism, etc.). Comparing the results of digitizing the three-dimensional CAD model provides a complete deviation from the projected area of the product format and in a few million measuring points.

This approach is important for products of complex geometry with free-shaped surfaces, and provides a completely reliable verification forms and detecting the cause of irregularities. Analysis of mutual deviation of two objects and their shapes is conducted with products manufactured on basis of prototype or sample. Both objects are digitized and compared the same as in comparing with CAD model. Overview of mutual deviation form indicates whether the product is similar enough to its original, and enables analyzing the causes of possible errors. Symmetry structures are controlled by digitizing and comparing both sides of the object.

The result of the analysis is the detection of object shape asymmetry and determining the effective line of symmetry. Control of shape before montage allows timely detection and correction of irregularities which would cause problems when installing For example, in the production stage segment of construction and location of the structure where the part should be installed are being measured. Comparison of two measurement results indicate possible irregularities which are easier to correct in the production stage than if it is determined only after the installation. Optimization of production is carried out by constant controlling of product shapes and necessary corrections in tools and parameters of production until the product meets required standards. Quality assurance for serial production is carried out by digitizing and analyzing random samples or periodic check of the tool regularity. Comparison of digitizing results with a CAD model or a prototype is usual..

Product and tools development - design and reversible engineering

The development of new products or tools is often based on existing products or physical models. They need to be reconstructed in one of the CAD system in order to obtain a model suitable for design and preparation of production. This process is called reversible engineering; because it begins with the existing building, rather than make a product based on a blueprint. Simple geometric shapes can easily be defined in a computer based on some simple measurements such as diameters, lengths, etc.

Today's products from the functional, aesthetic and ergonomic point of view are mostly complex shape. These freely defined (curved) surfaces can be accurately reconstructed only on the basis of a large number of measurement points, which are difficult or impossible to measure as much as needed by traditional methods of measurement. The result of digitization are polygonized networks or point clouds (to a few millions of measurement points as needed), shape of contour, characteristic lines or separate counts. These measurement results provide very precise and fast computer reconstruction of the shape, and so reduce development time and increase product quality.

Copying objects

The result of detailed digitizing facility is particularly suitable for making copies. The classic procedure would be to, based on the results of digitization, make CAD model (reversible engineering) implement the necessary finish processing, and using a numerically controlled machine tools make the required copy of the original object. High quality digitized results provide direct copy, without conducting the reconstruction of the CAD model. Using appropriate CAM system, a copy is made directly on polygonized network.

Optimizing processing with particulate

After the process of casting and forging the objects are precisely finally processed into their final shape with separation of particles (e.g. using a CNC milling machine). If 3D digitization establishes the exact form of the raw pieces, the process of routing can be significantly optimized and accelerated in a way to avoid idle running and prevent its collision with the material. Without knowing the exact form of the raw pieces, machine must be programmed with considerably more reserve, resulting in a significantly longer duration of treatment.

Repairs, reconstruction and development of replacement parts

Detailed object digitizing or 3d measuring determines the current situation, analyzes problems, plans repairing or modification. A common problem is the lack of technical documentation, especially the lack of physical CAD model, by which they could easily make any necessary replacement parts. Digitizing and reversible methods of engineering, or copying gives us model replacement parts for original pieces that are worn out.

Analyzing and planning

Computer model of some object is obtained with 3d digitization. It is often used to analyze their own and especially some of competing products. Virtual configuring of circuits in computer is possible and it verifies if the parts fit in entire unit.

Archiving, visualization and presentation

The latest generation of optical measuring methods enables fast, easy and accurate recording of the shapes of different objects. The shape of the object remains stored on the computer for archival purposes (e.g., monuments, dentistry, etc.), or it is used for presentation and visualization, e.g. via the Internet.

Working principle of 3d digitizer

Principle of how is 3d Digitizer working is different accordingly to devices which record object geometry working on different principles.

They are most commonly used to capture the geometry, devices like digital cameras, camera, coordinate measuring machines (CMM) and 3D laser scanner. Accordingly, we distinguish 3 d digitization carried out with optical and mechanical methods. The principle of photogrammetric recording is the following: on the object that is subject to digitalizing, measurement points are lined-up that will accurately describe the respective object (gajeta-Figure 2). These measuring points are called the markers. Then the digital device records object from different positions and the data obtained by recording are processed on a computer.

Software, in digital photos, with high accuracy automatically discovers all the measurement points (the reference markings) visible as bright circles on a dark background. Since it established a position for each point in all recordings where this point appears, software is conducting pre-calibration based on principle of triangulation and optimization of the results with method of equalizing beam rays. The scale recording is determined by reference poles whose length calibrated at room temperature with accuracy of ± 0.01 mm and corrected according to the temperature of the room where the measurement is performed. The final results of this automated analysis are accurate 3d measurement point coordinates in mutual coordinate system.

Figure 3. The position of cameras and markers after shooting
Source: www.wikipedia.org
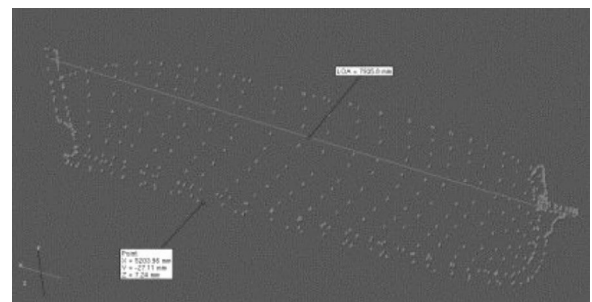
Figure 4. results of photogrammetric measurements
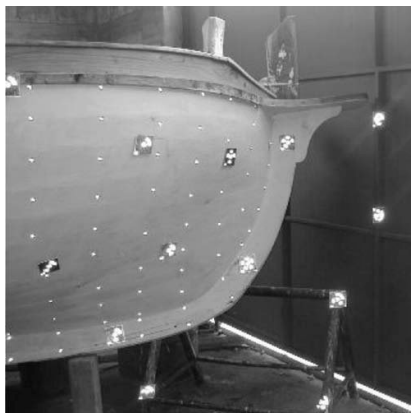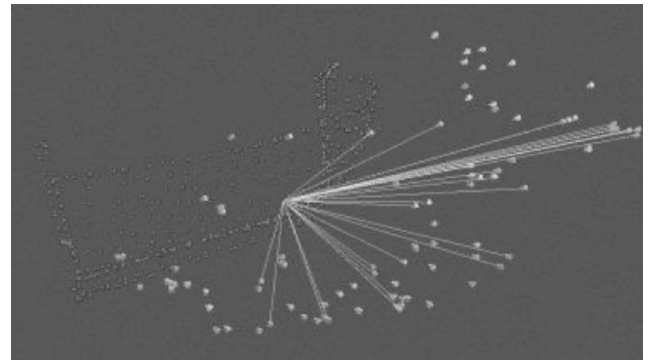source: www.wikipedia.org

Figure 2. Gajeta (ship)
Source: www.wikipedia.org

Figure 3 shows the position of measurement points with Hull gajetas (red circles) and the camera position where they recorded images (yellow). The lines represent the directions of the optical projection of a measuring point through a camera lens in all shooting positions in which this point was visible. The intersection of these lines defines the location of measurement points in space. Such lines are known for all measuring points, but not presented for visibility. After calculating the position of measurement points in space (coordinates X, Y, Z), 3-D shape gajetas became familiar. This enabled determination of its dimensions (e.g. length – figure 4), but also a complete computer reconstruction of the hull.
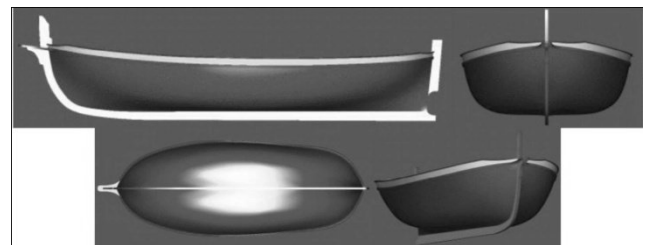

Figure 5. Computational model gajetas obtained on the basis of the photogrammetric measurements
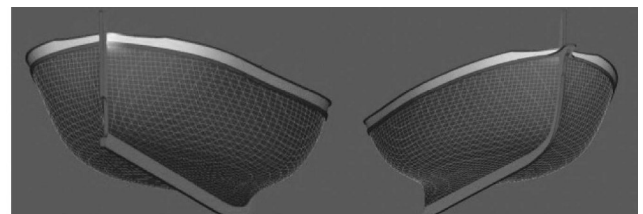source: www.wikipedia.org

Figure 6. The typical intersections of gajeta's hull
source: www.wikipedia.org

Using the results of digitization it is possible to form three-dimensional computer model (figure 6.) and give the characteristic parallel cross-sections in horizontal, longitudinal and transverse plane (Figure 7).

3D digitizing can be applied to large systems such as power plants (Fig. 8), oil rigs (Figure 9), pipelines (Figure 10), etc.

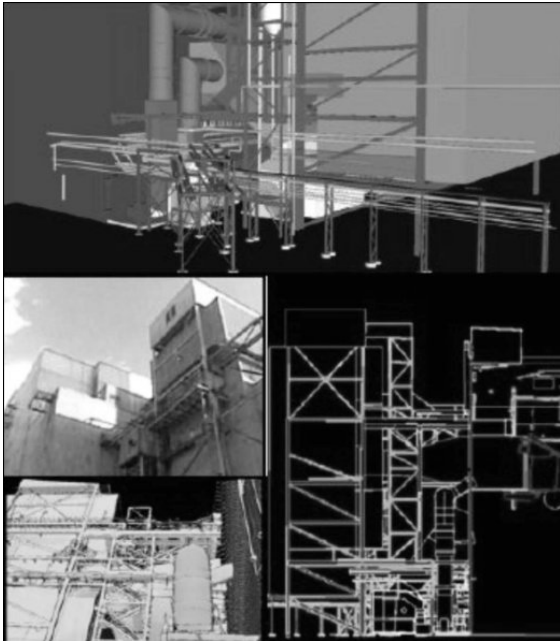The difference in methods of data collection can be seen in the figure below (Figure 10).

Figure 7. Appliance of digitization in recording power plant
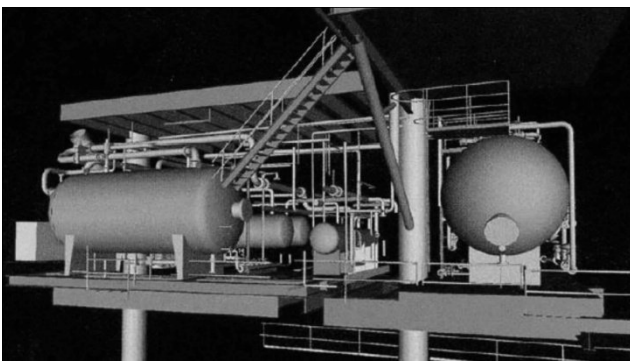source: www.wikipedia.org

Figure 8. Appliance of digitization in recording oil rigs
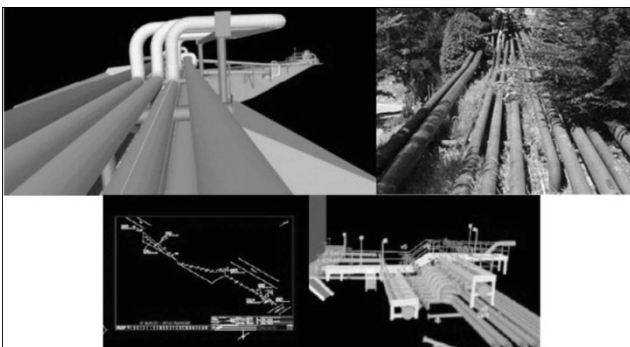source: www.wikipedia.org

Figure 9. Appliance of digitization in recording pipeline systems
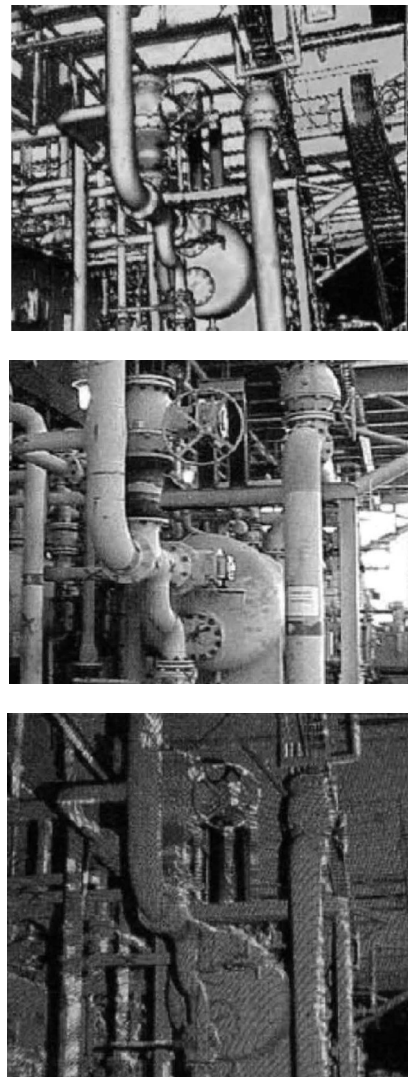source: www.wikipedia.org

Figure 10. Comparison of images obtained by shrink-wrap laser scanning (top), digital photography (center) and laser scanning (bottom)
source: www.wikipedia.org

Some of the systems used for 3d digitization

Each of the systems for the digitization has its own characteristics which differ it from the other systems. The common features could include the following::
• generate STL or CAD data;
• transfer of modified models in CAD;
• creation of management information for production of the NC-milling machines and systems for rapid prototyping;
• nominal / actual comparison of objects and models (CAD models, clouds or STL data points), comparisons of actual with CAD data, drawings and samples;
• quality control e.g. measuring deformation, dimensions and junk;
• rapid collection of data from the surface of the object for modeling on the computer e.g. CAD, FEM analysis, etc.

Some of the systems for 3D scanning are: • ATOS (ATOS, ATOS II, ATOS III) (Advanced TOpometric Sensor), • TRITOP, • 3D GURU, • PHOTOMODELER, • POINT MASTER. ATOS systems are used for recording and include two digital cameras that capture up to 4 million measuring points. Recording from one position lasts approx 10 seconds. When done shooting from all sides of object, data is stacked in one unit and we obtain the cloud of points that can be exported in a CAD model. Reference points to connect the pieces together we obtain using TRITOP system. This is an industrial optical measurement system used for no contact high-precision measurements of 3D coordinates of discrete points of the object. TRITOP system works on principle of photogrammetric recording using a digital camera. Relevant points of the object are marked with a marker and the object is recorded by high resolution camera from different directions. Based on these digital images TRITOP software automatically calculates the 3D coordinates of marked places or object lines. Its main purpose is to generate accurate and absolute reference points of the system in order to complete ATOS measurement.

Figure 13. TRITOP
source: www.wikipedia.org

Accuracy can be affected by temperature, ability of measured object to reflect light, light environment and other factors. 3d guru has an accuracy of ą3mm the measured size of 24m. Resolution is the distance between points in the scanned scene where the scanner can perform the measurements. It is usually defined as the minimum distance horizontally and vertically between the measured points.
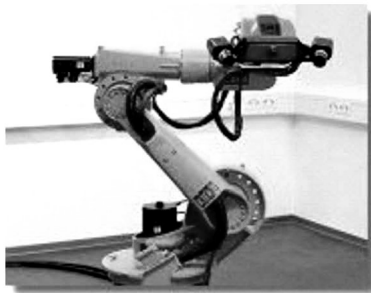

Figure 11. ATOS III
source: www.wikipedia.org

Figure 12. ATOS II
source: www.wikipedia.org

3D GURU uses laser technology to capture dimensional cloud of points. Points of the cloud could be edited, modeled, selected or presented as 3d images with links toward external files, and can be exported in wide range of CAD and 3d software packages. Some of the basic parameters of the scanner are: Accuracy, resolution and scanning speed. The accuracy of the scanner is the difference between the sensor readings and the actual size that is being measured.

Figure 14. 3D GURU
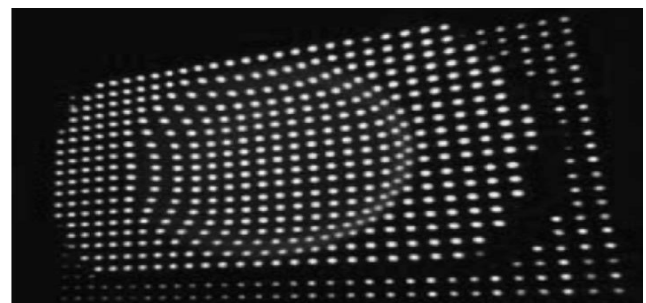source: www.wikipedia.org

Figure 15. 3D GURU
source: www.wikipedia.org

3d GURU offers a resolution of 1.03 mm and the horizontally and vertically while scanning the scene of 20 m.
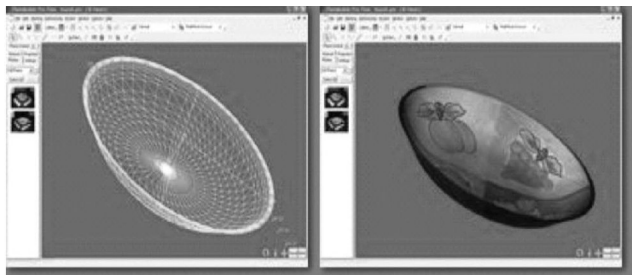
Figure 16. 3D GURU
source: www.wikipedia.org

Laser scanning speed is defined by the number of measurement points that were collected in a given period of time. GURU 3D scanner collects cloud points of 210 000 counts per second. PHOTOMODELER is the software which as input also uses a camera to capture data about the object that contains the markers. Object is recorded from different positions and in Photomodeler the images are being arranged. It is useful in those applications of industrial, scientific or engineering measurements, where the circular markers can be placed or projected on objects that move or change shape. For this purpose, PMV module (photomodeler video) is used.

There are two types of projects that use PMV: 1. when two or more synchronized stationary cameras are placed to capture moving or changing shape over time; 2. When we have one camera that shoots a set of photographs of an object (moving over time) or when the object or scene is not moving or changing shape and second set of photos after the changes occurred. Key tips are as follows: must be 4 or more stationary (fixed) points during the entire recording time and the object or scene have to be stationary over time while taking photos of each time interval.

Conclusion

Extremely important role of techniques and technology today makes much easier many jobs and tasks. Some of such tasks are connected with computer techniques and digitalization (libraries, technical projects,...). It is obvious that once modelled, some object can be easily transferred into other area or technological domain. In this article we point to digitalization of objects with obvious intention to use such technology in sport and kinesiology. Possible situations are connected with learning of sport technique, tactics, modelling of processes, and many other kinesiology fields.

Literature

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DIGITALIZACIJA OBJEKATA

Sažetak

Kompjuterom podržane tehnologije kao što su CAD, CAM, CAE i druge, zahtijevaju efikasnu koordinatnu mjernu tehniku da bi postigle podudaranje numeričkog modela i stvarne komponente. U sustavima u kojima je potrebno u kratkom vremenu obezbjediti visoku tačnost i količinu podataka do izražaja dolazi brzina i fleksibilnost koju pružaju sistemi za 3d digitalizaciju. Ovi sistemi posjeduju velik dijapazon veličina predmeta koje mogu mjeriti (od nekoliko milimetara do nekoliko desetina metara) što im daje veliku prednost u odnosu na druge sustave. Njihova primjena u kineziologiji je samo pitanje dana.

Ključne riječi*: tehnika, digitalizacija, objekti, tehnologija, kineziologija, sport*