

PORTABLE 3D SCANNER IN DESIGNING OF THE PERSONALISED 3D PRINTED MECHANICAL HAND

The study presents the effect of cooperation between SMARTTECH and the e-Nable Foundation (with department in Poland) in the project of designing a personalised hand prosthesis, so-called a 3D printed mechanical hand or an e-Nable hand.

SMARTTECH, one of the leading 3D scanners manufacturers, was asked to join the Foundation's project and to perform 3D scans of the patient's post-operative hand stump. The further step was to design- based on scans- the 3D printed mechanical hand, which would be fully adjusted to the patient's hand stump. 3D scans could shortage the process of hand desining. It was crucial to create a prosthesis that would be matched to the patient's hand stump as well as his lifestyle. The final step included making the e-Nable hand by using 3D printing technology.

CASE STUDY

INTRODUCTION



The aim of this study was to use a Portable 3D scanner from SMARTTECH and 3D printer to design a functional 3D printed mechanical hand prosthesis, which would be fully adjusted to the individual patient. 3D technology could reduce costs and working time, especially compared to the traditional methods.

AN EXAMPLE OF A PRINTED PROSTHESIS ▶ ▶ ▶



Historical view. The first material used for prosthesis was wood considered as widely accessible, but unfortunately easy to destroy. For this reason wood had been soon replaced by metals that made the artificial hand useful to fight. As metal prostheses had been made of bronze or iron they were very heavy and uncomfortable. Thus, in a short period of time these heavy materials had led to impaired blood flow, tissue hypoxia, and as a consequence they contributed to necrosis of damaged organs. Nowadays, carbon fiber or titanium are most frequently used for prosthesis preparation. As they are light and very resistant materials, they can ensure longer life and strength of the prosthesis. Simultaneously, they are considered as enormous expensive and time-consuming in the prosthesis production. The matter of costs is particularly important in young patients who require several different-sized prostheses during their lifetime. As the traditional prosthesis production is expensive and time-consuming, it exceeds the budget of most families. Thus, cheap and easily accessible prostheses for children are particularly important due to the process of getting used to the artificial organ, especially to the feeling and its weight. Otherwise, it is common that people with disabilities will soon resign from the prosthesis in their adulthood. The speed of new habit pattern development is largely determined by the age. Therefore, if the patient did not use the prosthesis in his youth, and received it only in his adulthood, he will not develop the habit of using the prosthesis. The psychological barrier will be stronger than the awareness of benefits from his hand improvement.

New technologies. The development of new 3D technologies is a milestone in medical treatment. People with hand defects, such as the lack of fingers or the entire metacarpus do not have to be socially excluded. Using the non-invasive 3D scanning technology and 3D printing, you can create a fitted prosthesis. This so-called personalized, 3D printed mechanical hand, can be dedicated to specific needs of patients. The artificial 3D hands can be equipped with replaceable tips designed using 3D scans. They are dedicated to various types of work, from working in the garden to manual housework.

Once again, the vision of human mind combined with modern technological solutions have made useful things faster and more efficiently. Indeed, due to optical 3D measurements and printing, medicine can be fully personalized. Since now, working on customized prostheses has been no longer so invasive, expensive and time-consuming. SMARTTECH, the leading manufacturer of 3D scanners, joined the project of 3D printed mechanical hand designing. E-Nable foundation asked for 3D scans of the patient's post-operative stump in order to design well-fitting 3D hand. Below, we present you the first stage of the whole process of creating a personalized hand prosthesis – the 3D scanning process.

SCANNING PROCESS OBTAINING THE GEOMETRY OF THE POST-SURGICAL HAND STUMP



In the first stage the object (patient's post-operative stump) was scanned. For measurement, we used an optical 3D scanner operating in structural light technology- SMARTTECH Portable. The device is not only extraordinary accurate, but also non-invasive and completely safe for the human skin. In addition, it does not cause any discomfort to the patient. Purchased SMARTTECH optical measuring system allows us to obtain precise data in color by projecting stripes of light on the measured object. We used the scanner with a measuring field of 300 x 200 x 210 mm² and an accuracy of 0.06 mm and a detector resolution of 0.23 mm.

Thanks to this, the structure and color of the patient's stump were faithfully reproduced on the scans. Applied accuracy of the scanner also allowed copying even the smallest deformations of the scanning object, which had a direct impact on further stages of designing. The human body is difficult to measure by traditional methods. The non-contact 3D scanning enables precise measurement and perfect adjustment of the prosthesis based on the 3D scans. That kind of prosthesis is precisely matched to the specific irregular shape of the human body or post-operative stump. A single partial measurement lasts only 0.2 seconds, thus moving and live objects can be successfully scanned. We also managed to automate the measurement thanks to the SMARTTECH3Dmeasure software.

As a result of a single scan, a point cloud was obtained (each point is described by X, Y, Z coordinates and RGB color components (Red Green Blue) The cloud was further transformed into a triangle mesh which was used in 3D graphics and then 3D printing. The entire process of scanning took about 30 minutes. Based on series of partial scans, SMARTTECH specialists created a 3D model of hand stump using specialized software SMARTTECH3Dmeasure v2018.



SMARTTECH3D portable

SPEED, PRECISION, LIGHTNESS

SMARTTECH 3D Portable is ultra-fast 3D scanner, which combining the best features of handheld and stationary measurement devices. It's not only portable but also performs instant color measurements with certified accuracy.

The measurement is based on analysis of deflection in series of striped patterns projected onto the object. Lines which are parallel on a flat surface, become deflected on a scanned object according to the object's shape. The deflection is recorded and converted by an algorithm that creates the point cloud mentioned before. Measuring the object from all sides requires carrying out a few measurements or using a numerical control rotary table. Each point in the cloud is given a colour value (R, G, B) directly from an image captured during the measurements. This photograph is also used as a structure of a 3D object created afterwards.

Ultra-fast measurement in medicine

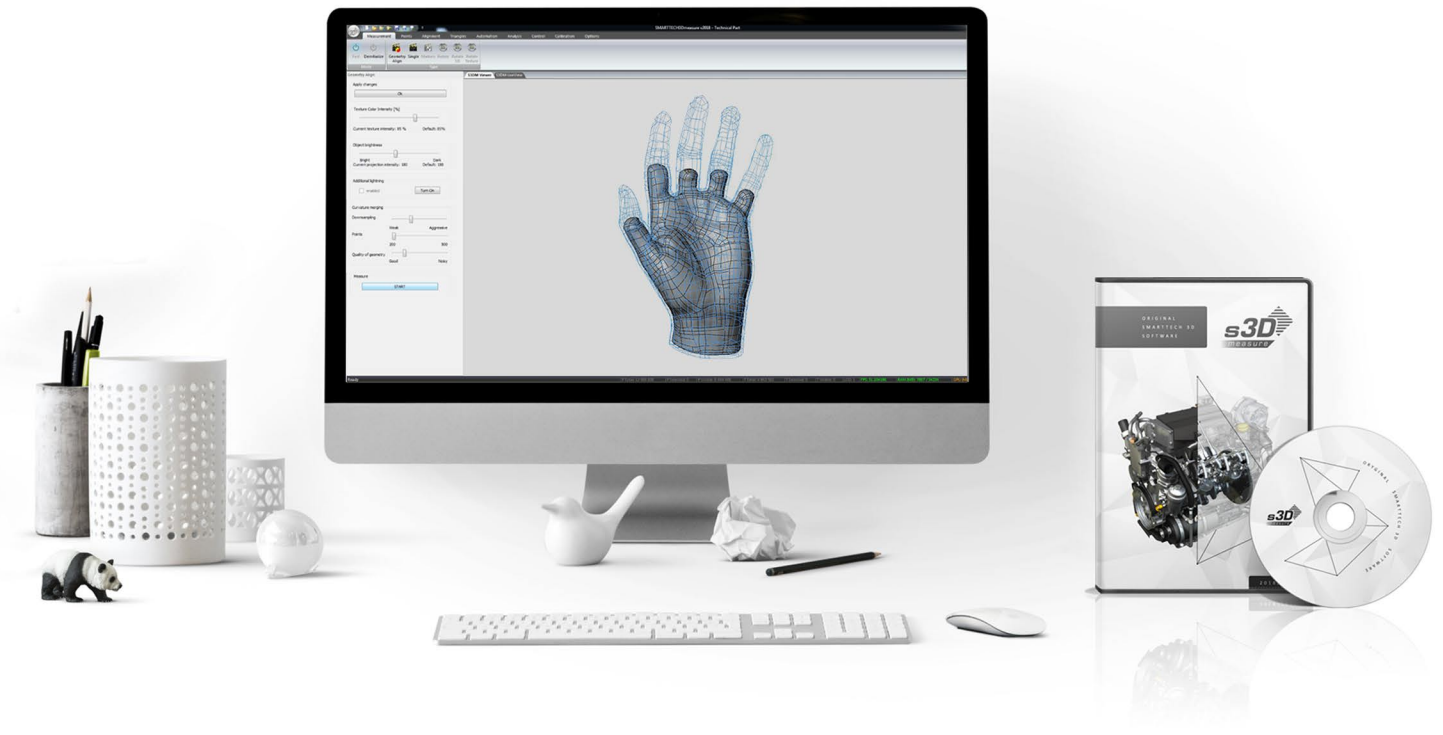
SMARTTECH 3D Portable can be successfully used directly in the doctor's office to scan the face and other parts of the patient's body. The duration of a single measurement does not exceed 0.2 seconds, allowing to quickly prepare a precise virtual patient model. It is one of the fastest 3D scanners for medical applications on the market with such a high accuracy (0.06mm).

Color measurement also allows to keep information about skin lesions. This is particularly useful for verifying whether the treatment is effective. Measurements allow to track the size of the wound and estimate the effectiveness of the treatment.

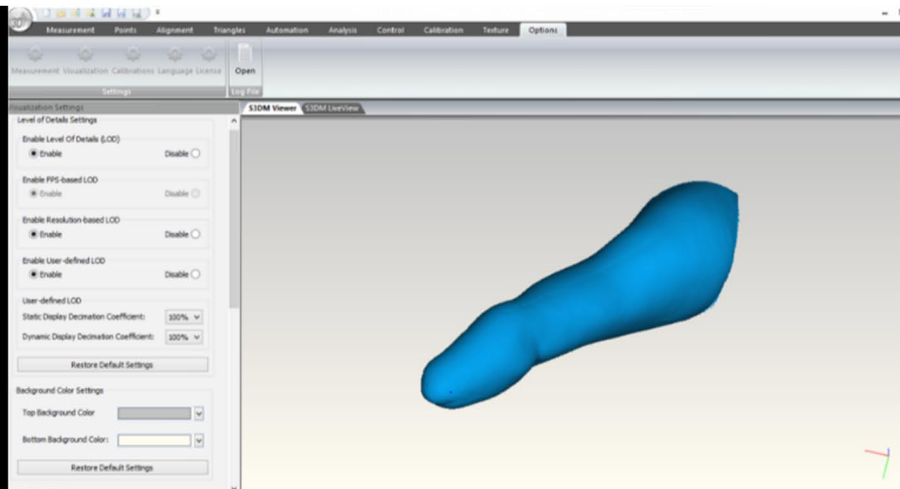
Certified accuracy. SMARTTECH 3D portable combine mobility with metrologically-certified accuracy.

The software. With every 3D scanner SMARTTECH provides specialized multifunctional software with very intuitive interface – SMARTTECH3Dmeasure.

DATA PROCESSING IN SMARTTECH3DMEASURE V2018



SMARTTECH3Dmeasure v2018 program (window view) with a complete CAD model of patient's post-operative stump



The **SMARTTECH3Dmeasure Portable** software is used to control the 3D scanner. The measurement results are displayed as point clouds. Individual partial scans were fitted to each other, and then a triangle mesh was obtained. The option of choosing the Automated Mode to the triangle mesh in STL format minimizes user involvement and accelerates post-processing.

The editing module of SMARTTECH3Dmeasure v2018 software made it possible to create a complete 3D model of hand stump. Moreover, the control module of the software made it possible not only to analyze cross-section of the stump, but also to calculate the volume or surface area. The final result of this stage is the file in STL format, which is fully compatible with all 3D printers available on the market. Based on the created 3D model of hand stump, e-Nable volunteers had the great opportunity to design 3D printed mechanical hand prosthesis. Finally, the model was printed in separated parts on the 3D printer and composed in the final artificial 3D hand.

SUMMARY OF THE PROJECT



The personalized 3D printed mechanical hand is the result of volunteers work. The e-Nable volunteers were supported by the SMARTTECH Company, which performed 3D scans and made precise measurements of the patient's post-operative stump. This stage of the project significantly reduced the time and costs of the whole process of creating the prosthesis. In the end, a personalized 3D hand was printed (3D printer) using plastic, an inexpensive and lightweight material suitable for artificial hands.

The cooperation between the e-Nable Foundation and the SMARTTECH improved the 3D printed hand designing process, including the improvement of the artificial hand quality, time and costs reduction. **Most of all, we successfully managed to restore the efficiency of the patient's hand. Without a doubt, the combination of two different 3D techniques - scanning and printing - is a very promising direction in medicine.** The 3D technology gives new possibilities to create inexpensive and useful prostheses, designed with all anatomical features of a single dysfunction and individual patient requirements. Thus, the designed 3D hand is dedicated to one particular patient. The prosthesis, designing based on a precisely dimensioned virtual model of the post-surgical stump, is more comfortable to use.

The form of digital 3D measurement and design is not limited only to archiving objects, it also creates their virtual replicas, and thus – de facto – a completely new quality. An important issue related to creating replicas of objects is the accurate representation of shape and color to make the copy indistinguishable from the original. You can simply measure the object, prepare a 3D documentation or create a completely new virtual model based on 3D scans. In this situation it is no wonder that the key issue is the accurate mapping of the original shape and color onto the copy. Thanks to the possibilities of interference (3D modeling) in the structure of the object's model, the nonexistent or missing elements can be designed. The most efficient and inexpensive way to do the 3D printed mechanical hand is to make an imprint in a plastic material as the e-Nable Foundation does.

The results of 3D scanning are characterized by metrological accuracy and high resolution. These parameters in combination with the editing and analysis functions in the SMARTTECH3Dmeasure control software give many new possibilities. 3D scanning technology is a promising alternative to traditional, expensive and time-consuming methods of designing dentures. From scanning to the final result (a triangle mesh), we need a few minutes. It depends on the size of the object and the number of individual scans that we perform. The scanner application is fast, precise and provides non-contact measurement as well as, at the further stage, a possibility of computer adjustment and 3D modeling without the need of processing in the real object.

Scanning with the use of non-contact 3D scanners from SMARTTECH parts of the human body and even the whole body is becoming more and more widespread today and is used for various purposes, most often in order to create customized and functional products that improve our comfort of life. Undoubtedly, this multiplicity and variety of uses locates 3D scanning on the top of the list of methods for obtaining and storing information about objects. It appears that once it is popularized it will become an important tool in researches and medical practice.

ABOUT OUR PROJECT

PARTNERS

SMARTTECH is a leading global manufacturer of professional grade 3D scanning solutions for the rapid digitizing of customized products utilizing its proprietary consumables across a variety of markets. Established as a spin of company on Warsaw University of Technology under the leadership of Prof Małgorzata Kujawińska in 2000, SMARTTECH has been constantly developing it's 3D scanning technologies based on structured LED light.

Read more at <http://smarttech3dscanner.com>



The department of e-Nable Foundation in Poland was established in September 2016. After the foundation had obtained an approval of the international e-Nable Community, it was added to the official list of global e-Nable volunteers. Now it is so-called as the e-Nable Poland. The main goal of foundation interests is to promote the idea of creating personalised 3D printed e-Nable hands with the strong cooperation of volunteers and a number of cooperating companies.

Read more at www.e-nable.pl