Author
Féry, Corentin (Muttenz CH) | MSc
University of Applied Sciences and Arts Northwestern Switzerland - School of Life Sciences, Institute for Medical Engineering and Medical Informatics

Title
A smart textile as an alternative to plaster molding

Coauthors
Nicolas H, Schumacher R, Ruepp T, Pascal J

Summary
Plaster cast is a method used to design orthoses and prostheses. In this way a patient specific negative model is obtained. However, this process is wet, inaccurate and time consuming. This work presents a smart textile to digitize limb shapes. This new process is clean, versatile, and more precise.

Introduction/ basics
Digitizing the plaster mold liner with an optical scanner is a widely used technique to design orthoses and prostheses. A direct optical scan of body parts without using any plaster is also common practice. Unlike plaster molding, it does not allow correcting manually the limb position since the hands of the orthopedist prevent to have the required line of sight. A prosthesis or orthosis must fit the patient to avoid discomfort or even skin complications. To obtain the perfect fit, using plaster casting, it is often needed to perform several design iterations as described in Fig. 1. Each iteration represents up to four hours [1]. In this work we propose a digital scanning method, which enables haptic feedback to adapt the model according to the orthopedists experience. The acquired shape is accurate and can be obtained with a single acquisition within few seconds. As lower limbs represent more than 75% of orthoses and prostheses, this study addresses a foot shape.

Material method; implementation/ process
Fig. 2 describes the process to obtain a foot shape. Any other limb could be digitized using the same method. The patient wears a reusable, washable textile. The textile integrates a network of hundreds of magnetic sensor chips whereas an external magnetic source, located underneath the patient, generates a weak magnetic field. Each sensor in the textile measures a

unique field value which is related to its position. An algorithm uses this relationship to calculate a point cloud, which is then interpolated and filtered. Eventually a STL file of the 3D limb shape is provided. This patented technique [2] avoids material distortion and shrinkage of molding material. Unlike optical scanner this system does not require any line of sight since the human body is transparent for magnetic fields. The STL file can be used by the orthopedist like any other STL file he commonly uses within his favorite computer aided design software.

Results

The estimated duration of a single session with a patient necessary to digitize a foot shape using plaster is between 15 and 25 minutes. This process performed with the proposed smart textile does not last more than 10 minutes. Durations include cleaning time, care and placement of the plaster or textile. As the STL data does not need to be reworked, the average time to obtain a STL file, which is ready for use to design an orthosis or a prothesis, is 25 minutes with the smart textile. With synthetic plaster this average time is estimated to 80 minutes.

The presented system exhibits a mean absolute error of 2.5 mm with a standard deviation of 2.2 mm. This preliminary result was obtained comparing the STL file provided by the system with the reference STL file obtained with an optical scanner [3]. This characterization was performed on a 3D printed foot, which was printed from the reference STL file. A visual superimposition between the reference shape acquired with the optical scanner and the shape obtained with the presented system is shown in Fig. 3.

A user interface has been created to easily launch an acquisition, visualize the obtained shapes, and to save them in STL format. The refresh rate of the system allows one to generate a new STL file after ten seconds.

Discussion/ conclusion; conclusion for the practice

The presented system implementing a smart textile can possibly replace all cases where the use of a plaster cast and its optical digitization is required. Thus, this technology allows the orthopedist to save time and to increase the design precision and finally the patient comfort. The modeling of the limb shape is quicker and more accurate with the presented system. Besides, the indirect costs for the society of having patients not wearing their non-fitting orthosis can also be reduced. The societal goals are the improvement of patients' quality of life and mobility, as well as their integration into society. It improves patient wellbeing reducing their time spent in orthopedic practices. It also reduces the risk of complications such as dermatitis, joint pain, and injury.

The next steps are to make the acquisition system faster with a target of refreshing the shapes every three seconds, to make the textile reusable 50 times, and to lower its residual error to 1 mm absolute error. Eventually, tests on volunteer patients will be carried out to evaluate their satisfaction with the proposed plaster-free design of orthoses and prostheses. The feedback from the orthopedists involved in these first tests will also be crucial to improve the final development of the system.

References

[1] C. Mavroidis et al., “Patient specific ankle-foot orthoses using rapid prototyping,” J. NeuroEngineering Rehabil., vol. 8, no. 1, pp. 1–11, Dec. 2011, doi: 10.1186/1743-0003-8-1.

[2] T. Ruepp, J. Pascal, and R. Schumacher, “SYSTEM UND VERFAHREN ZUR ERFASSUNG EINER OBERFLÄCHENFORM AM MENSCHLICHEN ODER TIERISCHEN KÖRPER,” 01532/19.

[3] “O&P Scan,” Rodin4D. http://rodin4d.com/en/Products/acquisition/rodin4d-3d-scanners/oand-p-3d-scanner (accessed Apr. 23, 2020).

Image: Figure 1_122.png

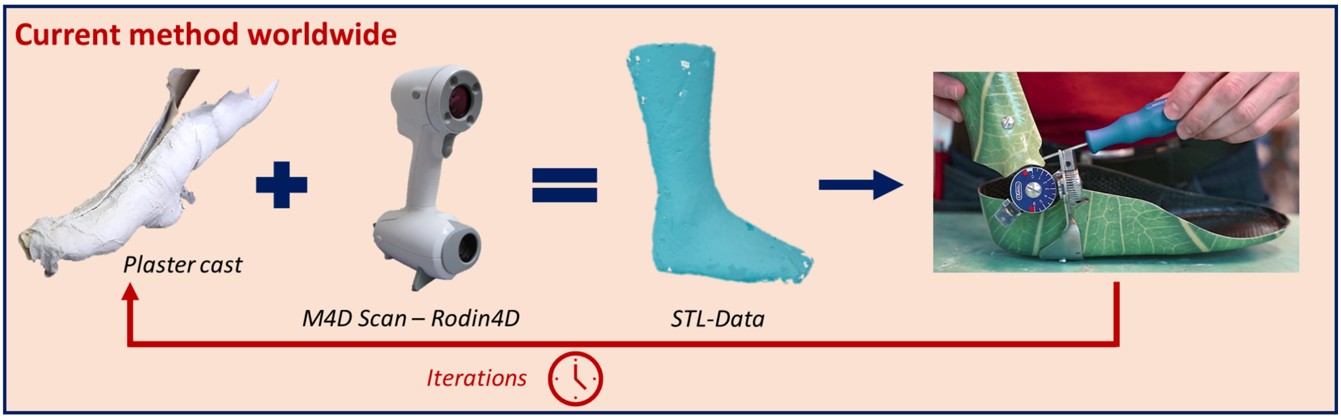

Image: Figure 2_123.png

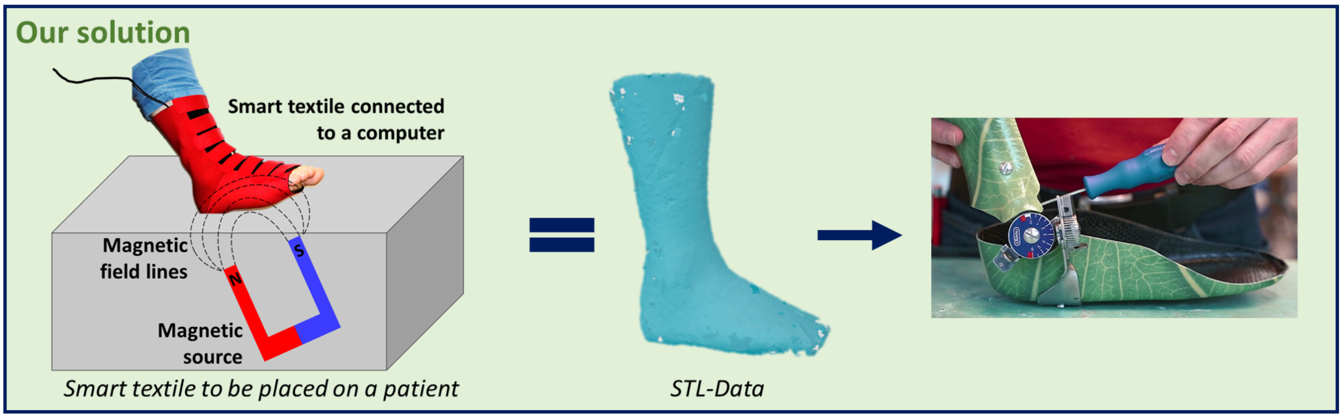

Image: Figure 3_124.png