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ICT

# FOOTWORK

**Automation and innovation for quality assurance in choice, design and fabrication of orthopedic shoes and corrective insoles**

**Nearly 200 million Europeans suffer from restrictive foot or ankle pain. Fortunately, orthoses offer pain relief: from orthopedic shoes and insoles to ankle-foot orthoses (or AFOs). The current production process of these orthoses is however very labor intensive and leads to variable end results. It often relies on plaster moulds and manual corrections, or in the best (digital) case scenario on virtual modelling, milling and vacuum forming. Ultimately, the quality of every orthotic device also depends on the technician who makes it.**

"In the context of FOOTWORK, the project consortium wanted to develop an automated digital orthotics workflow consisting of digital patient measurement, computer-aided analysis, 3D modeling and digital fabrication of the orthoses," says Toon Huysmans, Research Lead of the FOOTWORK project. "The aim was to apply, for the first time ever, a data-driven methodology using statistical foot models at each stage of the orthotics development. By developing such an automated digital process, the FOOTWORK project can strongly increase the efficiency and reliability of the orthotics workflow thereby ensuring the quality of the orthopedic shoes and corrective insoles."

## THE OUTCOMES

### 1. A modular scan setup able to handle different scanning needs in a cost-efficient and accurate way

As part of the FOOTWORK project, the team has explored various cost-efficient and accurate scanning setups. This resulted in a modular setup that can handle different scanning needs – depending on the foot pathology. Fien Burg, Project Lead: "This allows us to measure different regions of interest, e.g. the foot (for developing lasts or insoles) or the foot and lower leg (for developing ankle-foot orthoses). The setup includes dynamic plantar pressure measurement and 3D scanning techniques; and acquisition protocols have been designed for both static and dynamic 3D scans."

For the dynamic scans, where simultaneous capture from multiple viewpoints is required, an innovative watermarking procedure allows the team to automatically choose the most optimal reconstruction technique for each part of the scanned foot. This hybrid method results in higher accuracy and completeness of the dynamic scans and is the first of its kind. For the plantar pressure measurements, a new analysis technique was developed that allows analyzing the plantar pressure video in full, without reducing the measurement data and as such loosing relevant information.

### 2. Innovative digital techniques to (1) detect the pathology (by using statistical foot models) and (2) provide design criteria for the orthoses (by using artificial intelligence)

An automated digital method has been introduced for detecting shape abnormalities in feet. The new data-driven approach will be useful in the medical diagnosis of foot pathologies and in automated orthotic design – a world first.

Toon Huysmans: "First, we created a 3D statistical healthy foot model and quantified normal variation – based on a large database of dynamic plantar pressure measurements and 3D scans of healthy individuals. The measurement data of new, potentially pathologic individuals can then be compared to this healthy foot model and significant deviations can be marked. These deviations can provide objective insights in abnormalities to the clinician. Second, the 'abnormality' information is used as input for a supervised artificial intelligence (AI) framework (neural networks). This framework allows building a 3D model of the orthoses (insoles and lasts) and automatically estimating the design parameters."

### 3. New techniques for 3D printing of lasts and ankle-foot orthoses (AFOs)

While 3D printing is emerging as a technology for fabricating insoles, lasts and AFOs are currently manually created in labor intensive processes. With the proposed automated design process, the opportunity also raises to digitally fabricate these more complex orthoses. As part of the FOOTWORK project, a unique concept was developed for a 3D printed custom last that can withstand all the forces (pressure, heat or nails) at play during the subsequent production process of the shoe. For AFOs, the proposed automated digital workflow has been tuned to the needs of a specific ankle-foot pathology (i.e. foot drop), and a partially automated workflow was developed for designing and printing the AFOs.

# NEXT STEPS

Fien Burg: "We are currently preparing the integration of the workflow in a cloud-based platform that will improve the collaboration between clinicians, researchers and retailers. This collaborative platform will lift the traditional processes to a level that ensures consistency in quality of the overall process. The platform will also increase the number of data sets, allowing us to improve the developed statistical foot models, which today give us about 70% accuracy in pathology detection."

Research-wise, the statistical techniques will be further improved in a follow up project (a Marie Curie Individual Fellowship), focusing on the personalization of the reference models.

FOOTWORK project partners:

de prêtre orthopedie n.v. | runners' lab | phits | rs scan

AGENTSCHAP INNOVEREN & ONDERNEMEN | Vlaanderen is ondernemen

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# FACTS

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| NAME | FOOTWORK |
| OBJECTIVE | Automating the digital production process of foot and ankle orthoses to improve the process efficiency and reliability and to enhance product quality. |
| TECHNOLOGIES USED | artificial intelligence and neural networks, statistical modelling, 3D scanning, stereo photogrammetry, dynamic plantar pressure measurement techniques, 3D printing |
| TYPE | imec.icon project |
| DURATION | 01/10/2015 – 30/09/2017 |
| PROJECT LEAD | Fien Burg, RS Scan International |
| RESEARCH LEAD | Toon Huysmans,<br>Vision Lab, an imec research group at the University of Antwerp |
| BUDGET | 1,859,674 euro |
| PROJECT PARTNERS | Orthopedie De Prêtre, RSLab, RSPrint, RS Scan International |
| IMEC RESEARCH GROUPS | PSI, an imec research group at KU Leuven<br>Vision Lab, an imec research group at the University of Antwerp |

WHAT IS AN

## IMEC.ICON PROJECT?

The imec.icon research program equals demand-driven, cooperative research. The driving force behind imec.icon projects are multidisciplinary teams of imec researchers, industry partners and / or social-profit organizations. Together, they lay the foundation of digital solutions which find their way into the product portfolios of the participating partners.

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