# Modular Course B: Creative Design in shoe Industry

# Unit B2 – Computational tools and prototyping

## Lecture LB2.4 – Foot Scanning / Foot Pressures Mapping / Fit Analysis

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T2.2 – Development of modular courses and training material.

D2.2 – Modular Course in Creative Design

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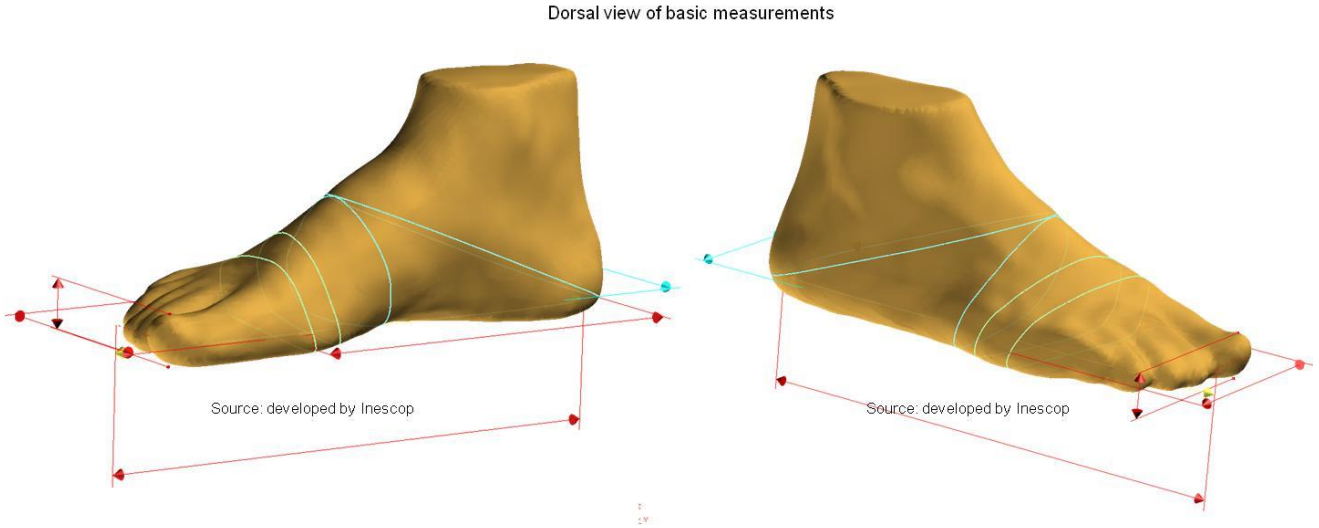
# Introduction

- Our body as a locomotive system fulfills the necessary functions to be able to move from one place to another by walking, running, jumping, etc.
- The feet are of special importance.
- When we put on shoes, we totally change the physiology and morphology of our feet.
- Different shapes of the feet in each person is a great challenge for the construction of correct lasts and shoes, and their relationship with comfort.

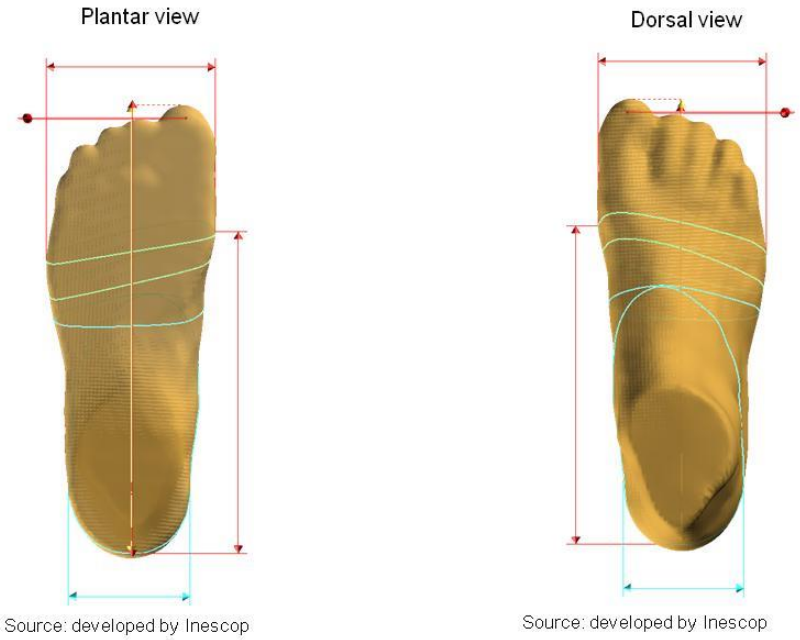
Our feet are not identical
Source: INESCOP

Footwear is completely symmetrical
Source: INESCOP

# Foot measurements

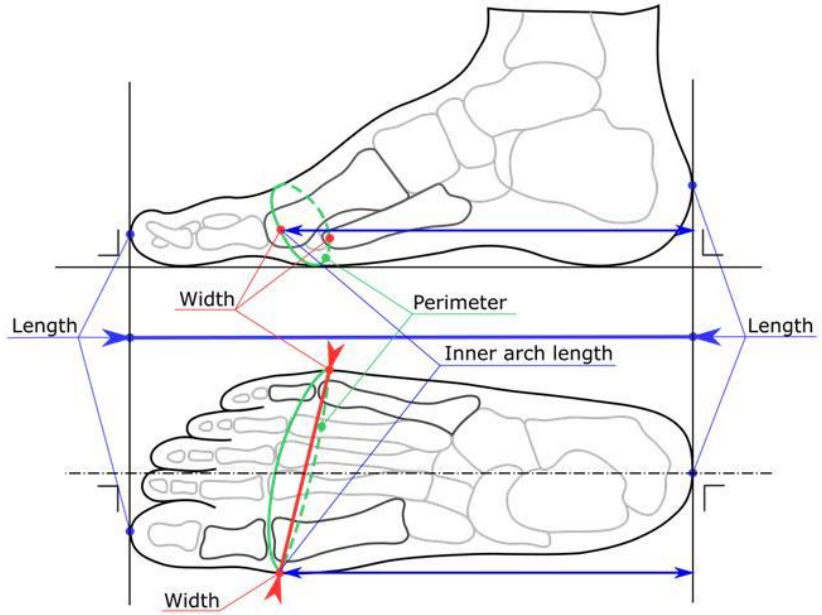



*Dorsal view of basic measurements*



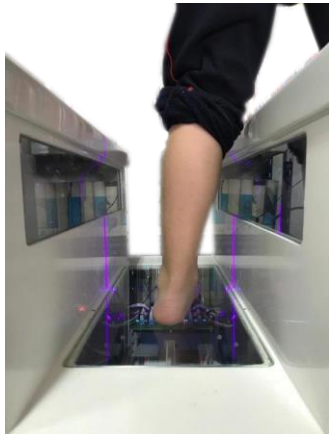

*Plantar and dorsal view of the most relevant measurements*

# Foot measurements

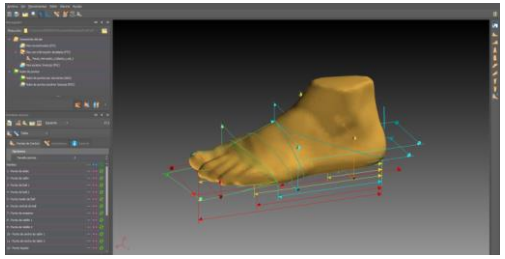



*Basic measurements in order to design a last and achieve good fit*
*Source: https://en.wikipedia.org/wiki/Shoe_size modified by INESCOP*

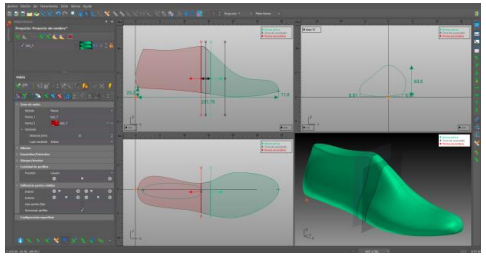
# Methodologies and computational tools

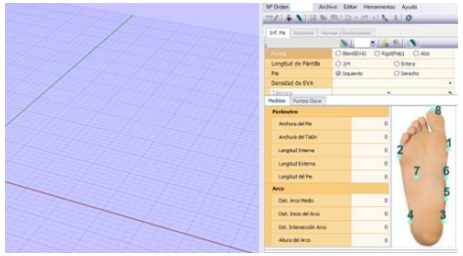

*Laser digitiser for 3D capture. Source: INESCOP*



*Foot measurements*
*Source: INESCOP*



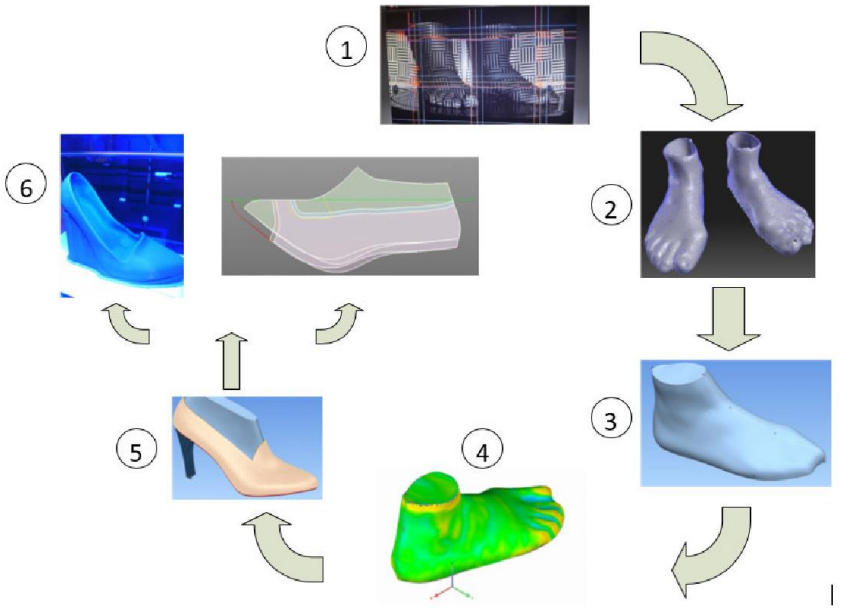
*Last design*
*Source: INESCOP*



*Insole design*
*Source: INESCOP*

# Methodologies and computational tools

- 3D digitized technologies allow:
  1. 3D foot scanning
  2. Design of a 3D foot model
  3. Conversion into a 3D point cloud of coordinates of the foot model
  4. Comparison of the generated 3D digitized foot model with the actual scanned foot,
  5. Shoe design
  6. Different options for the production of customized or more demanding footwear.




Digitized process of 3D foot scanning, footwear construction and manufacturing
Source: Baksa S., et al. 2019.

# 3D Foot Scanning

- 3D surface scanning has been used since the mid-1990s,
  - recently has statistical shape modeling been used using sophisticated morphometric and multivariate statistical analysis techniques to identify distinct foot types from 3D shape data.
  - Allow the separation of foot shape from the overall size of the object using rich 3D data
    - identify features that cannot be measured using predefined 2D measurements.
- The ability to differentiate foot shape according to gender, age, ethnicity, and pathology has practical applications for footwear design from a structural and functional perspective.

# 3D Foot Scanning

- The capture of a 3D model of the foot has been achieved through a variety of methods since its inception.
- Types of 3D scanning systems vary:
  - use of stereophotogrammetry - multiple photographs from different angles
  - structured light systems - patterns projected onto the object
  - laser scanning - laser repeatedly projected onto a surface while camera and a computer system acquire the 3D data.
- Early scanning equipment involved the use of a projector in conjunction with a charged device.
- Smartphone cameras, digitizers, RealSense depth cameras, and height-adjustable pins have been used to generate 3D foot data
- A wide range of laser scanners are now available.

# 3D Scanner specifications

- Accuracy: acquisition of “rich” foot shape data to extract 3D foot features.
- Resolution: width x height (pixels), megapixels (width x height divided by 1 million), or total point clouds at intervals per foot length section (mm).
- Acquisition time: important specification, as distortion of shape data can be minimized with faster acquisition speeds.

# Scanning systems

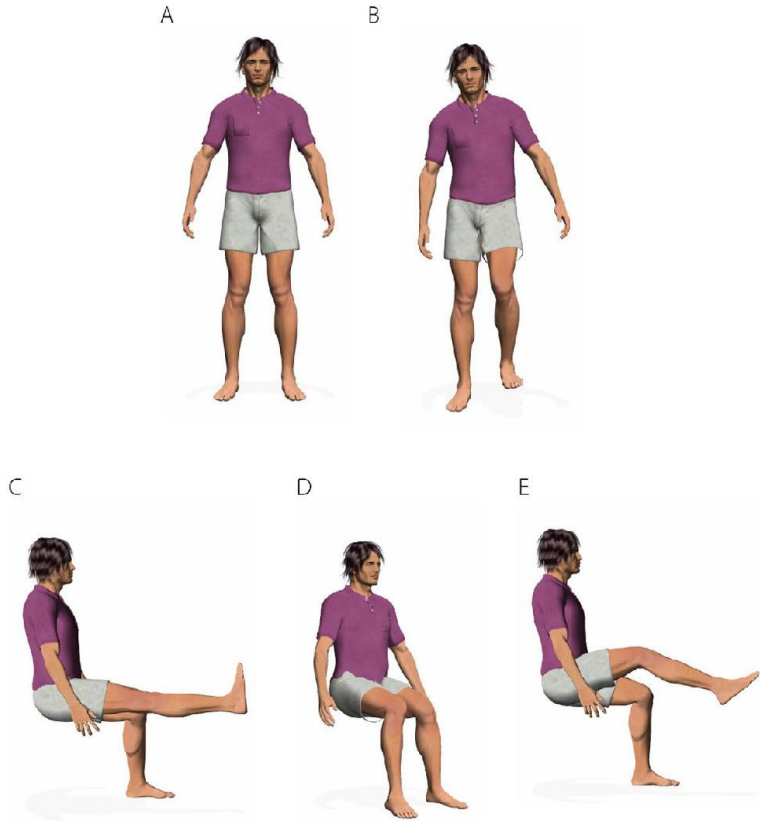
- **INFOOT USB** scanning system (IFU-S-01, I-Ware Laboratory Co., Ltd, Japan)
- **YETI** foot scanner (Vorum Research Corporation, Canada)
- **Microsoft® Kinect**
- **3D easy-foot-scan** (Ortho- Baltic, Kaunas, Lithuania)
- **FotoScan 3D scanner** (Precision 3D Limited, United Kingdom)
- **FootIn3D** (Elinvision, Lithuania)
- **FootSABA** (Ph.D. Sarajko Baksa)

*INFOOT USB scanning system.*
*Source: Allan, J. J., et al., 2023*

*"FootSABA" scanning*
*Source: Baksa S., et al. 2019.*

# 3D foot scanning postures

- Diagrammatic representations of the most frequently reported 3D foot scanning postures, are:
  - A: half-weightbearing (bipedal)
  - B: fully weightbearing (unipedal)
  - C: non-weightbearing
  - D: partial weightbearing (seated)
  - E: partial weightbearing, seated, inclined plane




*Diagrammatic representations of the most frequently reported 3D foot scanning postures. Source: Allan, J. J., et al., 2023*

# Plantar Pressure systems (Foot)

- Foot plantar pressure distributions have attracted considerable attention in biomedical and sport related applications.
- Receiving and recording plantar pressures of the foot, in real time, that do not expose the person to radiation and do not create discomfort and pain.
- Typical applications are:
  - footwear design
  - sports performance analysis and injury prevention
  - improvement in balance control
  - diagnosing disease
  - human identification
  - Biometric
  - monitoring posture allocation
  - rehabilitation support systems

# Plantar Pressure systems

- Vary in sensor configuration to meet different application requirements
- Configuration type is:
  - pressure distribution platforms, imaging technologies with sophisticated image processing software and in-shoe systems.
- The key requirements for that systems are spatial resolution, sampling frequency, accuracy, sensitivity and calibration.
- Current technology devices are divided into two main categories:
  - platforms (flat surfaces)
  - portable, wearable devices

# Plantar Pressure Platforms

- Platform or plate devices have a surface on which the user can stand, walk and perform activities.
  - The user is in contact with the platform surface, barefoot.
  - Suitable surface size for one or two feet.
  - Placed in special gait cycle measurement laboratories in synergy with other sensors.

*MobileMat, Tekscan*

*Strideway System, Tekscan*

# Plantar Pressure Wearable devices

- In wearable devices, the results are obtained from a sensor system that has the form of a flat sole and is placed between the foot and the sole of the shoes.
  - Portable devices provide great freedom of movement outside the laboratory, even outdoors.
  - Plantar pressure measurements during dynamic movements: walking, running, jumping.

*F-Scan GO System, Tekscan*

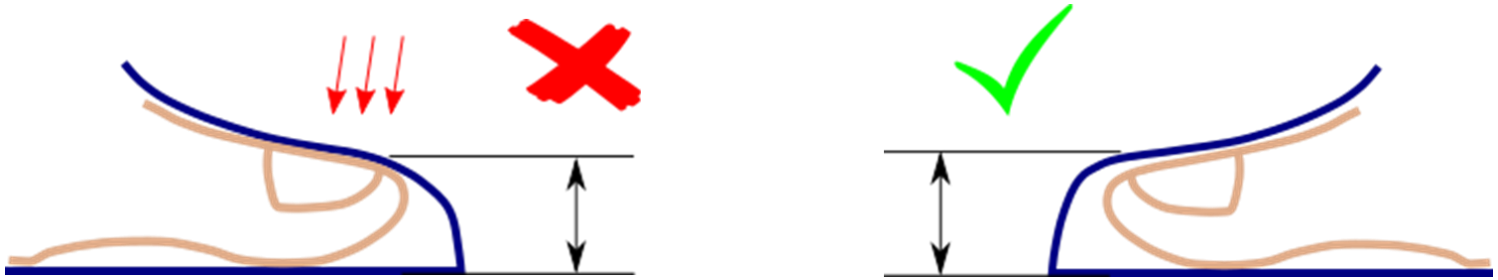

*An in-shoe based foot plantar pressure sensor by Pedar© Novel*

# Footwear fit analysis

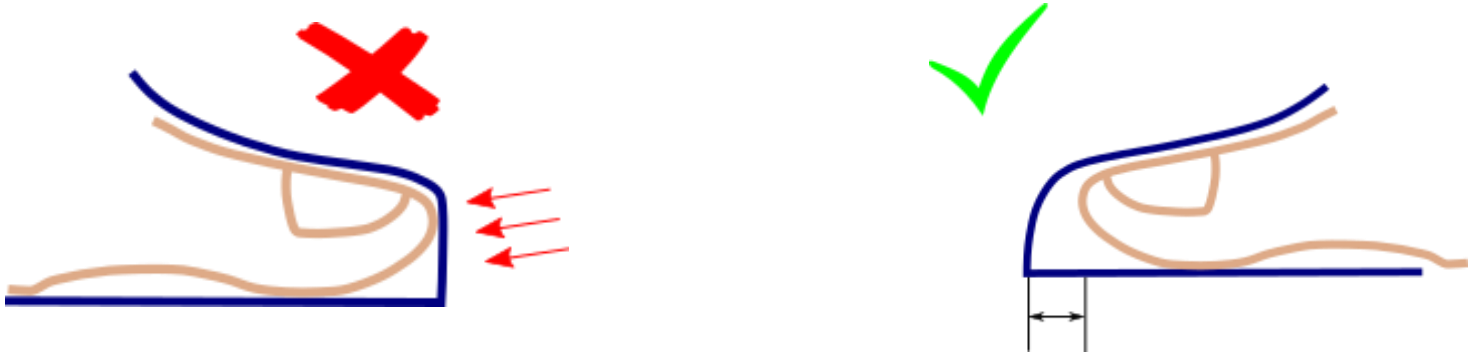
- Fitting is defined as the adjustment of the shoe to the foot.
- A good fit is the one that does not generate any type of pathology.
- The morphology of the foot undergoes dynamic changes during walking.
- These changes are least apparent when wearing high-heeled footwear, typically require a rigid structural design
- In contrast, athletic footwear is generally much more flexible.


*Foot morphology changes as you walk Source: Developed by INESCOP*

# Footwear fit analysis

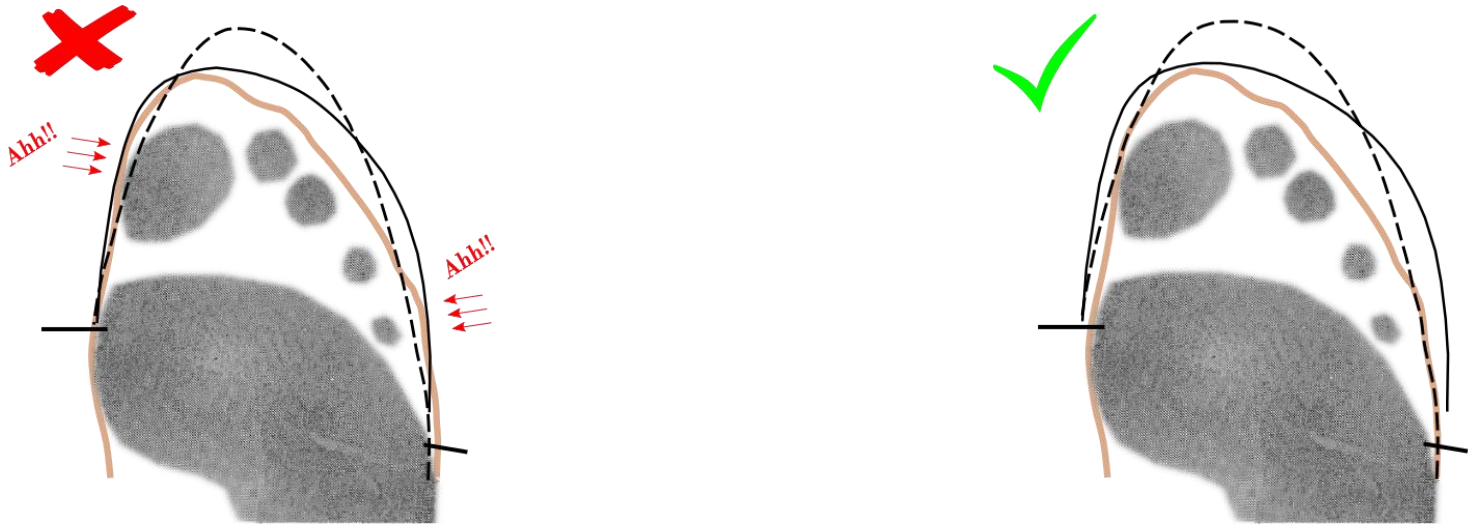


The toe area is one of the most sensitive and vulnerable parts of the shoe. Adequate last depth is essential.  Source: Developed by INESCOP



*Depending on the toe shape, a space should be left in front of the toes to ensure a good fit.*
Source: Developed by INESCOP

# Footwear fit analysis




*The correct width of the sole avoids injuries to the foot, particularly to the toes, which are very exposed*
*Source: Developed by INESCOP*

# Questions

- Who are the steps for a 3d design customized footwear?
- Classified foot measures into longitudinal, transversal, height and girth measures. **True or False**
- Lasts are not the base on which the footwear is manufactured. **True or False**
- The measurement of height of the first toe (big toe) is very important for a comfortable fit. **True or False**
- Static conditions are when standing and dynamic conditions when walking or running. **True or False**
- When the foot is weight-bearing when the parameters really change and when the foot is in motion especially morphological changes occur. **True or False**
- Measurement platforms are systems for receiving and recording plantar pressures of the foot. **True or False**
- Fitting is defined as the adjustment of the shoe to the foot, that does not generate any type of pathology. **True or False**

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