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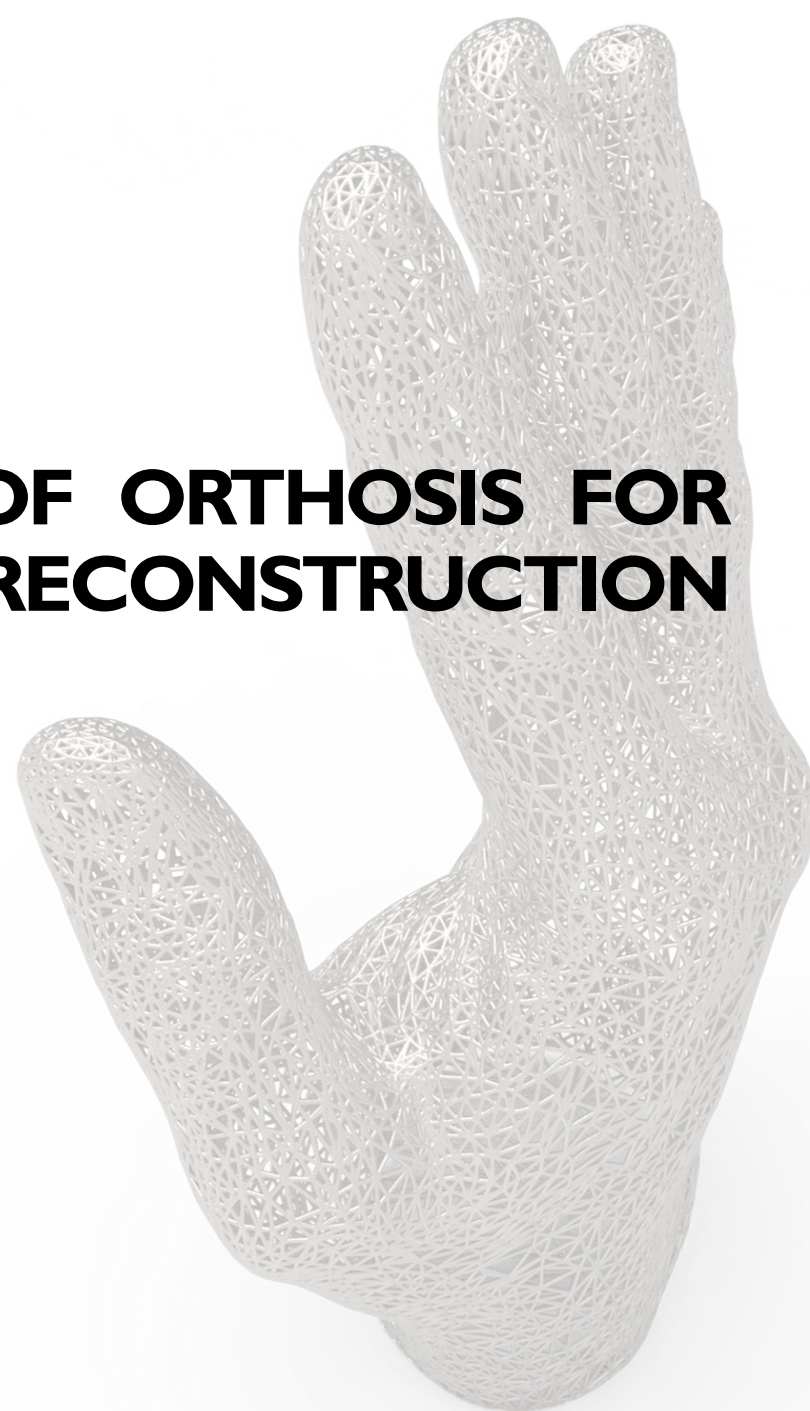
**DIEF**  
DIPARTIMENTO  
DI INGEGNERIA  
INDUSTRIALE

October 17th–18th, 2022

# DESIGN AND MANUFACTURING OF ORTHOSIS FOR PEDIATRIC PATIENS THROUGH 3D RECONSTRUCTION TECHNIQUES AND AM

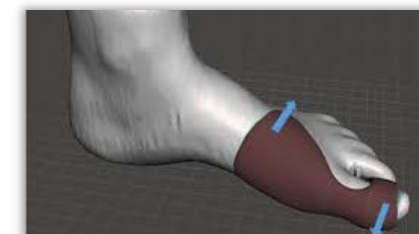
Giulia Pascoletti

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# INTRODUCTION

Orthopaedic rehabilitation with orthoses requires devices to be able to **faithfully replicate the actual morphology** of patients



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Orthopaedic rehabilitation with orthoses requires devices to be able to **faithfully replicate the actual morphology** of patients

## Classical approach

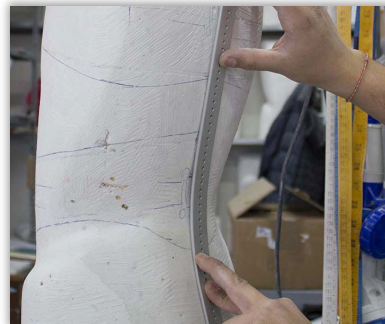
Plaster moulds directly taken on the patient



Positive plaster model of the region of interest



Orthosis design



Thermoforming process for orthosis manufacturing



# INTRODUCTION

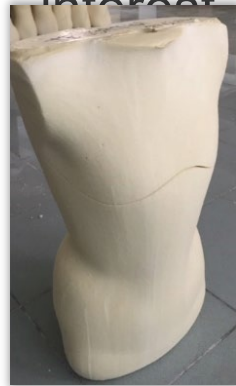
- × Invasiveness
  - × Patient still during curing time
  - × Limited accuracy ( $> 15$  mm)
  - × Patient's comfort

## Classical approach

Plaster moulds directly taken on the patient



Positive plaster model of the region of interest



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# INTRODUCTION

- Non-collaborative patients
  - Paediatric patients
  - Patients with intellectual disabilities
- Patients with severe malformations

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# INTRODUCTION

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## Innovative approach

Geometry acquisition with non-contact techniques

- Photogrammetry
- Laser scanner
- Structured light scanner

+

Additive manufacturing

- Orthosis manufacturing
- Mould manufacturing



**Gather input data (geometry) of the anatomical region of interest with high accuracy and low operating time**



# CASE STUDIES

Activity in collaboration with a local orthopaedic company - *Officina Ortopedica Semidoro s.r.l. (PG)*



*Due to frequent patients movements classical approach failed*



## 1<sup>st</sup> CASE

|                           |  |
|---------------------------|--|
| <b>Gender</b>             | Female                                   |
| <b>Age</b>                | 11 yo                                    |
| <b>Region of interest</b> | Bust                                     |
| <b>Orthosis</b>           | Orthopaedic corrective brace             |
| <b>Difficulties</b>       | Maintaining still position for long time |

## 2<sup>nd</sup> CASE

|                           |   |
|---------------------------|---|
| <b>Gender</b>             | Male  |
| <b>Age</b>                | 4 yo  |
| <b>Region of interest</b> | Bust  |
| <b>Orthosis</b>           | Orthopaedic brace for correction and spine support                    |
| <b>Difficulties</b>       | Maintaining still position for long time<br>Intellectual disabilities |

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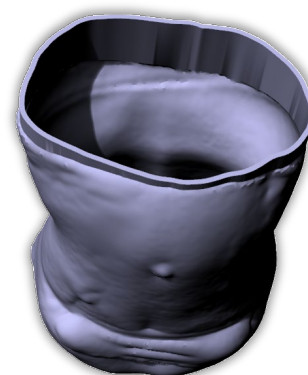
# MATERIALS AND METHODS - PROCEDURE



Non-contact  
Geometry  
Acquisition



3D Geometry  
Reconstruction



3D Mould Design



Mould 3D Printing



Final Orthosis





# MATERIALS AND METHODS - INSTRUMENTATION



Structured light hand-held scanner  
(*Creafom Go!SCAN 50*)

- ✓ Accuracy 0.1 mm
- ✓ Resolution 0.5 mm
- ✓ High speed of acquisition
- ✓ Scanning area 380 x 380 mm
- ✓ Medium-large objects (0.3 – 3 m)
- ✓ Measurement rate 550000 measurements/s
- ✓ Natural geometrical and colour features
- ✓ Positioning targets



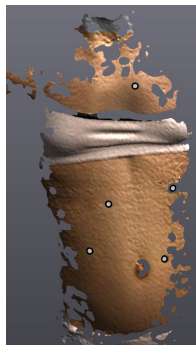
# MATERIALS AND METHODS - SCANNING



For every subject 2 scans have been obtained

1<sup>st</sup> CASE

Chest



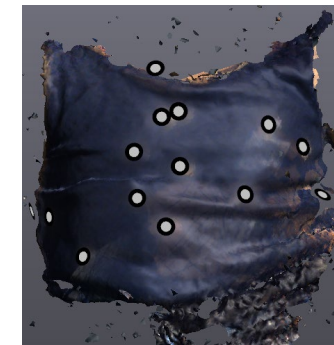
Total time ≈ 20 min

Back



2<sup>nd</sup> CASE

Chest



Total time ≈ 45 min

Back



# MATERIALS AND METHODS - SCANNING

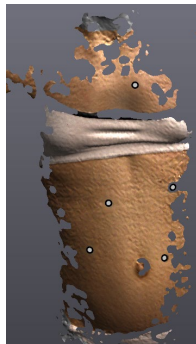


Scans registration using features as

references

1<sup>st</sup> CASE

Chest



Back



2<sup>nd</sup> CASE

Chest



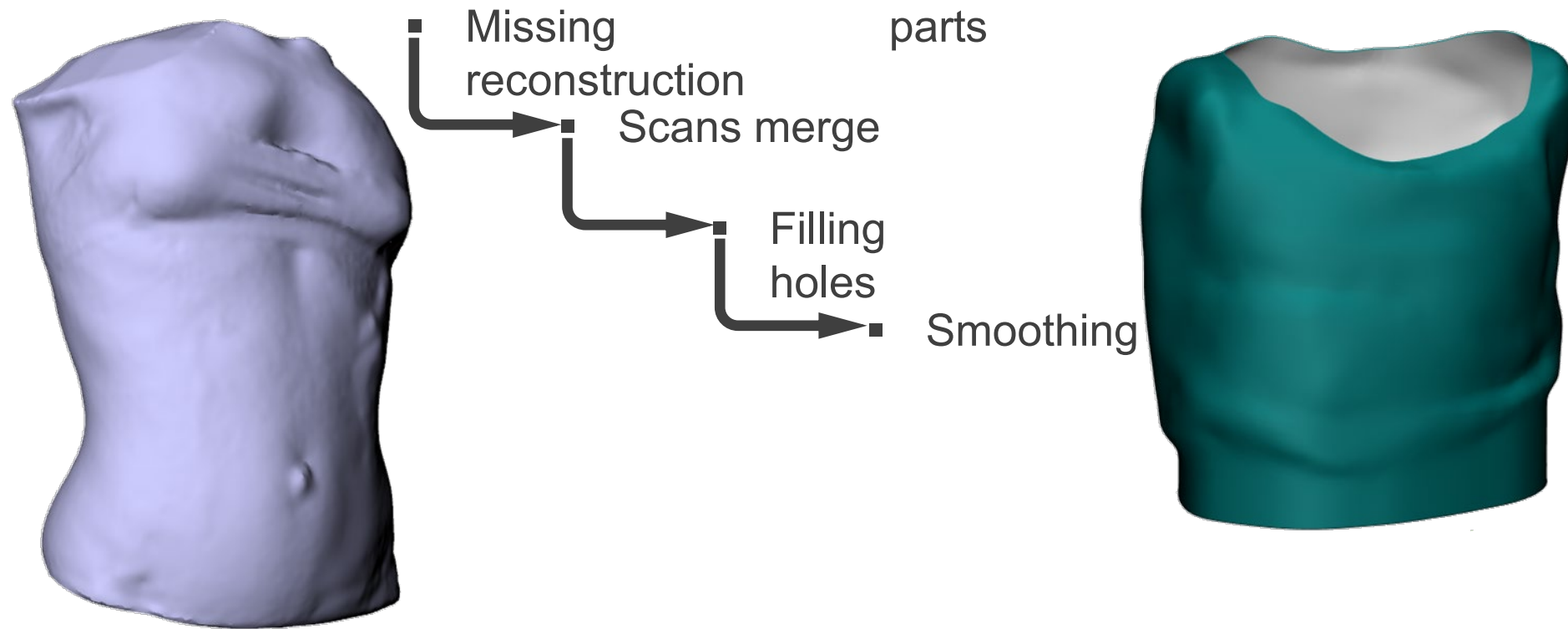
Back



# MATERIALS AND METHODS – 3D GEOMETRY



## Scans Post-Processing



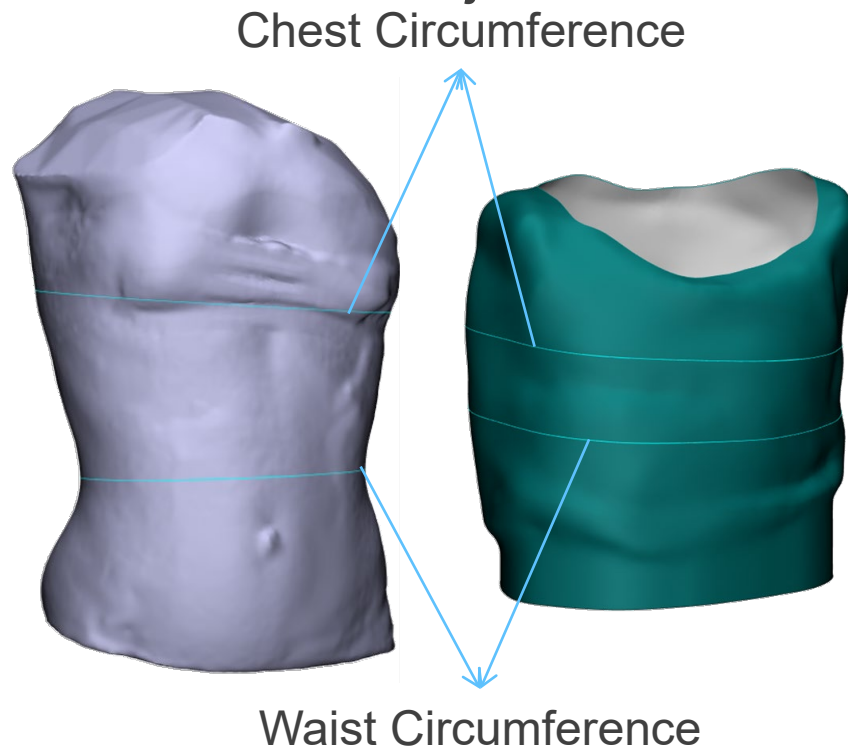


# MATERIALS AND METHODS - 3D GEOMETRY



Geometry check with actual measurements taken on subjects

| 1 <sup>st</sup> CASE |             |          |
|----------------------|-------------|----------|
|                      | Actual [mm] | CAD [mm] |
| Chest Circumference  | 780         | 783      |
| Waist Circumference  | 640         | 647      |

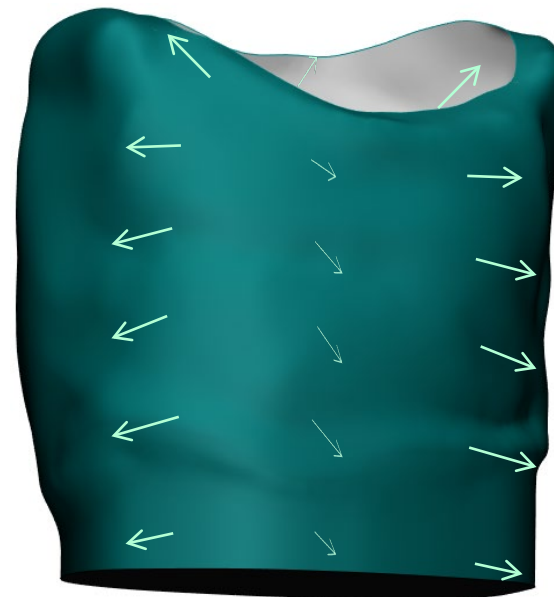
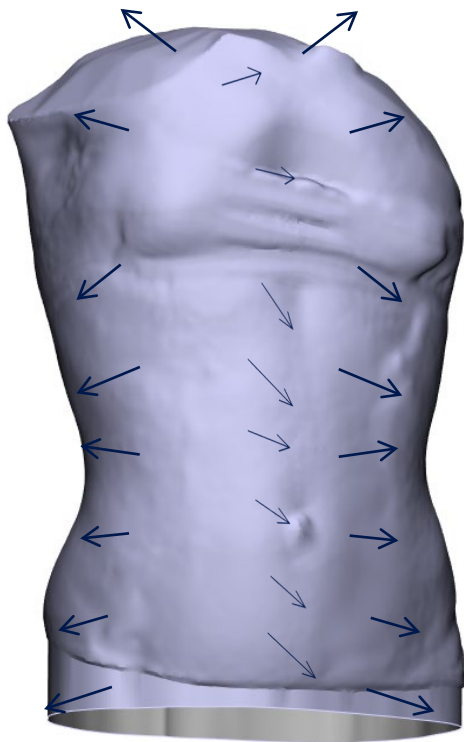


| 2 <sup>nd</sup> CASE |             |          |
|----------------------|-------------|----------|
|                      | Actual [mm] | CAD [mm] |
| Chest Circumference  | 500         | 522      |
| Waist Circumference  | 470         | 536      |

# MATERIALS AND METHODS - 3D GEOMETRY



Mould 3D geometry creation with an external extrusion of 5 mm



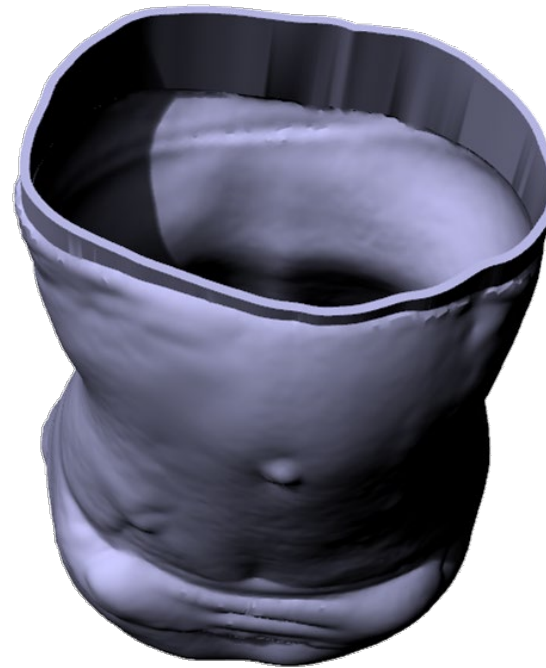
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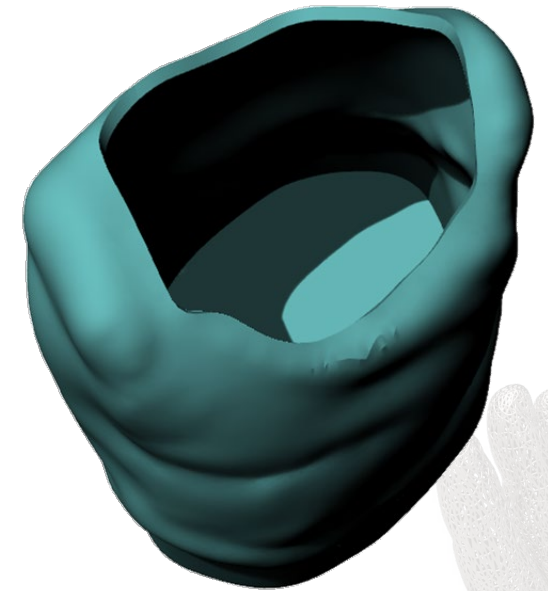
Mould 3D geometry creation with an external extrusion of 5 mm



Mould 3D model – 1<sup>st</sup> case



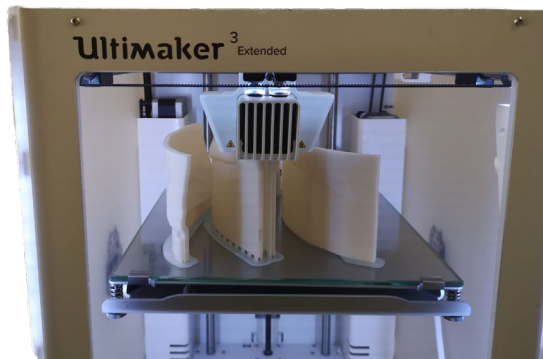
Mould 3D model – 2<sup>nd</sup> case



# MATERIALS AND METHODS - 3D PRINTING

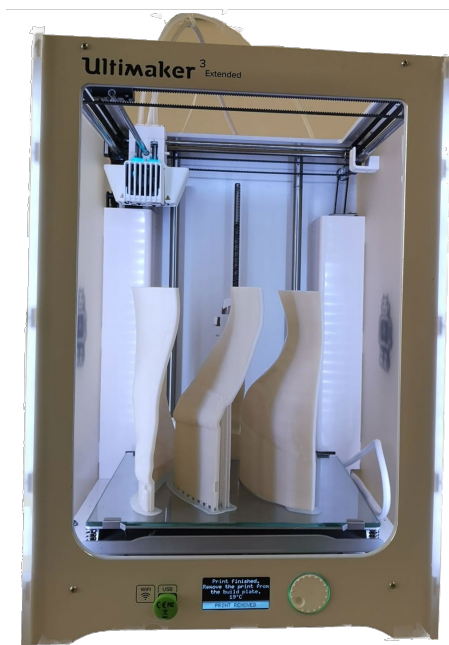


## 3D printing of moulds



Ultimaker 3 Extended

|                   |                |
|-------------------|----------------|
| Technology        | FDM            |
| Build Volume      | 215x215x300 mm |
| Filament Material | PLA            |
| Filament Diameter | 2.85 mm        |
| Layer Height      | 0.2 mm         |
| Infill            | 20%            |





# RESULTS – FINAL ORTHOSIS



Plaster casting



Positive plaster model



Orthosis manufacturing by thermoforming



Final orthosis



# CONCLUSIONS

- Full procedure for patient-specific orthopaedic brace manufacturing has been setup
- Ease and speed of patient's geometry acquisition
- High accuracy of the final 3D model (7 mm for 1<sup>st</sup> case study, about 2 cm for the 2<sup>nd</sup> case)
- Perfect adaptability of the final orthosis to the patient's morphology
- Better patients experience
- Future developments of this activity will be focused on the creation of the final orthosis directly using additive manufacturing, completely removing the plaster casting procedure



# THANK YOU FOR YOUR ATTENTION

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