Through the HoloLens™ looking glass: augmented reality for extremity reconstruction surgery using 3D vascular models with perforating vessels

AR for Skin reconstruction in lower extremities

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Introduction

1- What is reconstruction surgery? How is it done?

2- What are the challenges? What needs to be improved?

3- How AR can be involved?

Reconstruction Surgery

Severe injuries, loss of soft tissue (muscles, tendons, ligaments, fascia, nerves, fibrous tissues, fat, blood vessels,...) in a wide area, which leads to an open wound.

- Danger of infection, loss or limitation of functionality and mobility

In cases where the wound can not be closed by dressing or stitches, **borrowed skin from other parts of the body** is used to cover the wound.

Donner area
This segment will be used to cover the wound

Arteries and Veins that stay connected to the leg, to **feed and keep the patch alive**

The wounded area

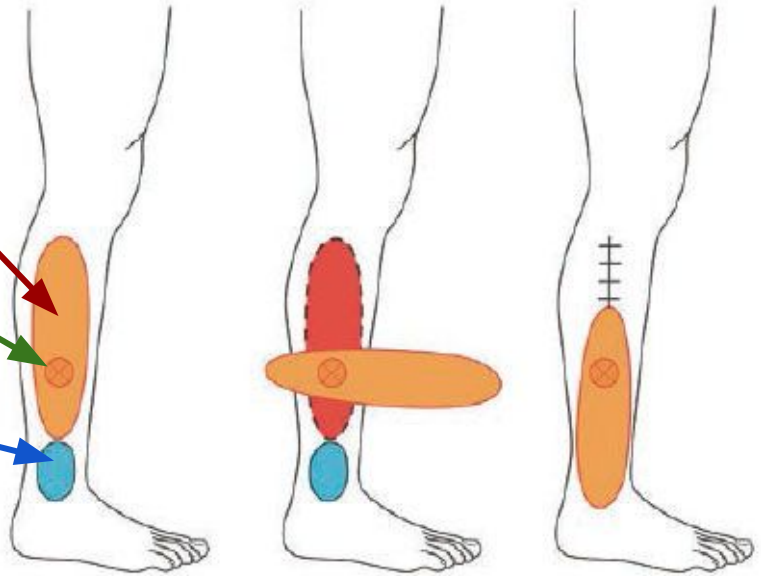
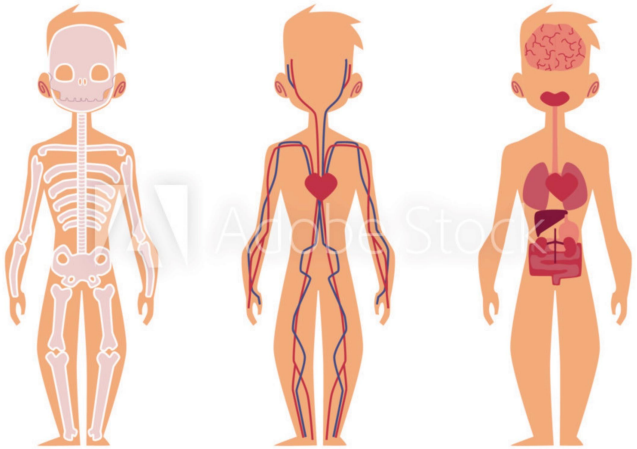


Image copyright: **Propeller flaps for lower-limb trauma**[S. Afr. j. surg. vol.52 n.4 Cape Town Nov. 2014]

A D Rogers; G Dos Passos

Poor vascularization leads to **poor healing**.

detailed knowledge of **the local anatomy** is needed, to select the best surgical alternative for each patient.



Human bodies are different!

Basic Workflow

1- Taking CTA scan from the donor and receiver area

2- Mark vessels that have the potential to feed the patch, by hand and eye

- Calculating the position from anatomical landmarks

3- Mark approximate position of those chosen vessels on patient’s body

- Use Doppler audible ultrasound to navigate

4- Start surgery and try to find the vessel in depth

Drawbacks

1- Depth analysis is not possible before surgery (No access to internal organs!)

2- Complex and error prone

3- Time consuming

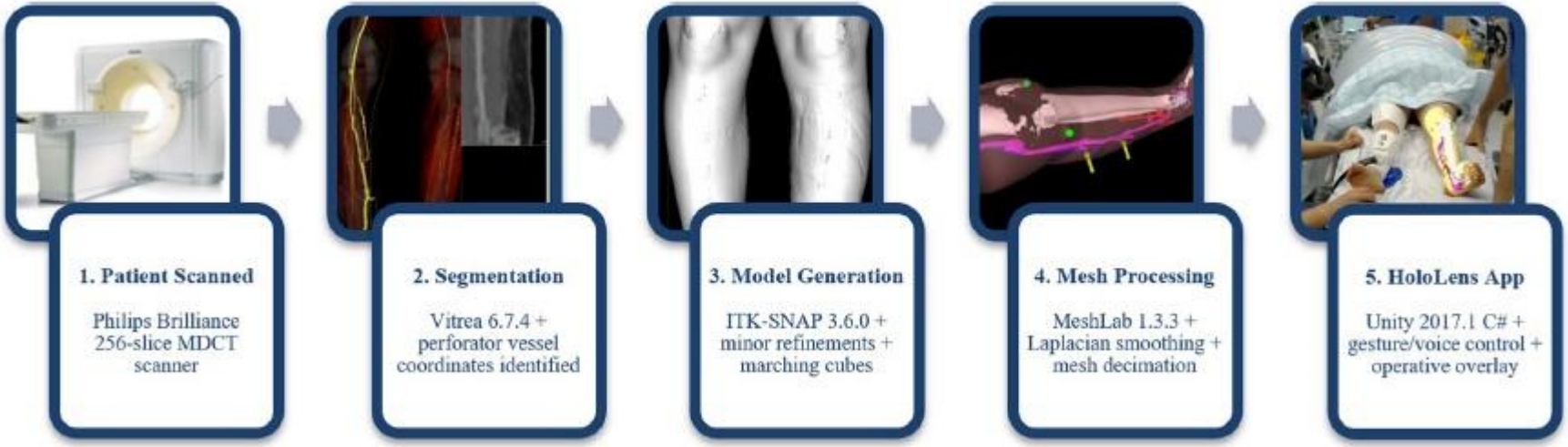
4- Sometimes the landmarks are damages

What AR can improve

1- Convert CTA scan image to usable information (3D model)

2- Map the 3D model to patient's body automatically, hence reducing error and operation time

3- Add accuracy



(Image copied from the paper)

New Workflow

1- Contrast enhanced CTA scan using a 256 slice scan machine

2- Segment images into vessels, muscles, fascia, etc.

- Thresholding and morphological operations

3- Discuss with surgeon to candidate potential vessels to feed the patch

4- Save segmented images in DICOM format

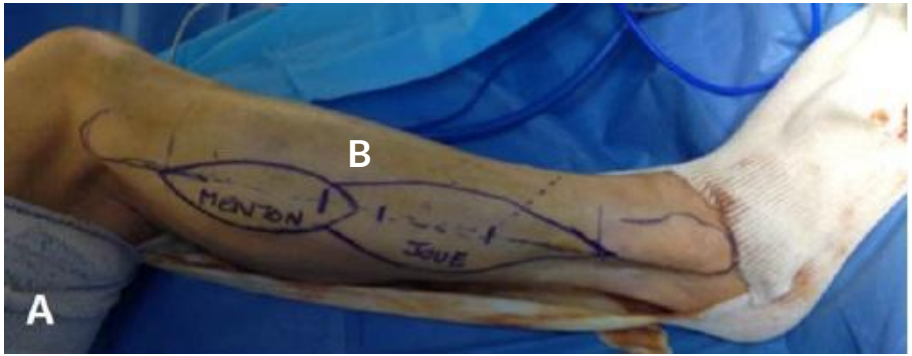
- Manual refinements using marching cube algorithm + smoothing the mesh

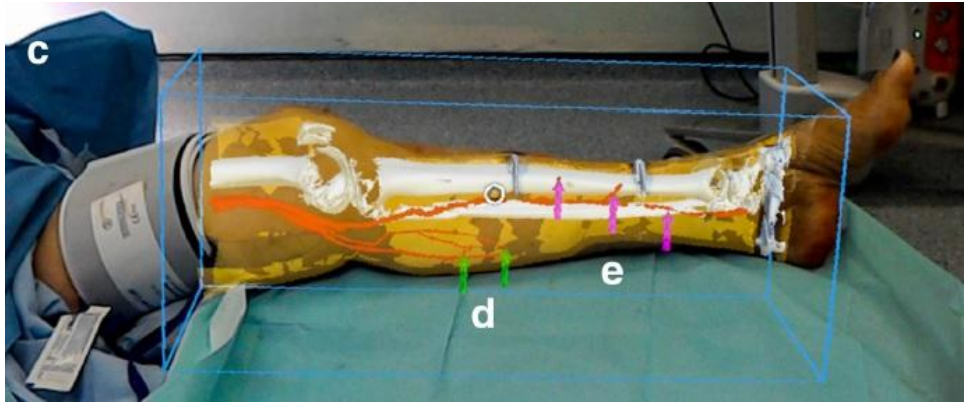
New workflow, cont.

5- Run a custom application for Hololens to make it project the 3D model on patient body,at a default distance and rotation with respect to the wearer’s coordinate frame

- The surgeon can control the position and angle of the projected model via hand gestures
- Spatial scale information are retained in this process, so there is no need to scale

Marking patch area on patient body without AR
(Franck M. Leclère et al, 2013)





Using AR to show details
(image taken from the paper)

Results

The HoloLens proved to be a powerful tool that has the potential to reduce anaesthetic time and morbidity associated with surgery as well as to improve training and provide remote support for the operating surgeon. Detailed feedback from the surgical team verified that this new approach is more reliable and therefore considerably less time-consuming than the previous method.

Evaluation

Markerless	Time consuming in preoperative phase
Can be used for educational purposes	Changes the workflow of the surgery
Hands-free -> sterility	For now, limited to lower extremities
More precise -> reduce operation time	
3D telemedicine support	