CRCSI Project 4.409

An audit of clinical photography, photogrammetry tools and spatial techniques to assist burn assessment

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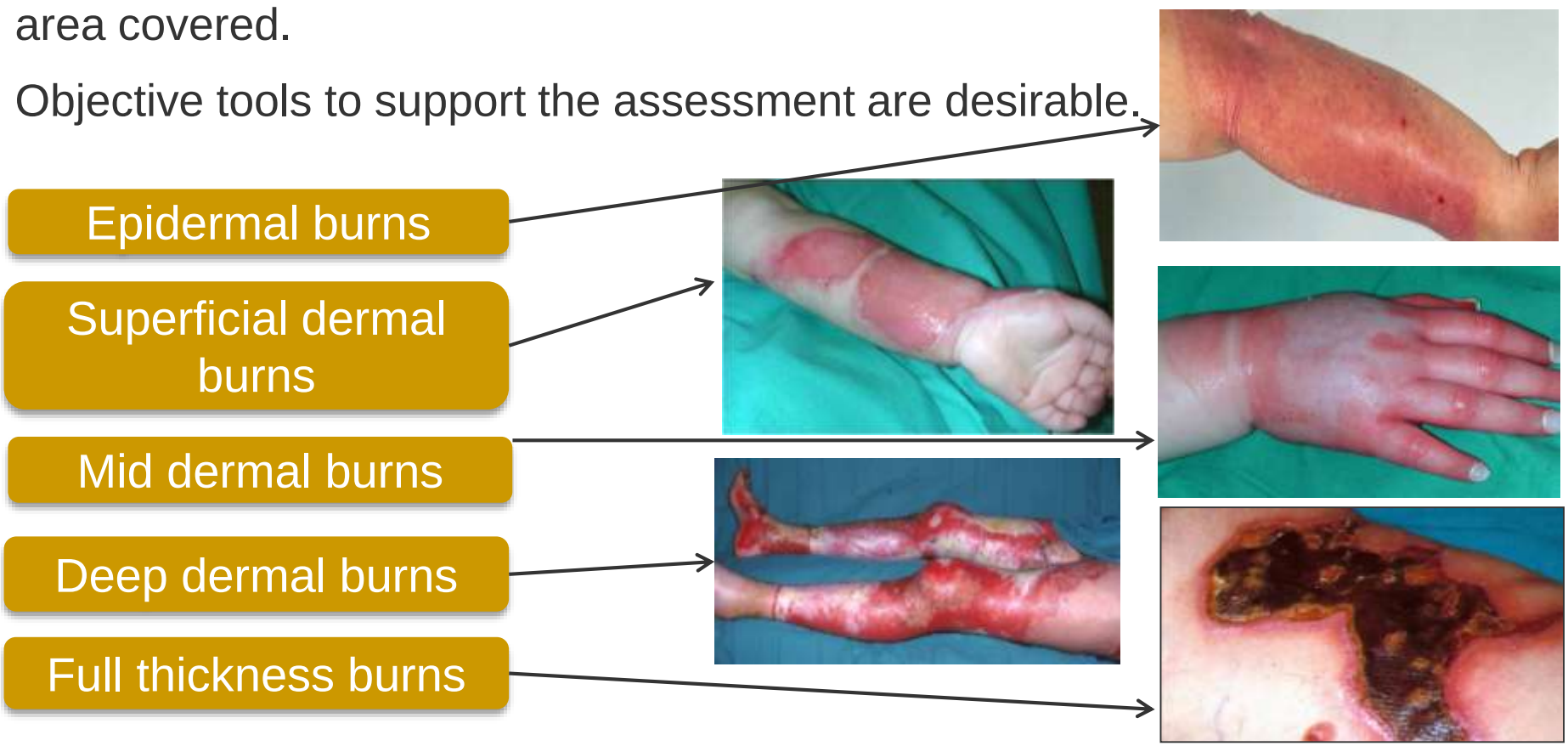
This symbols indicates that the next slide contains graphic content.

Thanks to Genetic Services of Western Australia (GSWA) and Gareth Baynam to have the opportunity to use the *VectraH1* camera is part of this study. A special thanks to Lyn Schofield and Dylan Gration from GSWA who assist to capture the 3D models using the *VectraH1* camera.

Motivation

- Measurements to assess burns are often subjective and identification requires lots of training.
- Important measurements are (beside others) the depth of the burn and the area covered.
- Objective tools to support the assessment are desirable.



Motivation

Assessment

Appearance	Capillary Refill	Sensation	…
e.g. dry and red with no blisters, pale pink with blisters, dark pink with large blisters, …	e.g. blanches, sluggish, no	e.g. painful, very painful, maybe – reduced pain	

Measurements

Colour	Surface Area	Scarring/ Swelling	Texture	…
e.g. red, pink, dark pink, stained	e.g. measurement is difficult when the wound will have to be touched	e.g. volume of the wound	e.g. no blisters, blisters, large blisters, blotchy	

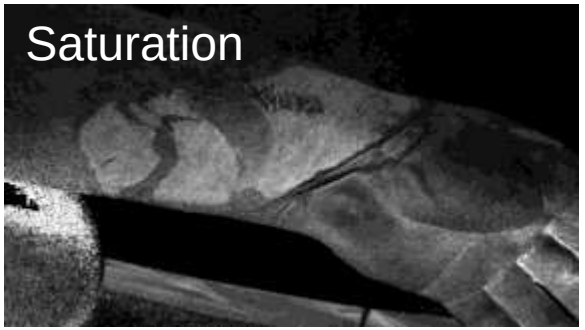
Are supportive objective measurements possible using Photogrammetry and RS?

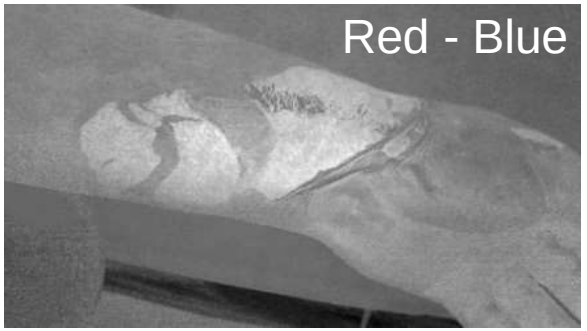
Outline

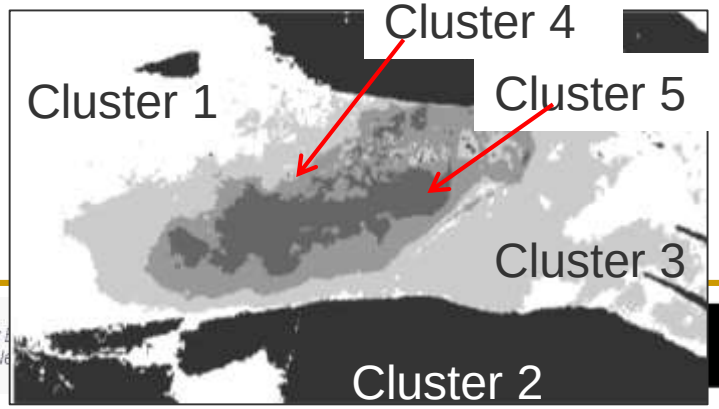
- Background
- Spectral Analysis
- Geometric Analysis
- Conclusion

Spectral Analysis - Intro

- Goal: Performing a clustering analysis using burn images and assess if skin with different burn depth can be separated.
- Images for this test were downloaded from the internet. The images were 21 RGB images.
- The chosen clustering algorithm for initial test is *k-means* due to the small number of images and missing labels.
- Feature used for clustering:
  - Bands in RGB colour space,
  - Bands in HSB (Hue, Saturation, Brightness) colour space,
  - Statistical information per band (entropy, standard deviation…)
  - Combination of bands (subtraction, division…)
- Tested were different band combinations and different number of cluster classes.

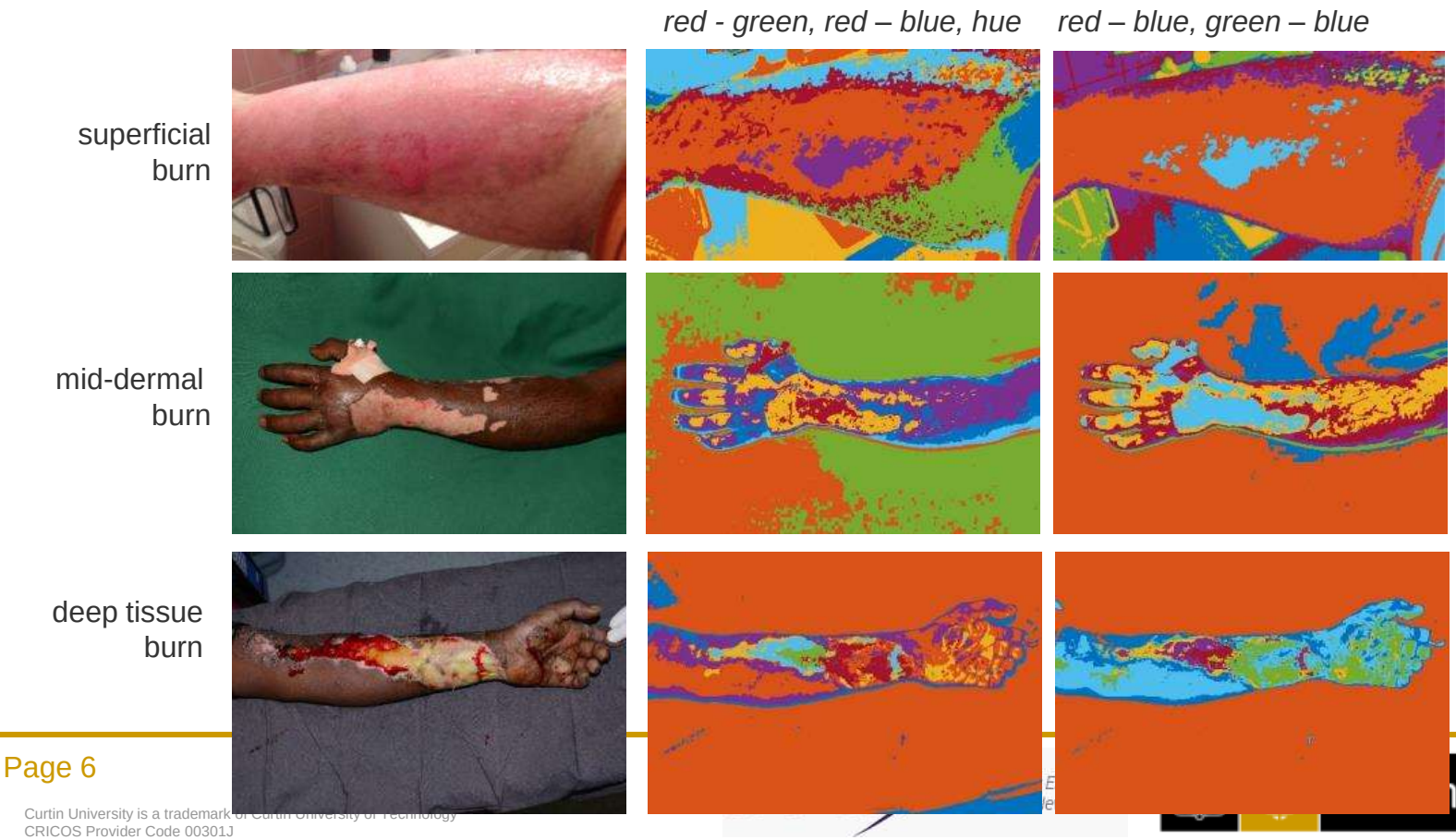






Spectral Analysis Results

- Empirical testing found that the clustering results using the bands *red - green, red – blue, hue* AND *red – green, red – blue, green – blue* produce the best results
- Empirical testing has also found that 8 clusters achieve good results



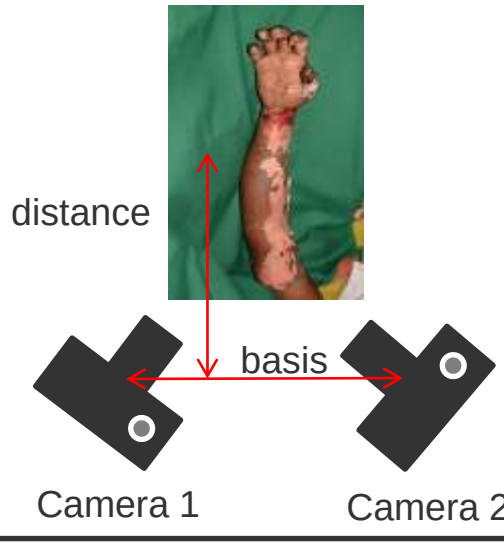
Spectral Analysis Conclusion

- It is possible to separate between different burn areas.
- Current challenges for objective burn assessment:
  - The way the images were captured (radiometric calibration, controlled conditions),
  - Additional features based on wavelength outside of RGB, and an extended analysis of these features (e.g. infrared and thermal-infrared),
  - The steps involved to transition between the stages of the clustering, segmentation, and finally classification (feature space selection, training data, more samples, segmentation and classification).

Geometric Analysis - Intro

- Goal: To determine the surface area of burn wounds in order to analyse changes over time.
- Images from previous test were not suitable for geometric analysis.
- Therefore, images of “simulated” burns were captured with a photogrammetric camera (*Vectra H1*) and a structured light camera (*Skanet*).
- *Vectra H1* is a DSLR camera with a special lens which simulates to take two images within a known basis and a known approximate distance to the object enabling 3D reconstruction is possible.
- Output: Dense 3D point clouds which can be further processed with MIRROR software.
- *Skanet* sensor uses structured light and captures a depth map as well as RGB and IR data.
- Outputs are coloured 3D meshes.


Vectra H1

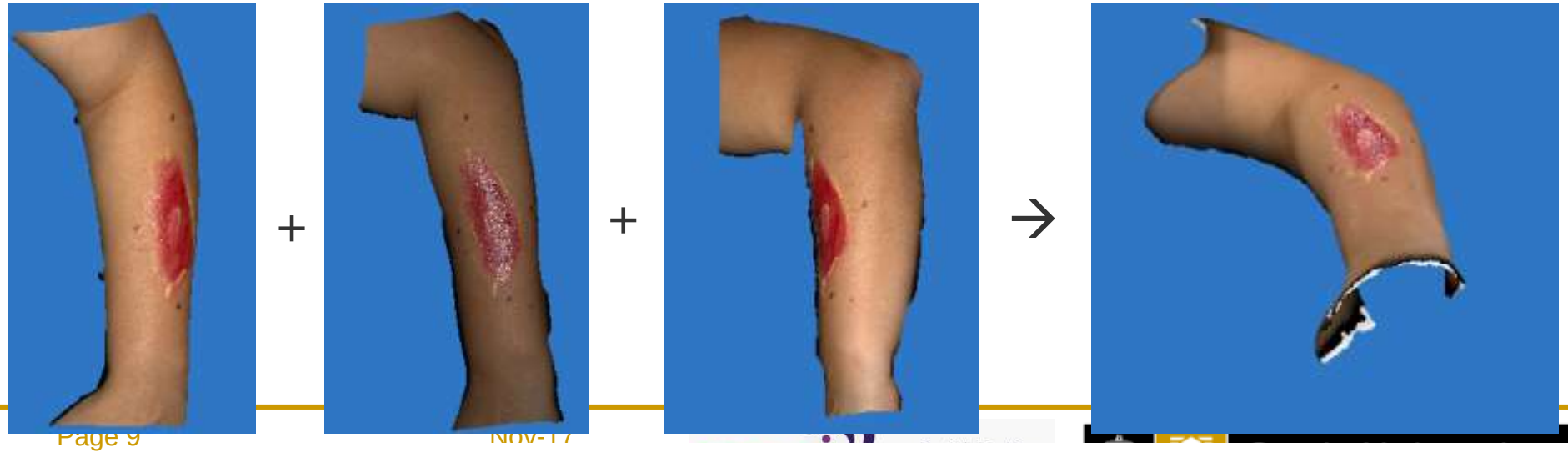



Skanet

Vectra H1 - Results

- Data capturing takes less than 1 min with nearly always successful stitching results.
- Separate models could be stitched to a more complete model.
- Within the 3D models it is possible to extract 3D measurements including distances, areas, perimeter.
- Distances can be observed along the curved surface or as direct distance.
- Three different stitched datasets were captured to assess these measurements.

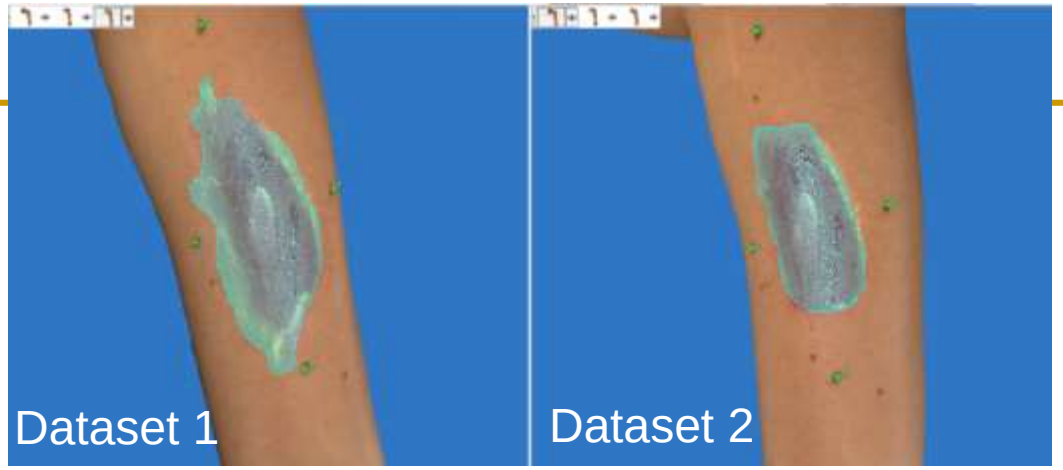
Left model *Centre model* *Right model* *Stitched model*



Note, these and all following figures are 2D screenshots of 3D Models.

VectraH1 - Results

- First test: Comparison of two datasets which simulate a healing burn wound.
- Measurements:



Performed Measurements	Dataset 1 (large burn)	Dataset 2 (healed burn)	Differences
Perimeter of selected burn areas	338.213 mm	253.266 mm	84.947 mm
Area selected burn areas	28.183 cm^2	19.241 cm^2	8.942 cm^2
Area of forearm (stitched area)	521.42 cm^2		
Calculated percentage area of the burn to the stitched area (manual calculated)	5.4 %	3.7 %	1.7 %
Straight line between landmark 1 and 3	127.354 mm	127.494 mm	- 0.14 mm
Line across the surface from landmark 1 to 3	127.510 mm	127.590 mm	-0.08 mm
Straight line between landmark 2 and 4	52.635 mm	52.714 mm	- 0.079 mm
Line across the surface from landmark 2 to 4	59.146 mm	59.024 mm	0.122 mm

- Conclusion: Precise and accurate measurements were possible.

VectraH1 - Results

- Further results can be created, e.g. brown spots and red areas enhancing the visualization of pigmentation and vascularity.
- These and all pervious results were extracted using the *Vectra* software which comes with the camera.

Brown spots

Red spots

Skanet - Results

- Data capturing was a challenge as success was highly dependant on the background (shape, texture, colour).
- Creation of the models were done using the application which comes with sensor.
- Measurements were extracted using *CloudCompare* software.

3D model

Measurement

Skanet - Results

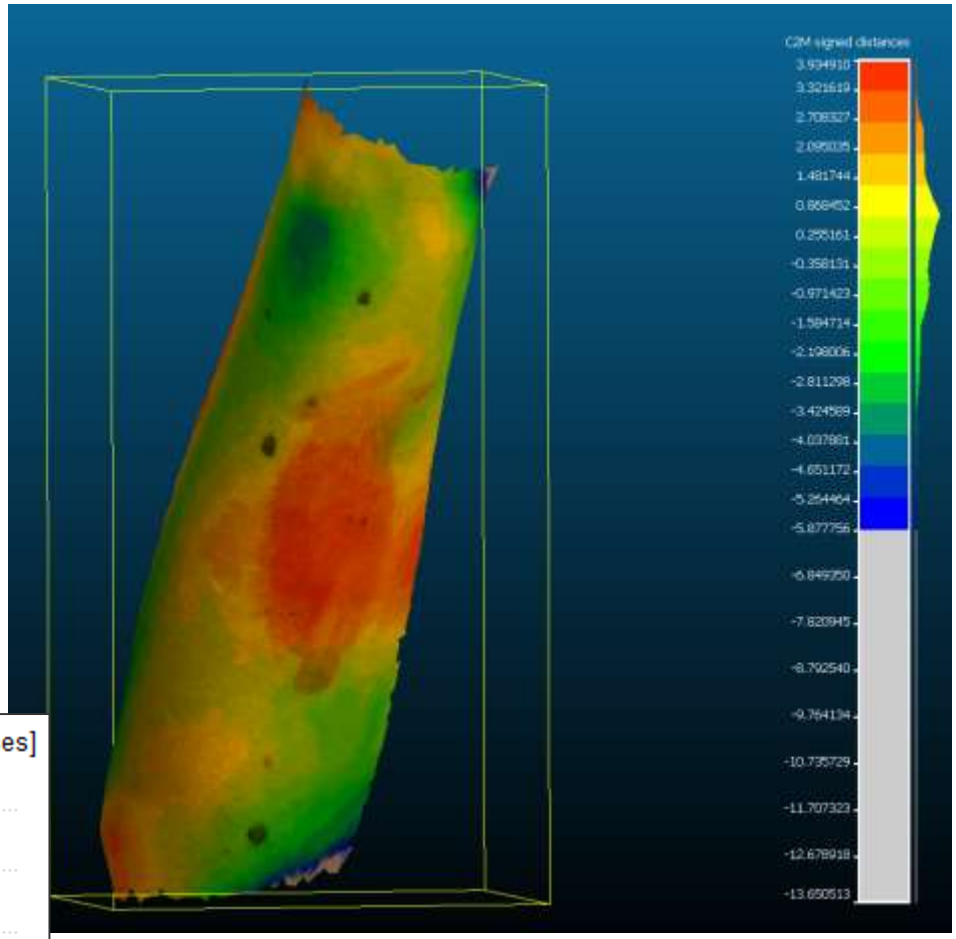
- In this test the distances between landmarks were compared.

Test person	Measurement 1	Measurement 2	Measurement 3	Average	Std. Dev.	Reference	Difference
1	154.10	154.57	154.95	154.54	0.348	148	6.54
2	89.44	88.48	94.50	90.81	2.641	94	-3.19
3	94.90	91.19	NA	93.045	1.855	NA	NA

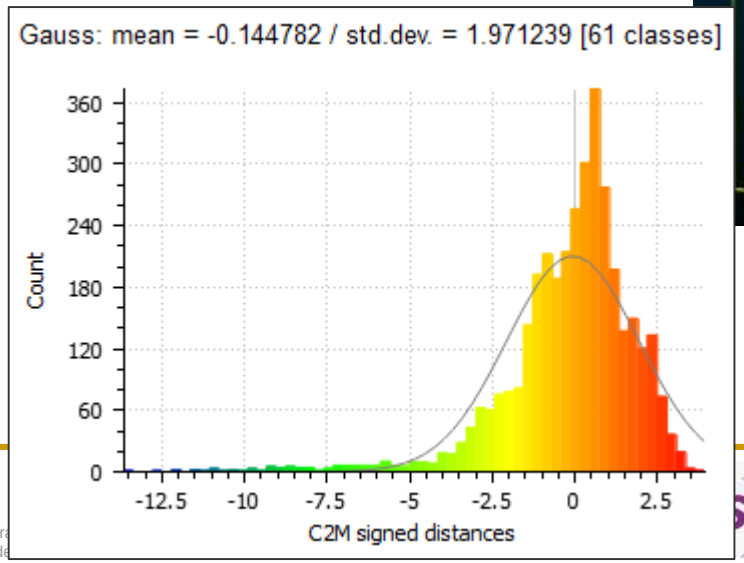
- Distance observations of the *Skanet* (mm range) are less precise compared to the *Vectra H1* camera (range of less than 1 mm).
- Further issues: the rendering was not always successful, e.g. the landmarks on the arm were not visible in all models. Therefore, measurement 3 of test person 3 was not possible.

Comparison Vectra H1 and Skanet Models

- In this test, the whole model is compared, not the just distances between discrete landmarks.
- Overall the models from *VectraH1* and *Skanect* sensor are comparable (within 3-5 mm range).

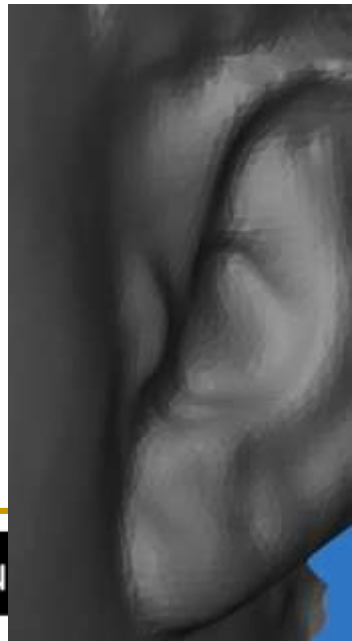


Heat map showing the differences between both models. Units are in mm.



Geometric Analysis Conclusion

- Both sensors produce suitable 3D models, however the accuracy and precision of *Vectra H1* camera is higher.
- Rendering issues of *Skanect* sensor will be an issue when comparing the burn wound over time.
- It is uncertain how both sensors behave when assessing body areas with higher curvature. It is predicted that the *Vectra H1* can handle it better (due to the method used).
  → See images to the right.
- Workflow of *VectraH1* camera from data capturing over data processing and analysis of the 3D models is straight forward and possible with software which comes with camera.
- Tool is helpful in monitoring the wound development over time (surface as well as volume measurements).



Overall conclusion

- The potential of image analysis for the radiometric analysis of burn images could be shown.

  → Challenges for quantification are remaining (radiometric calibration, additional features, from clustering over segmentation to classification).

- The geometric analysis of the 3D models captured with stereo-photogrammetry (*VectraH1*) as well as structured-light photogrammetry (*Skanect*) could be shown.

  → *VectraH1* useable for a longitudinal study to assess the burn wounds over time (area and volume).

  → Less useful technique for burn severity assessments.

- Next step: clinical trial including additional cameras capturing e.g. infrared image data.