Computerized Localization and Tracking of Pigmented Skin Lesions on 3D Whole Body Textured Skin Meshes

Mengliu Zhao*, Jeremy Kawahara* (* joint-first authors). Sajjad Shamanian, Kumar Abhishek, Ghassan Hamarneh

{mengliuz, hamarneh}@sfu.ca, jeremy.kawahara@gmail.com

Medical Image Analysis Lab, School of Computing Science, Simon Fraser University

While computerized approaches to classify skin conditions have shown the potential to reach a similar diagnostic performance as human experts using 2D color images, limited research considers using 3D whole-body skin images captured across time. 3D skin imaging provides context beyond a single localized photograph, such as the presence of multiple nevi (an important melanoma risk factor) and capturing the skin at multiple time points may allow for improved monitoring of lesion changes or the progression of treatments.

We propose a novel computational approach to detect and track lesions from 3D skin images. We map the 3D skin of human subjects to 2D texture images, train a deep region proposal artificial neural network to localize lesions within 2D texture images, and map the detected lesions to the 3D body. For subjects with multiple scans, we apply a matching algorithm to track lesions across time. We evaluated our method on three datasets. First, we scanned a mannequin with synthetic skin lesions under varying poses. Second, we augmented a dataset of 3D human meshes to produce 900 whole-body, skin-colored 3D meshes with different postures and lesions appearances. Finally, we also used a publicly available dataset of 3D scans that imaged the skin of real human subjects and manually annotated over 17,000 locations that appeared to the human eye to contain a pigmented skin lesion. We trained and tested our neural network using these manual annotations and achieved a recall of 0.84 and precision of 0.66 averaged per-scan.
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{mengliuz, jkawahar, hamarneh}@sfu.ca

Learning objective:
Can a computerized approach detect pigmented skin lesions from 3D skin images and track lesions across time?
Outline

- Strong performance using computerized approaches to predict types of skin disorders from 2D clinical or dermoscopy images
- Less research on computerized analysis of 3D skin images taken over time
- We present an approach to detect and track lesions on 3D skin images
- Clinically, this can potentially reduce the amount of human effort required to monitor a large number of atypical nevi over time, which may improve patient outcomes (e.g., melanoma)
Computers Reaching Human-Level Diagnostic Performance on 2D Images

Deep-learning-based, computer-aided classifier developed with a small dataset of clinical images surpasses board-certified dermatologists in skin tumour diagnosis*

Y. Fujisawa,1 Y. Otomo,2 Y. Ogata,3 Y. Nakamura,1 R. Fujita,2 Y. Ishitsuka,1 R. Watanabe,1 N. Okiyama,3 K. Ohara4 and M. Fujimoto1

Man against machine: diagnostic performance of a deep learning convolutional neural network for dermoscopic melanoma recognition in comparison to 58 dermatologists

H. A. Haenssle1,7, C. Fink1,1, R. Schneiderbauer3, F. Töberer1, T. Buhl1, A. Blum1, A. Kalloo1, A. Ben Hadj Hassen3, L. Thomas2,6, A. Enk2 and L. Uhlmann7

Deep learning outperformed 136 of 157 dermatologists in a head-to-head dermoscopic melanoma image classification task

Titus J. Brinker a,b,*, Achim Hekler a, Alexander H. Enk b, Joachim Klode c, Axel Hauschild d, Carola Berking c, Bastian Schilling f, Sebastian Haferkamp g, Dirk Schadendorf c, Tim Holland-Letz h, Jochen S. Utikal i,j,l, Christof von Kalle a,i, Collaborators2
Imaging a wide area of the skin allows for viewing multiple and irregular nevi.

3D Longitudinal Skin Imaging Provides Important Context

Tracking lesions across time allows for monitoring lesion changes.

Improved melanoma outcomes and survival in patients monitored by total body photography: A natural experiment

Jennifer L. Strunck, Tristan C. Smart, Kenneth M. Boucher, Aaron M. Secrest, Douglas Grossman

Sequential digital dermatoscopic imaging of patients with multiple atypical nevi

Philipp Tschandl

Benefits of total body photography and digital dermoscopy (“two-step method of digital follow-up”) in the early diagnosis of melanoma in high-risk patients

Gabriel Salerni, MD, Cristina Carrera, MD, [...], and Josep Malvehy, MD, PhD.
Computational Pipeline for Whole Body Longitudinal Lesion Detection

- 3D imaging
- 3D coloured mesh
- Unwrapping to a 2D image
- Machine learning to detect lesions
- Match lesions across time
Data

Hand-held Scanner
- Mannequin
- Stickers represent lesions

FAUST (Bogo. CVPR. 2014)
- 3D human subjects **without** texture
- Added pose variations, skin tones based on the Fitzpatrick scale, and synthetic lesions

3DBodyTex (Saint. 3DV. 2018)
- 3D human subjects **with** texture
- Lesions visible, but not annotated
Manually annotated over 17,000 locations from 200 subjects

https://www.robots.ox.ac.uk/~vgg/software/via/
Green = human annotator
Red = AI annotator
Map the 2D detected lesions back to the 3D body
Label specific lesions
Match lesions of the same subject in different scans

Automated approach that considers the body location and the lesion distances
Lesion Detection Results

AI compared with a single human annotator

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<th>Recall</th>
<th>Precision</th>
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<td>0.84</td>
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2 out of 3 human annotators agreed* more with the AI annotations than any other human

*Agreement measured by F1-score

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(preliminary)
Conclusions

Promising computerized approach to detect and track lesions on 3D skin scans

Clinically, may reduce the manual effort needed to monitor a large number of suspicious lesions over time