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Artificial intelligence and sensory assessment of hair assembly features: a combined approach

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Machine learning and hair

What has been published so far?

- Work on hair recognition and classification of hair styles from images in the wild [1]
- 3D structure recovery of a head of hair from an image – different hair types and styles [2]

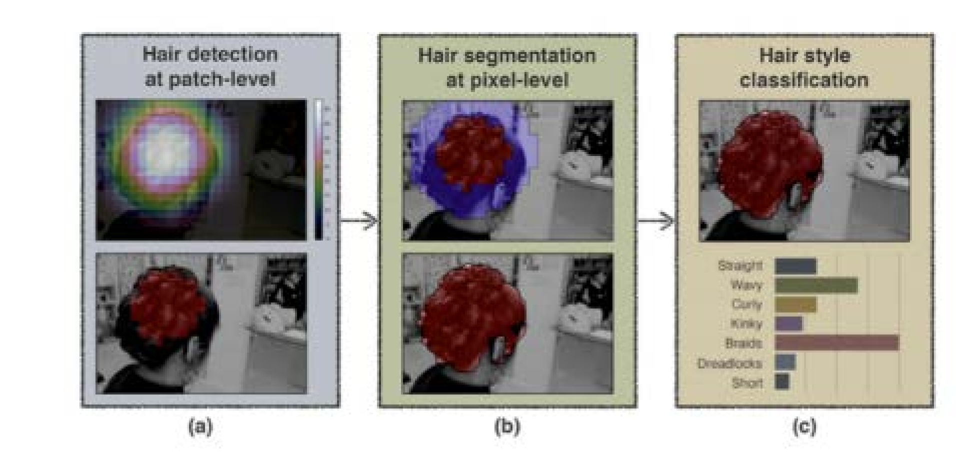

Fig. 1. Processing chain from hair detection to style classification

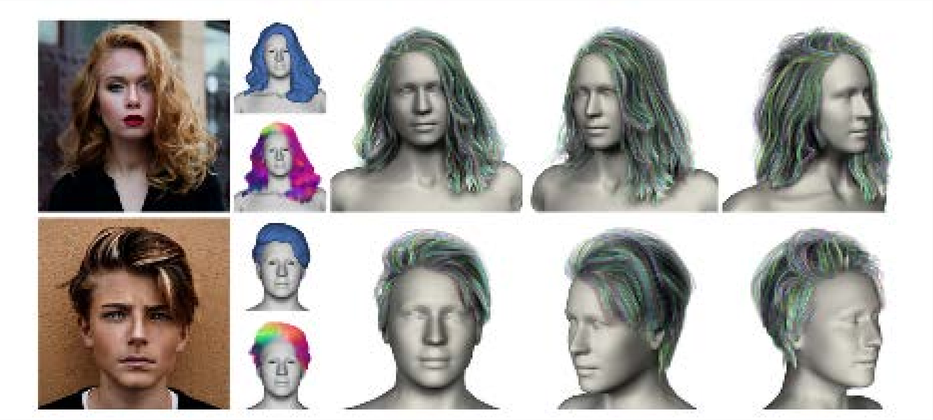

Fig. 2. Processing chain from a single-view input to complete strand-level 3D hair model

Where are the main gaps in the public domain?

- AI has not been used for hair assembly property analysis
- All machine learning in the industry via proprietary datasets (not shared)

Aim and objectives

Aim: To compare the sensitivity of human perception with that of classification algorithms for machine learning, when applied to human hair tresses

Objectives:

- Develop a training dataset
- Perform image analysis and machine learning
- Carry out sensory tests
- Carry out online survey, based on images from the training dataset
- Compare the outcomes of AI analysis with human assessments

Materials

- Caucasian virgin hair tresses (n=120), fine medium brown hair, length=10cm, weight=3g

- Half of the sample (n=60) was kept as virgin hair; half of the sample (n=60) was bleached lightly with a commercial bleaching product

- Commercial shampoo and conditioner (volumising and conditioning) were used for treating all hair tresses

Theoretical predictions: The treatment will cause volume increase, increase in alignment and reduction of flyway. The virgin and bleached hair will display the same effects, but the magnitude in bleached hair will be higher.

Methods: hair treatments

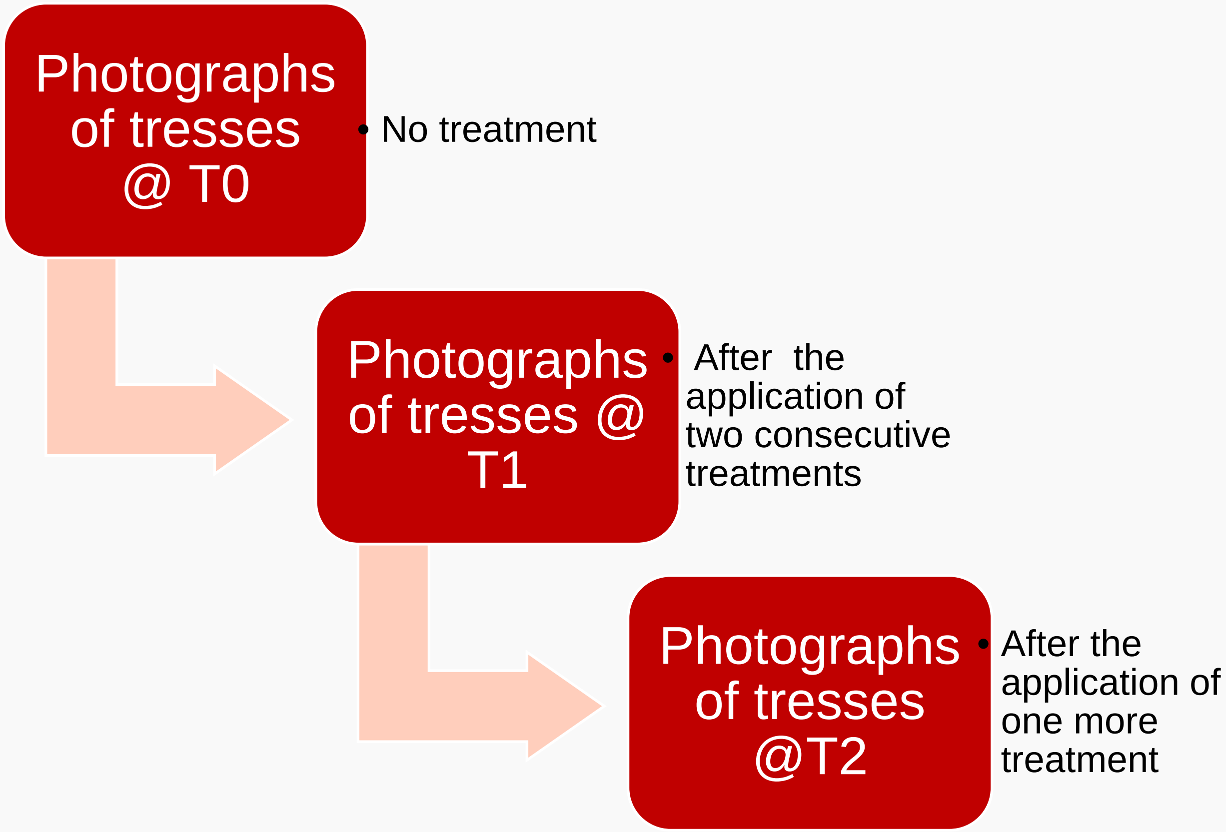

Fig.3. Workflow representation of the image dataset generation

The hair treatment comprised the controlled application of a shampoo, followed by a rinse off conditioner, followed by natural drying at 35ºC.

Methods: image dataset creation

Figaro tresses database: n=1080 images, available via Mendeley dataset and Data in Brief [3][4]

-45º 0º +45º

Fig. 5,6,7. Images of the same hair tress (bleached) taken from the three different angles.

Methods: machine learning

Training dataset was created using 70% of each image subset (virgin and bleached hair).

- Features for analysis that were selected were: Volume (Global & Local Hair volume) and Alignment (Histogram of Gradients- HOG) [5] as, in combination, these provide information on the hair assembly responses to a volumizing but also conditioning treatment
- Two validation tests were conducted using 30% of images (unseen):
- "Time order tests" - *could images of the same tress from two unknown treatment points be correctly ordered?*
- "Classification test" - *could a tress image from unknown treatment point be assigned to the correct treatment points*

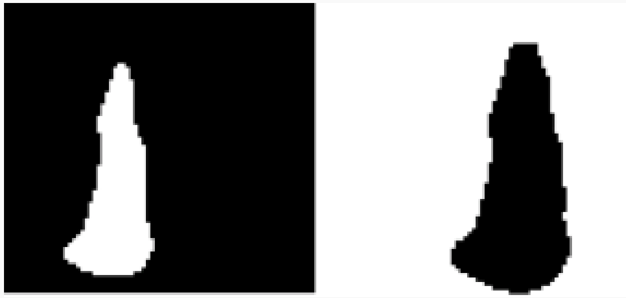

Fig. 8. Example of extracted hair segmentation mask

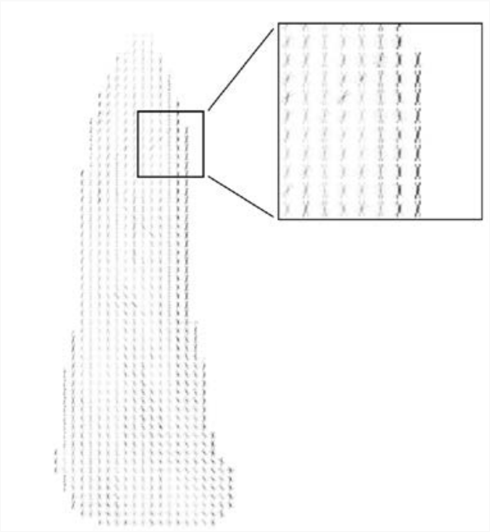

Fig. 9. Example of HOG extraction

Methods: sensory and online tests

Sensory and online tests included three questions, asking the participants to assess: tress volume, straightness and flyaway.

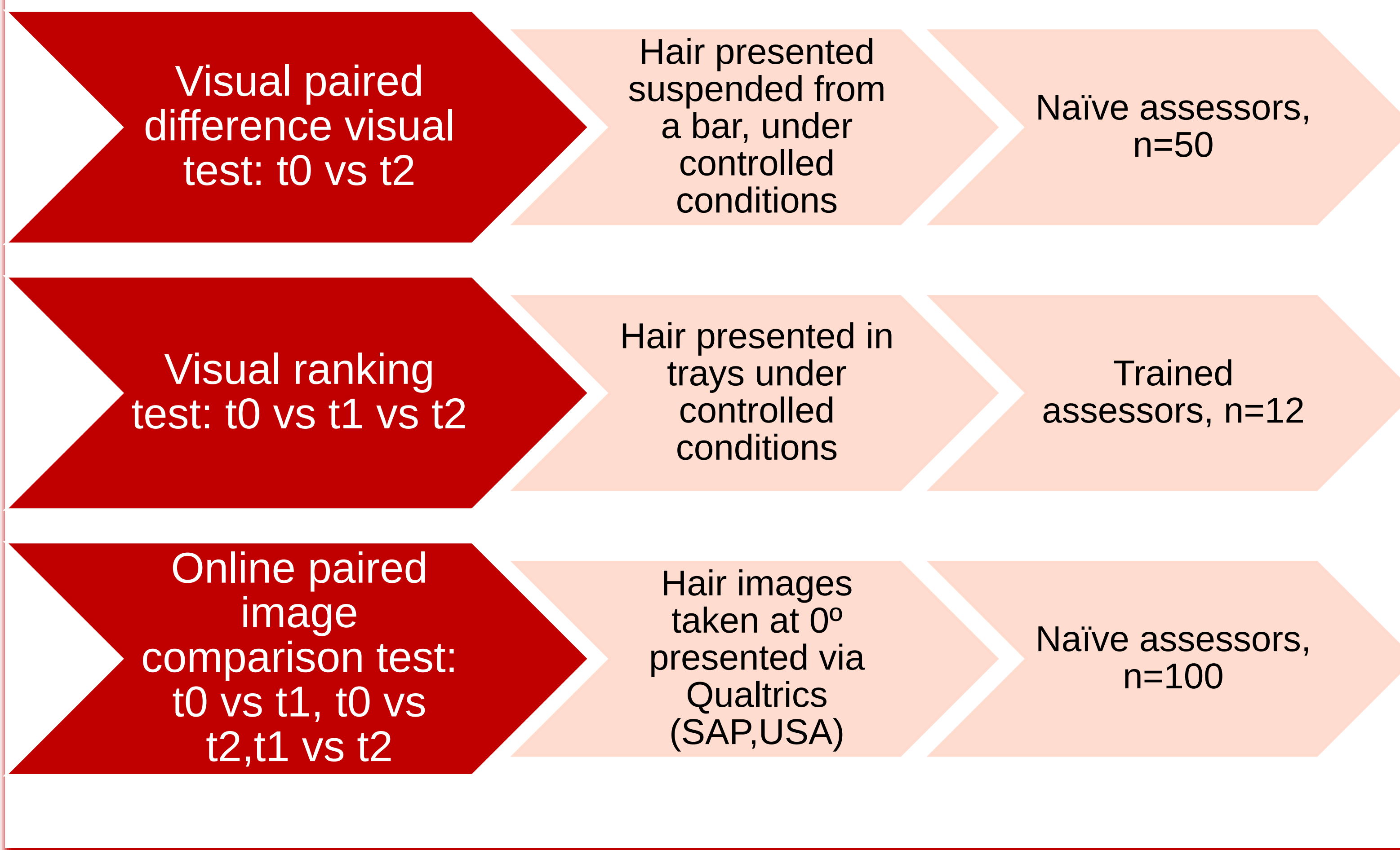

Fig.10. Summaries of the sensory human assessment

Results: AI analysis of volume and alignment

Virgin hair:

- Volume: **GHV** reduction at t1 and t2 vs t0, resulting from mostly from **LHR**
- Alignment index: alignment increased by 5% and 4% for t1 and t2 vs t0

Bleached hair:

- Volume: **GHV** reduction at t1 and t2, resulting from mostly from **LHR**
- Alignment index: alignment increased by 7% and 4% for t1 and t2 vs t0

Key: **G**lobal **HV**=0 Upper HV=1 **M**iddle **HV**=2 **L**ower **HV**=3

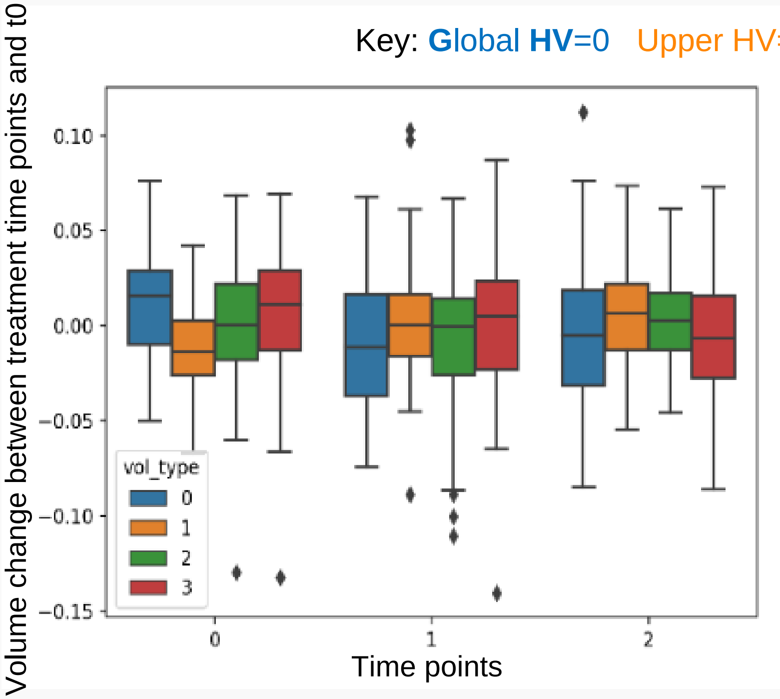

Fig. 11. Hair volume analysis of the virgin hair subset

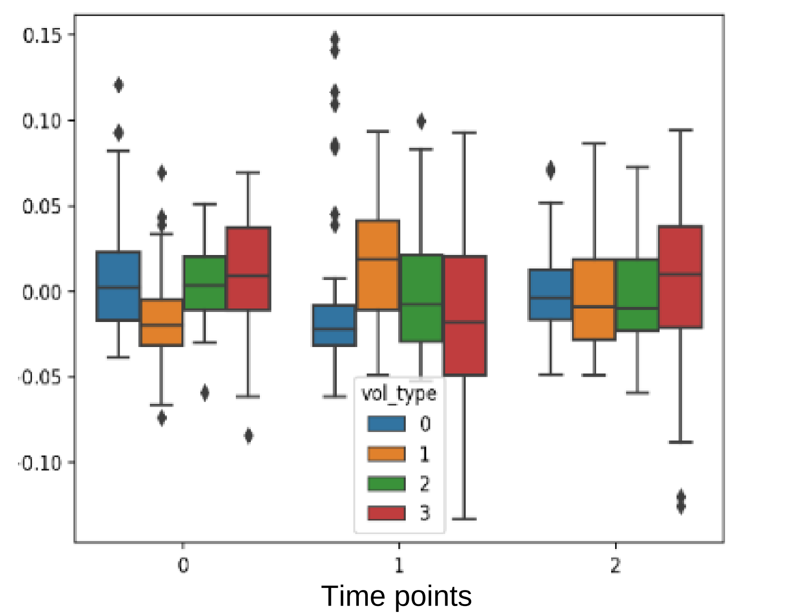

Fig. 12. Hair volume analysis of the bleached hair subset

The AI analysis identified treatment effects and the validation tests confirmed correct sorting in the Time order test and Treatment order test. The treatments reduced volume (against prediction) and increased the alignment, related to straightness (confirmed prediction).

Results: paired difference test

Table 1. Results from the visual paired comparison test, n=50

	Virgin hair			Bleached hair		
Question	**t0**	**t2**	**p-value**	**t0**	**t2**	**p-value**
Which tress is more voluminous?	33	17	0.016	32	18	0.032
Which tress is straighter?	11	39	0.000	18	32	0.032
Which tress has more flyaway?	22	28	0.240	31	19	0.059

Fig.13. Presentation of the hair tresses for paired difference test

- Treated hair at t2 has less volume and is straighter* than untreated hair at t0 (both virgin and bleached hair)
- Flyway** result is borderline for bleached hair
- Results infer that the conditioning effect outweighs the volumising effect when hair is viewed in person and vertically suspended
- This effect is not in line with the predictions but is in line with the AI analysis

* =hair straightness has been used as the closest possible away to describe good alignment in human terms
** = flyaway, defined as individual fibers separation from the bulk of the assembly, was not included in the AI analysis; however, it corresponds to conditioning

Results: visual ranking test

Fig.14. Presentation of the hair tresses for the visual ranking test

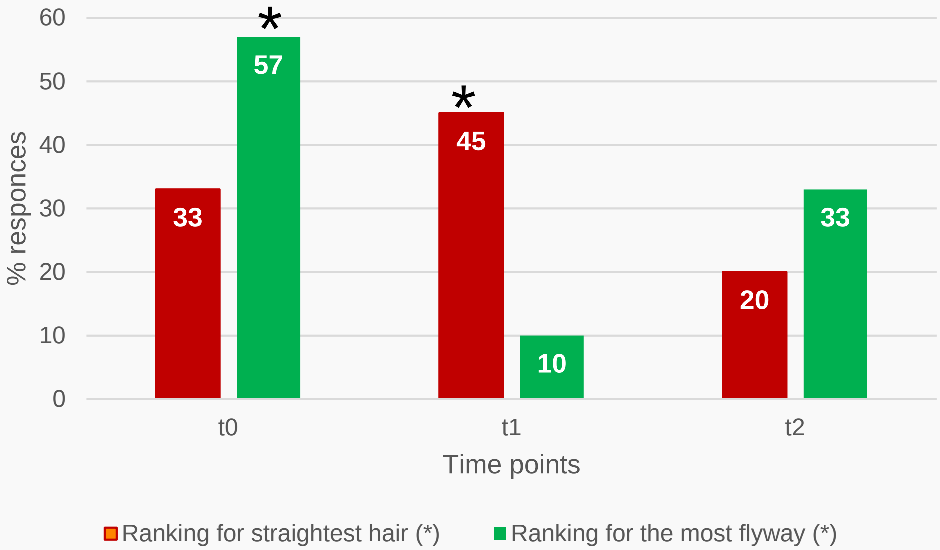

Fig. 15. Bleached hair visual ranking results for straightness and flyway

- Volume assessment did not identify significant differences between time points, inferring that volume assessment is sensitive to presentation settings

- Virgin hair did not return results that match the theoretical prediction or AI analysis, inferring the test settings are not sensitive to the changes in virgin hair

- Bleached hair at t1 was ranked as the straightest and at t0 was ranked as having most flyway, inferring that the conditioning effect is stronger for this type hair. This is in line with the predicted effect.

Results: online image paired difference test

- The subset of images used for the survey was analysed and reflected the changes measured by AI in the large data subsets.
- Volume changes for bleached hair are not consistent with the AI analysis, but consistent with the theoretical prediction; the opposite was recorded for virgin hair
- Hair straightness for bleached hair was in line with AI and predictions, whilst for virgin hair the results were not.
- Flyway assessments were in line with the theoretical predictions
- The results infer that frontal images of hair do not allow for accurate human assessment when effects are more complex than flyway reduction

Green=consistent with theoretical prediction
Red =not consistent with theoretical predictions

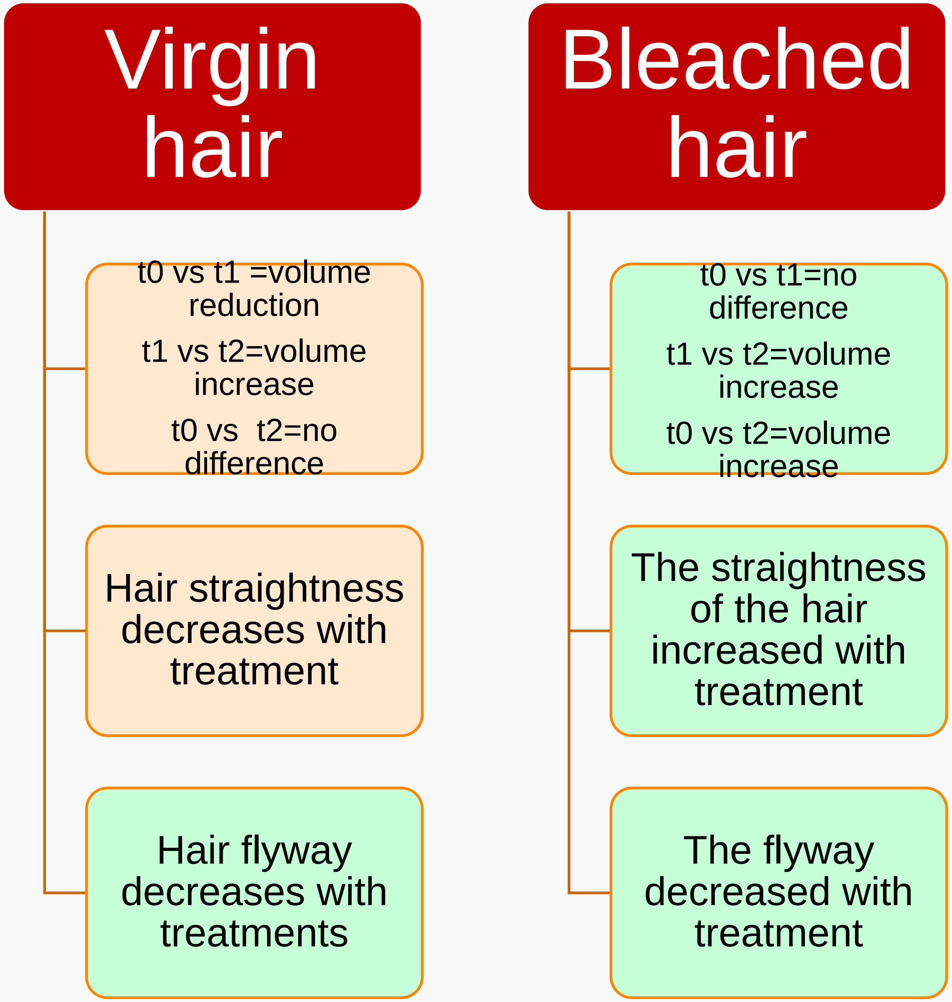

Fig.16. Summary of results from the on-line paired image tests

Conclusions

- **This study highlights the usefulness of AI for hair tress assessment, as it could include several hair features which are difficult to define and assess individually by humans. It also provides more sophisticated overall assessment of the hair assembly appearance.**
- **Human assessments based on a 3D-view of the hair corroborate the AI assessment.**
- **Human assessment of hair conducted from one viewpoint only is not sensitive to the more subtle shape and volume effects resulting from shampoo and conditioning treatments.**

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[2] M. Zhang, Y. Zheng, *Hair-GAN: Recovering 3D hair structure from a single image generative adversarial networks*, Visual Informatics, 2019 3(2) pp.102-112

[3] M. Savardi, G. Daniels, S. Tamburic, U. Muhammad, S. Benini, *Figaro-tresses: a dataset for evaluating hair assembly features before and after cosmetic treatment* (v2020), Mendeley Datasets

[4] M. Savardi, G. Daniels, S. Tamburic, U. Muhammad, S. Benini, *Figaro-tresses: a dataset for evaluating hair assembly features before and after cosmetic treatment,* Data in Brief, 2020, 31

[5] Learn OpenCV, (Accessed on 2020.07.20)

Acknowledgements

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