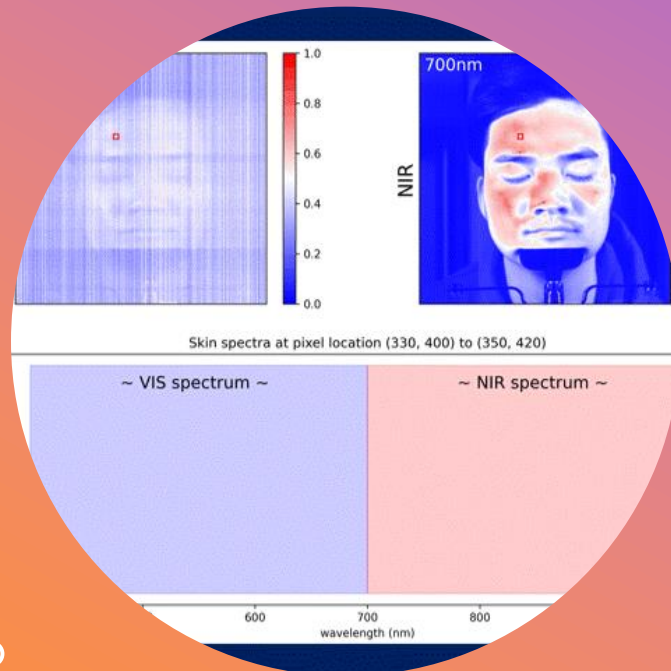


HYPER-SKIN: A HYPERSPECTRAL DATASET FOR RECONSTRUCTING FACIAL SKIN-SPECTRA FROM RGB IMAGES



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Motivation

- Hyperspectral image: contain rich spatio-spectral information
 - Non-invasive approach for skin analysis
- Expensive >\$20k
- Consumer cameras: smartphone, DSLR
- Cheaper <\$2k
- Question:
- Can we **reconstruct** valuable information from **expensive hyperspectral cubes** using **accessible RGB images**, enabling hyperspectral skin analysis directly on consumer devices?



<https://www.canfieldsci.com/imaging-systems/visia-complexion-analysis/>



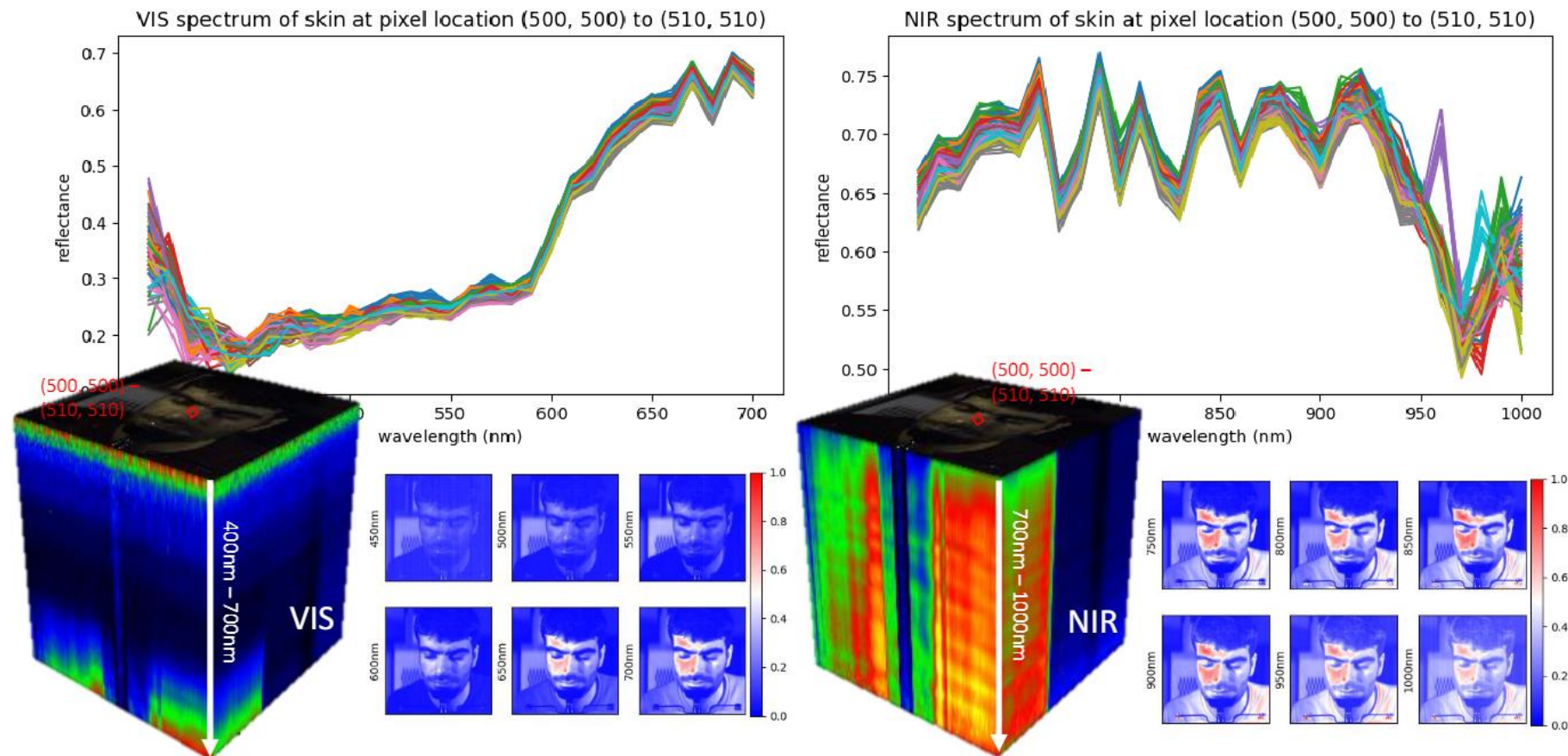
Credit: Getty Images

Hyper-Skin 2023

- a hyperspectral dataset covering wide range of wave-lengths from **visible (VIS) spectrum (400nm - 700nm)** to **near-infrared (NIR) spectrum (700nm - 1000nm)**
- Facial skin-spectra reconstruction for cosmetology applications on consumer devices.

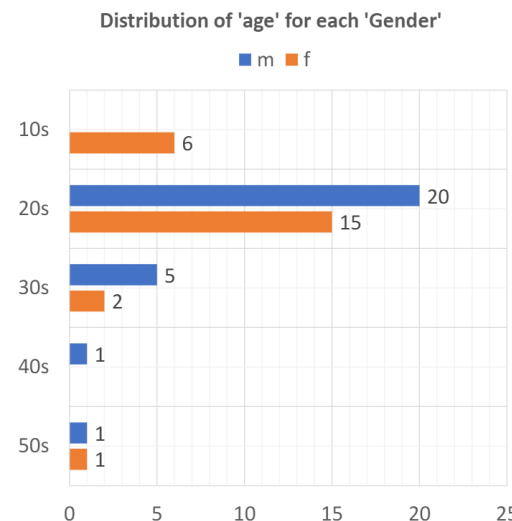
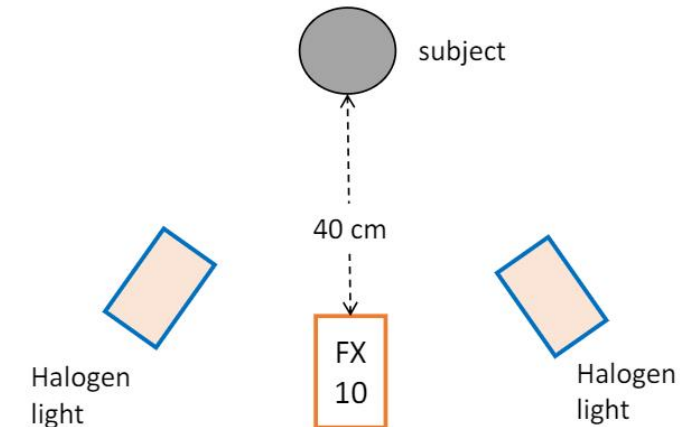
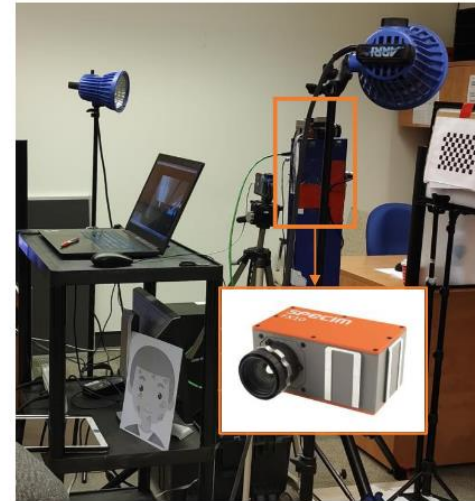
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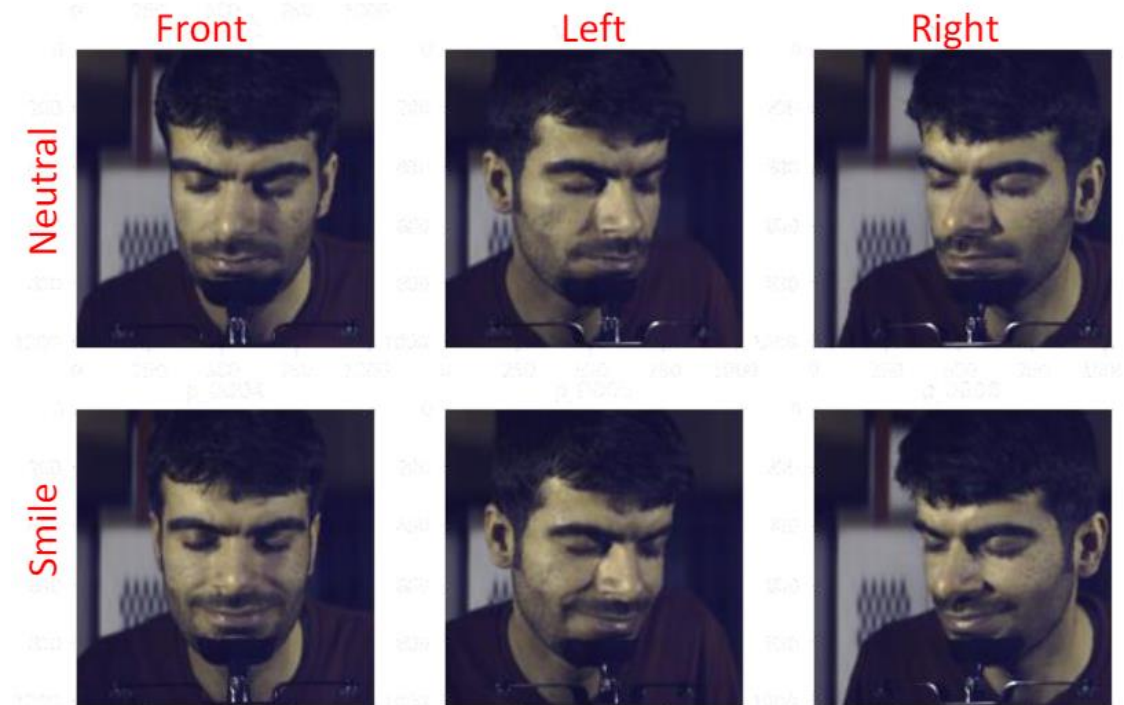
Dataset Collection

- Compliance to the University's research ethics protocol.
 - **Approved** protocol: RIS-42284
 - Participants signed informed consent
- Data Acquisition Set up:
 - **Specim FX10** camera – pushbroom camera
 - moved using a **customized scanner** for precise scanning
 - The distance between the camera and the face was set at **40cm**
 - With a frame rate of **45Hz** for one line, it took approximately 22.7 seconds to capture all 1024 line, 448 spectral bands from 400nm to 1000nm
- Demographic:
 - 51 participants (10s – 50s)
 - Male > Female
 - Aisan, European, Latino



Dataset Attributes

- **306** Hyperspectral cubes from **51 subjects**
- Facial skin from **3 different angles** and **2 facial poses**
- Cube dimension: 1024x1024x448
- Resampled into two separate 31-band datasets
 - VIS spectrum from 400nm to 700nm (10nm step)
 - NIR spectrum from 700nm to 1000nm (10nm step)



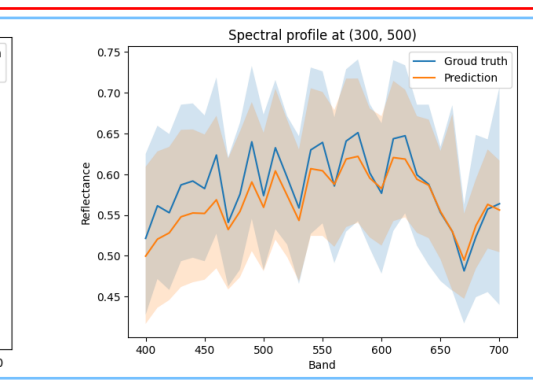
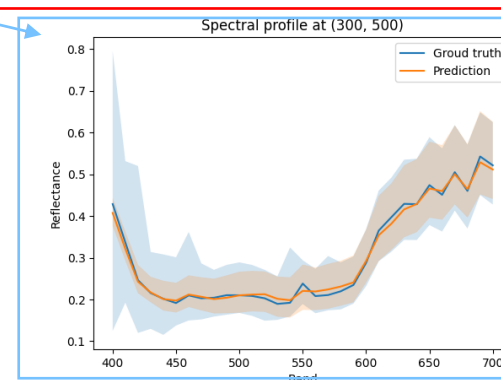
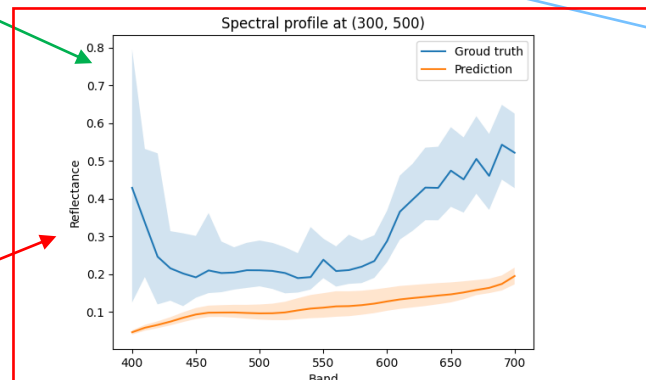
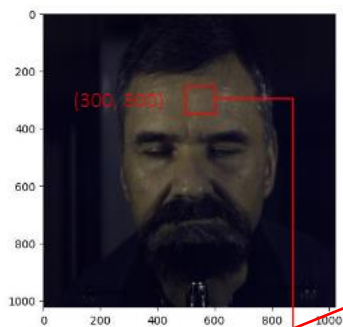
Description	(RGB, VIS)	(MSI, NIR)
Input	RGB	MSI (RGB + Infrared at 960nm)
Output	VIS (400nm - 700nm)	NIR (700nm - 1000nm)
Skin physiological features	surface-level characteristics (e.g., pigmentation and melanin map)	deeper tissue properties (e.g., collagen content and hemoglobin map)

Evaluation and Benchmarks

- Facial skin-spectral reconstruction: RGB $R \in \mathbb{R}^{w \times h \times c} \rightarrow$ HIS $H \in \mathbb{R}^{w \times h \times C}, c = 3 \ll C = 31$
- Baseline Models: (1) Hyperspectral Convolutional Neural Network (HSCNN), (2) Hierarchical Regression Network (HRNet), and (3) Multi-stage spectral-wise transformer (MST++)
 - Winners in NTIRE competition series held in conjunction with CVPR from the year of 2018, 2020 to 2022
 - Pretrained models: <https://github.com/caiyuanhao1998/MST>
- Evaluation metrics: (1) Structural Similarity Index(SSIM), and (2) Spectral Angle Mapper (SAM)

	Data	Pre-trained Models		Re-trained Models	
		(RGB, VIS)	(MSI, NIR)	(RGB, VIS)	(MSI, NIR)
with Back-ground	HSCNN [37]	0.683 ± 0.027	-	0.916 ± 0.013	0.943 ± 0.007
	HRNet [38]	0.704 ± 0.023	-	0.933 ± 0.021	0.955 ± 0.006
	MST++ [39]	0.602 ± 0.042	-	0.923 ± 0.011	0.959 ± 0.006
w/o Back-ground	HSCNN [37]	0.816 ± 0.021	-	0.950 ± 0.011	0.964 ± 0.006
	HRNet [38]	0.813 ± 0.023	-	0.961 ± 0.014	0.971 ± 0.005
	MST++ [39]	0.766 ± 0.035	-	0.954 ± 0.010	0.974 ± 0.004

	Data	Pre-trained Models		Re-trained Models	
		(RGB, VIS)	(MSI, NIR)	(RGB, VIS)	(MSI, NIR)
with Back-ground	HSCNN [37]	0.677 ± 0.061	-	0.119 ± 0.008	0.091 ± 0.010
	HRNet [38]	0.648 ± 0.062	-	0.147 ± 0.014	0.094 ± 0.009
	MST++ [39]	0.707 ± 0.054	-	0.113 ± 0.009	0.086 ± 0.006
w/o Back-ground	HSCNN [37]	0.621 ± 0.049	-	0.113 ± 0.009	0.083 ± 0.012
	HRNet [38]	0.596 ± 0.046	-	0.133 ± 0.015	0.086 ± 0.010
	MST++ [39]	0.628 ± 0.050	-	0.107 ± 0.010	0.076 ± 0.005



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... cameras: smartphone, DSLR
<https://www.canfieldsystems.com/vision-computer>

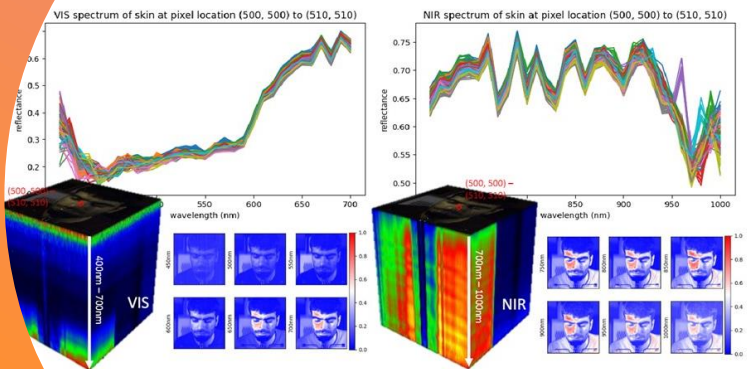
... spectrally valuable information
... hyperspectral cubes using
... cameras, enabling
... analysis directly on
...
... cubes from 51 subjects
... different angles and 2
... : 1024x1024x448
... calibrated and resampled into
... -band datasets
<https://github.com/hyperspectral-skin/Hyper-Skin-2023>

(RGB, VIS)	(MSI, NIR)
RGB	MSI (RGB + Infrared at 960nm)
VIS (400nm - 700nm)	NIR (700nm - 1000nm)
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THANK YOU

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Halogen light

Computer to control the Hyperspectral camera and scanner motor

Computer to control the visible-light and red-light cameras

Halogen Light

Distribution of 'age' for each 'Gender'

Age	m	f
6	6	0
20	20	0
15	0	15
5	0	5
2	0	2
1	0	1
1	1	0
1	0	1