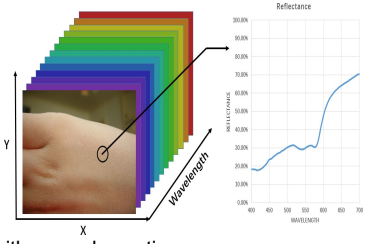
Fast Determination of Melanin based on Skin Hyperspectral Reflectance

Shiwei LI[1]
Dr. Mohsen ARDABILIAN[1],
Dr. Abdel-Malek ZINE[2]
1 LIRIS UMR 5205 CNRS
2 ICJ UMR 5208 CNRS

1 Abstract

A 3layered skin model is built to simulate hyperspectral reflectance using Monte Carlo simulations based on biological components, which include melanin volume fraction, water level, blood volume fraction, oxygen saturation, etc. A forward neural network is trained for mapping biological components and reflectance. Then a database, which contains 50,000 samples spectra from 450 to 750 nm with randomly given biological components information, are generated by this forward neural network. Support vector regression, inverse neural networks and random forest are applied for the regression analysis of reflectance data and melanin volume fraction. The performances of three regression methods are measured and show promising prediction results.

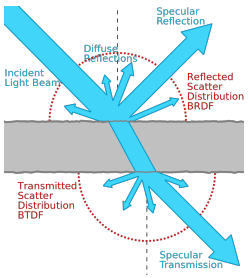


2 Methods

Skin Model : a computational model with several equations that calculate the optical properties from the biological components of skin.

Database Generation : by using Monte Carlo simulations, we generate a database which contains 50,000 samples of skin hyperspectral reflectance and its corresponding biological components.

Melanin Determination :
Tree machine learning methods used :
Inverse Neural Networks
Random Forest
Support Vector Regression



3 Results

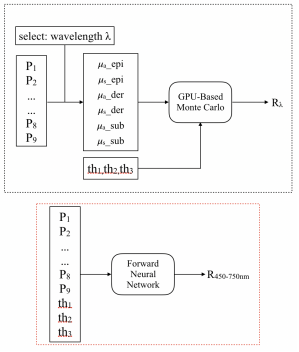
Synthetic Spectra : We have created 10 samples of reflectance spectra for each skin type using MC simulations, which are used as the first validation data. These 30 samples in total are analyzed respectively by INN, SVR, and RF for extracting melanin volume fraction. The root-mean-square errors (RMSE) of RF, INN, and SVR are 0.48%, 0.30%, and 4.47% respectively. And the standard deviations (STD) of errors are 0.47%, 0.30% and 1.33%. It turns out that INN is the best method for estimating melanin volume fraction in lightly pigmented skin group among these three.

Measured Spectra : To our best knowledge, there is not a public database which contains skin reflectance spectra and the corresponding biological parameters simultaneously. Most of the researchers compare their approaches to MC when dealing with measured spectra. INN and INN+LVF are used to extract melanin volume fraction compared with MC.

Dimensionality Reduction : Low variance filter.

TABLE III
MELANIN[%] DETERMINATION RESULTS OF OUR DIRECT METHODS FOR MODERATELY PIGMENTED SKIN TYPE

Samples	no.11	no.12	no.13	no.14	no.15	no.16	no.17	no.18	no.19	no.20
Target	15.63	12.44	12.18	13.01	13.82	13.48	11.24	14.28	14.45	11.43
RF	15.94	11.56	12.92	12.49	12.77	14.93	13.32	14.24	13.61	12.80
INN	15.72	12.59	12.28	12.60	13.77	13.64	12.10	13.89	14.05	11.98
SVR	15.45	12.76	12.30	11.77	12.86	13.30	12.35	15.96	13.66	9.82



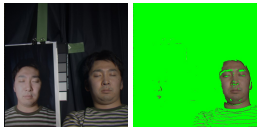
4 Conclusion and Future Work

Our research focus mainly on fast determination for melanin volume fraction. It is related to several skin diseases, such as melanoma and vitiligo, which seriously affect the normal lifestyle of victims. A synthetic reflectance spectra database based on a 3-layered skin model is generated by FNN instead of MC to speed up.

- Around 19.4 ms for FNN to generate a spectrum (20 s for MC);
- INN has the best performance in estimating melanin volume fraction;
- The RMSE and STD are less than 5%.

Future Work :

- Collecting hyperspectral skin images;
- Skin and non-skin classification : A preview results using hyperspectral images from CAVE;



- Implementation of our fast melanin determination with the help of hyperspectral images reconstruction from RGB images

5 References

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