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Smart Skincare Assistant

Subjects : Introduction to NN, CNN and GNN (24AIM113)
Analog system design (24AIM114)

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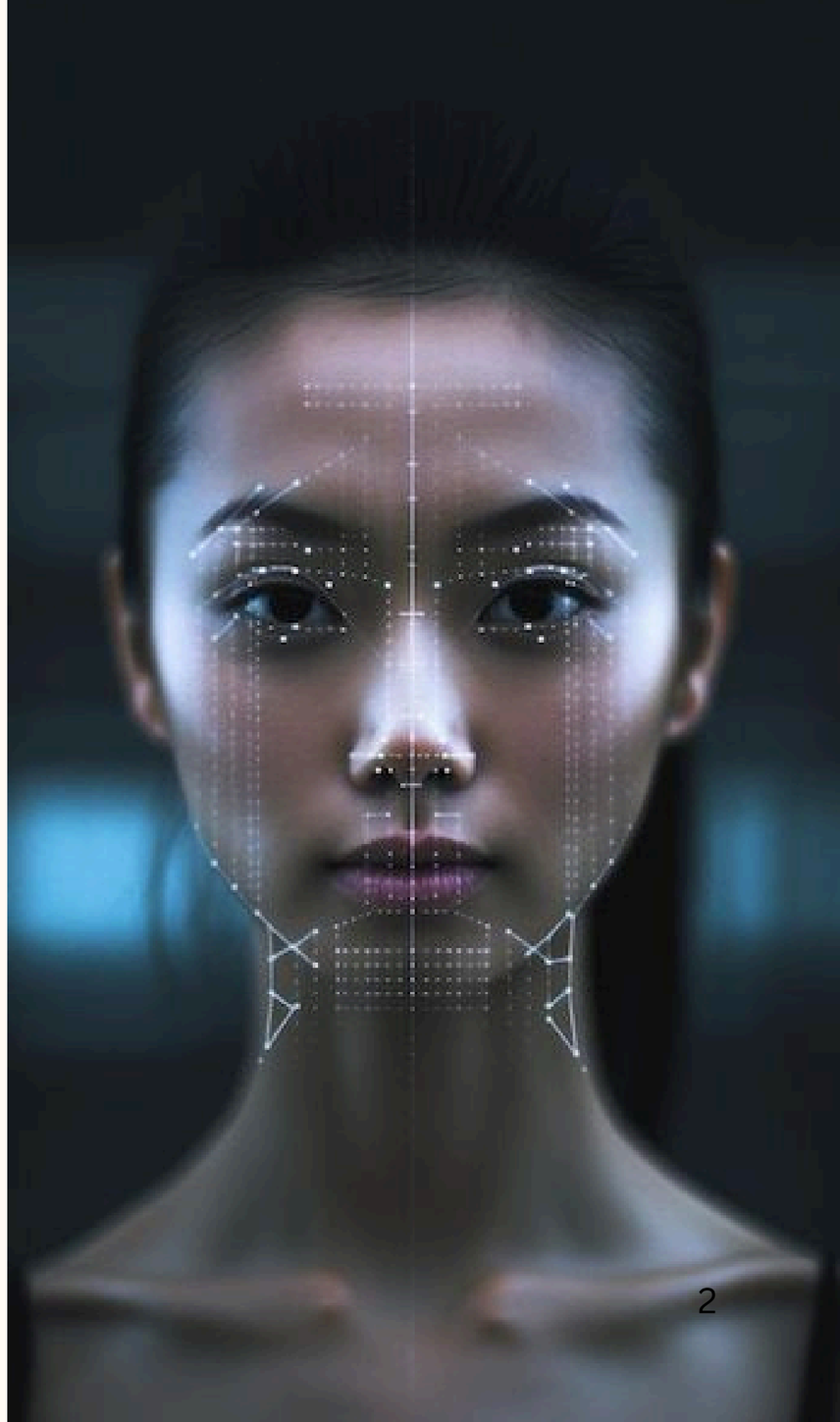
Introduction

Maintaining healthy skin requires continuous monitoring of factors like moisture levels, oil balance, and environmental exposure.

Our IoT-Based Skincare Assistant provides a personalized, AI-driven approach by:

- Real-time skin analysis using sensors
- Dynamic skincare recommendations.
- On-demand scanning & continuous assessment for trend-based skincare

This project integrates IoT sensors with AI models to deliver accurate, adaptive, and real-time skincare solutions for users.



Problem Statement

Traditional skincare solutions often fail to address individual needs :

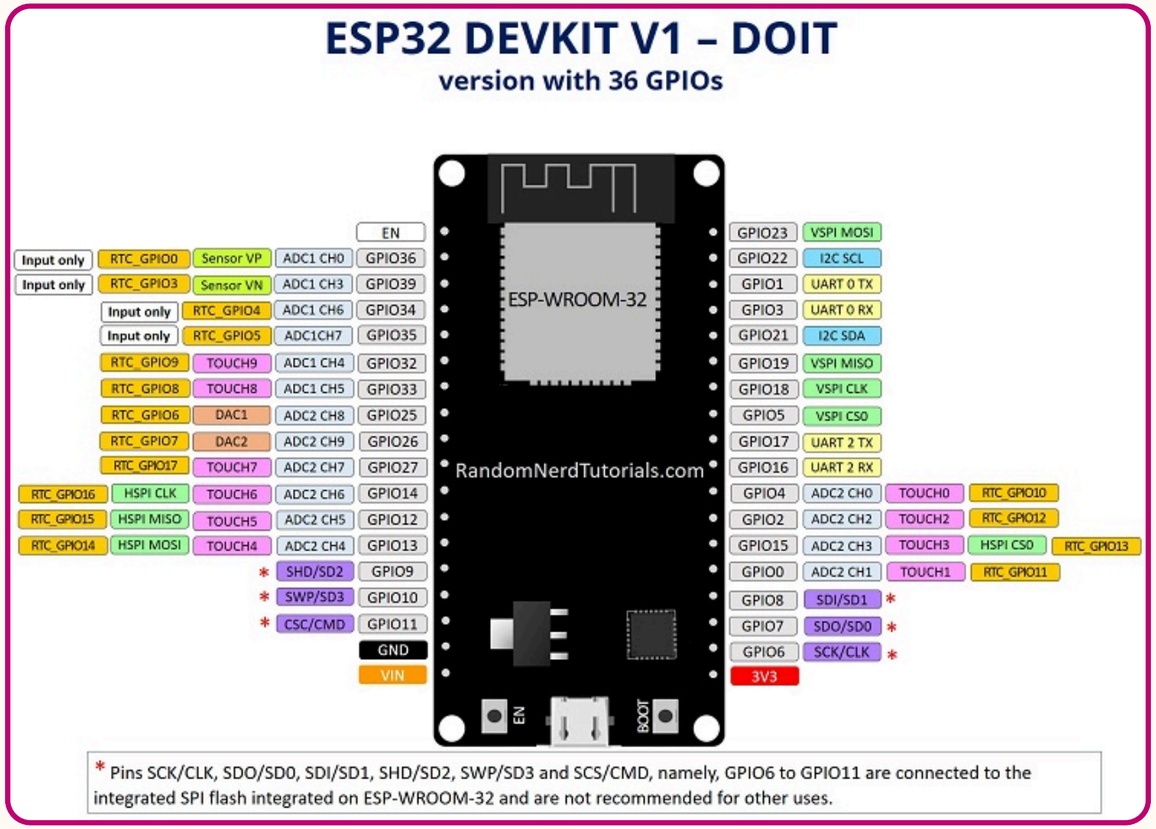
- Provide static recommendations that don’t adapt to changing skin conditions.
- Lack real-time monitoring.
- Ignore environmental factors like humidity, UV exposure, temperature.
- Often bulky or home-based.

Our Solution :

- Recommendations and alerts based on real time conditions.
- On spot skin scanning .
- Compact & portable IoT device, enabling on-the-go skincare analysis.

Hardware Components

ESP32 -



- **Power**: 3.3V - 5V
- **ADC Input Voltage Range**: 0V - 3.3V
- **Wi-Fi Operating Frequency**: 2.4 GHz
- **Memory**: 520 KB SRAM, 4MB Flash
- **Active Mode Current Consumption**: 160 - 240 mA

Parameter	Raw Sensor Range	Mapped Range in Code	Input Voltage Range	Output Type
Moisture (skin)	0 – 1023 (analogRead)	24 – 39	3.3V – 5V	Analog voltage (0–3.3V/5V)
Oil (skin sebum)	~10 kHz – 90 kHz (TCS3200 freq.)	19 – 38	2.7V – 5.5V	Digital frequency (Hz)
Temperature	-40°C to 80°C (DHT11 spec)	Used as-is	3.3V – 5V	Digital (Single-wire)
Humidity	0% – 100% RH	Used as-is	3.3V – 5V	Digital (Single-wire)
UV Index	0 – 1023 (analogRead)	0 – 11	3.0V – 5V	Analog voltage (0–3.3V/5V)

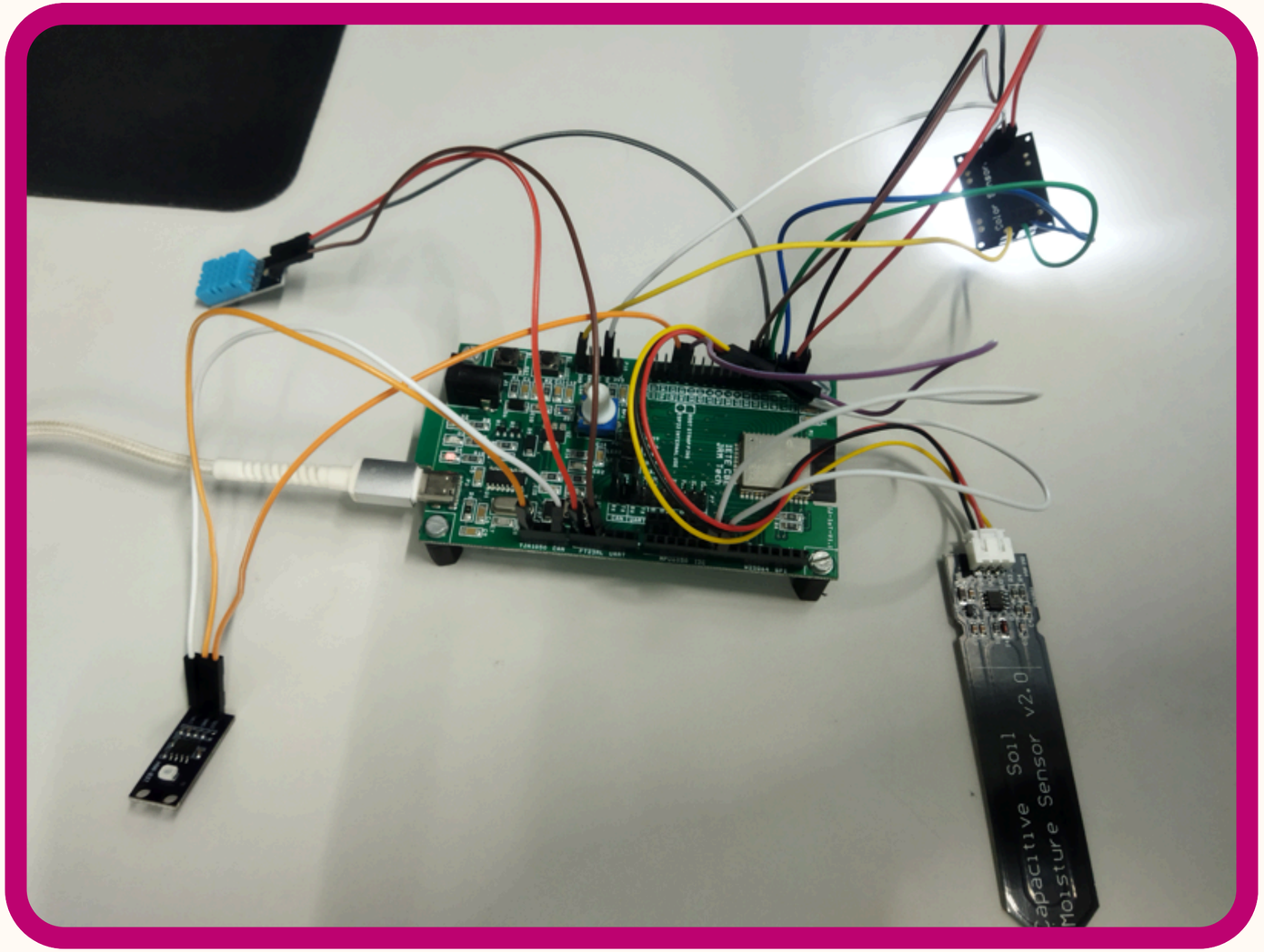
TCS3200 (Color Sensor)

Capacitive Moisture Sensor

DHT11 (Temp & Humidity)

GUVA-S12SD (UV Sensor)

System design



Sensors and Skin Compatibility

TCS3200

The sensor’s wavelength range aligns well with skin reflectance properties, confirming its suitability for detecting oil content in skin.

Source :
https://www.mdpi.com/1424-8220/22/8/3016

Capacitive Moisture sensor

The sensor detects measurable change in capacitance corresponding to varying moisture levels, indicating its sensitivity to moisture.

Source :
https://www.mdpi.com/1424-8220/22/19/7151

DHT11 & GUVA-S12SD

Since both are environmental sensors, they need not be compared to the skin’s specifications.

CSV file used for model training

	A	B	C	D
1	SkinTone	Moisture	Oil	RecClass
2	olive	28.56883593	26.92615	olive_low_low
3	tan_brown	26.78579046	21.94147	tan_brown_low_low
4	medium	28.20633028	26.00248	medium_low_low
5	tan_brown	27.88823223	24.32797	tan_brown_low_low
6	tan_brown	29.32659333	22.18495	tan_brown_low_low
7	light	27.53012728	22.62901	light_low_low
8	medium	29.12853588	27.77774	medium_low_low
9	medium	28.73586302	26.28961	medium_low_low
10	medium	26.4615473	24.55472	medium_low_low
11	tan_brown	26.69053864	20.50781	tan_brown_low_low
12	olive	26.47082419	25.78732	olive_low_low
13	medium	27.38606633	25.41599	medium_low_low
14	deep_brown_black	28.15671286	22.03166	deep_brown_black_low_low
15	tan_brown	29.12514021	24.60854	tan_brown_low_low
16	light	26.06950176	28.07203	light_low_low
17	olive	29.76545461	22.80674	olive_low_low
18	deep_brown_black	27.49773541	21.07402	deep_brown_black_low_low
19	deep_brown_black	28.84726439	24.46402	deep_brown_black_low_low
20	light	29.64472848	25.5504	light_low_low
21	olive	28.15653281	22.53322	olive_low_low
22	tan_brown	27.58768817	25.67365	tan_brown_low_low
23	fair	28.38910657	27.93588	fair_low_low
24	olive	29.01464928	26.01901	olive_low_low
25	light	29.41530396	24.38636	light_low_low
26	deep_brown_black	26.15864399	23.15597	deep_brown_black_low_low
27	tan_brown	28.73531525	24.99954	tan_brown_low_low

JSON file used for recommendation system

Recommendation_system.json

D: > MiDerma > {} Recommendation_system.json > ...

```
    "medium_low_low": {
        ]
    },
    "light_low_low": {
        "morning_routine": [
          "Cream Cleanser",
          "Hydrating Toner",
          "Hyaluronic Acid Serum",
          "Rich Moisturizer",
          "SPF 50 Sunscreen"
        ],
        "night_routine": [
          "Oil Cleanser",
          "Hydrating Toner",
          "Peptide Serum",
          "Rich Night Cream",
          "Facial Oil"
        ]
    },
    "deep_brown_black_low_low": {
        "morning_routine": [
          "Cream Cleanser",
          "Hydrating Toner",
          "Hyaluronic Acid Serum",
          "Rich Moisturizer with Ceramides",
          "SPF 30+ Sunscreen (Non-comedogenic)"
        ],
        "night_routine": [
          "Cleansing Balm",
          "Hydrating Toner",
          "Peptide Serum",
          "Rich Night Cream",
          "Facial Oil"
        ]
    },
```

Feed forward Neural Network for Skincare Recommendations

Neural networks process sensor data for personalized **skincare recommendations**.

Feedforward Neural Network (FNN) is good at handling structured data like moisture, oil and skintone. FNN efficiently maps input features to skincare recommendations without needing spatial awareness.

Pre Processing Steps :

- **One-Hot Encoding** – Converts categorical sensor data into numerical values.
- **LabelEncoder()**– Converts categorical class labels into numerical class indices for model training.

Model Architecture

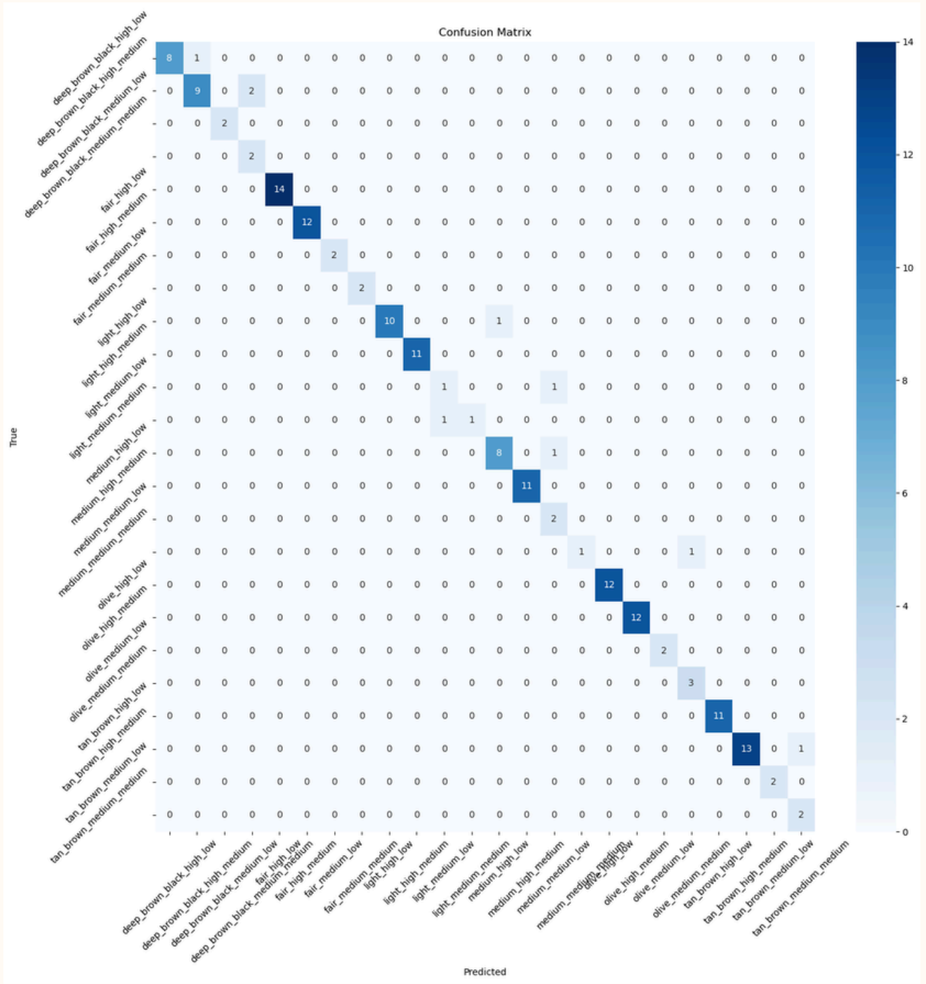
Layer Type	Output Shape	Activation	Additional Notes
Input	(3,)	-	3 input features
Dense	64	ReLU	First hidden layer
BatchNormalization	64	-	Normalizes activations
Dropout	64	-	Dropout rate 0.2
Dense	32	ReLU	Second hidden layer
BatchNormalization	32	-	Normalizes activations
Dense (Output)	num_classes	Softmax	Multi-class output

- Batch Size - 16
- Epochs - 50
- Accuracy - 94%
- Optimizer: Adam with learning rate = 0.0005
- Loss function: Categorical crossentropy

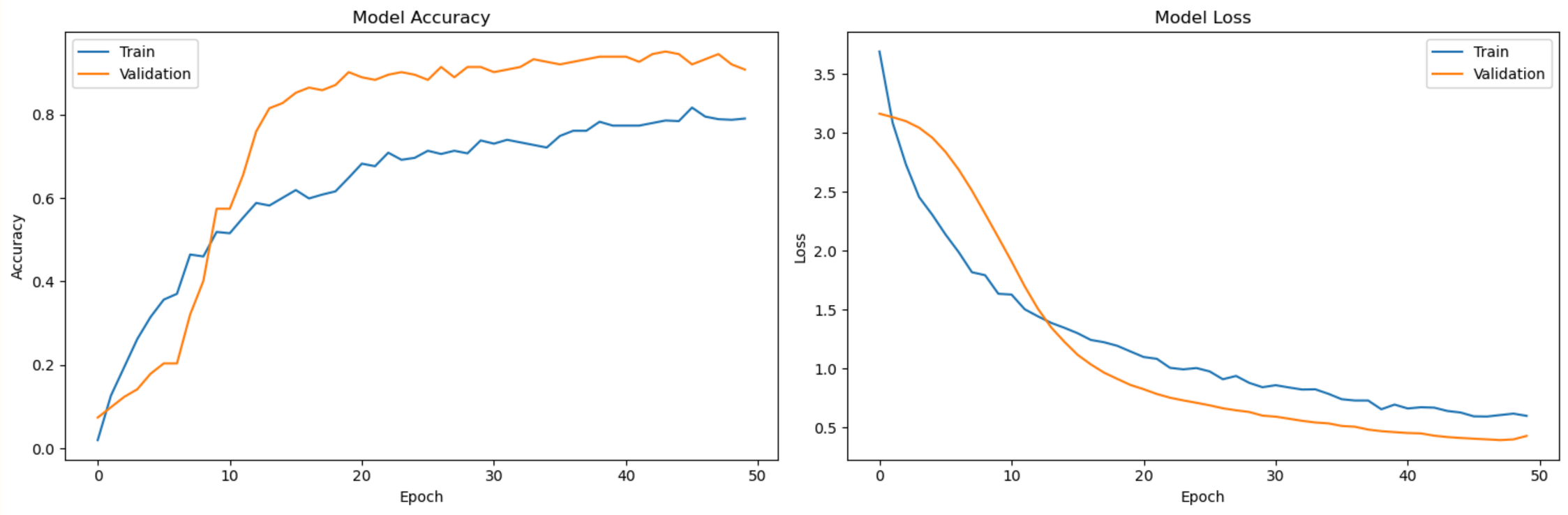
Evaluation Metrics of the current FNN model

Classification Report:

	precision	recall	f1-score	support
deep_brown_black_high_low	1.00	0.89	0.94	9
deep_brown_black_high_medium	0.90	0.82	0.86	11
deep_brown_black_medium_low	1.00	1.00	1.00	2
deep_brown_black_medium_medium	0.50	1.00	0.67	2
fair_high_low	1.00	1.00	1.00	14
fair_high_medium	1.00	1.00	1.00	12
fair_medium_low	1.00	1.00	1.00	2
fair_medium_medium	1.00	1.00	1.00	2
light_high_low	1.00	0.91	0.95	11
light_high_medium	1.00	1.00	1.00	11
light_medium_low	0.50	0.50	0.50	2
light_medium_medium	1.00	0.50	0.67	2
medium_high_low	0.89	0.89	0.89	9
medium_high_medium	1.00	1.00	1.00	11
medium_medium_low	0.50	1.00	0.67	2
medium_medium_medium	1.00	0.50	0.67	2
olive_high_low	1.00	1.00	1.00	12
olive_high_medium	1.00	1.00	1.00	12
olive_medium_low	1.00	1.00	1.00	2
olive_medium_medium	0.75	1.00	0.86	3
tan_brown_high_low	1.00	1.00	1.00	11
tan_brown_high_medium	1.00	0.93	0.96	14
tan_brown_medium_low	1.00	1.00	1.00	2
tan_brown_medium_medium	0.67	1.00	0.80	2



Learning curve



Arduino IDE output

```
{"temperature":33,"humidity":75,"uvIndex":0,"moisture":26,"oil":24.24243}
{"temperature":33,"humidity":74,"uvIndex":0,"moisture":39,"oil":24}
{"temperature":33,"humidity":73,"uvIndex":0,"moisture":26,"oil":24.3}
{"temperature":33,"humidity":73,"uvIndex":0,"moisture":26,"oil":24}
```

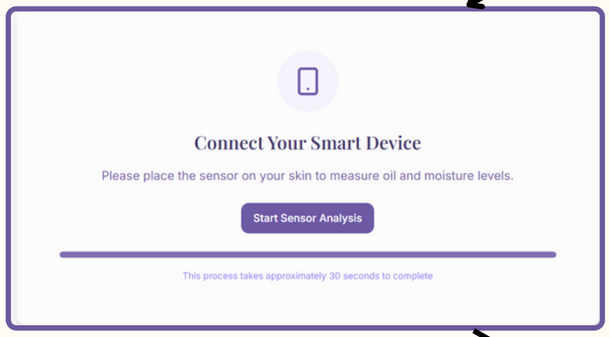
FNN output

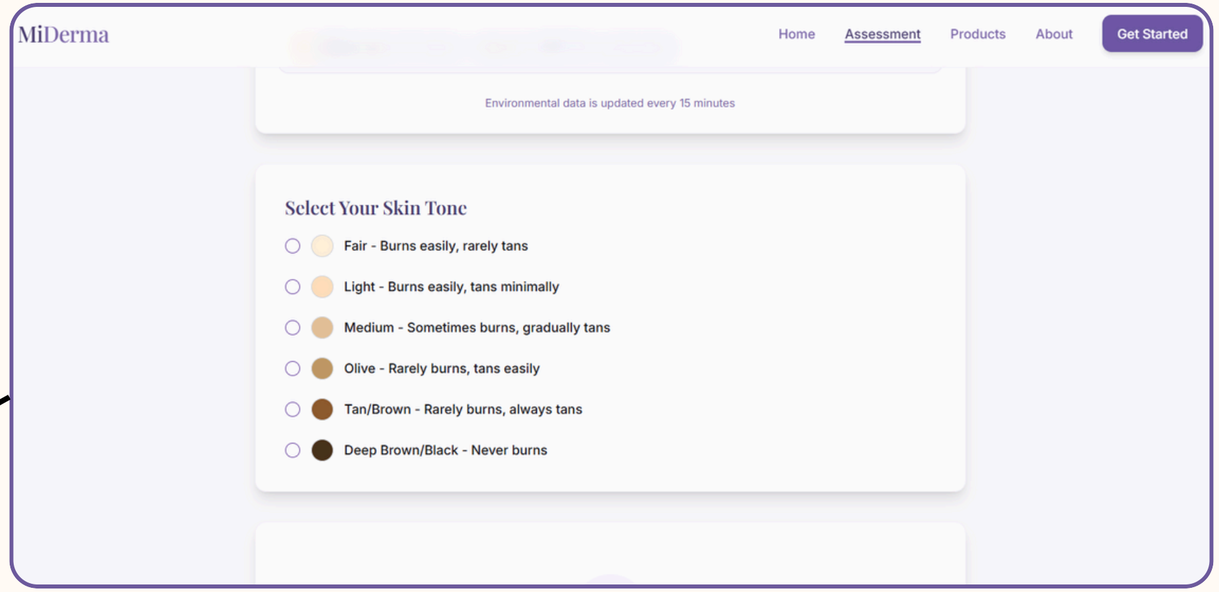
```
=== MiDerma Skin Analysis ===
Available skin tones: fair, light, medium, tan_brown, deep_brown_black, olive

=== Recommended Routine ===
{'morning_routine': ['Gentle Cleanser', 'Balancing Toner', 'Vitamin C Serum', 'Lightweight Moisturizer', 'SPF 40 Sunscreen'],
'night_routine': ['Double Cleanse', 'Balancing Toner', 'Retinol Serum', 'Medium-weight Night Cream']}
```

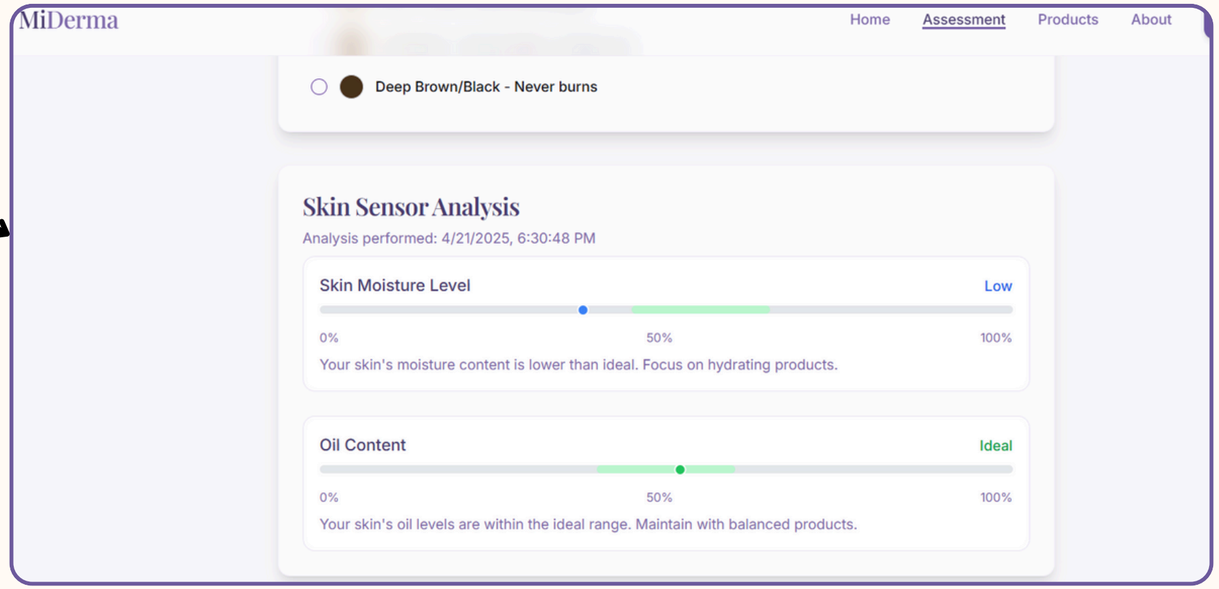
Working

User gives the input of skintone manually

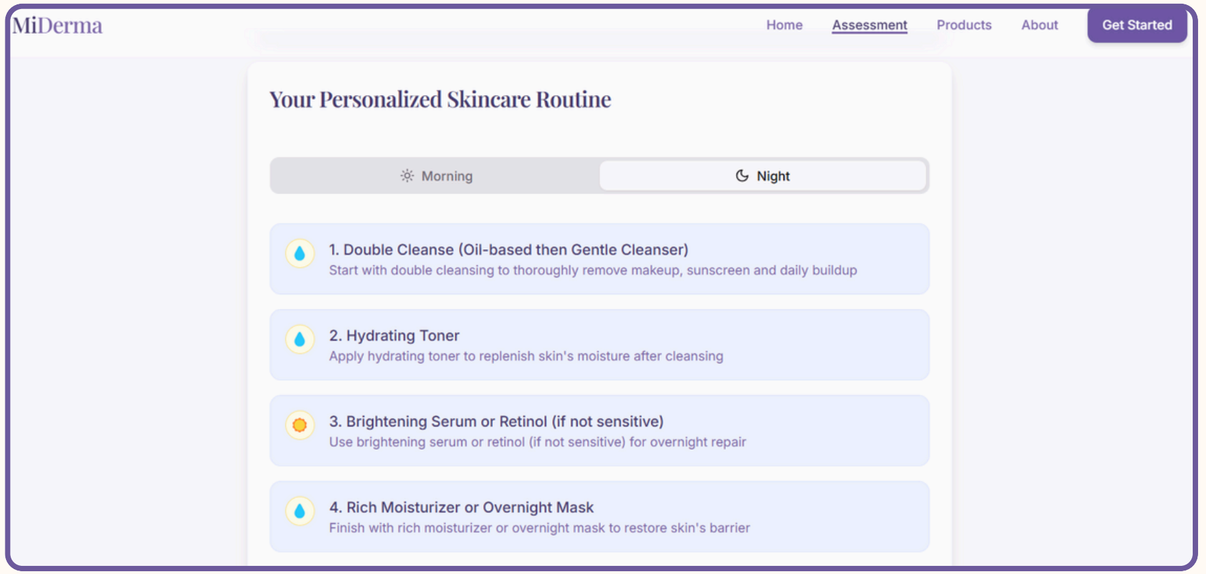




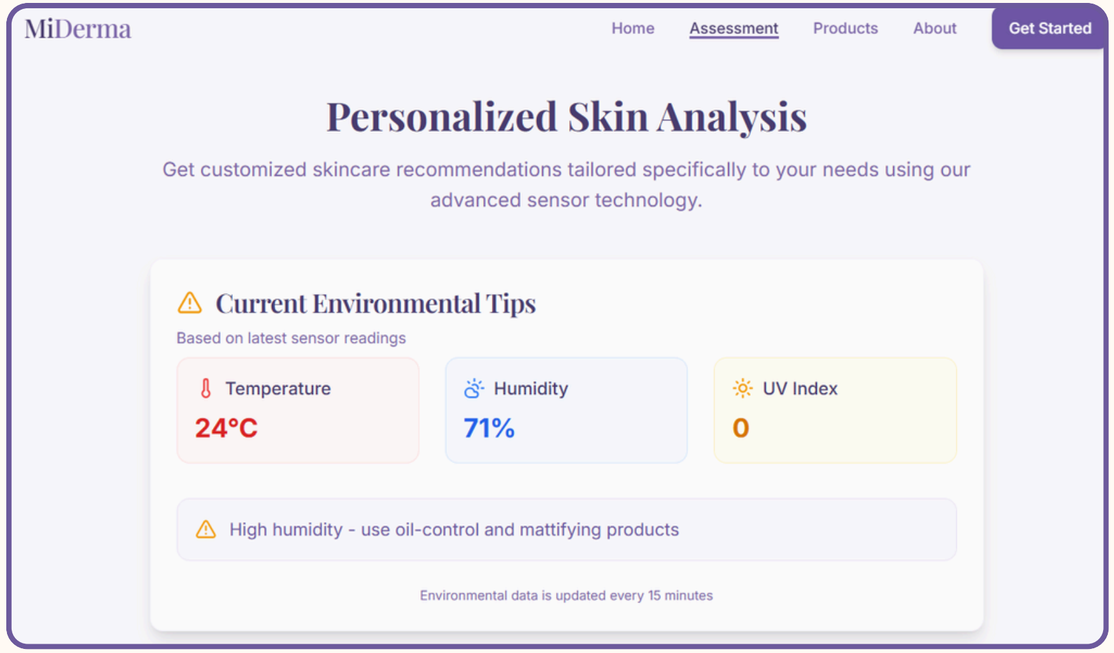
oil and moisture content from sensors is displayed



Personalised skincare routine



Environmental factors, alerts and tips

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Thank you