Technologies Used

🤖 **AI & Machine Learning:**

- **TensorFlow/Keras** - Deep learning framework
- **MobileNetV2** - Pre-trained CNN architecture for transfer learning
- **OpenCV** - Image processing and preprocessing
- **scikit-learn** - Data splitting, label encoding, and class weighting
- **NumPy & Pandas** - Data manipulation and numerical computations

🌐 **Backend & Web Framework:**

- **Flask** - Python web framework for API and frontend
- **Python** - Core programming language
- **Joblib** - Model serialization and loading

🎨 **Frontend:**

- **HTML5/CSS3** - Web page structure and styling
- **Bootstrap 5.3.2** - Responsive UI framework
- **JavaScript** - Client-side interactivity

📊 **Data & Storage:**

- **HAM10000 Dataset** - Medical image dataset with 10,000+ skin lesion images
- **File System Storage** - Local storage for uploaded images and model files
- **JSON** - Configuration and class mapping storage

🔄 How It Works

1. Data Preparation & Training Phase

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```
Medical Images → Preprocessing → Model Training → Saved Model
     ↓              ↓              ↓             ↓
   HAM10000      Resize &       Transfer      skin_cancer
   Dataset      Normalize      Learning       _model.h5
```

- **Data Collection**: Uses HAM10000 dataset containing 10,000+ dermatoscopic images
- **Preprocessing**: Images resized to 224x224 pixels and normalized (0-1 scale)
- **Class Balancing**: Handles imbalanced data using class weights
- **Transfer Learning**: MobileNetV2 pre-trained on ImageNet, fine-tuned for skin cancer
- **Data Augmentation**: Rotation, flipping, zooming to improve model robustness

2. Real-Time Prediction Process

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```
User Upload → Image Preprocessing → AI Analysis → Results Display
     ↓              ↓                ↓              ↓
   JPG/PNG      Resize &          Model          Confidence
   Image        Normalize       Prediction     + Recommendations
```

3. Step-by-Step Workflow:

Step 1: Image Upload

- User uploads skin lesion image through web interface
- File validation (format, size restrictions)
- Temporary storage in static/uploads/ directory

Step 2: Image Preprocessing

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```python
# Image is processed to match training specifications
img = cv2.resize(img, (224, 224))  # Resize to 224x224
img = img / 255.0                  # Normalize pixel values
img_array = np.expand_dims(img, axis=0)  # Add batch dimension
```

Step 3: AI Model Prediction

- Preprocessed image fed into trained MobileNetV2 model
- Model outputs probability scores for 8 classes
- Returns confidence percentage and predicted class

Step 4: Result Processing

```python
# Model returns probabilities for each class
predictions = model.predict(processed_image)
confidence = np.max(predictions)  # Highest confidence score
predicted_class = np.argmax(predictions)  # Index of highest probability

# Apply confidence threshold (85%)
if confidence > 0.85:
    if predicted_class == "normal":
        return "No cancer detected"
    else:
        return f"Detected: {predicted_class}"
```

Step 5: Results Display

- Clear classification result with confidence percentage
- Expert medical recommendations
- Doctor referrals and dietary advice
- Important medical disclaimers

4. Model Architecture Details

MobileNetV2 Backbone:

- Pre-trained on ImageNet (1.4M images)
- Depthwise separable convolutions for efficiency
- 53 layers with residual connections

Custom Classification Head:

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Global Average Pooling → Dropout (30%) → Dense (128 neurons)
→ Dropout (20%) → Output (8 neurons with softmax)
```

5. Key Features & Capabilities

Multi-Class Classification:

1. Actinic keratoses (AKIEC)
2. Basal cell carcinoma (BCC)
3. Benign keratosis-like lesions (BKL)
4. Dermatofibroma (DF)
5. Melanoma (MEL) - Most dangerous
6. Melanocytic nevi (NV)
7. Vascular lesions (VASC)
8. Normal skin

Confidence-Based Results:

- **High Confidence (>85%)**: Clear diagnosis with recommendations
- **Medium Confidence (50-85%)**: Cautious prediction with doctor consultation advice
- **Low Confidence (<50%)**: Request for better quality image or professional evaluation

Medical Safety Features:

- Always recommends professional consultation
- Clear disclaimers about AI limitations
- Emergency contact suggestions for serious cases
- Regular model updates and validation

6. Performance & Accuracy

- **Training Accuracy**: 90%+ on validation set
- **Inference Time**: <2 seconds per image
- **Confidence Threshold**: 85% for reliable predictions
- **Class Balance**: Handled through strategic weighting

This system demonstrates how AI can assist healthcare professionals by providing instant preliminary assessments while maintaining proper medical safeguards and always emphasizing the need for professional diagnosis.