🧠 Brain Tumor Detection

📌 Overview

This report summarizes the experiments and results of our brain tumor classification project using MRI images.
The objective was to build an accurate machine learning model capable of classifying MRI scans into four categories: **Glioma, Meningioma, Pituitary tumor, and No Tumor**.

Three different approaches were explored:

1. **Support Vector Machine (SVM)** using extracted features.
2. **Convolutional Neural Network (CNN)** built from scratch.
3. **MobileNetV2** with transfer learning.

The models were evaluated based on standard classification metrics such as accuracy, precision, recall, and F1-score.

🧪 Model Training & Results

1️⃣ SVM on Extracted Features

- **Input:** Flattened features from images.
- **Preprocessing:** StandardScaler.
- **Kernel:** Linear.
- **Test Accuracy: 65%**
- **Strengths:** Fast, simple baseline model.
- **Weaknesses:** Poor accuracy compared to deep learning models.

2️⃣ CNN from Scratch

- **Input Size:** 128×128×3.
- **Architecture:**
    - 2× Conv2D layers + MaxPooling
    - 1× Dense(128) + Dropout(0.5)
- **Epochs:** 10
- **Test Accuracy: 95.5%**
- **Classification Report:**

- Glioma → Precision: 0.92, Recall: 0.94, F1: 0.93
- Meningioma → Precision: 0.92, Recall: 0.88, F1: 0.90
- No Tumor → Precision: 0.98, Recall: 1.00, F1: 0.99
- Pituitary → Precision: 1.00, Recall: 0.98, F1: 0.99

- **Strengths:** High accuracy, efficient, strong performance.
- **Weaknesses:** May not generalize as well to unseen complex datasets.

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3 MobileNetV2 (Transfer Learning)

- **Input Size:** 128×128×3.
- **Pretrained on:** ImageNet.
- **Trainable Layers:** Top classifier head only.
- **Epochs:** 10
- **Test Accuracy: 87.7%**
- **Performance:**
  - Glioma → Precision: 0.92, Recall: 0.86, F1: 0.89
  - Meningioma → Precision: 0.88, Recall: 0.64, F1: 0.74
  - No Tumor → Precision: 0.87, Recall: 0.99, F1: 0.92
  - Pituitary → Precision: 0.84, Recall: 0.89, F1: 0.91
- **Strengths:** Lightweight, efficient for deployment.
- **Weaknesses:** Lower accuracy compared to custom CNN.

📊 Comparative Results (Per Class)

Model / Class	Precision	Recall	F1-Score
SVM (Glioma)	0.62	0.60	0.61
SVM (Meningioma)	0.54	0.68	0.60
SVM (No Tumor)	0.84	0.53	0.65
SVM (Pituitary)	0.70	0.80	0.74
CNN (Glioma)	0.92	0.94	0.93
CNN (Meningioma)	0.92	0.88	0.90
CNN (No Tumor)	0.98	1.00	0.99
CNN (Pituitary)	1.00	0.98	0.99
MobileNetV2 (Glioma)	0.92	0.86	0.89
MobileNetV2 (Meningioma)	0.88	0.64	0.74
MobileNetV2 (No Tumor)	0.87	0.99	0.92

⚠️ Limitations

- The CNN, while highly accurate, requires **more diverse data** to ensure generalization.
- Performance decreases on **low-quality or noisy MRI scans**.
- Current models classify only **presence and type of tumor**, but not severity or tumor size.
- Deployment on **low-resource devices** may face efficiency challenges.

✅ Conclusion

In this project, we successfully developed and evaluated multiple models for brain tumor classification.
Among all tested approaches, the **CNN built from scratch** achieved the highest accuracy (95.5%) and provided reliable predictions across all tumor classes.

While the results are promising, the project also highlighted important limitations such as sensitivity to image quality and the need for larger, more diverse datasets.
Future improvements may include exploring deeper architectures, integrating more advanced transfer learning models, and extending the system to estimate tumor severity and size.

Overall, the project demonstrates the potential of machine learning for assisting in medical image analysis, while also emphasizing the importance of further research and validation before clinical use.