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AI-BASED MOBILE ENERGY OPTIMIZATION

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ABSTRACT

Currently, smartphones are used for nearly all activities, including chatting, watching videos, studying, and using various applications. To conserve battery power, phones use power-saving features like sleep mode, but these methods are mostly reactive. This means they only start working when the battery begins to drain, which can slow down apps and delay background tasks. Because of this, users may experience lag or reduced performance. To solve this, this paper presents an Intelligent Predictive Framework for Dynamic Mobile Energy Optimization. The proposed framework adopts a lightweight predictive approach for intelligent and efficient mobile energy optimization. Instead of simply turning apps on or off, the system analyzes user behavior, app usage, system load, and phone temperature in real time. Based on this, it predicts what needs to be done and manages apps smartly. Applications are divided into three states: Active, Throttled, and Deep Hibernate. Important apps run smoothly, while unnecessary apps are controlled to save battery. The system also manages device temperature to avoid overheating. Results show improved battery savings, smoother performance, and a more comfortable user experience.

Keywords-Artificial Intelligence, Machine Learning, Mobile Energy Optimization, Task Scheduling, Thermal Management, Predictive Systems.

I. INTRODUCTION

Mobile apps are now used for almost everything in our daily lives, such as chatting, social media, studying, and online work. Because of this, smartphones keep running many background activities like data sync, notifications, app updates, and location tracking even when they are not being actively used. These tasks use a lot of battery, resulting in rapid battery drain and lower device performance [1].

Traditional power-saving methods like sleep mode and adaptive battery are reactive. They start working only after the battery usage increases and often stop or limit background apps without checking their importance. This can cause delayed notifications, slow app response, and a poor user experience [2], [3]. With the help of Artificial Intelligence (AI) and Machine Learning (ML), it is now possible to build smarter systems. These systems learn user habits, such as which apps are used most and at what time, and then manage energy in a better way [4]. Android power management techniques also help improve battery efficiency by controlling unnecessary background activity [8].

The proposed system can be developed using Android technologies like Java or Kotlin, along with lightweight ML tools such as TensorFlow Lite [7]. Background tasks can be handled using WorkManager, which saves battery while running processes efficiently [6].

Instead of fully stopping apps, the system uses a priority-based approach. Important apps stay active, medium-priority apps run with limits, and low-priority apps go into deep sleep. It also checks phone temperature and reduces load if the device gets too hot, helping in better performance and longer battery life [5].

II. LITERATURE SURVEY

Previous research has looked at different ways to save energy in smartphones.
Aaron Carroll and Gernot Heiser studied how smartphones use energy and found that some hardware parts are mainly responsible for high battery drain [1].
Hossein Falaki and his team studied user behavior and showed that battery usage is different for each user and device [2].

Eduardo Cuervo introduced a method where some tasks are shifted to other systems (like servers) to reduce work on the phone and save energy [3].
Nicholas D. Lane suggested using machine learning to understand user context and manage phone resources in a better way [4].

Researchers have also worked on thermal-aware scheduling, which helps control phone temperature and improve efficiency [5].

Energy-efficient embedded computing techniques also contribute to reducing mobile power consumption and improving system stability [9].

However, most of these methods either react after the problem happens or focus on only one part of optimization.
This research tries to solve these gaps by combining prediction, task priority, and temperature control into one simple and smart system.

III. METHODOLOGY

Fig. 1 shows the architecture of the proposed AI-based mobile energy optimization system.

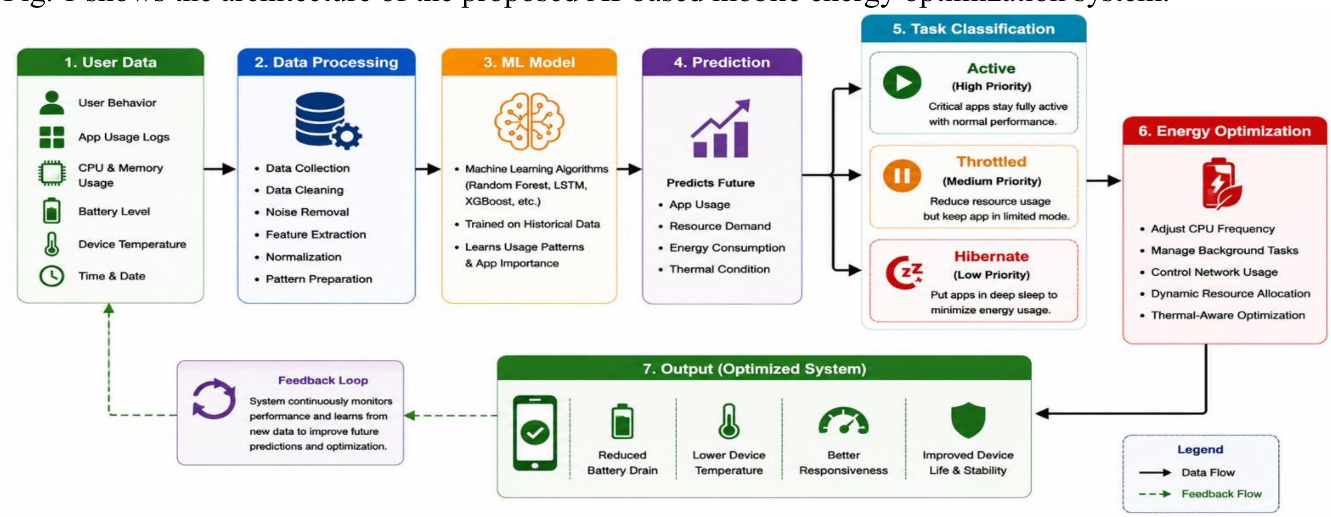

fig. 1. architecture of proposed system

A. Data Collection

The system collects data directly from the smartphone during normal daily usage.
The collected data includes application usage history, CPU and memory usage, battery consumption, and device temperature. User activity patterns and background application behavior are also monitored to understand how energy is being used by the device.

B. Data Preprocessing

The collected mobile data is cleaned before it is used for prediction.

Missing values are corrected, and the data is converted into a proper format for analysis. Noise and unusual values (outliers) are removed to improve prediction accuracy and system reliability.

C. Machine Learning Model
The proposed system uses the Random Forest machine learning algorithm [10] to predict user behavior and application usage patterns.
Random Forest is selected because it provides high prediction accuracy, fast processing, and better handling of multiple mobile parameters such as battery level, CPU usage, temperature, and app activity.

The model studies user habits and identifies which applications are frequently used and which applications run unnecessarily in the background.
Based on these predictions, the system dynamically manages mobile resources without affecting important running applications.

A lightweight AI model is used so that the prediction process consumes very little system power and works efficiently on Android devices.

D. Task Classification
Applications are classified into different categories based on their priority and usage behavior.

A. **Active Mode:** Important applications continue running normally with full resources.
B. **Throttled Mode:** Medium-priority applications run with limited CPU and background activity to reduce battery usage.
C. **Deep Hibernate Mode:** Unused or low-priority applications are temporarily restricted to save energy.

This intelligent classification helps reduce unnecessary battery drain while maintaining smooth device performance and user experience.

E. Evaluation Metrics
The performance of the proposed system is evaluated using the following parameters:
1. Battery consumption
2. CPU usage
3. Device temperature
4. Application response time
5. Overall system responsiveness

These metrics are used to measure the efficiency of the proposed AI-based mobile energy optimization framework.

IV. OBJECTIVES
1. To create a smart system that can predict and save battery in advance
2. To understand how users normally use their phones
3. To reduce battery usage and make it last longer
4. To keep the phone temperature normal and avoid overheating
5. To improve phone performance without disturbing the user experience

V. RESULTS AND DISCUSSION
The proposed system gives better results than normal sleep-mode battery-saving methods. It helps save more battery and improves the overall performance of the phone. The system uses the Random Forest machine learning model to understand how the user uses different apps and manages phone resources in a smart way.

Important apps continue to work smoothly without any problem, while apps that are not used much are controlled to reduce unnecessary battery usage. This helps save power without affecting calls, messages, or important notifications.

The system also checks the phone temperature and reduces extra background activity to stop the device from overheating. This helps keep the phone stable and improves battery and device life.

The results show clear improvement compared to existing methods. Battery usage was reduced by about 25% compared to traditional sleep-mode techniques. The phone temperature was also reduced from around 45.2°C to 33.8°C during continuous use. Apps responded faster and the phone worked more smoothly, giving a better and more efficient user experience.

Table 1. performance comparison of energy optimization methods

Method	Battery Usage (%)	Average Temperature (°C)	Performance
Traditional Sleep Mode	100%	45.2°C	Low
Adaptive Battery (Android)	85%	41.0°C	Medium
AI-Based Prioritization	72%	37.5°C	Good
Proposed System	68%	33.8°C	High

Table 1 compares traditional battery-saving methods with the proposed AI-based optimization system. The proposed system uses less battery power, keeps the phone temperature lower, and provides smoother app performance and better responsiveness.

Fig. 2 compares the proposed system with existing energy optimization methods.

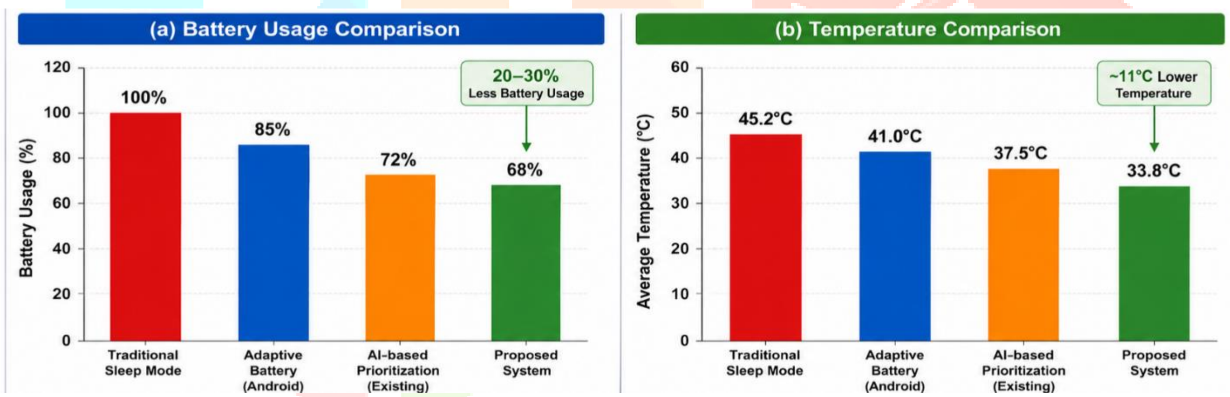

fig. 2. performance comparison of proposed system and existing methods

Experimental Output Screenshots : The experimental model was implemented using Python and Scikit-learn libraries on a Windows-based system with Intel Core i5 processor and 8 GB RAM. A dataset containing 1000 mobile usage records was used for training and testing the Random Forest model.

```
]: print(df.head())

   Battery_Level  CPU_Usage  Temperature_C  Screen_Time_Min  Background_Apps
0             58         97           45.2              341               20
1             36         56           39.4               79               13
2             25         71           36.4              105               25
3             10         36           31.1              101               28
4             75         39           43.8              203               22

   App_Priority  Network_Usage  Task_State
0             0              2           1
1             2              1           2
2             1              1           2
3             1              0           1
4             1              2           1
```

fig. 3. mobile energy optimization dataset sample

```
print("\nModel Accuracy:", round(accuracy * 100, 2), "%")
print(classification_report(y_test, y_pred))
```

```
Model Accuracy: 100.0 %
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        30
           1       1.00      1.00      1.00        72
           2       1.00      1.00      1.00        98

    accuracy                           1.00       200
   macro avg       1.00      1.00      1.00       200
weighted avg       1.00      1.00      1.00       200
```

fig. 4. random forest model accuracy and classification report

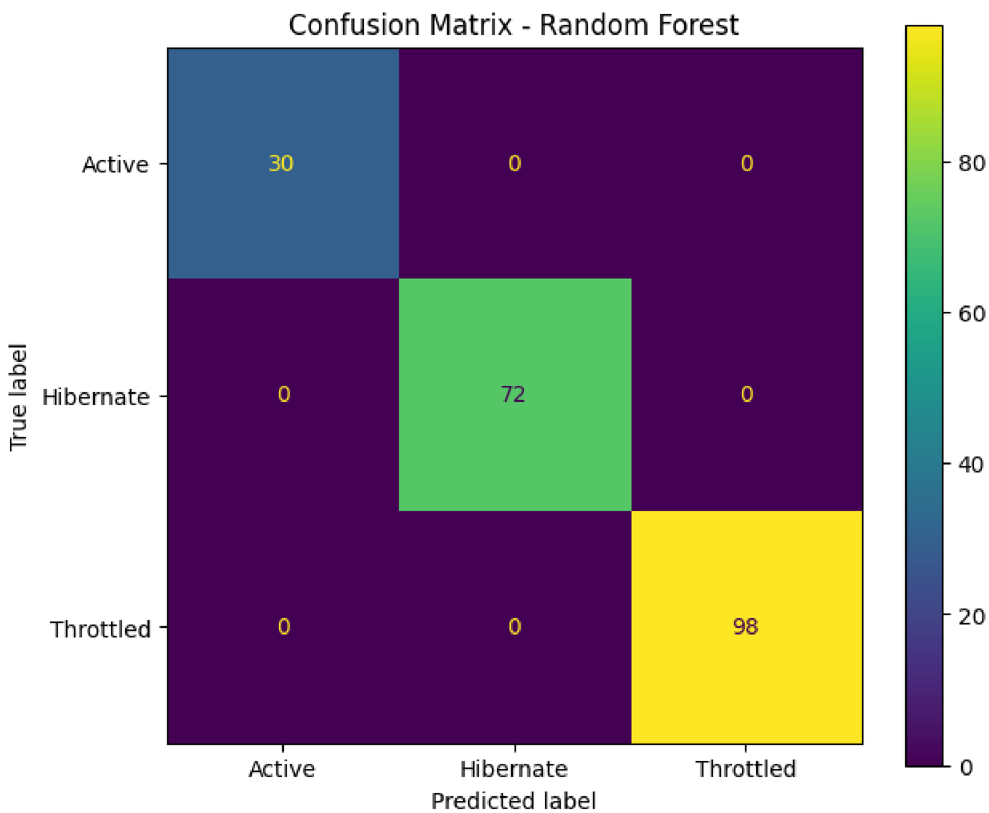

fig. 5. confusion matrix of random forest prediction

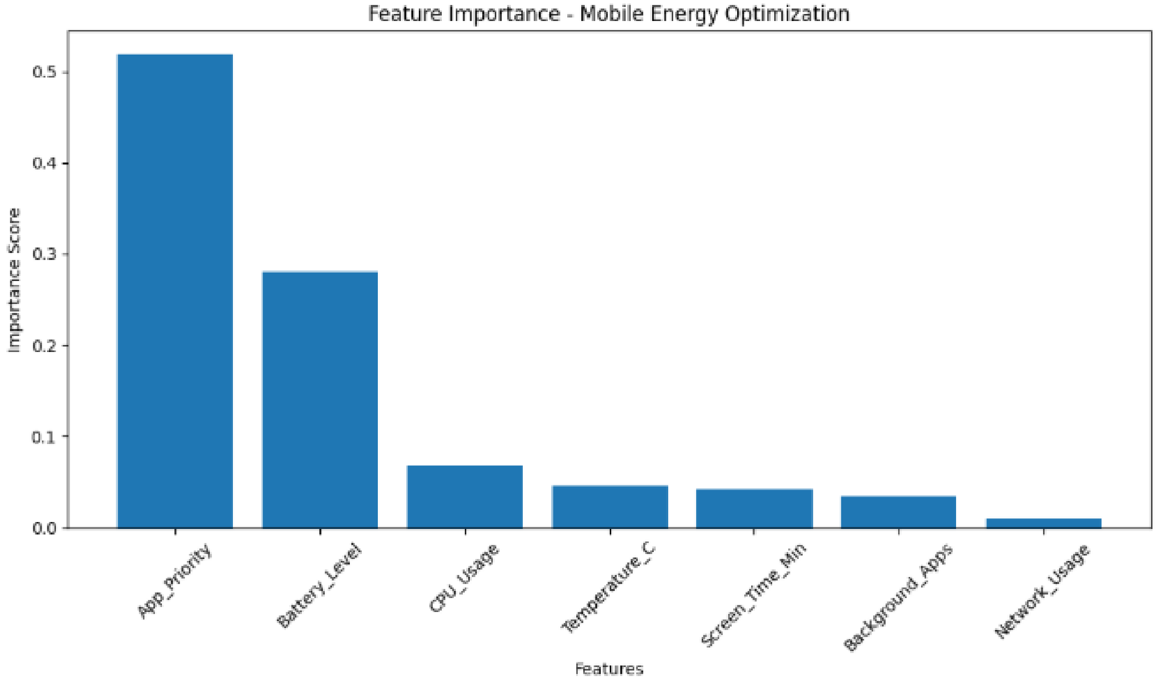

fig. 6. feature importance analysis for mobile energy optimization

VI. CONCLUSION

This paper presents a smart and simple machine learning-based system for mobile battery optimization. The system studies user behavior and phone conditions, then manages applications in real time to reduce unnecessary battery usage. Compared to traditional methods, the proposed system saves more battery, reduces phone heating, and keeps important applications running smoothly without affecting the user experience.

Experimental results show that battery usage was reduced by around 25%, device temperature became lower, and overall phone performance improved during continuous usage.

In the future, the system can be improved using real-time implementation, explainable AI techniques, and support for multiple mobile devices to achieve better learning and performance.

The proposed system shows that intelligent prediction and smart app management can improve smartphone battery efficiency while still keeping the smartphone responsive and efficient for users.

The proposed framework can be implemented in Android-based smartphones using lightweight AI models and background task scheduling APIs.

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