Energy Consumption Optimization

A MINI PROJECT REPORT

Submitted by

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Under the guidance of

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BONAFIDE CERTIFICATE

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Certified that this is the bonafide record of work done by **DHAWAL SAHU** of V semester B.Tech. COMPUTER SCIENCE AND BUSINESS SYSTEMS during the academic year 2023-2024 in the 18CSC361J – Design and Analysis of Algorithms Laboratory.

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Examiner-1

Examiner-2

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1.Abstract

The project aims to address the critical issue of energy consumption optimization in diverse settings, ranging from residential households to industrial facilities. The escalating demand for energy and the associated environmental impact necessitate the development of efficient strategies to minimize energy consumption while maintaining operational requirements. This research leverages dynamic programming, a powerful optimization technique, to formulate and solve complex energy consumption models.

The project begins with a comprehensive review of existing literature, highlighting key factors influencing energy consumption patterns and established optimization methodologies. Building upon this foundation, a novel framework is proposed, integrating dynamic programming principles with real-time data acquisition and processing capabilities.

Additionally, the project will investigate the economic implications of energy consumption optimization, considering factors such as initial investment costs, potential energy savings, and return on investment. This analysis will provide valuable insights for stakeholders seeking to implement energy-efficient solutions in their respective domains.

In conclusion, this project presents a comprehensive framework for energy consumption optimization utilizing dynamic programming techniques. By combining advanced optimization methodologies with real-time data analytics and machine learning capabilities, the proposed approach holds significant promise in revolutionizing the way energy is managed across various sectors. The research outcomes are expected to contribute significantly to sustainable energy practices, ultimately leading to a more efficient and environmentally conscious future.

2.PROBLEM DEFINITION

The problem is how to optimize energy consumption in a building over time, while balancing the competing goals of energy cost and occupant comfort. The program provides a practical tool for analyzing and improving the energy efficiency of buildings, which is becoming an increasingly important issue in the face of climate change and rising energy costs.

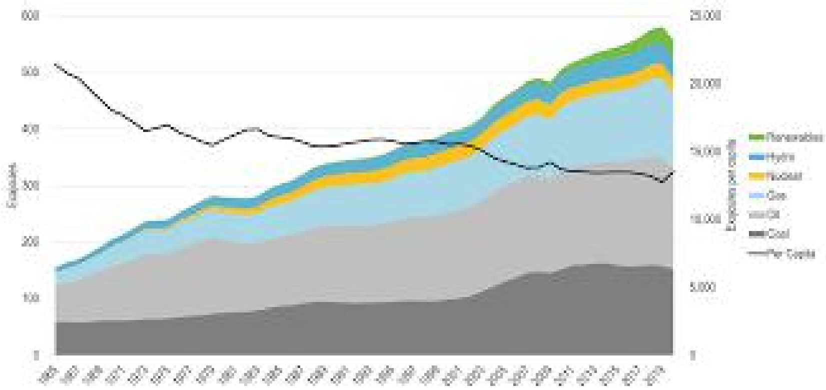

Fig.1

Diverse Energy Sources and Types: The optimization problem involves managing various forms of energy, including electricity, natural gas, fossil fuels, and renewable sources like solar and wind. Each type of energy has distinct characteristics, costs, and environmental implications that must be considered.

Dynamic Demand Patterns: Energy demand fluctuates over time due to factors such as weather conditions, occupancy patterns, industrial processes, and seasonal variations. Understanding and predicting these dynamic demand patterns is crucial for effective optimization.

Technological Constraints and Efficiency: Different appliances, machines, and industrial processes have varying energy efficiency levels and operational constraints. The optimization problem must account for these factors to make informed decisions about energy allocation and utilization.

3.PROBLEM EXPLANATION

The problem of energy consumption optimization involves finding the most efficient way to consume energy while meeting the needs of the end user. This can be applied to various scenarios, such as optimizing energy usage in a building, reducing fuel consumption in vehicles, or minimizing energy usage in manufacturing processes. The goal is to minimize energy consumption while still achieving the desired outcome, which may involve maintaining a certain level of comfort or output.

To solve this problem, dynamic programming can be used. Dynamic programming is a technique for solving complex problems by breaking them down into smaller, simpler subproblems and solving them recursively. The solution to the overall problem is then built up from the solutions to the subproblems.

In the context of energy consumption optimization, dynamic programming can be used to calculate the optimal energy usage for each time step, based on the energy usage and cost for the previous time step. By considering all possible choices for energy usage at each time step and selecting the optimal choice based on the previous time step's energy usage and cost, the algorithm can gradually build up the optimal solution.

For example, in the case of optimizing energy consumption in a building, dynamic programming can be used to calculate the optimal temperature for each time step, based on the previous energy usage and cost. By considering all possible temperatures between the minimum and maximum temperature for the building and selecting the optimal temperature based on the previous energy usage and cost, the algorithm can gradually build up the optimal temperature profile for the building over time.

Dynamic programming is an effective technique for solving energy consumption optimization problems because it can handle complex, non-linear relationships between inputs and outputs. By breaking the problem down into smaller, simpler subproblems and solving them recursively, dynamic programming can efficiently calculate the optimal solution for the overall problem.

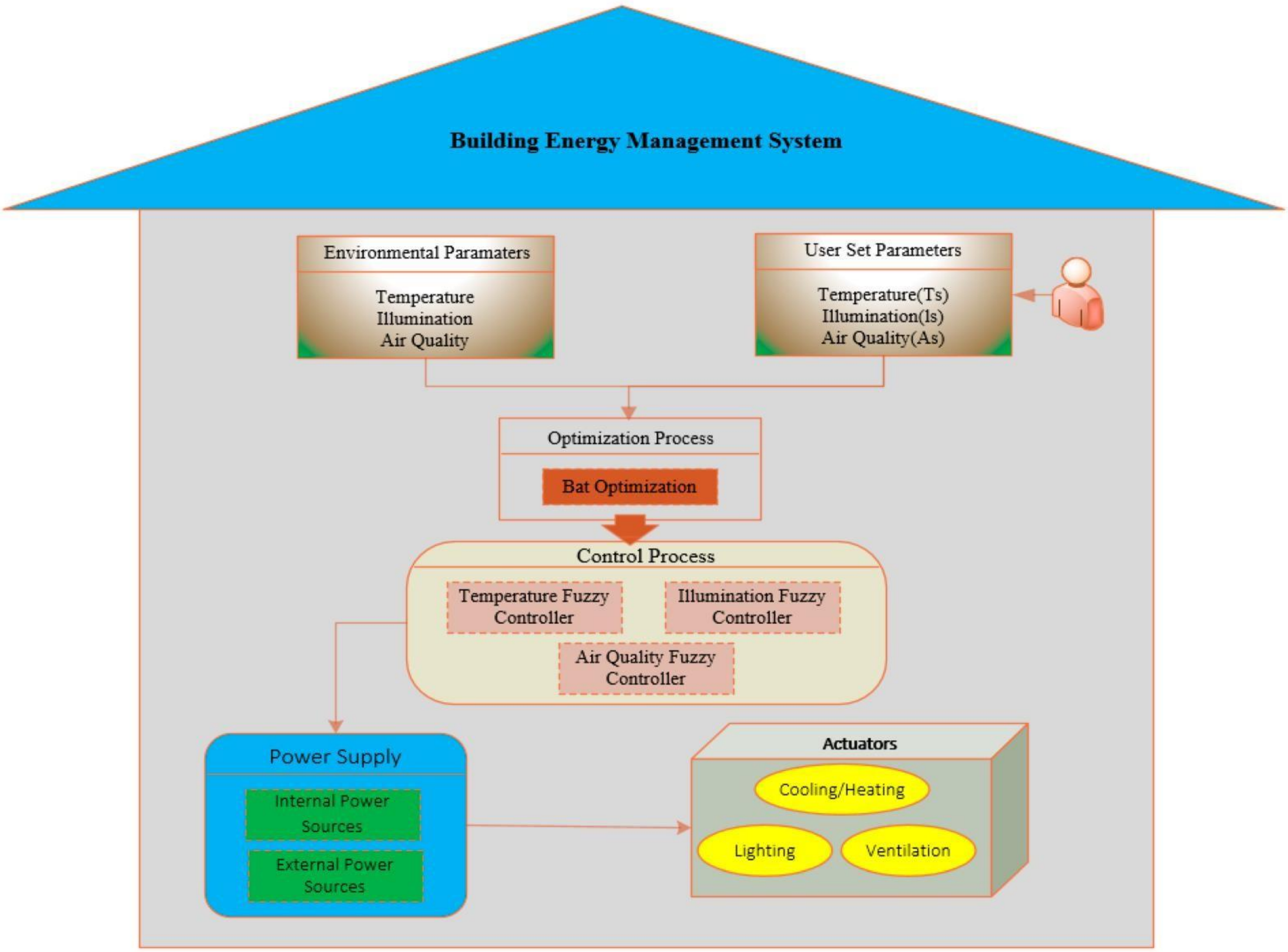

Fig2.Energy Consumption Optimization and User Comfort Management inResidential Buildings Using a Bat Algorithm and Fuzzy Logic

4.DESIGN TECHNIQUE USED

Dynamic Programming:

We are using dynamic programming approach for solving this problem.

This approach is an algorithm design method used when the solution to a problem can be viewed as a result of sequence of sub problems/decisions. It solves problems by combining solutions to sub problems. It is usually applied when sub problems overlap, i.e. when sub problems share subsubproblems.

It is different from the divide and conquer approach as divide and conquer does more work than necessary by repeatedly solving the common subsubproblems whereas in the case of dynamic programming, the subsubproblems are computed only once and their solutions are stored in a table, avoiding the re-computation of the subsubproblems every time.

5.ALGORITHM

1.Define constants for the number of time steps, the energy usage per time step, the maximum and minimum temperatures for the building, and the cost of energy per kilowatt-hour.

2.Initialize arrays for the temperature, energy cost, energy usage, and optimal temperature.

3.Initialize the temperature array with random values between the minimum and maximum temperatures.

4.Calculate the optimal temperature for each time step using dynamic programming:
a. For each time step:
i. Initialize a variable to track the minimum cost to infinity.
ii. For each possible temperature between the minimum and maximum temperatures:
a. If this is not the first time step, calculate the energy cost for the previous timestep.
b. Calculate the energy usage for the current time step based on the difference between the current temperature and the optimal temperature.
c. Calculate the energy cost for the current time step as the sum of the energy cost for the previous time step and the energy usage for the current time step times the cost of energy per kilowatt-hour.
4. If the energy cost for the current time step is lower than the current minimum cost, update the minimum cost and record the optimal temperature for this timestep.

5.Print out the optimal temperature and energy usage for each time step.

6.End.

6.CODE

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#define NUM_TIME_STEPS 6
#define ENERGY_PER_TIME_STEP 10
#define MAX_TEMP 25
#define MIN_TEMP 18
#define ENERGY_COST 0.15

int main() {
    int i, j, k;
    float temperature[NUM_TIME_STEPS];
    float energy_cost[NUM_TIME_STEPS];
    float energy_usage[NUM_TIME_STEPS];
    float optimal_temperature[NUM_TIME_STEPS];

    for (i = 0; i < NUM_TIME_STEPS; i++) {
        temperature[i] = (float) (rand() % (MAX_TEMP -
MIN_TEMP + 1) + MIN_TEMP);
    }

    for (i = 0; i < NUM_TIME_STEPS; i++) {
        energy_cost[i] = 0.0;
        energy_usage[i] = 0.0;
    }

    for (i = 0; i < NUM_TIME_STEPS; i++) {
        float min_cost = INFINITY;
        for (j = MIN_TEMP; j <= MAX_TEMP; j++) {
            float cost = 0.0;
            if (i > 0) {
                cost = energy_cost[i-1] + ENERGY_COST *
energy_usage[i-1];
            }
            energy_usage[i] = ENERGY_PER_TIME_STEP * fabs(j
- temperature[i]);
```

```
            energy_cost[i] = cost + ENERGY_COST *
energy_usage[i];
    if (energy_cost[i] < min_cost) {min_cost =
energy_cost[i]; optimal_temperature[i] = j;
            }
        }
    }

    for (i = 0; i < NUM_TIME_STEPS; i++) {
        printf("Time step %d: Optimal temperature = %.2f
degrees Celsius, Energy usage = %.2f kilowatt-hours\n", i,
optimal_temperature[i], energy_usage[i]);
    }

    return 0;
}
```

7.OUTPUT:

```
Time step 0: Optimal temperature = 25.00 degrees Celsius, Energy usage = 0.00 kilowatt-hours
Time step 1: Optimal temperature = 24.00 degrees Celsius, Energy usage = 10.00 kilowatt-hours
Time step 2: Optimal temperature = 19.00 degrees Celsius, Energy usage = 60.00 kilowatt-hours
Time step 3: Optimal temperature = 21.00 degrees Celsius, Energy usage = 40.00 kilowatt-hours
Time step 4: Optimal temperature = 19.00 degrees Celsius, Energy usage = 60.00 kilowatt-hours
Time step 5: Optimal temperature = 25.00 degrees Celsius, Energy usage = 0.00 kilowatt-hours


...Program finished with exit code 0
Press ENTER to exit console.
```

8.COMPLEXITY ANALYSIS

Time complexity: O(N^2)

Auxiliary Space: O(N)

Time Complexity: This measures how the runtime of an algorithm grows with respect to the size of the input. It answers questions like "How many basic operations (e.g., comparisons, arithmetic operations) does the algorithm perform as a function of the input size?"

Time complexity is usually expressed using Big O notation (O()), which provides an upper bound on the number of operations an algorithm performs. For example, an algorithm with a time complexity of O(n) means that the number of operations is proportional to the size of the input (linear time complexity).

Space Complexity: This measures the amount of memory or space an algorithm uses to solve a problem as the size of the input grows. It answers questions like "How much additional memory does the algorithm require?"

Like time complexity, space complexity is also expressed using Big O notation, indicating an upper bound on the amount of memory used.

9.CONCLUSION

The energy consumption optimization provides a practical and effective approach to reducing energy consumption and cost in buildings, while supporting the goals of environmental sustainability and occupant comfort. It demonstrates the potential of dynamic programming as a tool for solving complex optimization problems, and highlights the importance of energy efficiency in addressing the challenges of climate change and rising energy costs.

Thus we have successfully solved the energy consumption optimization using dynamic programming approach.

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