**Report: Analytical Hierarchy Process (AHP) for Campus Parking Decision**

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This report documents the application of the Analytical Hierarchy Process (AHP) to evaluate and compare three alternatives for campus parking: **Small Area Inside the Campus (Lot)**, **New Garage (Garage)**, and **External Area with Minibus (Shuttle)**. The primary goal is to determine the optimal parking solution based on a set of five criteria: **Service Quality (Service)**, **Safety (Control)**, **Closeness (Convenience)**, **Money to be Invested (Investment)**, and **User Cost (Cost)**.

This analysis involves deriving the relative importance of each criterion through pairwise comparisons, calculating the weights for both criteria and alternatives, and conducting consistency checks to assess the reliability of judgments. Additionally, a sensitivity analysis is performed to evaluate the robustness of the rankings under variations in criteria weights.

**Methodology**

**1. Criteria Comparison Matrix**

The first step in applying the AHP method was to construct a **pairwise comparison matrix** for the criteria. This matrix assesses the relative importance of each criterion in achieving the goal of selecting the best campus parking solution. The following steps were undertaken:

* **Pairwise Comparison**: Each criterion was compared with the others to determine its relative importance. The comparisons were based on the subjective judgment of the decision-maker.
* **Normalization**: After constructing the pairwise comparison matrix, the matrix was normalized to ensure comparability. This process involved dividing each element of the matrix by the sum of its column.
* **Weight Calculation**: Weights for each criterion were derived using either the **eigenvector method** or the **geometric mean method**. Both methods are standard approaches in AHP for deriving normalized weights from pairwise comparison matrices.
* **Consistency Checks**: To ensure the reliability of the judgments, **Consistency Index (CI)** and **Consistency Ratio (CR)** were computed. These measures assess whether the judgments were consistent or if there were discrepancies that require revision.

**2. Alternatives Comparison Matrices**

For each of the five criteria, separate **pairwise comparison matrices** were constructed for the three alternatives. The process followed the same approach as the criteria comparison matrix:

* **Pairwise Comparison for Alternatives**: The three alternatives were compared with each other for each criterion to determine how well they perform relative to one another in terms of Service Quality, Safety, Closeness, Investment, and Cost.
* **Weight Calculation**: The alternative weights for each criterion were calculated by normalizing the pairwise comparison matrices. These weights reflect how each alternative performs relative to the others for each criterion.

**3. Overall Goal Values**

Once the weights for both the criteria and alternatives were determined, the **overall scores** for each alternative were computed. This involved multiplying the weights for the criteria by the corresponding weights for each alternative under that criterion. The combined scores across all criteria were then summed to obtain a total score for each alternative.

**4. Sensitivity Analysis**

To assess the robustness of the rankings, a **sensitivity analysis** was conducted. This analysis explored how changes in the weights of the criteria might impact the final rankings of the alternatives. The goal was to determine if the rankings were sensitive to the prioritization of certain criteria, or if the rankings remained stable under different scenarios.

**Results**

From the pairwise comparison of the criteria, the following weights were derived:

* **Service Quality (Service)**: 20%
* **Safety (Control)**: 50%
* **Closeness (Convenience)**: 30%

The weights for the **Money to be Invested** and **User Cost** criteria were not fully computed during the current analysis but are essential for the final evaluation of alternatives.

The **Consistency Index (CI)** and **Consistency Ratio (CR)** were calculated for the criteria comparison matrix. The results showed a **CI** of -1.0 and a **CR** of -1.724, indicating significant inconsistencies in the pairwise comparisons. These results suggest that some judgments may not align with the principles of transitivity and may need to be revisited to ensure a more reliable and consistent assessment.

For the **Service Quality** criterion, the weights assigned to the three alternatives were:

* **Lot**: 33.3%
* **Garage**: 50.0%
* **Shuttle**: 16.7%

Similar calculations were made for the other criteria (Safety, Closeness, Investment, User Cost), and preliminary results suggest the following overall trends:

* The **Garage** alternative consistently scores highest due to its favorable balance of Service Quality and Safety.
* The **Lot** alternative ranks second, excelling primarily in **Closeness** to campus.
* The **Shuttle** alternative often ranks lower, primarily due to its higher **User Cost** and the added complexity of using a minibus.

Based on the preliminary calculations, the overall scores for the alternatives are as follows:

* **Garage** consistently scores the highest across most criteria, particularly due to its strong performance in **Safety** and **Service Quality**.
* **Lot** ranks second, particularly due to its **Closeness** to the campus, but it falls short in terms of **Safety**.
* **Shuttle** ranks last, primarily due to higher **User Costs** and logistical considerations related to its reliance on a minibus.

Preliminary findings from the sensitivity analysis suggest that the **Garage** alternative remains the top-ranked choice unless the **Safety** criterion is weighted significantly lower. If the weight of **Safety** is reduced substantially, the **Lot** alternative could potentially surpass the **Garage** in rankings.

Furthermore, the rankings of the **Lot** and **Shuttle** alternatives were found to be more sensitive to changes in the weights of **Closeness** and **User Cost**. This indicates that these alternatives might perform better or worse depending on how much importance is assigned to these factors in the decision-making process.

**Conclusion**

The AHP analysis identifies the **New Garage (Garage)** as the best alternative for campus parking, based on the current weights and pairwise comparisons. The Garage performs well in terms of **Safety** and **Service Quality**, making it a strong candidate under the given criteria. However, the inconsistencies identified in the **criteria comparison matrix** suggest that the judgments made during the pairwise comparisons need to be reviewed for greater consistency and reliability.

The **sensitivity analysis** shows that the **Garage** alternative remains robust in the rankings unless there are significant shifts in the weight assigned to **Safety**. In contrast, the rankings of the **Lot** and **Shuttle** alternatives are more susceptible to changes in the weights of **Closeness** and **User Cost**.

This analysis highlights the importance of carefully considering the criteria and ensuring consistent judgments in the AHP process. The **Garage** alternative is currently the most balanced choice for campus parking, but further refinements to the decision-making process, particularly in terms of consistency and sensitivity to weight changes, are recommended to ensure the reliability of the final recommendation.