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Supplementary Document

Correlation Analysis of Battery Capacity, Range, and Charging Time in Electric Vehicles Using Pearson Correlation and MATLAB Regression

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Appendix

The current section provides a more detailed explanation of the MATLAB code.

```
% Statistical Analysis of Electric Vehicles (LFP vs NMC)
%% Input Data
% LFP Vehicles Data
lfp_models = {'BYD Han', 'Wuling Cloud EV', 'Chery Omoda 5', 'MG 4 EV'};
lfp_capacity = [76.9, 50.6, 61.4, 51.0];                % kWh
lfp_range = [605, 408, 450, 350];                       % km
lfp_charging = [30, 30, 30, 30];                        % minutes

% NMC Vehicles Data
nmc_models = {'Hyundai Ioniq 5', 'KIA EV 7', 'Tesla Model 3', 'Toyota bZ4x'};
nmc_capacity = [72.6, 77.4, 62.0, 71.4];                % kWh
nmc_range = [430, 460, 560, 460];                       % km
nmc_charging = [18, 18, 30, 30];                        % minutes

%% 1. Correlation Analysis
% Combine data for correlation analysis
all_capacity = [lfp_capacity nmc_capacity];
all_range = [lfp_range nmc_range];

% Calculate correlation matrix
corr_matrix = corr([all_capacity' all_range']);

% Visualize correlation matrix
figure('Position', [100, 100, 800, 600]);
heatmap({'Capacity', 'Range'}, ...
        {'Capacity', 'Range'}, ...
        corr_matrix, 'Colormap', jet);
title('Correlation Matrix of EV Parameters');

%% 2. Regression Analysis
% Figure for capacity vs range regression
figure('Position', [100, 100, 1200, 400]);

% LFP Regression
subplot(1,2,1);
mdl_lfp = fitlm(lfp_capacity, lfp_range);
```

```
scatter(lfp_capacity, lfp_range, 100, 'filled', 'b');
hold on;
x_lfp = linspace(min(lfp_capacity), max(lfp_capacity), 100);
y_lfp = mdl_lfp.Coefficients.Estimate(1) + mdl_lfp.Coefficients.Estimate(2) * x_lfp;
plot(x_lfp, y_lfp, 'b-', 'LineWidth', 2);
xlabel('Battery Capacity (kWh)');
ylabel('Range (km)');
title(['LFP Regression (R^2 = ' num2str(mdl_lfp.Rsquared.Ordinary, '%.3f') ')']);
grid on;
text(min(lfp_capacity), max(lfp_range), ...
    sprintf('y = %.2fx + %.2f', mdl_lfp.Coefficients.Estimate(2), ...
    mdl_lfp.Coefficients.Estimate(1)), ...
    'VerticalAlignment', 'top');

% NMC Regression
subplot(1,2,2);
mdl_nmc = fitlm(nmc_capacity, nmc_range);
scatter(nmc_capacity, nmc_range, 100, 'filled', 'r');
hold on;
x_nmc = linspace(min(nmc_capacity), max(nmc_capacity), 100);
y_nmc = mdl_nmc.Coefficients.Estimate(1) + mdl_nmc.Coefficients.Estimate(2) * x_nmc;
plot(x_nmc, y_nmc, 'r-', 'LineWidth', 2);
xlabel('Battery Capacity (kWh)');
ylabel('Range (km)');
title(['NMC Regression (R^2 = ' num2str(mdl_nmc.Rsquared.Ordinary, '%.3f') ')']);
grid on;
text(min(nmc_capacity), max(nmc_range), ...
    sprintf('y = %.2fx + %.2f', mdl_nmc.Coefficients.Estimate(2), ...
    mdl_nmc.Coefficients.Estimate(1)), ...
    'VerticalAlignment', 'top');

%% 3. Battery Capacity vs Charging Time
% Scatter plot for LFP and NMC
figure('Position', [100, 100, 1200, 400]);

% LFP Analysis
subplot(1,2,1);
mdl_lfp_charging = fitlm(lfp_capacity, lfp_charging);
scatter(lfp_capacity, lfp_charging, 100, 'filled', 'b');
hold on;
x_lfp_charging = linspace(min(lfp_capacity), max(lfp_capacity), 100);
y_lfp_charging = mdl_lfp_charging.Coefficients.Estimate(1) + mdl_lfp_charging.Coefficients.Estimate(2) *
x_lfp_charging;
plot(x_lfp_charging, y_lfp_charging, 'b-', 'LineWidth', 2);
xlabel('Battery Capacity (kWh)');
ylabel('Charging Time (minutes)');
title(['LFP Charging Time Regression (R^2 = ' num2str(mdl_lfp_charging.Rsquared.Ordinary, '%.3f') ')']);
grid on;
text(min(lfp_capacity), max(lfp_charging), ...
    sprintf('y = %.2fx + %.2f', mdl_lfp_charging.Coefficients.Estimate(2), ...
    mdl_lfp_charging.Coefficients.Estimate(1)), ...
    'VerticalAlignment', 'top');

% NMC Analysis
subplot(1,2,2);
mdl_nmc_charging = fitlm(nmc_capacity, nmc_charging);
scatter(nmc_capacity, nmc_charging, 100, 'filled', 'r');
hold on;
x_nmc_charging = linspace(min(nmc_capacity), max(nmc_capacity), 100);
y_nmc_charging = mdl_nmc_charging.Coefficients.Estimate(1) + mdl_nmc_charging.Coefficients.Estimate(2)
* x_nmc_charging;
plot(x_nmc_charging, y_nmc_charging, 'r-', 'LineWidth', 2);
xlabel('Battery Capacity (kWh)');
```

```
ylabel('Charging Time (minutes)');
title(['NMC Charging Time Regression (R^2 = ' num2str(mdl_nmc_charging.Rsquared.Ordinary, '%.3f') ')']);
grid on;
text(min(nmc_capacity), max(nmc_charging), ...
    sprintf('y = %.2fx + %.2f', mdl_nmc_charging.Coefficients.Estimate(2), ...
    mdl_nmc_charging.Coefficients.Estimate(1)), ...
    'VerticalAlignment', 'top');

%% Statistical Tests and Metrics
fprintf('\nStatistical Analysis Results:\n');

% Correlation Analysis Summary
fprintf('\n1. Correlation Analysis:');
fprintf('\nCapacity-Range Correlation: %.3f', corr_matrix(1,2));

% Regression Analysis Summary
fprintf('\n\n2. Regression Analysis:');
fprintf('\nLFP Range-Capacity Model:');
fprintf('\n    R-squared: %.3f', mdl_lfp.Rsquared.Ordinary);
fprintf('\n    p-value: %.4f', mdl_lfp.Coefficients.pValue(2));
fprintf('\nNMC Range-Capacity Model:');
fprintf('\n    R-squared: %.3f', mdl_nmc.Rsquared.Ordinary);
fprintf('\n    p-value: %.4f', mdl_nmc.Coefficients.pValue(2));

% Performance Metrics Summary
fprintf('\n\n3. Performance Metrics:');
fprintf('\nEnergy Efficiency (km/kWh):');
fprintf('\nRange (km):');
fprintf('\n    LFP Mean: %.2f, Std: %.2f', mean(lfp_range), std(lfp_range));
fprintf('\n    NMC Mean: %.2f, Std: %.2f', mean(nmc_range), std(nmc_range));

% Statistical Analysis Summary
fprintf('\n4. Battery Capacity vs Charging Time Analysis:');
fprintf('\nLFP Regression Model:');
fprintf('\n    R-squared: %.3f', mdl_lfp_charging.Rsquared.Ordinary);
fprintf('\n    p-value: %.4f', mdl_lfp_charging.Coefficients.pValue(2));
fprintf('\nNMC Regression Model:');
fprintf('\n    R-squared: %.3f', mdl_nmc_charging.Rsquared.Ordinary);
fprintf('\n    p-value: %.4f', mdl_nmc_charging.Coefficients.pValue(2));
```