Documentation for Best Fit Line Calculator with Uncertainties

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1 Introduction

This document provides detailed documentation for the implementation of a web-based calculator that computes the best fit line using the least squares method, as well as the uncertainties in the gradient (slope) and y-intercept. Additionally, the calculator provides the centroid of the input data points and displays the equations used for calculating the uncertainties.

2 HTML Structure

The HTML structure consists of a basic form where users can input their X and Y data points as comma-separated values. Upon clicking the "Calculate Best Fit Line" button, the calculations are performed using JavaScript, and the results are displayed on the webpage.

3 CSS Styling

The CSS used in the code is minimal and focuses on providing a clean, user-friendly interface. The form elements, button, and output area are styled to enhance readability.

4 JavaScript Calculations

The main logic for the calculator is implemented in JavaScript. The following steps outline the calculations performed:

4.1 Input Data

The user inputs X and Y data points as comma-separated values, which are parsed into arrays.

4.2 Calculating Slope and Intercept

The slope m and intercept b of the best fit line are calculated using the least squares method with the following formulas:

$$m = \frac{n \sum xy - \sum x \sum y}{n \sum x^2 - (\sum x)^2}$$

$$b = \frac{\sum y - m \sum x}{n}$$

4.3 Uncertainties in Slope and Intercept

The uncertainties in the slope (σ_m) and intercept (σ_b) are calculated using the following formulas:

$$\sigma_m = s \sqrt{\frac{n}{n \sum x^2 - (\sum x)^2}}$$

$$\sigma_b = s \sqrt{\frac{\sum x^2}{n \sum x^2 - (\sum x)^2}}$$

Where s is the standard error of the estimate, calculated as:

$$s = \sqrt{\frac{\sum y^2 - m \sum xy - b \sum y}{n - 2}}$$

4.4 Calculating Centroid

The centroid of the data points is calculated using the mean of the X and Y data points:

$$\text{Centroid} = \left(\frac{\sum x}{n}, \frac{\sum y}{n} \right)$$

5 Displaying Results

The results are displayed on the webpage, including:

- The equation of the best fit line in the form $y = mx + b$.

- The coordinates of the centroid.

- The uncertainties in the slope and intercept.

- The equations used for calculating the uncertainties.

6 Complete HTML, CSS, and JavaScript Code

Below is the complete code for the implementation:

```
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="UTF-8">
    <meta name="viewport" content="width=device-width, initial-scale=1.0">
    <title>Best Fit Line Calculator with Uncertainties</title>
    <style>
        body {
            font-family: Arial, sans-serif;
            margin: 20px;
        }
        .container {
            max-width: 600px;
            margin: auto;
            padding: 20px;
            border: 1px solid #ccc;
            border-radius: 8px;
            background-color: #f9f9f9;
        }
        input[type="text"] {
            width: 100%;
            padding: 8px;
            margin: 8px 0;
            box-sizing: border-box;
        }
        button {
            padding: 10px;
            width: 100%;
            background-color: #4CAF50;
            color: white;
            border: none;
            border-radius: 8px;
            cursor: pointer;
        }
        button:hover {
            background-color: #45a049;
        }
        .output {
            margin-top: 20px;
        }
        .equation {
```

```
                font-style: italic;
                margin: 10px 0;
            }
        </style>
    </head>
    <body>
        <div class="container">
            <h2>Best Fit Line Calculator with Uncertainties</h2>
            <label for="xData">Enter X data points (comma-separated):</label>
            <input type="text" id="xData" placeholder="e.g., 1, 2, 3, 4, 5">
            <label for="yData">Enter Y data points (comma-separated):</label>
            <input type="text" id="yData" placeholder="e.g., 2, 4, 6, 8, 10">
            <button onclick="calculate()">Calculate Best Fit Line</button>
            <div class="output" id="output"></div>
        </div>

        <script>
            function calculate() {
                let xData = document.getElementById('xData').value.split(',').map(Number);
                let yData = document.getElementById('yData').value.split(',').map(Number);

                if (xData.length !== yData.length) {
                    document.getElementById('output').innerHTML = "<p style='color:red;'>X and Y data points
    must have the same length!</p>";
                    return;
                }

                let n = xData.length;
                let sumX = xData.reduce((a, b) => a + b, 0);
                let sumY = yData.reduce((a, b) => a + b, 0);
                let sumXY = xData.map((x, i) => x * yData[i]).reduce((a, b) => a + b, 0);
                let sumX2 = xData.map(x => x * x).reduce((a, b) => a + b, 0);
                let sumY2 = yData.map(y => y * y).reduce((a, b) => a + b, 0);

                let slope = (n * sumXY - sumX * sumY) / (n * sumX2 - sumX * sumX);
                let intercept = (sumY - slope * sumX) / n;

                let delta = n * sumX2 - sumX * sumX;
                let s = Math.sqrt((sumY2 - slope * sumXY - intercept * sumY) / (n - 2));
                let uncertaintySlope = s * Math.sqrt(n / delta);
                let uncertaintyIntercept = s * Math.sqrt(sumX2 / delta);

                let centroidX = sumX / n;
                let centroidY = sumY / n;

                document.getElementById('output').innerHTML = `
                    <p><strong>Best Fit Line Equation:</strong> y = ${slope.toFixed(2)}x + ${intercept.toFixed
    (2)}</p>
                    <p><strong>Centroid Coordinates:</strong> (${centroidX.toFixed(2)}, ${centroidY.toFixed(2)
    })</p>
                    <p><strong>Uncertainty in Slope:</strong> ${uncertaintySlope.toFixed(2)}</p>
                    <p><strong>Uncertainty in Intercept:</strong> ${uncertaintyIntercept.toFixed(2)}</p>
                    <div class="equation">
                        <p><strong>Equations:</strong></p>
                        <p>Uncertainty in Slope (\( m \)): <br> \(\sigma_m = s \sqrt{\frac{n}{n \sum x^2 - (\
    sum x)^2}}\)</p>
                        <p>Uncertainty in Intercept (\( b \)): <br> \(\sigma_b = s \sqrt{\frac{\sum x^2}{n \
    sum x^2 - (\sum x)^2}}\)</p>
                        <p>where \( s = \sqrt{\frac{\sum y^2 - m \sum xy - b \sum y}{n - 2}}\)</p>
                    </div>
                `;
            }
        </script>
    </body>
</html>
```

Listing 1: Best Fit Line Calculator with Uncertainties

7 Conclusion

This document outlines the complete implementation of a web-based calculator that computes the best fit line using the least squares method, along with the uncertainties in the slope and intercept. The equations for these uncertainties are also provided, making this tool useful for educational and practical purposes.