**Fitting and Alignment in Computer Vision**

**Fitting and Alignment** are fundamental tasks in computer vision for aligning geometric models (e.g., lines, circles, planes) to data points. These techniques help to identify patterns and relationships from noisy or imperfect data.

**✅ Key Concepts:**

1. **Fitting**: Finding the best model (e.g., line, circle) that represents a set of points.
2. **Alignment**: Transforming one set of points to align with another (e.g., image registration).
3. **Least Squares (LS)**: Minimizes the squared error between the model and observed data.
4. **RANSAC (Random Sample Consensus)**: Robustly fits a model by handling outliers.

**Comparison of Least Squares and RANSAC:**

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| --- | --- | --- | --- |
| Method | Description | Pros | Cons |
| Least Squares | Minimizes the sum of squared residuals. | Accurate with small noise. | Sensitive to outliers. |
| RANSAC | Fits the model using random sampling. | Robust to outliers. | May fail if sample size is low. |

**1. Linear Fitting Using Least Squares (Line Fitting)**

**Goal:** Fit a straight line to noisy data using the **Least Squares** method.

**Formula:**

A line can be modeled as:

y=mx+c

Given n data points : **(x1​,y1​),(x2​,y2​),…(xn​,yn​)**

The goal is to minimize the error:

**min∑ (y− (mx+c)) 2**

**2. Robust Line Fitting Using RANSAC**

**Goal:** Use **RANSAC** to fit a line that is robust to outliers.

## ****3. Geometric Alignment (Image Alignment Using Least Squares)****

**Goal:** Align two sets of 2D points using **Least Squares** transformation.

**Least Squares vs. RANSAC: When to Use?**

|  |  |  |
| --- | --- | --- |
| Situation | Use Least Squares | Use RANSAC |
| Noisy Data (without Outliers) | More accurate and computationally faster. | Not required for small noise levels. |
| Outliers Present | **Fails** due to sensitivity to outliers. | Robust and effective in handling outliers. |
| Geometric Alignment | Accurate for small transformations. | Use RANSAC for complex datasets. |

**Key Takeaways:**

* **Least Squares**: Best for clean data with minimal outliers.
* **RANSAC**: Ideal for noisy data where **outliers** exist.
* **Alignment**: Uses least squares to compute rigid transformations (rotation + translation).

Would you like to dive deeper into **3D alignment**, **homography estimation**, or **RANSAC for other models**?