**G-H FILTER**

**Variation 1 – g-h filter without Outlier Detection**

Testing involves 6 methods, and each method was run with 2 different initial conditions.

Base – Testing the error in measured data (Filter should provide an error less than this)

Example 1 – Initial Position 125 and Initial Gain 1 (Close to actual)

Example 2 – Initial Position 175 and Initial Gain 5 (Far from actual)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Collection Algorithm** | **Example** | **Root Mean Squared Error** | **Mean Absolute Error** | **KL-Divergence** | **Inverse KL-Divergence** |
| Method 1 | Base | 38.854 | 17.697 | 0.0562 | 0.0499 |
| Example 1 | 25.8712 | 18.974 | 0.029 | 0.032 |
| Example 2 | 26.564 | 19.876 | 0.031 | 0.033 |
| Method 2 | Base | 19.953 | 8.3478 | 0.01358 | 0.01172 |
| Example 1 | 15.191 | 11.2366 | 0.0099 | 0.0099 |
| Example 2 | 16.4226 | 12.383 | 0.0113 | 0.0114 |
| Method 3 | Base | 38.727 | 17.4288 | 0.0565 | 0.0503 |
| Example 1 | 25.683 | 18.768 | 0.0297 | 0.03199 |
| Example 2 | 26.3877 | 19.706 | 0.0309 | 0.0333 |
| Method 4 | Base | 0.4053 | 0.4013 | 7.606x10-7 | 7.609x10-7 |
| Example 1 | 0.8104 | 0.5466 | 2.605x10-5 | 2.596x10-5 |
| Example 2 | 6.478 | 2.01 | 0.0018 | 0.0018 |
| Method 5 | Base | 0.05774 | 0.05 | 2.079x10-7 | 2.078x10-7 |
| Example 1 | 0.6978 | 0.3684 | 2.312x10-5 | 2.305x10-5 |
| Example 2 | 6.442 | 1.8355 | 0.0018 | 0.00177 |
| Method 6 | Base | 0.0592 | 0.0511 | 2.155x10-7 | 2.155x10-7 |
| Example 1 | 0.6998 | 0.37 | 2.321x10-5 | 2.314x10-5 |
| Example 2 | 6.44 | 1.836 | 0.0018 | 0.00178 |

The data shows that for Variation 1 the measurements under Methods 1, 2 and 3 are filtered by the algorithm effectively when appropriate initial conditions are applied. However, for last 3 methods the algorithm does not help in filtering the data.

**Variation 2 – g-h filter with causal Outlier Detection**

Testing involves 6 methods, and each method was run with 2 different initial conditions.

Example 1 – Initial Position 125 and Initial Gain 1 (Close to actual)

Example 2 – Initial Position 150 and Initial Gain 1 (Far from actual)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Collection Algorithm** | **Example** | **Root Mean Squared Error** | **Mean Absolute Error** | **KL-Divergence** | **Inverse KL-Divergence** |
| Method 1 | Base | 38.854 | 17.697 | 0.0562 | 0.0499 |
| Example 1 | 29.515 | 23.187 | 0.035 | 0.034 |
| Example 2 | 31.586 | 25.027 | 0.0402 | 0.0399 |
| Method 2 | Base | 19.953 | 8.3478 | 0.01358 | 0.01172 |
| Example 1 | 11.446 | 9.019 | 0.00355 | 0.00354 |
| Example 2 | 14.925 | 12.019 | 0.0069 | 0.00693 |
| Method 3 | Base | 38.727 | 17.4288 | 0.0565 | 0.0503 |
| Example 1 | 30.744 | 24.329 | 0.0385 | 0.0381 |
| Example 2 | 31.379 | 24.924 | 0.0403 | 0.04 |
| Method 4 | Base | 0.4053 | 0.4013 | 7.606x10-7 | 7.609x10-7 |
| Example 1 | 0.8104 | 0.5466 | 2.605x10-5 | 2.596x10-5 |
| Example 2 | 7.046 | 4.528 | 0.002288 | 0.0022466 |
| Method 5 | Base | 0.05774 | 0.05 | 2.079x10-7 | 2.078x10-7 |
| Example 1 | 0.6978 | 0.3684 | 2.312x10-5 | 2.305x10-5 |
| Example 2 | 7.012 | 4.553 | 0.00222 | 0.00218 |
| Method 6 | Base | 0.0592 | 0.0511 | 2.155x10-7 | 2.155x10-7 |
| Example 1 | 0.6998 | 0.37 | 2.321x10-5 | 2.314x10-5 |
| Example 2 | 7.113 | 4.518 | 0.002268 | 0.002229 |

The data shows that for Variation 2 the measurements under Methods 1, 2 and 3 are filtered by the algorithm effectively when appropriate initial conditions are applied. However, for last 3 methods the algorithm does not help in filtering the data.

**Variation 3 – g-h filter with statistical Outlier Detection**

**Results got are statistically same as the previous variation however the mechanism in which outliers are detected is different here.**

Testing involves 6 methods, and each method was run with 2 different initial conditions.

Example 1 – Initial Position 125 and Initial Gain 1 (Close to actual)

Example 2 – Initial Position 150 and Initial Gain 1 (Far from actual)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Collection Algorithm** | **Example** | **Root Mean Squared Error** | **Mean Absolute Error** | **KL-Divergence** | **Inverse KL-Divergence** |
| Method 1 | Base | 38.854 | 17.697 | 0.0562 | 0.0499 |
| Example 1 | 29.515 | 23.187 | 0.035 | 0.034 |
| Example 2 | 31.586 | 25.027 | 0.0402 | 0.0399 |
| Method 2 | Base | 19.953 | 8.3478 | 0.01358 | 0.01172 |
| Example 1 | 11.446 | 9.019 | 0.00355 | 0.00354 |
| Example 2 | 14.925 | 12.019 | 0.0069 | 0.00693 |
| Method 3 | Base | 38.727 | 17.4288 | 0.0565 | 0.0503 |
| Example 1 | 30.744 | 24.329 | 0.0385 | 0.0381 |
| Example 2 | 31.379 | 24.924 | 0.0403 | 0.04 |
| Method 4 | Base | 0.4053 | 0.4013 | 7.606x10-7 | 7.609x10-7 |
| Example 1 | 0.8104 | 0.5466 | 2.605x10-5 | 2.596x10-5 |
| Example 2 | 7.046 | 4.528 | 0.002288 | 0.0022466 |
| Method 5 | Base | 0.05774 | 0.05 | 2.079x10-7 | 2.078x10-7 |
| Example 1 | 0.6978 | 0.3684 | 2.312x10-5 | 2.305x10-5 |
| Example 2 | 7.012 | 4.553 | 0.00222 | 0.00218 |
| Method 6 | Base | 0.0592 | 0.0511 | 2.155x10-7 | 2.155x10-7 |
| Example 1 | 0.6998 | 0.37 | 2.321x10-5 | 2.314x10-5 |
| Example 2 | 7.113 | 4.518 | 0.002268 | 0.002229 |

The data shows that for Variation 3 the measurements under Methods 1, 2 and 3 are filtered by the algorithm effectively when appropriate initial conditions are applied. However, for last 3 methods the algorithm does not help in filtering the data.

**Comparison among Variations of g-h Filter**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Method Number** | **Examples** | **Variation 1** | **Variation 2**  **(Causal Outlier)** | **Variation 3**  **(Statistical Outlier)** |
| **Method 1** | **Example 1** | **Better** |  | |
| **Example 2** | **Better** |  | |
| **Method 2** | **Example 1** |  | **Better** | |
| **Example 2** |  | **Better** | |
| **Method 3** | **Example 1** | **Better** |  | |
| **Example 2** | **Better** |  | |
| **Method 4** | **Example 1** | **Equal** | | |
| **Example 2** | **Better** |  | |
| **Method 5** | **Example 1** | **Equal** | | |
| **Example 2** | **Better** |  | |
| **Method 6** | **Example 1** | **Equal** | | |
| **Example 2** | **Better** |  | |

From the above observations in general using outlier detection is not beneficial for g-h Filter and we should go for the standard algorithm itself which in general gives better filtering results. Also, for Methods 4,5 and 6 all the variations are not overall effective.