Compressing unstructured mesh data from computer simulations is very challenging. Using a test problem from a fusion simulation, we compare three methods on the accuracy of reconstruction and the reduction in data size. Our results indicate that compressed sensing works well if the data are sparse, regression requires regions with nearly uniform values, and spline fits, with the fewest restrictions on the data, performs the best.

**Description of the methods**

Scale the data at each time step by the absolute of the maximum value and extract the three slices. Apply the methods to each slice and evaluate metrics for different parameters.

**Spline fits using ISABELA:**
- Split data into fixed size windows of size W.
- Sort the data and fit B-splines with C coefficients.
- Store relative error between estimated and actual values when errors exceed threshold E.

**Compressive sensing using GPSR:**
- To introduce sparsity, set all scaled values in range \([-0.03, 0.03]\) to zero.
- Apply the gradient projection for sparse reconstruction (GPSR) method, with a user defined value of \(m\), the number of measurements.

**Machine learning using locally-weighted kernel regression (LWKR):**
- Choose a percentage, S, of samples randomly as far apart from each other.
- Use the values at these samples as the training set at each time step.
- Use locally weighted kernel regression to predict values at remaining points.
- Identify a fixed percentage (HERR %) of sample points with highest errors; write out values along with indices.

**Performance metrics for comparing methods**

**Coefficient of determination between actual data, \(a\), and reconstructed data, \(p\):**

\[
R^2 = \frac{(n \sum a_i p_i - \sum a_i \sum p_i)^2}{(n \sum a_i^2 - (\sum a_i)^2)(n \sum p_i^2 - (\sum p_i)^2)}
\]

**Output reduction factor:**

\[
\text{ORF} = \frac{\text{size of gzipped original data}}{\text{size of gzipped compressed data}}
\]

**Results of compression and comparison of methods**

<table>
<thead>
<tr>
<th>Time Step</th>
<th>ISABELA</th>
<th>GPSR</th>
<th>LWKR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500, Slice</td>
<td>parameters</td>
<td>(R^2)</td>
<td>ORF</td>
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<tr>
<td>1</td>
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<td>0.99791</td>
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</tr>
</tbody>
</table>

- **ISABELA:** Reducing window size reduces ORF as more windows result in more coefficients. Increasing error threshold increases ORF and decreases \(R^2\) as more error is tolerated. Results are independent of the time step or slices.

- **Compressed sensing (GPSR):** The more sparse slice 9 has perfect reconstruction, but not slice 1 with fewer non-zeros. Increasing the number of measurements improves \(R^2\) but usually lowers ORF.

- **Regression using LWKR:** Accuracy improves if we use a lower sampling rate but keep a higher percentage of the high-error points. Data that has large regions with roughly constant values (slice 1 at mid-time) gives better reconstruction.