Deep Learning for Efficient Riverine Bathymetry Inversion

Steven Das (scdas@stanford.edu)  Shima Salimi Tari (shsalimi@stanford.edu)
Department of Computer Science, Stanford University

INTRODUCTION

• Shipping, navigation, and flood risk assessment for a river are assisted by having the river’s bathymetry profile [2].
• Direct measurements and numerical methods based on more easily measurable data (e.g., surface velocity profiles) such as [2] are time-consuming and expensive.
• This project uses a combination of fully-connected and convolutional neural networks to improve the accuracy and runtime of the baseline method, PCGA (principal component geostatistical approach) [2].

METHODS

• Metrics
  - RMSE: \( J(x) = \sqrt{\frac{1}{m} \sum_{i=1}^{m} (y_i - \hat{y}_i)^2} \)
  - Prediction time
• Loss function: MSE
  - Exception: MAE superior for 1D convolution.
• Three architectures investigated:
  - Fully Connected
  - 2D Convolution
  - 1D Convolution

RESULTS

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Train RMSE (m)</th>
<th>Dev RMSE (m)</th>
<th>Test RMSE (m)</th>
<th>Training Time (s)</th>
<th>Prediction Time Per Sample (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully connected</td>
<td>0.388</td>
<td>0.584</td>
<td>0.268</td>
<td>593.701</td>
<td>0.121</td>
</tr>
<tr>
<td>2D convolutional</td>
<td>0.378</td>
<td>0.570</td>
<td>0.258</td>
<td>911.767</td>
<td>0.139</td>
</tr>
<tr>
<td>1D convolutional</td>
<td>0.254</td>
<td>0.563</td>
<td>0.271</td>
<td>1131.783</td>
<td>0.133</td>
</tr>
<tr>
<td>PCGA (baseline)</td>
<td>-</td>
<td>-</td>
<td>0.7</td>
<td>-</td>
<td>1 hour</td>
</tr>
</tbody>
</table>

Table 1: Best results for each architecture

Figure 1: 1) True depth profile with 2) a good (low RMSE) prediction.

Figure 2: 1) True depth profile with 2) a poor (high RMSE) prediction.

FUTURE WORK

• Need to iterate architectures on a machine with more memory to overcome hyperparameter tuning limits.
• Training should be performed on larger synthetic datasets.
• Training should be performed on noisier real-world data, and the resulting models deployed for field use.

REFERENCES


DATASET

• Synthetic data generated by the U.S. Army Corps of Engineers’ AdH library [1] on bathymetry profile of a section of the Savannah River.
• 851 samples: velocity and boundary conditions as inputs and depth profiles as outputs. Input data is reshaped for each architecture.
• 60/20/20 train/dev/test split.
• A sample of the true depth, surface velocity x, and surface velocity y:

FEATURES

• mesh (20541 x 2 matrix): x and y coordinates of depth and velocity measurements.
• Z (20541 x 1 vector): Depth at each mesh point.
• velocity prof (41082 x 1 vector): x and y surface velocity components at each mesh point with white Gaussian noise added.
• \( Q_b \) (scalar): Volumetric flow.
• \( z_f \) (scalar): Free surface elevation.