Weekly Report 3 (A)

Future plan for FWI low-frequency prediction with offsets

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Outline

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Introduction

- **Future plan** for the FWI low-frequency prediction:
  1. How to feed offset into the network.
  2. Interpolation: Pre- and post- processing.
  3. Derivative method: LSTM approximation.

Outline

Future Plan

How to feed offset into the network.

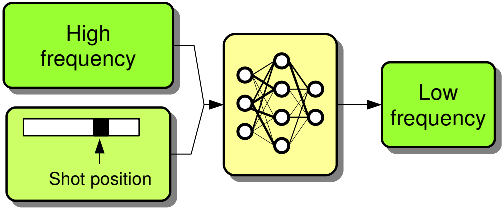


Figure 1: Incorporate offsets directly by one-hot vector.

- This method has been proved to be ineffective.
- In this method, we only give the position of the shot.

Future Plan

How to feed offset into the network.

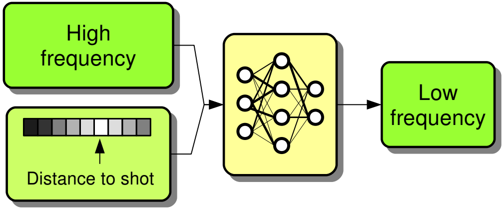


Figure 2: Incorporate offsets by distance to shot.

- This method is not expected to be effective.
- It is a similar approach. Dr. Hu has suggested me to do that, I would have a try.

Future Plan
Interpolation: Pre- and post- processing.

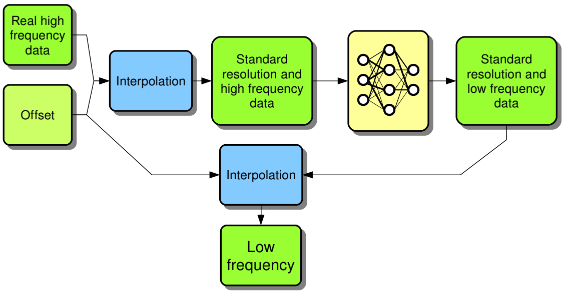


Figure 3: Adjust the signals by normalization.

- This method is expected to be effective, but it depends on pre- and post-processing.
- First, interpolate the signal into standard-resolution.
- Second, let network predict standard-resolution low-frequency data.
- Finaaly, downsample the prediction to the original resolution of input.

Future Plan

Interpolation: Pre- and post- processing.

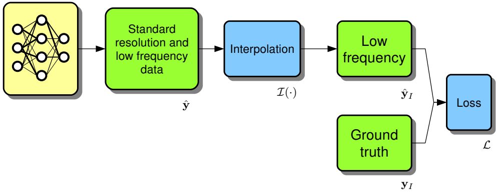


Figure 4: A detail setting for output layers.

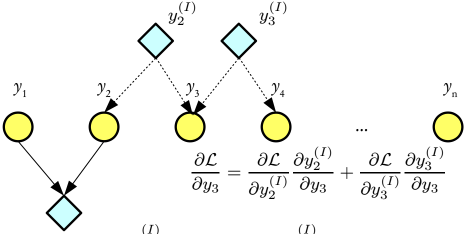
- We could calculate Jacobian matrix.

$$\mathbf{J} = \begin{bmatrix} \frac{\partial y_1^{(I)}}{\partial y_1} & \frac{\partial y_1^{(I)}}{\partial y_1} & \cdots & \frac{\partial y_1^{(I)}}{\partial y_M} \\ \frac{\partial y_2^{(I)}}{\partial y_1} & \ddots & \cdots & \frac{\partial y_2^{(I)}}{\partial y_M} \\ \vdots & & \ddots & \vdots \\ \frac{\partial y_N^{(I)}}{\partial y_1} & \cdots & \frac{\partial y_N^{(I)}}{\partial y_{M-1}} & \frac{\partial y_N^{(I)}}{\partial y_M} \end{bmatrix}. \quad (1)$$

- The interpolation could be viewed as a function $\mathscr{I}(\cdot, \mathbf{x})$, where $\mathbf{x}$ is the offset.
- $y_N^{(I)}$ denotes that we have N interpolated parameters, and y_M denotes that we have M output parameters before interpolation.

Future Plan

Interpolation: Pre- and post- processing.



$$\frac{\partial \mathcal{L}}{\partial y_3} = \frac{\partial \mathcal{L}}{\partial y_2^{(I)}} \frac{\partial y_2^{(I)}}{\partial y_3} + \frac{\partial \mathcal{L}}{\partial y_3^{(I)}} \frac{\partial y_3^{(I)}}{\partial y_3}$$

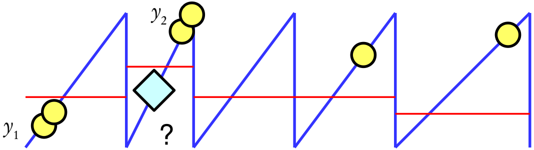
$$y_1^{(I)} = \frac{x_1^{(I)} - x_1}{x_2 - x_1} y_1 + \frac{x_2 - x_1^{(I)}}{x_2 - x_1} y_2$$

Figure 5: Linear interpolation method.

- Find the nearest 2 points, then we could use these two points to predict an interpolated point.
- The derivative could be calculated by back-propagation.
- The approximation could be popularized to the n-point case.

Future Plan

Interpolation: Pre- and post- processing.



$$y^{(I)} = y_1 + \int_{x_1}^{x^{(I)}} \frac{\partial y}{\partial x} \mathrm{d}x$$

$$y_2 - y_1 = \int_{x_1}^{x_2} \frac{\partial y}{\partial x} \mathrm{d}x$$

$$\left.\frac{\partial y}{\partial x}\right|_{x=x_1} = a \qquad \left.\frac{\partial y}{\partial x}\right|_{x=x_2} = b$$

Figure 6: Differential equation method.

- This method is applied when the derivative of points is predictable.
- The prediction of derivative has better to be in high-resolution.
- The example shows a case that we could only predict the boundary derivative.

Future Plan

How to make use of derivative.

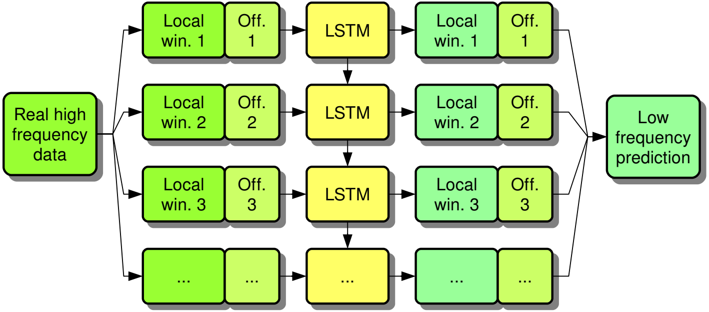


Figure 7: Incorporate offsets by window-wise LSTM.

- Extract the original signal into small windows. Each window is companied with a begin offset.
- Use local window to remove the sampling effect, and use LSTM to learn global feature.

Future Plan

How to make use of derivative.

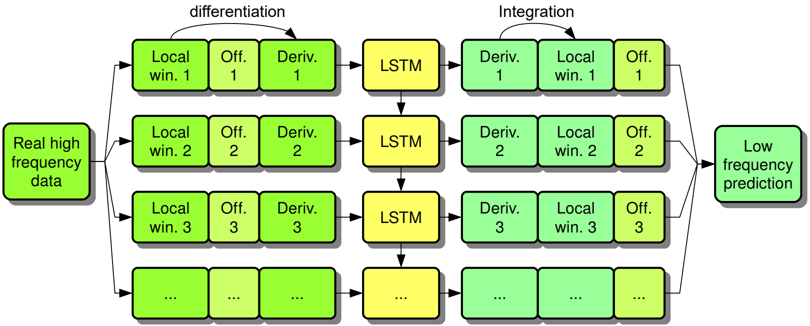


Figure 8: Incorporate offsets by window-wise LSTM and derivative calculation.

- Derivative is easy to calculate $\partial \mathbf{f}(\mathbf{x}) = {}^{\mathbf{f}(\mathbf{x}+1)-\mathbf{f}(\mathbf{x})}/_{\mathbf{Off}(\mathbf{x}+1)-\mathbf{Off}(\mathbf{x})}$.
- We use local begin value of the window to correct the deviation.
- The cumulative errors in the local window is small.

Thank you for Listening

It’s time for Q & A