Stokes Inversion for GST/NIRIS Using Stacked Deep Neural Networks

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1. Introduction

Obtaining high-quality magnetic and velocity fields through Stokes inversion is crucial in solar physics. Here, we present a new deep learning method, named Stacked Deep Neural Networks (SDNN), for inferring line-of-sight (LOS) velocities, Doppler widths and vector magnetic fields from Stokes profiles collected by the Near InfraRed Imaging Spectropolarimeter (NIRIS) on the 1.6 m Goode Solar Telescope (GST) at the Big Bear Solar Observatory (BBSO).

In this notebook, we provide an overview of the SDNN project, detailing how it can be used to perform Stokes inversion for GST/NIRIS data.

Since model training requires GPUs, it is omitted here.

2. Workflow of SDNN

2.1 Load model

Note that the SDDN has large model and fits files that can not be saved in public repository. Therefore, they must be downloaded first.

In [1]:
```
from utils import *
download_model()
download_fits()

```

```
File: pretrained_model.h5 already exists, no need to download it
File: inputs\cals_170713_162012.fts already exists, no need to download it
```

Import the load_model() function from SDNN module.

In [2]:
```
from SDNN import load_model
model = load_model()
```

```
Using TensorFlow backend.

Loading SDNN model...
Done Loading...
```

2.2 Setup input and output directory

You may set up your own data directory.

In [3]:
```
input_path = 'inputs'  # edit your input path
output_path = 'outputs'  # edit your output path
```

2.3 Predicting with Pretrained model

Import related libraries.

Produce LOS velocities, Doppler widths, and vector magnetic fields by using the pretrained model.

The code will also save b_total, inclination and azimuth if save_mag_field_o = True; otherwise it will only save bx, by, bz, Doppler width and LOS velocity.

The predicted results will be saved in the given output path.

In [4]:
```
from astropy.io import fits
import os
import time
import numpy as np
from SDNN import read_data
from SDNN import inverse
from SDNN import save_results

for file in os.listdir(input_path):
    print('---------- working on', file, '----------')
    fits_file = os.path.join(input_path, file)
    hdu = fits.open(fits_file)
    hdu.verify('fix')
    data = hdu[0].data
    test_data, data_height, data_width = read_data(data)
    start = time.time()
    predict_results = inverse(test_data, model)
    end = time.time()
    print('Inversion Time:', np.round(end - start, 1), 's')
    save_results(predict_results, output_path, file[: file.find('.')], data_height, data_width, save_mag_field_o=False)
```

```
---------- working on cals_170713_162012.fts ----------
Loading test data...
Done loading...
Start inversion...
End inversion...
Inversion Time: 684.7 s
Producing inversion results..
Done saving..
```

3. Conclusion

We develop a deep learning model (SDNN), which is an effective and alternative method for inferring LOS velocities, Doppler widths, and vector magnetic fields from Stokes profiles of GST/NIRIS. It is hoped that SDNN will be a useful tool in producing the high-quality velocity and magnetic fields that are crucial for understanding the evolution of physical properties of the solar atmosphere.

Acknowledgments

The authors gratefully acknowledge the use of data from the Goode Solar Telescope (GST) of the Big Bear Solar Observatory (BBSO). The BBSO operation is supported by NJIT and U.S. NSF grant AGS-1821294. This work was supported by U.S. NSF grants AGS-1927578, AGS-1954737, and AGS-2228996.

References

Inferring Line-of-sight Velocities and Doppler Widths from Stokes Profiles of GST/ NIRIS Using Stacked Deep Neural Networks. Haodi Jiang et al 2022 ApJ 939 66

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