VARIATIONAL AUTOENCODER (VAE) ANALYSIS

NEW VS OLD DATASETS

AMIRHOSSEIN GHANAATIAN

DATA PREPROCESSING

- Selected relevant columns
- Sorted data based on 'expt', 'plot', and 'entry'
- Replaced "." with null values
- Converted columns to numeric format
- Aggregated data by grouping and calculating means
- Added 'yield' and 'stage' columns back
- Reordered columns

AGGREGATED DATA BY GROUPING AND CALCULATING MEANS

E10 =AVERAGEIF(E2:E9,"<>",E2:E9)

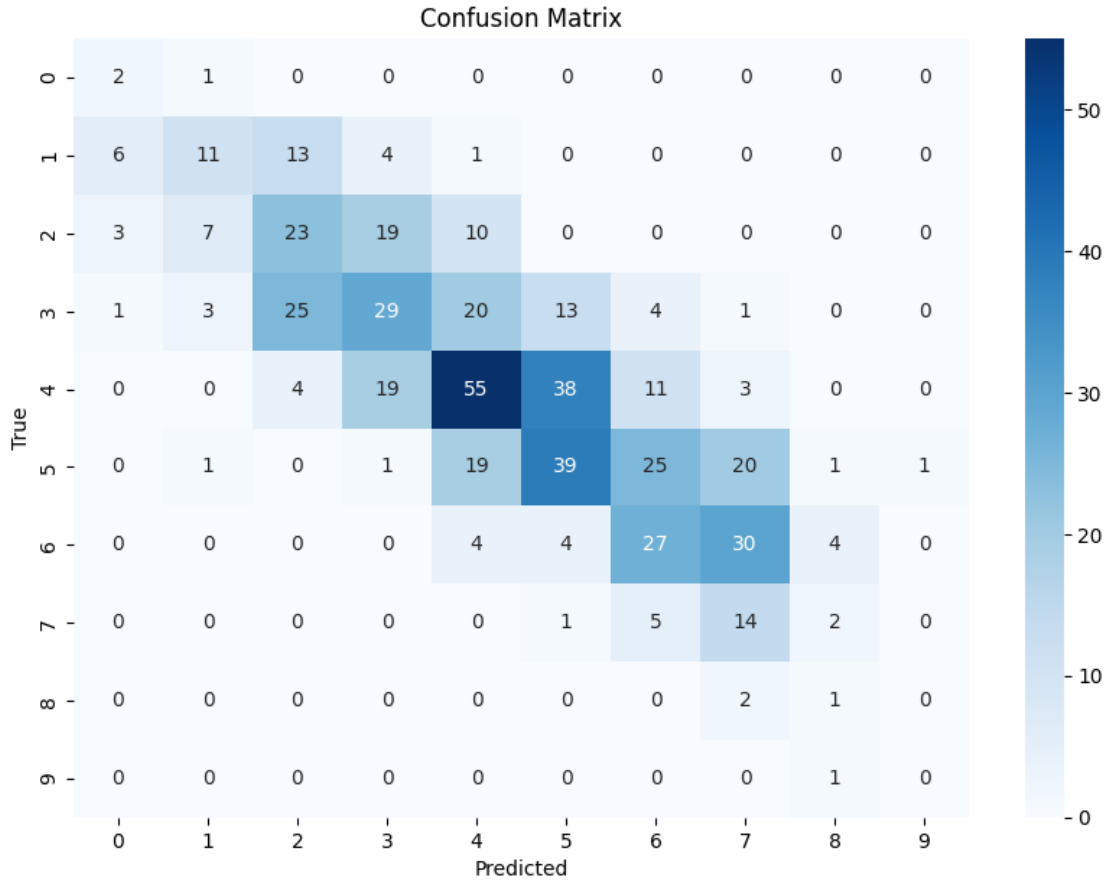
	A	B	C	D	E	F	G	H	I	J	K
1	expt	plot	entry	yield	CC	ndvi	blu	gre	red	re	nir
2	22 KPE GG F2	1321	621	40.3440678	30388	0.82174715	0.01098792	0.02802799	0.01337262	0.01098792	0.13666843
3	22 KPE GG F2	1321	621	40.3440678		0.86837615	0.0129881	0.03221868	0.01321263	0.13637333	0.18755086
4	22 KPE GG F2	1321	621	40.3440678		0.87546337	0.01012124	0.02541223	0.01187734	0.11676214	0.17886724
5	22 KPE GG F2	1321	621	40.3440678		0.88695479	0.01092556	0.02367702	0.01014531	0.10361819	0.16934593
6	22 KPE GG F2	1321	621	40.3440678		0	0.01058852	0.02319826	0.02319826	0.02319826	0.02319826
7	22 KPE GG F2	1321	621	40.3440678		0.88070039	0.01240885	0.02690455	0.01254708	0.13273332	0.19779861
8	22 KPE GG F2	1321	621	40.3440678		0.77044222	0.01598618	0.04152398	0.02389031	0.14763777	0.18425173
9	22 KPE GG F2	1321	621	40.3440678		0.47161309	0.0161965	0.02680502	0.0365112	0.07100984	0.10168753
10					30388	0.69691215	0.01252536	0.02847096	0.01809434	0.0927901	0.14742107

VAE IMPLEMENTATION

- Implemented a Variational Autoencoder on the preprocessed data
- Performance metrics:

Metric	Value
Test Mean Squared Error	45.9015
Test R^2	0.7479
Test Mean Absolute Error	5.1987
Test Mean Percentage Error	13.5262%

CONFUSION MATRIX



CONFUSION MATRIX ANALYSIS

- Multi-class classification model performance (classes 0-9)
- Best performance for classes 4, 5, 6, 7
- Class 9: insufficient data, misclassified as class 8
- Classes 0, 1, 2: few instances, class imbalance, similarity
- Misclassifications more common between adjacent classes
- Higher precision for middle classes, better recall for classes 6, 7

DATA PREPROCESSING FOR STAGE

- Drop the Rows which 'Stage' is null
- Divided the dataset based on the "Stage" columns
- Preprocess every sub-dataset based on number of nulls
- If a column has 100% null, we remove that column in training the models
- If percentage of columns is low, we remove only rows with nulls in that columns

R1

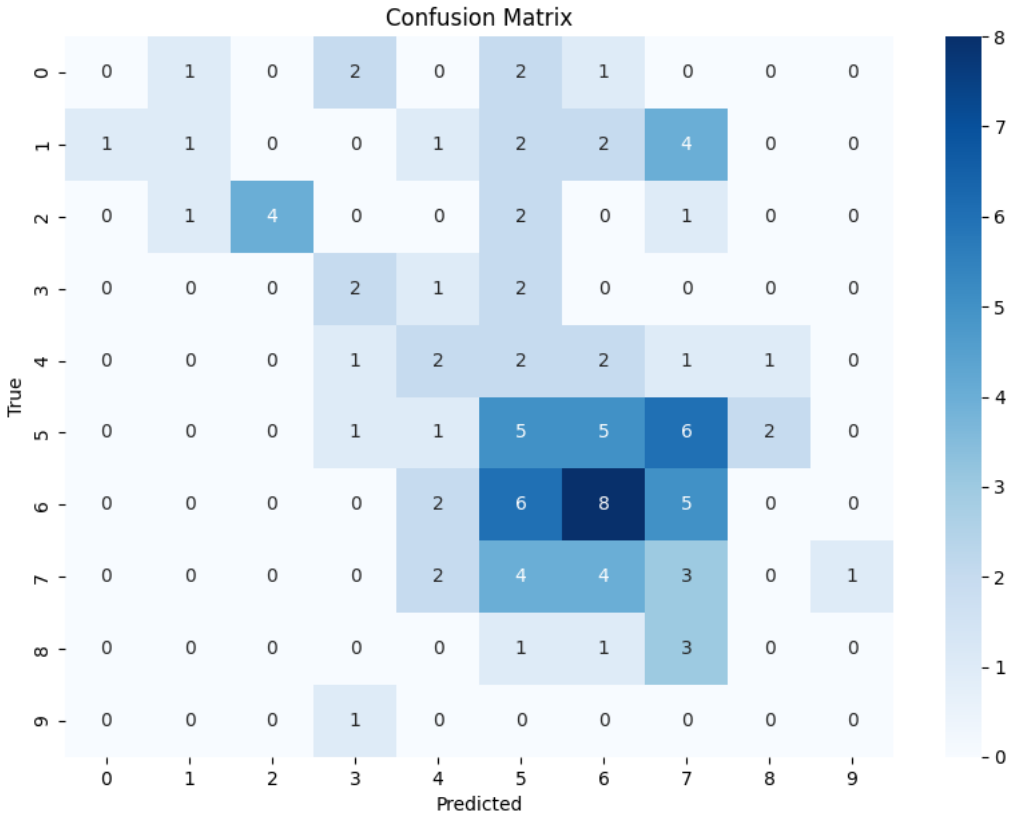
Precentage of nulls in each column:

- yield 0.0
- stage 0.0
- CC 100.0
- ndvi 0.0
- blu 0.0
- gre 0.0
- red 0.0
- re 0.0
- nir 0.0
- expt 0.0
- plot 0.0
- entry 0.0
- loc 0.0
- prow 0.0
- pcol 0.0

Ignoring CC Column,

Trained on: 'ndvi', 'blu', 'gre', 'red', 're', 'nir'

Test R^2: 0.1278



R5

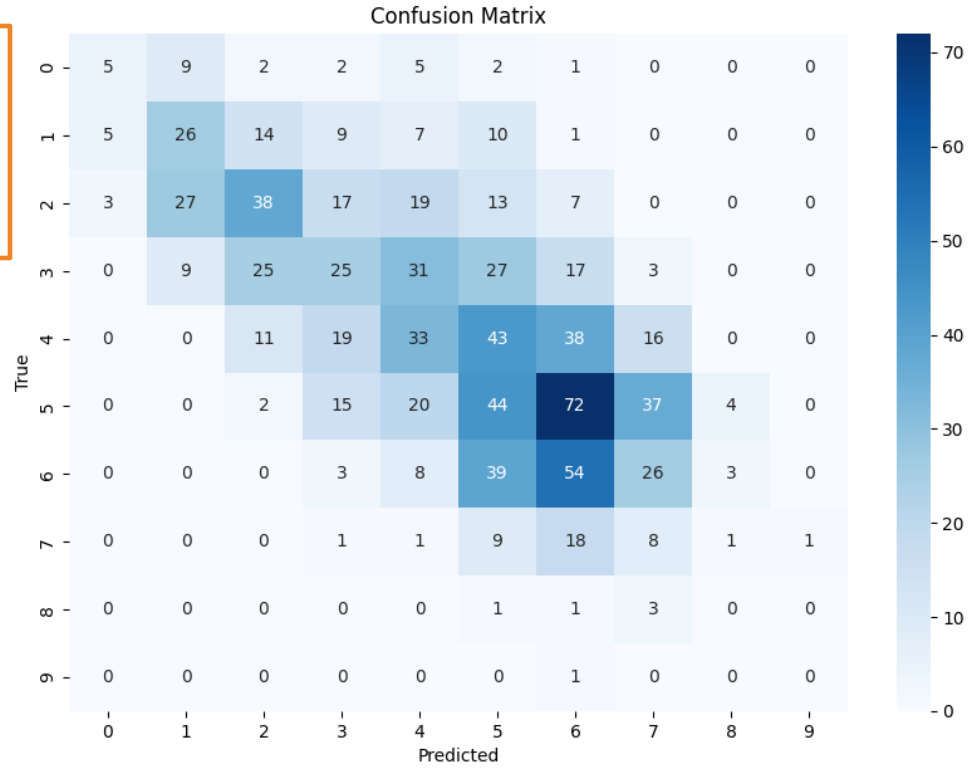
Percentage of missing values in each column:

yield	1.980198
stage	0.000000
CC	32.673267
ndvi	0.000000
blu	0.000000
gre	0.000000
red	0.000000
re	0.000000
nir	0.000000
expt	0.000000
plot	1.980198
entry	1.980198
loc	0.000000
prow	0.000000
pcol	0.000000

Ignoring CC Column, Removing rows with nulls in Yield

Trained on: 'ndvi', 'blu', 'gre', 'red', 're', 'nir'

Test R^2: 0.3878



R5

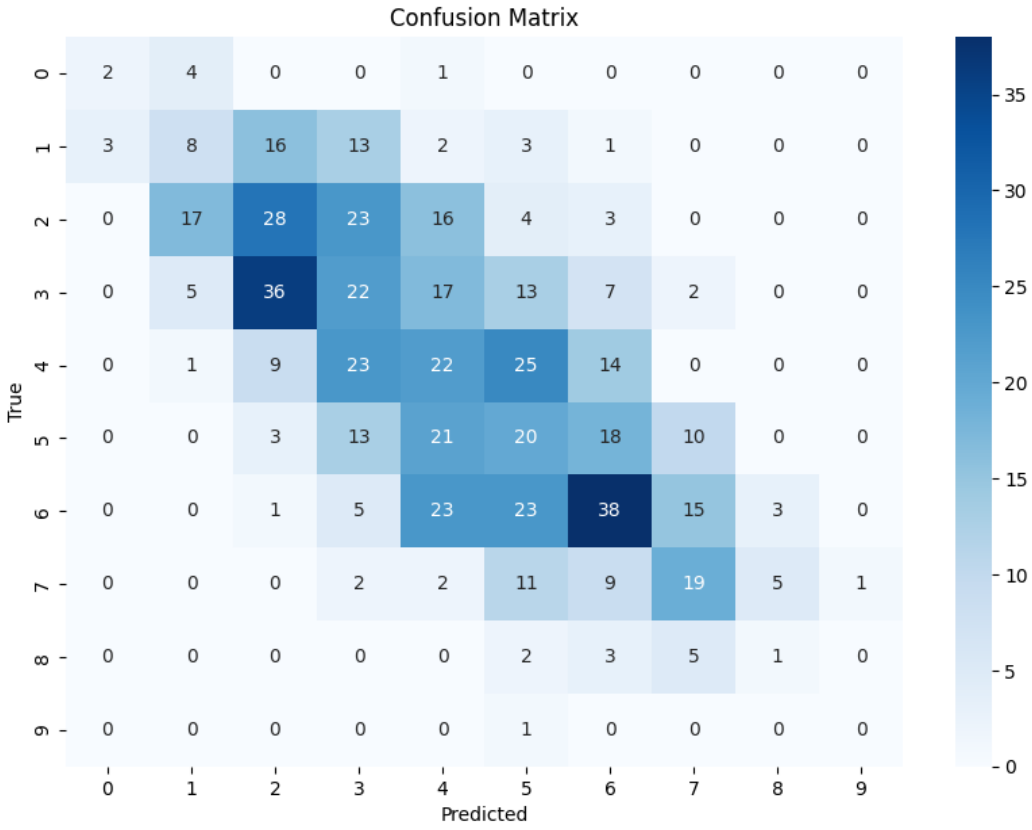
Percentage of missing values in each column:

yield	1.980198
stage	0.000000
CC	32.673267
ndvi	0.000000
blu	0.000000
gre	0.000000
red	0.000000
re	0.000000
nir	0.000000
expt	0.000000
plot	1.980198
entry	1.980198
loc	0.000000
prow	0.000000
pcol	0.000000

Removing rows with nulls in Yield and CC

Trained on: 'CC', 'ndvi', 'blu', 'gre', 'red', 're', 'nir'

Test R^2: 0.5063



SUMMARY

Stage	Which Column Ignored?	Null Cleaning on?	nu. of rows after preproccessing	R2 (test, 20%)
R1	CC	-	660	0.1278
R2	CC	yield	3300	0.1041
R3		yield	1320	0.7206
R4		yield, CC	1320	0.024
R4	CC	yield	1980	0.1092
R5	CC	yield	5940	0.3878
R5		yield, CC	3960	0.5063
R6	CC	-	1320	0.633
R7	CC	yield	7260	0.6245
R8	CC	-	660	0.1296
V4	-	ndvi', 'blu', 'gre', 'red', 're', 'nir'	0	-
V6.5	CC	-	660	0.3291

DATA PREPROCESSING

23 CRS F1 AND HO COMBINED AGRON AND SPECTRAL DATA_WEATHER TO CARAGEA 9_16_24.XLSX

- Selected relevant columns
- Sorted data based on 'expt', 'plot', and 'entry'
- Replaced "." with null values
- Converted columns to numeric format
- Aggregated data by grouping and calculating means

MORE DETAILS

- all P4 data = [cc, blu, gre, red, re, nir, ndvi]
  - 4800 rows
- all Thermal data = [TH]
  - 3072 rows
- Agron = [Yeild]
  - 384 rows
- Merge these data based on the uniqe match of 'expt', 'plot', and 'entry', remove rows with nulls
  - 381 rows

AGGREGATED DATA BY GROUPING AND CALCULATING MEANS

E10 =AVERAGEIF(E2:E9,"<>",E2:E9)

	A	B	C	D	E	F	G	H	I	J	K
1	expt	plot	entry	yield	CC	ndvi	blu	gre	red	re	nir
2	22 KPE GG F2	1321	621	40.3440678	30388	0.82174715	0.01098792	0.02802799	0.01337262	0.01098792	0.13666843
3	22 KPE GG F2	1321	621	40.3440678		0.86837615	0.0129881	0.03221868	0.01321263	0.13637333	0.18755086
4	22 KPE GG F2	1321	621	40.3440678		0.87546337	0.01012124	0.02541223	0.01187734	0.11676214	0.17886724
5	22 KPE GG F2	1321	621	40.3440678		0.88695479	0.01092556	0.02367702	0.01014531	0.10361819	0.16934593
6	22 KPE GG F2	1321	621	40.3440678		0	0.01058852	0.02319826	0.02319826	0.02319826	0.02319826
7	22 KPE GG F2	1321	621	40.3440678		0.88070039	0.01240885	0.02690455	0.01254708	0.13273332	0.19779861
8	22 KPE GG F2	1321	621	40.3440678		0.77044222	0.01598618	0.04152398	0.02389031	0.14763777	0.18425173
9	22 KPE GG F2	1321	621	40.3440678		0.47161309	0.0161965	0.02680502	0.0365112	0.07100984	0.10168753
10					30388	0.69691215	0.01252536	0.02847096	0.01809434	0.0927901	0.14742107

VAE IMPLEMENTATION

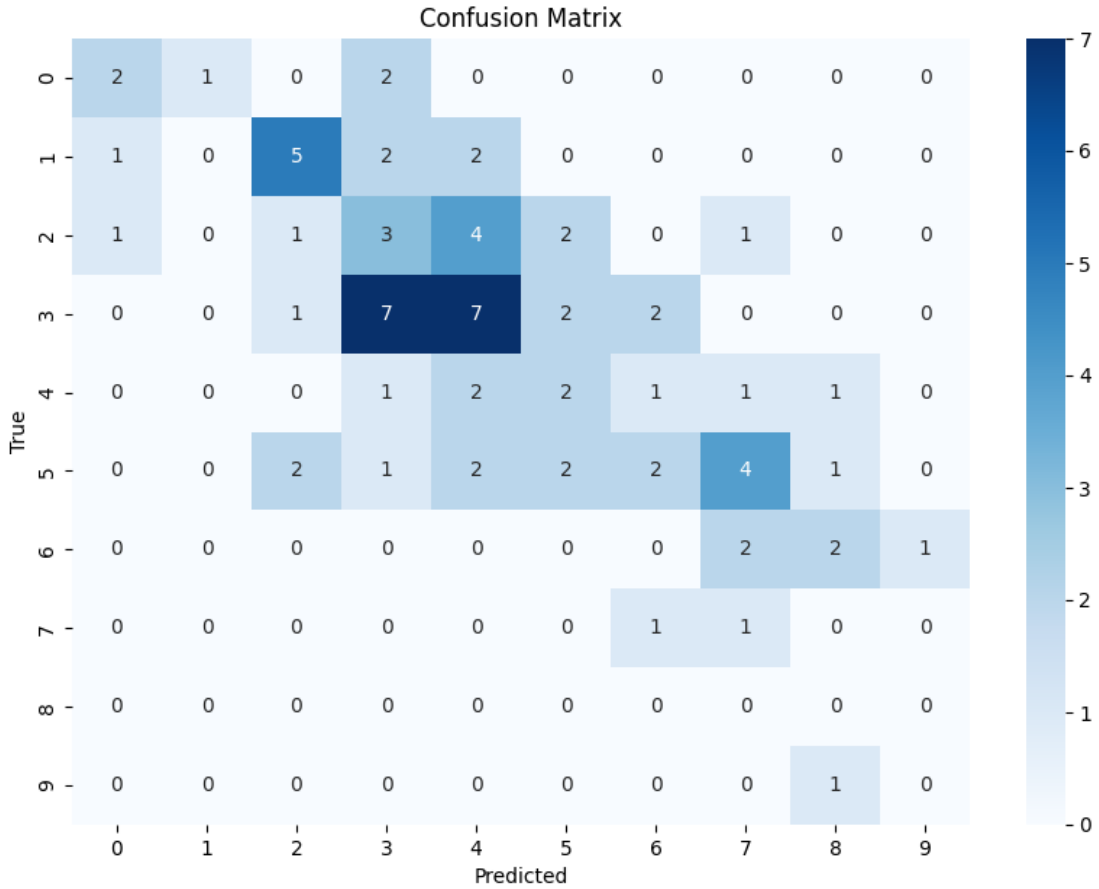
- Implemented a Variational Autoencoder
- K-fold cross-validation results (K=5)

- Average Metrics
  - Mean Squared Error (MSE): 60.1191
  - R^2 Score: 0.5313

Fold	MSE	R^2	MAE	MPE
1	70.2446	0.4908	6.0127	13.2878%
2	39.6278	0.7020	5.1391	11.2822%
3	61.5302	0.5877	6.1645	12.9856%
4	64.1423	0.3772	5.9125	12.7816%
5	65.0506	0.4986	5.9600	12.5112%

$$\text{MPE} = \frac{1}{n}\sum_{i=1}^{n}\frac{|actual_y - predicted_y|}{actual_y} \times 100\%$$

CONFUSION MATRIX



RESULTS FOR "SAS" DATA

23 CRS F1 AND HO COMBINED AGRON AND SPECTRAL DATA_WEATHER TO CARAGEA 9_16_24.XLSX

Model Performance Evaluation
K-fold cross-validation results (K=5)
Average Metrics
- Mean Squared Error (MSE): 53.0747
- R^2 Score: 0.5893

Results by Fold

Fold	MSE	R^2	MAE	MPE
1	69.3842	0.4971	6.1160	13.5881%
2	30.8453	0.7681	4.4166	9.1228%
3	55.6282	0.6272	5.6451	12.2313%
4	50.9172	0.5056	5.3736	11.7496%
5	58.5982	0.5483	5.7079	11.4970%

DATA OVERVIEW

- Old Data
  - Multispectral
  - Thermal
- Data Aggregation
  - Aggregate based on experiment plot entry
  - Calculate averages for:
    - NDVI
    - RED
    - GREEN
    - ...
    - THERMAL
- Data Cleaning
  - Row count mismatch between multispectral and thermal data
  - Remove extra multispectral entries to synchronize
  - Final row count after cleaning: 1980 rows
  - Merge based on experiment plot entry
    - To have Thermal and Multispectral together

MODEL PERFORMANCE

- Old DATA Performance
  - Metrics
    - Test Mean Squared Error: 53.6881
    - Test R^2: 0.7681
    - Test Mean Absolute Error: 5.7176
    - Test Mean Percentage Error: 14.0103%

- New DATAPerformance
  - Metrics
    - Test Mean Squared Error: 68.9005
    - Test R^2: 0.5616
    - Test Mean Absolute Error: 6.5699
    - Test Mean Percentage Error: 14.6783%

MODEL TRANSFER TEST

- Old Data
  - 90% used for training
  - 10% used for testing
  - Model saved after training
- Old Data TEST
  - MSE = 54
  - R^2 = 0.976
- New Data TEST (ALL 381 ROWS)
  - Saved model tested on new data
  - R^2 = -2.5
  - MSE = 468

NEGATIVE R-SQUARED?

$$R^2 = 1 - \frac{SS_{\text{res}}}{SS_{\text{tot}}}$$

$$SS_{\text{res}} = \sum_i (y_i - f_i)^2 = \sum_i e_i^2$$

$$SS_{\text{tot}} = \sum_i (y_i - \bar{y})^2$$

For example, a model with an R-squared value of 0.9 means that approximately 90% of the variance in the dependent variable is explained by the independent variables. This suggests a strong relationship between the variables and indicates that the model provides a good fit to the data.

R2 is negative only when the chosen model does not follow the trend of the data, so fits worse than a horizontal line.

When *SS*res is greater than *SS*tot, that equation could compute a negative value for *R*2, if the value of the coeficient is greater than 1.

It simply means that the chosen model (with its constraints) fits the data really poorly.