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| **Name:** Syed Wamiq Ul Islam  **Batch:** BSCS 2024 | **Name:** Abdul Rehman Tahir  **Batch:** BESE 2023 |
| TUKL-DLL, NUST | **Date:** 23rd July 25 |
| **Supervisor:** Dr. Naseer Bajwa | |

**Progress Report**

**Problem:**

The objective of this project is to develop a deep learning model that uses time-series Sentinel-2 satellite images to classify crop types across agricultural fields in the Lombardy region of Italy. The classification is supervised using annual ground truth maps collected from farmers at the end of each growing season.

**Dataset Description**

**Data Source**

* Kaggle Dataset: Sentinel-2 Crop Mapping
* URL: <https://www.kaggle.com/datasets/ignazio/sentinel2-crop-mapping>
* The dataset contains Sentinel-2 satellite imagery over the Lombardy region of Italy. Ground truth labels are annual crop maps provided by farmers at the end of each growing season.

**Regions and Years**

* There are three regions in the dataset: Lombardia, Lombardia2, and Lombardia3.
* The dataset covers the years 2016, 2017, 2018, and 2019.
* Each region-year combination contains approximately 3328 tiles.
* For training, only images from Lombardia and Lombardia2 from the years 2016 to 2018 were used.

**Tile and Image Structure**

* Each tile folder contains between 33 to 71 .tif images, one for a date/timestep throughout the year.
* Each image is of size 48×48 pixels with 9 spectral bands.
* Each tile folder also contains one y.tif file, which provides the ground truth crop labels in a pixel-wise segmentation format.

**Labels**

* The original dataset contains 21 crop classes.
* These classes were remapped into 7 broader groups: cereal, corn, rice, non-agricultural, unknown, forage, and woods.

**Preprocessing**

* Z-score normalization was applied independently to each of the 9 spectral bands.
* Labels were remapped from the original 21 crop classes to 7 target classes: cereal, corn, rice, non-agricultural, unknown, forage, and woods.
* An 80/20 train-validation split was used.
* Data augmentation included random horizontal and vertical flips, random rotations, and adding Gaussian noise.
* Class weights were calculated from the training data to address class imbalance and were used during model training.

**Models Summary**

**A screenshot of a graph

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v5.4**: 2D CNN**

**Input**

* Fixed Timesteps used (first 32)
* 9 bands per Image/timestep
* Each Image is a 48×48 patch
* Since We are using **2D CNN** reshaping to 3d: (32 × 9, 48, 48) = (288, 48, 48)
* Final input shape to CNN: **[Batch, 288, 48, 48]**

**Output**

* Final output shape: **[B, 7, 48, 48]**
* A class score (logit) for each of the 7 crop types per pixel
* Argmax is applied to get a final predicted class map of shape **[B, 48, 48]** which is compared with ground truth

**Hyperparameters**

* Dropout: 0.3
* Batch size: 16
* Learning rate: 1e-3
* Weight decay: 1e-4
* Number of epochs: 30
* Optimizer: Adam
* Learning rate scheduler: StepLR(step\_size=5, gamma=0.5)
* Loss function: CrossEntropyLoss with label smoothing and weights
* Label smoothing value: 0.1

**Structure**

**Encoder**:2 × Conv2D (kernel: 3×3) + BN + ReLU + Dropout + Skip connection

|  |  |  |  |
| --- | --- | --- | --- |
| **Block** | **Input Channels** | **Output Channels** | **Dilation** |
| encoder1 | 288 | 256 | 1 |
| encoder2 | 256 | 256 | 2 |
| encoder3 | 256 | 256 | 4 |
| encoder4 | 256 | 512 | 2 |
| encoder5 | 512 | 512 | 1 |
| final\_conv | 512 | 7 | - |

**Loss and Accuracy plots**

A graph of a graph

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**Sample Prediction**

A screenshot of a computer

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**Evaluation**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Class** | **Total Pixels** | **Pred Pixels** | **Accuracy** | **IoU** |
| **Cereals** | 64275 | 72384 | 0.7579 | 0.5539 |
| **Maize** | 143445 | 132067 | 0.7347 | 0.6195 |
| **Rice** | 178002 | 195582 | 0.9152 | 0.7732 |
| **Forage** | 58554 | 67653 | 0.6996 | 0.4806 |
| **Unknown crop** | 86047 | 61660 | 0.3673 | 0.2722 |
| **Woods/tree crops** | 51711 | 93106 | 0.8599 | 0.4431 |
| **Non-agricultural** | 109166 | 68748 | 0.4216 | 0.3490 |
| **Total Accuracy**: 0.6945 | | | | |
| **Mean IoU**: 0.4988 | | | | |
| **F1 Score** : 0.6512 | | | | |

A graph of blue and pink bars

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A screenshot of a computer

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