One-Pager for submission

this project is made as submission for the lecture Intelligent Production Systems

Purpose

On the aereal image the following objects has to be indentified and marked with a segmentation mask.

- Buildings
- Solar plants, in most of the cases installed on building roofs

The data should be saved in a format for further anaysis in the open Source GIS software QIS.

Dataset

The source of the aereal image is the "Autonome Provinz Bozen - Südtirol". The aereal image is aviable in a resolution of 20cm per pixel on a WMS-Service. The aereal images are aviable via the Website MapView in this resolution and quality are made aereal images for the years:

- 'p_bz-Orthoimagery:Aerial-2011-RGB-20CM',
- 'p_bz-Orthoimagery:Aerial-2014-RGB',
- 'p_bz-Orthoimagery:Aerial-2015-RGB',
- 'p_bz-Orthoimagery:Aerial-2017-RGB',
- 'p_bz-Orthoimagery:Aerial-2020-RGB',
- 'p_bz-Orthoimagery:Aerial-2023-RGB',

To train the model 250 images are downloaded in the size 640 x 640 pixel at locations with different kinds of vegetation and building styles from the aereal image of the year 2023 using the Notebook 01_Dataset.ipynb and the library owslib. The annotation was done using label-studio. There are annotated the segmentation masks for the class 'roof' and 'solar'. The dataset is split randomly to 200 images for training and 50 images for validation (proportion 20/80). The total annotated aerea is 640 x 640 pixel * 0,2 m/pixel = 16.384 m^2 * 250 images = 4.096.000 m^2 = 4,1 km^2. In the 50 images of the validation set are present 195 instances of class roof and 73 instances of class solar.

Model

To resolve the task training on all avialbe YOLO11 segmentation models is performed on a workstation with a Intel... CPU, 128 GB memory and two GPU Nvidia RTX A5000 with 24 GB memory each. The training is performed using the Notebook 02_Training.ipynb for 100 epochs with the default hyperparameters. In the following graph the results are shown

model	device	epochs	train_t	train_t_epoch	inf_t	P_roof	P_solar	R_roof	R_solar	mAP50_roof	mAP50_solar	mAP50-95_roof	mAP50-95_solar
yolo11n-seg	notebook	10	464	46,4	93	0,662	0,571	0,785	0,346	0,790	0,374	0,543	0,201
yolo11s-seg	workstation	100	272	2,7	6	0,879	0,535	0,862	0,568	0,877	0,534	0,648	0,316
yolo11n-seg	workstation	100	259	2,6	6	0,895	0,485	0,872	0,562	0,912	0,435	0,680	0,227
yolo11m-seg	workstation	100	383	3,8	8	0,855	0,501	0,872	0,562	0,883	0,466	0,668	0,274
yolo11s-seg	workstation	250	522	2,1	6	0,896	0,609	0,862	0,534	0,895	0,526	0,687	0,294
yolo11l-seg	workstation	100	468	4,7	10	0,865	0,687	0,846	0,562	0,890	0,517	0,667	0,303
yolo11x-seg	workstation	100	695	7	13	0,902	0,619	0,799	0,507	0,890	0,544	0,665	0,334
yolo11x-seg	workstation	200	1345	6,7	14	0,884	0,664	0,821	0,534	0,892	0,529	0,666	0,297

The precisioan (P), recal (R) and mAP50 for the model XXX are the highest, becaus the model is not used for a time critical application like a real time detection the large model can be selected for further use. In the following image a prediction on the validation dataset is shown (ground truth on the left / prediction on the right).

Use in QGIS

for the use of the trained model in QGIS the following two ways are taken in concern. To work directly on the data and because of difficults getting the desired output fomat the second way 'PNG with world-file' is implementet for this work.

Plugin Deepness

The QGIS pluging Deepness is made for the simple usage of AI-models on geodata. The model has to be made in ONNX format and give as output a tensor with shape [n_classes, width, height]. the plugin applies the model on a given input layer in raster format and save the segmentation masks as polygons.

PNG with world-file

There are defined two simple functions in xxx to perform the following tasks:

- download the image from wMS service and save the world-file, a standardized file with information abaut the location of the image in a directory. the areal image can be eather stored in the same directory or returned as PIL image for further processing
- make prediction with a given yolo-model and PIl image as input and store the prediction as png file

The png files then can be loaded in QGIS for furth processing and analyzing. On the example image below the proportion of bebaung for the whole area of the 'Marktgemeinde Lana' is visualized.

Problems and Improvements

There are the following improvements wich can be optimized in further work

- There are reconized apple fields as solar plants and streets as buildings. With mor training data and augmentation during training process the problem shuold be solved or be better
- an the edges the objects are not detected well, in most cases a row of one pixel is empty. this could be done better having an overlap between images
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Conclusion

this is a quick and simple implementation to use yolo for segmentation of aereal images. with different training data it is als possible to detect other objects wich can be trees, pools, apple fields.