Assignment – Object Detection using AutoML in Vertex AI Platform

Google's pre-trained Vision models are trained on millions of real-world images and they are able to detect many types of objects. However, sometimes they are not able to detect certain objects according to specific needs. Using AutoML, we can use transfer learning to customize a model to a given task without having to train it from scratch. This allows us to build models quickly for specific uses. For example, a model capable of identifying specific types of poisonous plants or weeds would be useful to an agriculture company keen to protect their crops.

In this individual assignment, you will craft a business case, prepare your images and use Google AutoML to train and deploy a model for object detection. Details of the tasks are provided in the following sections. Document all your work in the Jupyter notebook templates provided.

This assignment carries a total of 40 marks and constitutes 40% of the unit grade.

Schedule

- In week 7 practical, your tutor will conduct a progress check
- Zip your input images, Jupyter notebooks and reflection video (mp4) and upload the zip file to Brightspace by Sun 8 Dec 2024, 2359h

Templates

- DataPreparation.ipynb
- AutoML.ipynb

1. Business Case

Describe the following:

- What is the outcome you're trying to achieve and why?
- What kinds of categories or objects would you need to recognize to achieve this outcome?
- What kind of images would you need for training and testing your model?

Provide as much relevant information as possible.

2. Data Preparation

2.1. Images and Bounding Boxes

1. Prepare your images for training, testing and evaluating your model according to the following project criteria:
   i. Number of labels: either 2 or 4
   ii. If 2 labels, number of bounding boxes for each label: 100 to 150
   If 4 labels, number of bounding boxes for each label: 25 to 50
   iii. Total size of all your images: ≤ 15MB
2. Ensure each image meets the following requirements:
   i. Format: JPEG
   ii. Maximum width or height: 1000 pixel
3. Prepare 10 extra images for online prediction
4. Provide a reference link if you obtain your images from any public source
5. Show workings of image processing (e.g. resizing, etc.) clearly
6. Draw bounding boxes of objects inside your images. You may use one of the following free tools:
   - makesense.ai
   - roboflow
   - Label Studio

   Describe, with screenshots, the process of creating one bounding box (any label)
7. Display a few images and verify that the bounding boxes have been drawn accurately

2.2. Google Cloud Storage

1. Download your service account credentials[1] from your student email
2. Create a Cloud Storage bucket
3. Ensure your directory structure is set up correctly with the names of the labels (refer to Annex A)
4. Prepare an annotation csv file that shows the association of the bucket image URL and the corresponding label and bounding boxes (refer to Annex A)
5. Upload images you have prepared and the csv file to your bucket
6. Create a function to check and ensure all the bucket image URI images specified in your csv file are present in your bucket (i.e. check path for missing characters, spaces, etc.)
7. Create an image dataset in Vertex AI by specifying the annotation file in your bucket as the source

[1] Note that this account contains sensitive information that gives you permission to access chargeable Google

services. Do not share these credentials with anyone and keep it only in your local environment.

3. Training

This section incurs charges. You have ONE attempt to train your model. Check all settings and data before you proceed. You will be penalised under Resource Management if you need to retrain your model. Contact your tutor immediately for instructions on retraining your model.

Use the settings provided in the notebook template to run the training pipeline.

4. Evaluate the model

Discuss the following:

1. The performance metrics provided by Vertex AI
2. The optimum Intersection over Union (IoU), confidence threshold and the corresponding metrics applicable for your use case

5. Deployment and Online Prediction

This section incurs charges. You will be penalised under Resource Management if you fail to complete this section within the stipulated durations specified in the rubrics.

Complete these tasks:

1. Deploy the model
2. Perform online predictions using the images you have prepared in Section 2
3. Undeploy the model
4. Explain your observations and findings

6. Reflection

Create a 10-min video to discuss your work done.

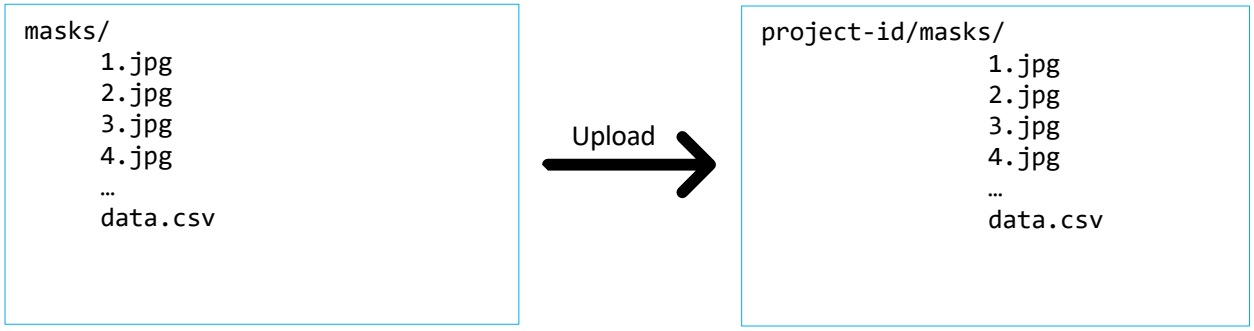
References

- AutoML Beginner's Guide
- Prepare image training data for object detection
- Evaluate Model

Annex A – Cloud Storage Setup

Directory Structure in bucket

For a masks dataset with 2 labels (mask-on, mask-off), a recommended directory structure in the local directory and the cloud storage with a bucket name "project-id" is shown below.



Local Directory

Cloud Storage

Content in Annotation File

Google AutoML supports two types of bounding boxes in an annotation file (data.csv):

a. Two vertices identified by top-left and bottom-right corners
b. Four vertices identified by all corners

In both cases, the vertices are normalized according to the image size. Refer to format of annotation file for more details. A sample of the content using (a) is shown below.

```
gs://project/masks/1.jpg,mask-on, 0.041015625,0.304411765,,,0.696289063,0.970588235,,
gs://project/masks/1.jpg,mask-on, 0.290039063,0.110294118,,,0.755859375,0.426470588,,
gs://project/masks/2.jpg,mask-off,0.290039063,0.110294118,,,0.755859375,0.426470588,,
gs://project/masks/2.jpg,mask-on,0.240234375,0.395314788,,,0.514648438,0.70863836,,
gs://project/masks/2.jpg,mask-off.178710938,0.2236671,,,0.73828125,0.950585176,,
…
```

Rubrics

Criteria	Poor	Satisfactory	Good	Excellent
Business Case [5 Marks]	Marks: 0.0 – 2.4	Marks: 2.5 – 3.4	Marks: 3.5 – 4.4	Marks: 4.5 – 5.0
Scope and Benefits	• Poorly defined, unclear and confusing	• Partially defined and shows limited benefits	• Mostly defined and shows some benefits	• Comprehensive, innovative and has a wide range of benefits
Data Preparation [10 Marks]	Marks: 0.0 – 4.9	Marks: 5 – 6.9	Marks: 7 – 8.9	Marks: 9.0 – 10.0
Project criteria	• < 3 labels	• 3 labels and total image size > 20MB	• 3 labels and total image size ≤ 20MB	• 3 labels and total image size ≤ 15MB
Individual image requirements	• Non-conforming images > 50%	• Non-conforming images ≤ 50% and > 25%	• Non-conforming images ≤ 25% and > 5%	• Non-conforming images ≤ 5%
Bounding Boxes	• Obtained from public sources	• Self-created with explanations of: (i) tool used	• Self-created with explanations of: (i) tool used (ii) data conversion	• Self-created with explanations of: (i) tool used (ii) data conversion (iii) best practices from credible sources
	• < 150	• >= 150 and < 225	• >= 225 and < 300	• >= 300
Google Cloud Storage (GCS)	• Bucket not created using Client Library	• Bucket created partially according to recommended structure	• Bucket created according to rec. structure with excess directories	• Bucket created according to rec. structure without excess directories

	• Annotation file is not found • Missing images > 50%	• Annotation file has errors in 10 or more rows • Missing images ≤ 50% and > 25%	• Annotation file has errors in less than 10 rows • Missing images ≤ 25% and > 5%	• Annotation file has no errors • Missing images ≤ 5%
AutoML Workflow [10 Marks]	Marks: 0.0 – 4.9	Marks: 5.0 – 6.9	Marks: 7.0 – 8.9	Marks: 9.0 – 10.0
Training	• Training is not completed	• Training is completed after resolving major errors	• Training is completed after resolving minor errors	• Training is completed with no errors
Evaluation	• Performance metrics are not available	• Poor rationale in the selection of thresholds and brief descriptions of some metrics	• Good rationale in the selection of thresholds and thorough descriptions of some metrics	• Excellent rationale in the selection of thresholds and thorough descriptions of all metrics
Online Prediction	• No results or poor explanations of results	• Partial explanations of results	• Good explanations of results	• Comprehensive explanations of all results
Resource Management [5 Marks]	Marks: 0.0 – 2.4	Marks: 2.5 – 3.4	Marks: 3.5 – 4.4	Marks: 4.5 – 5.0
Usage of Google cloud computing resources	• Excess charges incurred due to compromised service key, repeated training or 8 or more hours of deployment	• Major excessive charges; between 4 and less than 8 hours of deployment	• Minor excessive charges; between 1 and less than 4 hours of deployment	• No excessive charges; less than 1 hour of deployment

Source Codes & Reflection [10 Marks]	Marks: 0.0 – 4.9	Marks: 5.0 – 6.9	Marks: 7.0 – 8.9	Marks: 9.0 – 10.0
Notebooks Structure and Content	• Content is poorly organized and incoherent	• Content is partially organized without visualizations	• Content is mostly organized with some visualizations	• Content is well organized across all sections with excellent visualizations
	• Poor use of Markdown and comments to explain processes	• Moderate use of Markdown and comments to explain processes	• Good use of Markdown and comments to explain processes	• Excellent use of Markdown and comments to explain processes
Reflection	• Video conveys poor subject knowledge, insights and recommendations	• Video conveys sparse subject knowledge, insights and recommendations	• Video conveys good subject knowledge, insights and recommendations	• Video conveys excellent subject knowledge, insights and recommendations