

## 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: 3
  - ii. Number of bounding boxes for each label: 50 to 100
  - iii. Total size of all your images:  $\leq 15\text{MB}$
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](https://makesense.ai)
  - [roboflow](https://roboflow.com)
  - [Label Studio](https://labelstudio.com)

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<sup>1</sup> 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

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<sup>1</sup> 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.

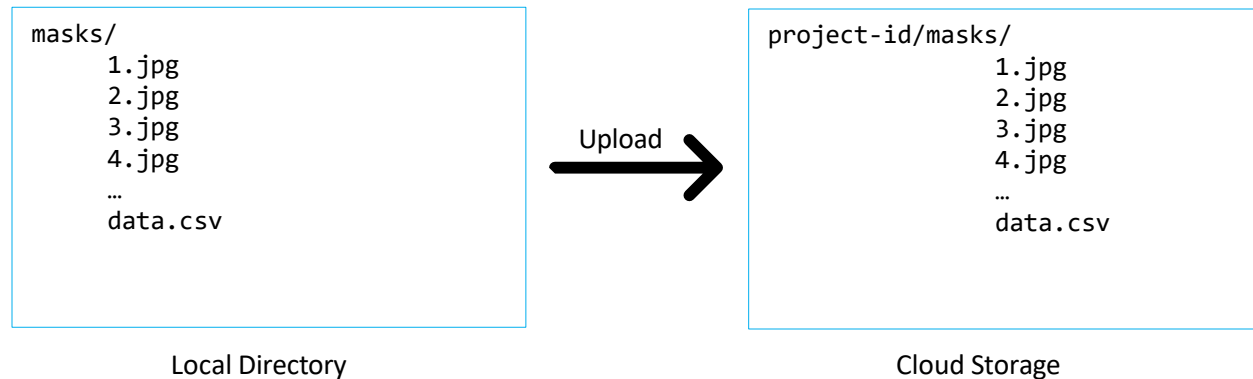
### References

- [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.



### Content in Annotation File

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

- Two vertices identified by top-left and bottom-right corners
- 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
<b>Business Case [5 Marks]</b>  Scope and Benefits	Marks: 0.0 – 2.4  <ul style="list-style-type: none"> <li>Poorly defined, unclear and confusing</li> </ul>	Marks: 2.5 – 3.4  <ul style="list-style-type: none"> <li>Partially defined and shows limited benefits</li> </ul>	Marks: 3.5 – 4.4  <ul style="list-style-type: none"> <li>Mostly defined and shows some benefits</li> </ul>	Marks: 4.5 – 5.0  <ul style="list-style-type: none"> <li>Comprehensive, innovative and has a wide range of benefits</li> </ul>
<b>Data Preparation [10 Marks]</b>  Project criteria  Individual image requirements  Bounding Boxes  Google Cloud Storage (GCS)	Marks: 0.0 – 4.9  <ul style="list-style-type: none"> <li>&lt; 3 labels</li> <li>Non-conforming images &gt; 50%</li> <li>Obtained from public sources</li> <li>&lt; 150</li> <li>Bucket not created using Client Library</li> </ul>	Marks: 5 – 6.9  <ul style="list-style-type: none"> <li>3 labels and total image size &gt; 20MB</li> <li>Non-conforming images ≤ 50% and &gt; 25%</li> <li>Self-created with explanations of: (i) tool used</li> <li>≥ 150 and &lt; 225</li> <li>Bucket created partially according to recommended structure</li> </ul>	Marks: 7 – 8.9  <ul style="list-style-type: none"> <li>3 labels and total image size ≤ 20MB</li> <li>Non-conforming images ≤ 25% and &gt; 5%</li> <li>Self-created with explanations of: (i) tool used (ii) data conversion</li> <li>≥ 225 and &lt; 300</li> <li>Bucket created according to rec. structure with excess directories</li> </ul>	Marks: 9.0 – 10.0  <ul style="list-style-type: none"> <li>3 labels and total image size ≤ 15MB</li> <li>Non-conforming images ≤ 5%</li> <li>Self-created with explanations of: (i) tool used (ii) data conversion (iii) best practices from credible sources</li> <li>≥ 300</li> <li>Bucket created according to rec. structure without excess directories</li> </ul>

	<ul style="list-style-type: none"> <li>• Annotation file is not found</li> <li>• Missing images &gt; 50%</li> </ul>	<ul style="list-style-type: none"> <li>• Annotation file has errors in 10 or more rows</li> <li>• Missing images <math>\leq</math> 50% and &gt; 25%</li> </ul>	<ul style="list-style-type: none"> <li>• Annotation file has errors in less than 10 rows</li> <li>• Missing images <math>\leq</math> 25% and &gt; 5%</li> </ul>	<ul style="list-style-type: none"> <li>• Annotation file has no errors</li> <li>• Missing images <math>\leq</math> 5%</li> </ul>
<b>AutoML Workflow [10 Marks]</b>  Training   Evaluation   Online Prediction	Marks: 0.0 – 4.9  <ul style="list-style-type: none"> <li>• Training is not completed</li> <li>• Performance metrics are not available</li> <li>• No results or poor explanations of results</li> </ul>	Marks: 5.0 – 6.9  <ul style="list-style-type: none"> <li>• Training is completed after resolving major errors</li> <li>• Poor rationale in the selection of thresholds and brief descriptions of some metrics</li> <li>• Partial explanations of results</li> </ul>	Marks: 7.0 – 8.9  <ul style="list-style-type: none"> <li>• Training is completed after resolving minor errors</li> <li>• Good rationale in the selection of thresholds and thorough descriptions of some metrics</li> <li>• Good explanations of results</li> </ul>	Marks: 9.0 – 10.0  <ul style="list-style-type: none"> <li>• Training is completed with no errors</li> <li>• Excellent rationale in the selection of thresholds and thorough descriptions of all metrics</li> <li>• Comprehensive explanations of all results</li> </ul>
<b>Resource Management [5 Marks]</b>  Usage of Google cloud computing resources	Marks: 0.0 – 2.4  <ul style="list-style-type: none"> <li>• Excess charges incurred due to compromised service key, repeated training or 8 or more hours of deployment</li> </ul>	Marks: 2.5 – 3.4  <ul style="list-style-type: none"> <li>• Major excessive charges; between 4 and less than 8 hours of deployment</li> </ul>	Marks: 3.5 – 4.4  <ul style="list-style-type: none"> <li>• Minor excessive charges; between 1 and less than 4 hours of deployment</li> </ul>	Marks: 4.5 – 5.0  <ul style="list-style-type: none"> <li>• No excessive charges; less than 1 hour of deployment</li> </ul>

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	<ul style="list-style-type: none"><li>• Content is poorly organized and incoherent</li><li>• Poor use of Markdown and comments to explain processes</li></ul>	<ul style="list-style-type: none"><li>• Content is partially organized without visualizations</li><li>• Moderate use of Markdown and comments to explain processes</li></ul>	<ul style="list-style-type: none"><li>• Content is mostly organized with some visualizations</li><li>• Good use of Markdown and comments to explain processes</li></ul>	<ul style="list-style-type: none"><li>• Content is well organized across all sections with excellent visualizations</li><li>• Excellent use of Markdown and comments to explain processes</li></ul>
Reflection	<ul style="list-style-type: none"><li>• Video conveys poor subject knowledge, insights and recommendations</li></ul>	<ul style="list-style-type: none"><li>• Video conveys sparse subject knowledge, insights and recommendations</li></ul>	<ul style="list-style-type: none"><li>• Video conveys good subject knowledge, insights and recommendations</li></ul>	<ul style="list-style-type: none"><li>• Video conveys excellent subject knowledge, insights and recommendations</li></ul>