Reproducible Open Benchmarks

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Background

- Inspired by the “Machine Learning Landscape of Top Taggers Paper”
  - https://arxiv.org/abs/1902.09914v2
  - They compiled and compared multiple top tagging models
- A significant amount of time is required to organize and evaluate large benchmarks
- Goal of the ROB is to provide a platform that **automates the collection, execution and comparison of submissions** of participants in the benchmark

How the ROB works

1. A workflow is defined by the coordinator of the benchmark along with input data
2. The users provide code that satisfy the steps in the workflow
3. The ROB back-end processes the workflow using the code provided by the user, and evaluates the metrics set by the coordinator
4. The Front end displays the results

Example Workflow: Top Tagging

- Coordinator provides: input data
- Coordinator provides 2 steps for submission:
    - Preprocessing
    - Tagger
- Coordinator Provides: Result evaluation task, which is displayed in the front end

User provides code to preprocess the input data, and a top tagging model which is used to evaluate the data

Current Problem:

- ROB currently requires participants to package their submissions into docker containers
    - Steep learning curve for people unfamiliar

Solution

- In order to increase ease of use, we implement support for the commonly used Jupyter Notebooks
    - We allow users to submit their implementations directly as Jupyter Notebooks

How to run a Jupyter Notebook?

- Jupyter Notebook executions are cell by cell
- Cannot be run like a python script

Issues we needed to solve:

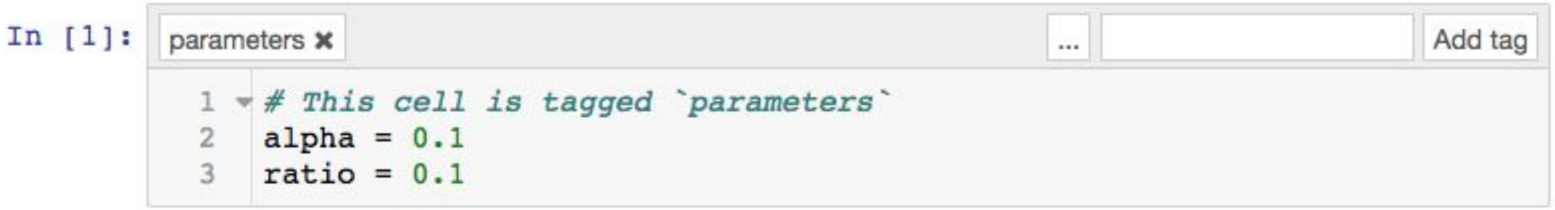
- How to define parameters within a jupyter notebook
- How to run the same jupyter notebook with new parameters without needing to open and edit the notebook it self
- How to run the Jupyter Notebook within the ROB without the need to open the python notebook using the Jupyter Notebook Editor

Papermill!

- Papermill is a convenient way to run Jupyter Notebooks
    - It is a tool that parametrizes, and executes notebooks in its entirety
    - https://papermill.readthedocs.io/en/latest/

How Papermill Works

- Users are required to define one cell in their Jupyter Notebook with the tag "parameters"

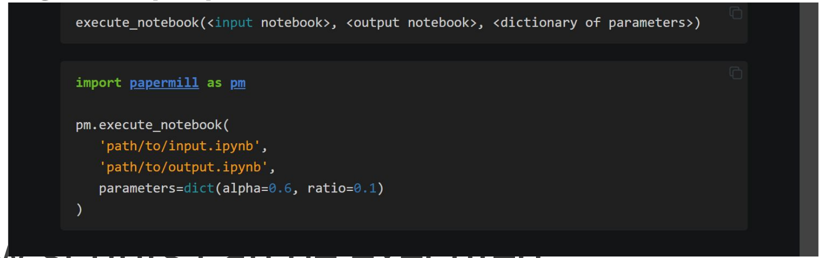


```
# This cell is tagged `parameters`
alpha = 0.1
ratio = 0.1
```

- Users need to ensure that the entire notebook runs with no errors (just like any python script)
- Ensure that all parameters that can or might be changed in the future is included in the parameters cell

How Papermill Works Continued.

- Users can then execute the notebook using the papermill “execute notebook function”
  - Inputs are:
    - Path to the input
    - Path to the output notebook
    - Dictionary of parameters



```
execute_notebook(<input notebook>, <output notebook>, <dictionary of parameters>)
```

```
import papermill as pm

pm.execute_notebook(
   'path/to/input.ipynb',
   'path/to/output.ipynb',
   parameters=dict(alpha=0.6, ratio=0.1)
)
```

- Will execute your notebook similar to how scripts can be executed
- Will generate an output notebook at the path of the outback notebook, with an output that is exactly like if you pressed “run all cells” in the Jupyter Notebooks
- Parameter values in the notebook will be replaced by the values defined in the function

Implementing Papermill Into ROB

- Create a new **Step Type** that uses papermill to execute the notebook
  - Current Step Types: ContainerStep, FunctionStep
  - Added Step Type: NotebookStep
  - This is the function in the ROB that takes defined workflow inputs and user inputs, and runs the functions
  - Done by implementing a subclass of the WorkflowStep Class
- Create a new “worker” that executes steps of the given context
  - Done by implementing a sub class of the Worker Class in ROB
  - A function that calls the step and executes the function
- Create another worker that is able to run Jupyter Notebooks contained within docker containers

Hello World Demo

Inputs:

- Data: list of names
- Jupyter Notebook that reads the list of names and writes greetings to an output file

Output: List of greetings

- List of greetings is then analyzed by counting average characters per line and max output length, which is then put in a json file as the final “output”

How to run demo:

- Create ROB User
- Create Hello World Workflow
- Start the Hello World Demo Run
- Submit python notebook and data in the command line
- Retrieve Results

Detailed functions/explanations at:
https://github.com/scailfin/rob-demo-hello-world

Jet Flavor Demo

- Implementation of the Jet Flavor Dataset into the ROB
  - http://mlphysics.ics.uci.edu/data/hb_jet_flavor_2016/
- Inspired by the “Jet Flavor Classification in High-Energy Physics with Deep Neural Networks” paper
  - https://arxiv.org/pdf/1607.08633.pdf

- Lots of combinations of features that need to be compared
- Hard to compile all the models and train all of them individually
- Implement into the ROB as a workflow to make comparison and training on the same validation set easier and more organized

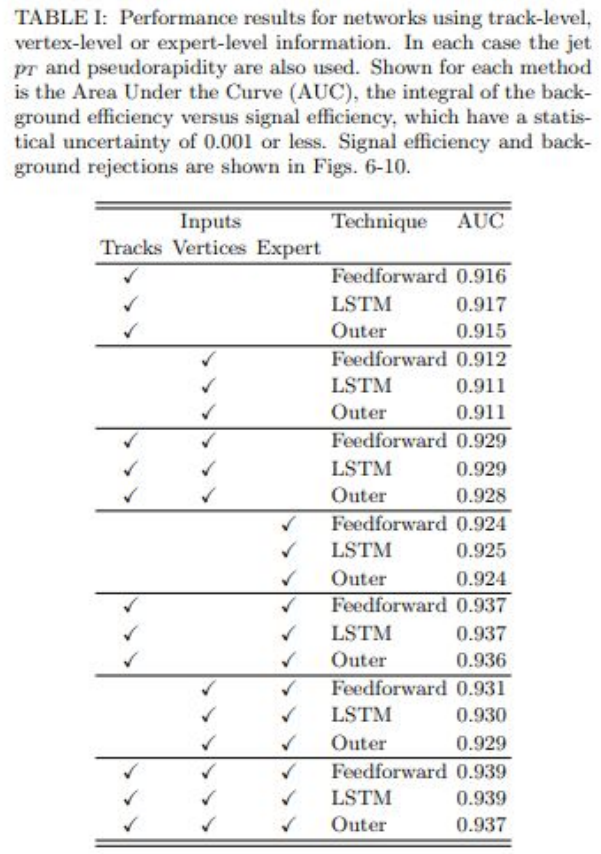


TABLE I: Performance results for networks using track-level, vertex-level or expert-level information. In each case the jet p_T and pseudorapidity are also used. Shown for each method is the Area Under the Curve (AUC), the integral of the background efficiency versus signal efficiency, which have a statistical uncertainty of 0.001 or less. Signal efficiency and background rejections are shown in Figs. 6-10.

Inputs			Technique	AUC
Tracks	Vertices	Expert		
✓			Feedforward	0.916
✓			LSTM	0.917
✓			Outer	0.915
	✓		Feedforward	0.912
	✓		LSTM	0.911
	✓		Outer	0.911
✓	✓		Feedforward	0.929
✓	✓		LSTM	0.929
✓	✓		Outer	0.928
		✓	Feedforward	0.924
		✓	LSTM	0.925
		✓	Outer	0.924
✓		✓	Feedforward	0.937
✓		✓	LSTM	0.937
✓		✓	Outer	0.936
	✓	✓	Feedforward	0.931
	✓	✓	LSTM	0.930
	✓	✓	Outer	0.929
✓	✓	✓	Feedforward	0.939
✓	✓	✓	LSTM	0.939
✓	✓	✓	Outer	0.937

Workflow

User inputs:

- Model architectures
- Preprocessing script
- Training script

Workflow Coordinator inputs:

- Training and validation data
- Validation script

Summary

- Implemented jupyter notebooks into the ROB as a form of input
- Created demos using Jupyter Notebooks for use of the ROB for
  - Quickdraw dataset
  - Jet Flavor Dataset
  - Top Tagging dataset
  - Mnist Dataset
- Github Repositories: https://github.com/anrunw/ROB, https://github.com/scailfin/flowserv-core

Future Work:

- Presenting at the ML4Jets conference on 6/7
- Fix flask web server for browser input into ROB

Questions?