Google Summer of Code Project

Jupyter and TMVA

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ROOT Data Analysis Framework

jupyter

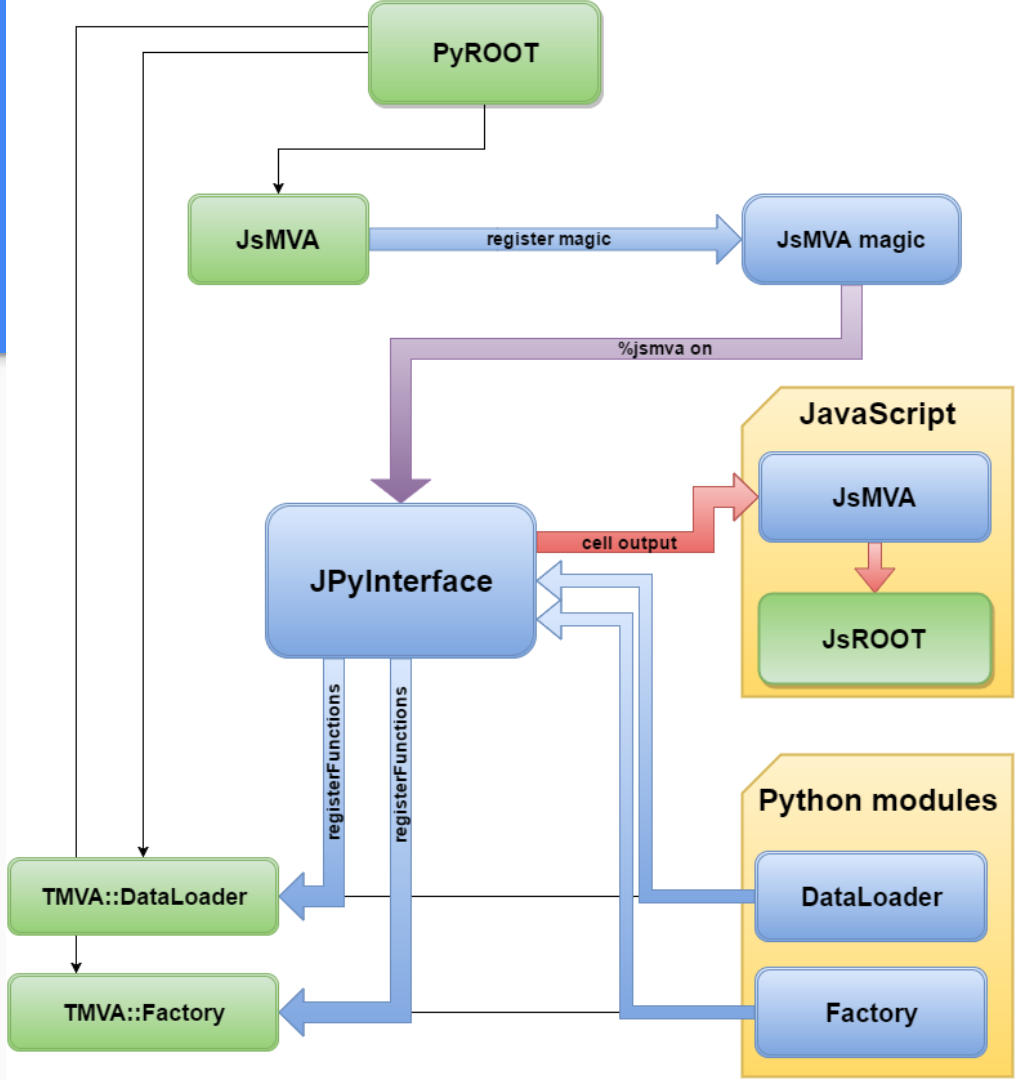
TMVA

Motivation

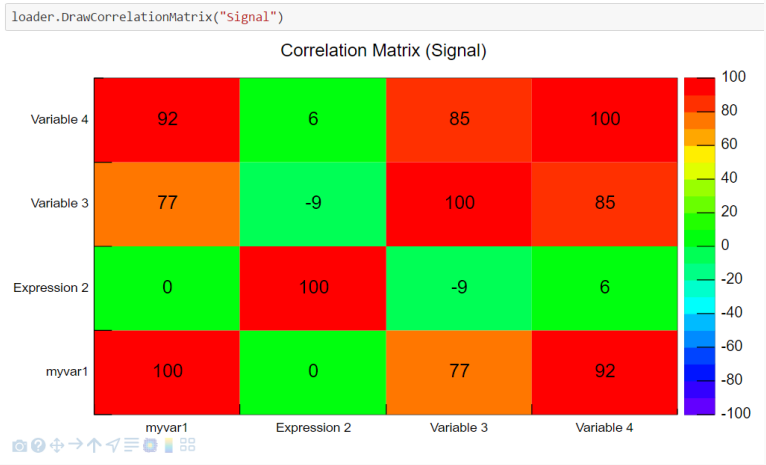
- Jupyter notebook:
  - Interactive coding
  - Document: HTML, Markdown support
  - Shareable: SWAN, nbviewer, binder
- Current status of TMVA:
  - We can’t use TMVAGui
  - We can read back the classifier outputs and we can make visualizations.
  - BUT users don’t want to spend time with making visualizations
- Integrating TMVA in Jupyter:
  - Support for TMVAGui in notebooks
  - New visualizations
  - Pythonic interface for a bunch of functions
  - Interaction: changes modify the state of TMVA
  - HTML formatted output

Code structure

- Importing ROOT will import JsMVA, this will register jsmva magic
- %jsmva on: JPyInterface inserts new methods to TMVA.DataLoader and TMVA.Factory, overloads some functions with a wrapper, register HTML transformer function
- New methods: inserting HTML to cell output, with JavaScript call for JsMVA.js
- JsMVA.js using JsROOT to create JavaScript plots



TMVAGui visualizations

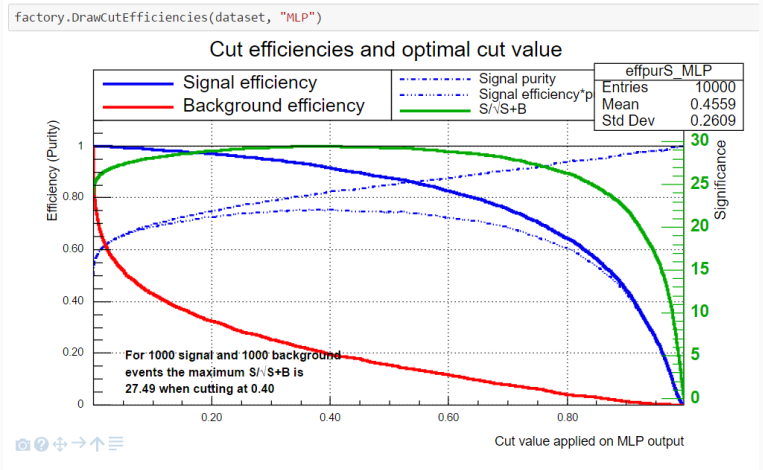


Visualizations related to input variables

- Correlation matrix
- Input variables
- Transform input variables & show

Visualizations related to classifier outputs

- ROC curve
- Output distributions
- Cut efficiencies



Classifier output: Neural networks, decision trees

Simple neural network

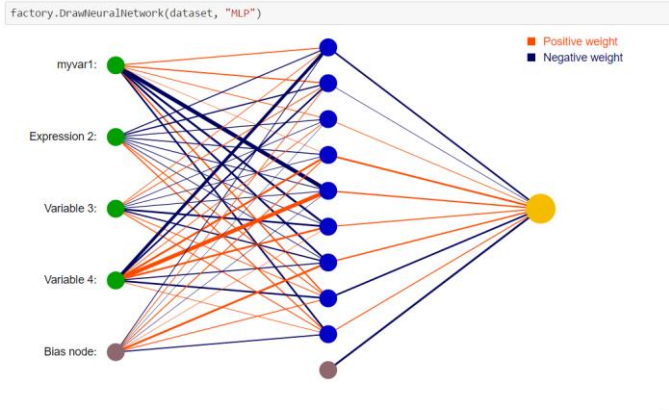
- Python function reads the network, converts to JSON; JS with d3js make the visualization from JSON
- Interactive: focusing connections, zooming, moving

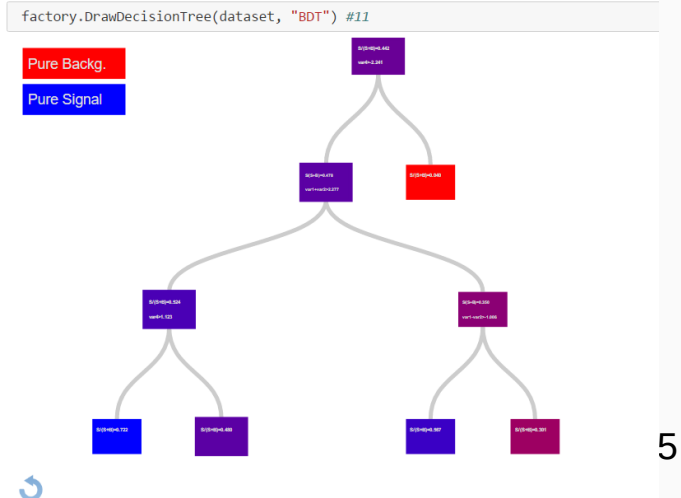
Deep neural network

- HTML5 Canvas visualization (speed)
- Less interactive: zooming, moving

Decision trees

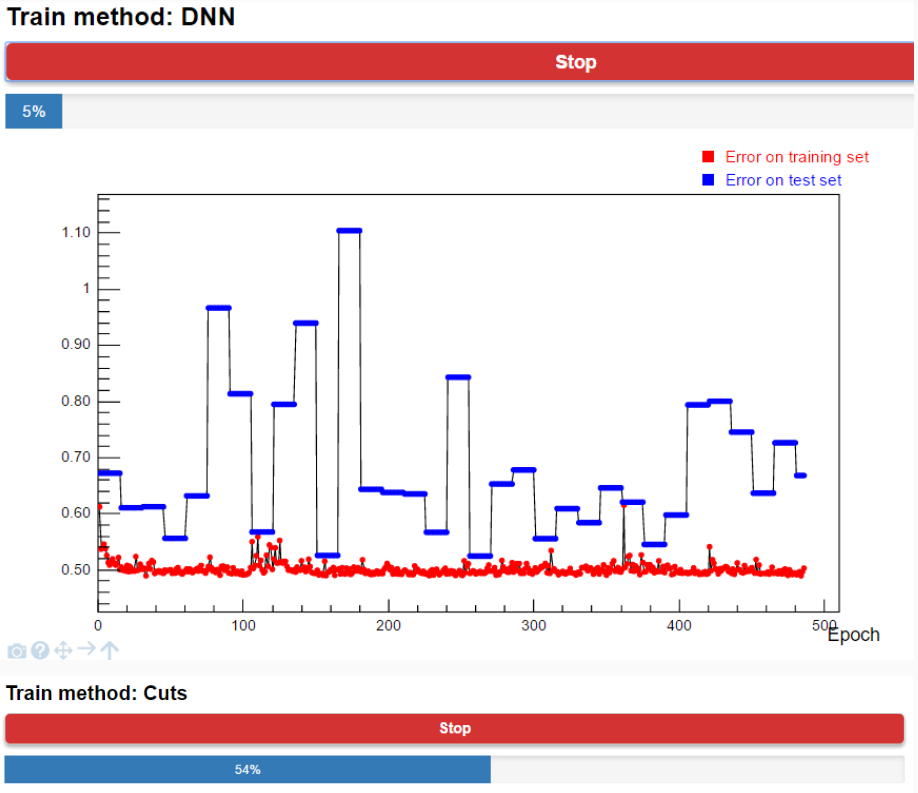
- Ipywidgets: input field for selecting the tree
- Visualization from JSON with D3js
- Interactive: closing subtree, showing the path, focusing, moving, zooming, reset





Interactive training mode

- C++ interface for tracking/stopping the training
- New thread for training
- Main thread periodically refreshes the plot (inserts small JS script, which removes itself)
- Error plots supported for MLP, DNN, BDT methods
- Progress bar for a bunch of methods
- Stop button: by clicking on it the main thread will send stop message for training loop (just the loop, no interfere with saving the net, or other data)



Pythonic user interface, tutorial notebooks

```
factory = TMVA.Factory(JobName="TMVAClassification", TargetFile=outputFile,
                       V=False, Color=True, DrawProgressBar=True, Transformations=["I", "D", "P", "G", "D"],
                       AnalysisType="Classification")
```

New interface

- Option strings not very nice, we can do better in python
- Bunch of functions use option string
- Wrapper functions for them, with jsmva magic these functions are replaced with corresponding wrapper function
- The settings can be passed by named arguments: V=True,Transformations=[“I”,“D”] will be translated to “!V:Transformations=I,D”

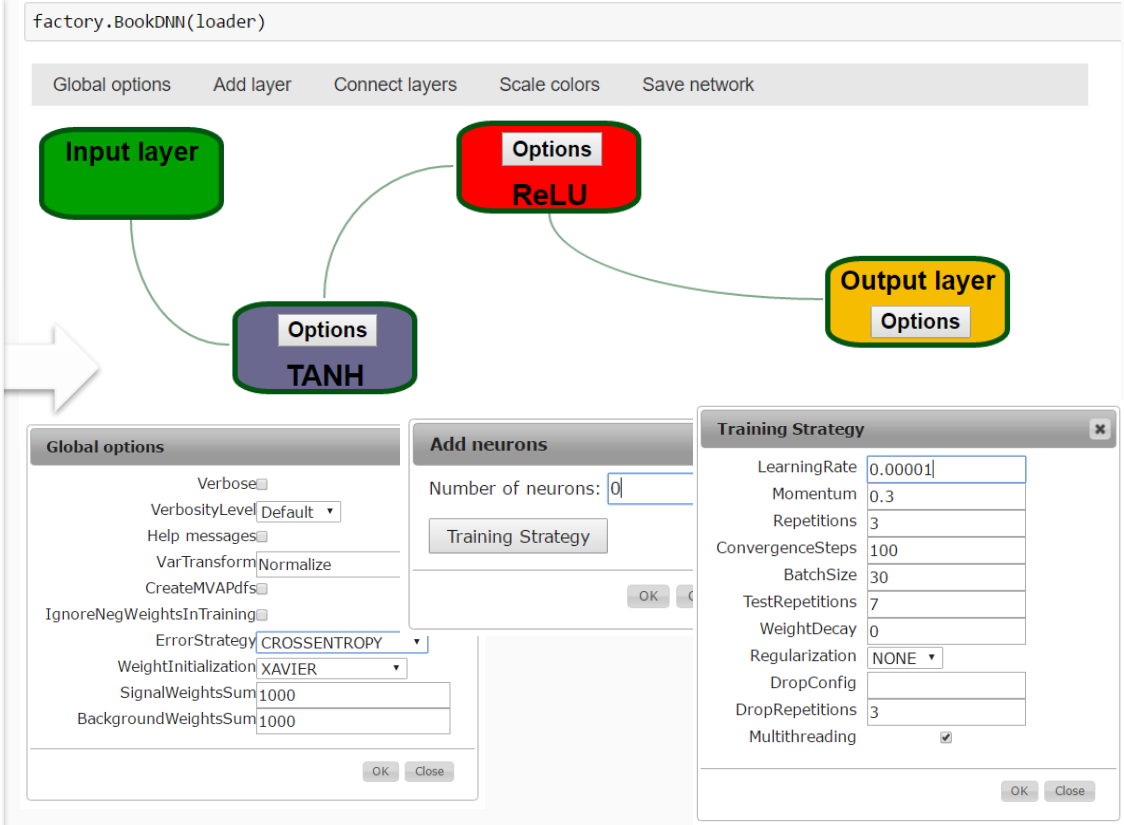
Arguments of constructor: The options string can contain the following options:

Keyword	Can be used as positional argument	Default	Predefined values	Description
JobName	yes, 1.	not optional	-	Name of job
TargetFile	yes, 2.	If not passed histograms won't be saved	-	File to write control and performance histograms histograms
V	no	False	-	Verbose flag
Color	no	True	-	Flag for colored output
Transformations	no	""	-	List of transformations to test. For example with "I;D;P;U;G" string identity, decorrelation, PCA, uniform and Gaussian transformations will be applied
Silent	no	False	-	Batch mode: boolean silent flag inhibiting any output from TMVA after the creation of the factory class object
DrawProgressBar	no	True	-	Draw progress bar to display training, testing and evaluation schedule (default: True)
AnalysisType	no	Auto	Classification, Regression, Multiclass, Auto	Set the analysis type

Tutorial: http://nbviewer.jupyter.org/github/qati/GSOC16/blob/master/notebooks/ROOTbooks-TMVA-JsMVA-UserInterface.ipynb

Deep neural network builder

- Booking DNN confusing: lot of settings, everybody forgets the exact names
- Graphical interface: booking DNN with pleasure
- We can add different types of layers
- Specify the neuron number and training strategy for layer
- Connect the layers: building the network
- Save network: transform the graphical representation to option string and books the method



HTML formatted output

- jsmva magic register output transformer function to JupyROOT
- also inserts CSS (for transformed output tables style) to notebook
- The output transformer class:
    1. Regular expressions for matching different output lines => logical units
    2. Based on matchings the output is transformed to table structure (style: CSS)
    3. Correlation matrix: table => histogram => JsROOT visualization in popup window (jquery)

	Number of training and testing events Signal: training events 2400; testing events 600; training and testing events 3000 Background: training events 2400; testing events 600; training and testing events 3000
DataSetInfo	Correlation matrix (Signal)
DataSetInfo	Correlation matrix (Background)
DataSetFactory	**Dataset: BDT_fold4**
Factory	Train method: BDT for Classification
BDT	#events: (reweighted) sig: 2400 bkg: 2400
	#events: (unweighted) sig: 2400 bkg: 2400
	Training 2 Decision Trees ... patience please
	Elapsed time for training with 4800 events : 0.0133 sec
BDT	**Dataset: BDT_fold4** Evaluation of BDT on training sample (4800 events)
	Elapsed time for evaluation of 4800 events : 0.00358 sec
	Creating xml weight file: BDT_fold4/weights/TMVAClassification_BDT.weights.xml
	Creating standalone class: BDT_fold4/weights/TMVAClassification_BDT.class.C

Notebooks

Everything on GitHub:

https://github.com/qati/GSOC16

Notebooks on nbviewer (static, rendered):

http://nbviewer.jupyter.org/github/qati/GSOC16/blob/master/index.ipynb

Notebooks on binder (interactive):

www.mybinder.org/repo/qati/GSOC16

Or you can download:

https://github.com/qati/GSOC16/tree/master/notebooks

Thank you for your attention!