

Configuration Manual

MSc Research Project
MSc in cloud computing

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Project Submission Sheet
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Configuration Manual

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1 Introduction

Various tools and libraries have been used to assemble the project. This document is aimed to give information about the procedure to follow to execute the project.

2 Prerequisites

As I have coded my project in python programming language, user of the document has to have understanding of python programming language and libraries associated in document.

Default recommended version of python is 3.7 and can be downloaded from official website. On linux operating system, python v2 comes as default. Python 3.7 can be installed using command line.

3 Required Python Libraries

Implementation of this project requires python libraries. To install additional libraries user has to install pip for python version 3.7. If pip is not getting installed on the system, updating the packages may solve the issue. Libraries that have to be installed are listed below:

3.1 Install pip

```
sudo apt install python3-pip
```

```

ashish@ubuntu:~/auto_scaling_v1$ sudo apt install python3-pip
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  build-essential cpp cpp-7 dh-python dpkg-dev fakeroot g++ g++-7 gcc gcc-7
  gcc-7-base libalgorithm-diff-perl libalgorithm-diff-xs-perl
  libalgorithm-merge-perl libasan4 libatomic1 libc-dev-bin libc6-dev libcc1-0
  libckitrt5 libdpkg-perl libexpat1 libexpat1-dev libfakeroot libgcc-7-dev
  libgcc1 libgomp1 libitm1 liblsan0 libmpx2 libpython3-dev libpython3.6
  libpython3.6-dev libpython3.6-minimal libpython3.6-stdlib libquadmath0
  libssl1.1 libstdc++-7-dev libstdc++6 libtsan0 libubsan0 linux-libc-dev make
  manpages-dev python-pip-whl python3-dev python3-distutils python3-lib2to3
  python3-setuptools python3-wheel python3.6 python3.6-dev python3.6-minimal
Suggested packages:
  cpp-doc gcc-7-locales debian-keyring g++-multilib g++-7-multilib gcc-7-doc
  libstdc++6-7-dbg gcc-multilib autoconf automake libtool flex bison gcc-doc
  gcc-7-multilib libgcc1-dbg libgomp1-dbg libitm1-dbg libatomic1-dbg
  libasan4-dbg liblsan0-dbg libtsan0-dbg libubsan0-dbg libckitrt5-dbg
  libmpx2-dbg libquadmath0-dbg glibc-doc git bzr libstdc++-7-doc make-doc
  python-setuptools-doc python3.6-venv python3.6-doc binfmt-support
The following NEW packages will be installed:
  build-essential dh-python dpkg-dev fakeroot g++ g++-7 gcc gcc-7
  libalgorithm-diff-perl libalgorithm-diff-xs-perl libalgorithm-merge-perl
  libasan4 libatomic1 libc-dev-bin libc6-dev libckitrt5 libexpat1-dev
  libfakeroot libgcc-7-dev libitm1 liblsan0 libmpx2 libpython3-dev
  libpython3.6-dev libquadmath0 libstdc++-7-dev libtsan0 libubsan0
  linux-libc-dev make manpages-dev python-pip-whl python3-dev
  python3-distutils python3-lib2to3 python3-pip python3-setuptools
  python3-wheel python3.6-dev
The following packages will be upgraded:
  cpp cpp-7 gcc-7-base gcc-8-base libcc1-0 libdpkg-perl libexpat1 libgcc1
  libgomp1 libpython3.6 libpython3.6-minimal libpython3.6-stdlib libssl1.1
  libstdc++6 python3.6 python3.6-minimal
16 upgraded, 39 newly installed, 0 to remove and 504 not upgraded.
Need to get 94.6 MB/95.0 MB of archives.
After this operation, 208 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 libpython3.6 amd64 3.6.9-1-18.04 [1,414 kB]
Get:2 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 libssl1.1 amd64 1.1.1-1ubuntu2.1-18.04.5
Get:3 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 python3.6 amd64 3.6.9-1-18.04 [203 kB]
Get:4 http://security.ubuntu.com/ubuntu bionic-updates/main amd64 libssl1.1 amd64 1.1.1-1ubuntu2.1-18.04.5 [1,300 kB]

```

Figure 1: pip installation

3.2 Tensorflow 2

If user does not want to install virtual environment then he has to specify `-user` while executing the command. This command will install or update the tensorflow library to latest version.

`pip3 install -user --no-cache-dir --upgrade tensorflow`

```

ashish@ubuntu:~/auto_scaling_v1$ pip3 install --user --no-cache-dir --upgrade tensorflow
Collecting tensorflow
  Downloading tensorflow-2.1.0-cp36-cp36m-manylinux2010_x86_64.whl (421.8 MB)
  |#####| 421.8 MB 349 kB/s
Collecting six>=1.12.0
  Downloading six-1.14.0-py2.py3-none-any.whl (10 kB)
Collecting tensorflow-estimator<2.2.0,>=2.1.0rc0
  Downloading tensorflow-estimator-2.1.0-py2.py3-none-any.whl (448 kB)
  |#####| 448 kB 428 kB/s
Collecting termcolor>=1.1.0
  Downloading termcolor-1.1.0.tar.gz (3.9 kB)
Collecting absl-py>=0.7.0
  Downloading absl-py-0.9.0.tar.gz (104 kB)
  |#####| 104 kB 490 kB/s
Collecting tensorboard<2.2.0,>=2.1.0
  Downloading tensorboard-2.1.1-py3-none-any.whl (3.8 MB)
  |#####| 3.8 MB 339 kB/s
Collecting keras-preprocessing>=1.1.0
  Downloading Keras-Preprocessing-1.1.0-py2.py3-none-any.whl (41 kB)
  |#####| 41 kB 691 kB/s
Collecting keras-applications>=1.0.8
  Downloading Keras-Applications-1.0.8-py3-none-any.whl (50 kB)
  |#####| 50 kB 521 kB/s
Collecting opt-einsum>=2.3.2
  Downloading opt_einsum-3.2.0-py3-none-any.whl (63 kB)
  |#####| 63 kB 550 kB/s
Collecting gast==0.2.2
  Downloading gast-0.2.2.tar.gz (10 kB)
Collecting grpcio>=1.8.6
  Downloading grpcio-1.28.1-cp36-cp36m-manylinux2010_x86_64.whl (2.8 MB)
  |#####| 2.8 MB 567 kB/s
Collecting astor>=0.6.0
  Downloading astor-0.8.1-py2.py3-none-any.whl (27 kB)
Collecting scipy==1.4.1; python_version >= "3"
  Downloading scipy-1.4.1-cp36-cp36m-manylinux1_x86_64.whl (26.1 MB)
  |#####| 26.1 MB 534 kB/s

```

Figure 2: Tensorflow 2

3.3 sklearn

sudo apt-get install python3-sklearn python3-sklearn-lib All essential libraries are covered

```
ashish@ubuntu:~/auto_scaling_v1$ sudo apt-get install python3-sklearn python3-sklearn-lib
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  blt fonts-lyx javascript-common libblas3 libgfortran4 libjs-jquery libjs-jquery-ui liblapack3 libpython-stdlib libpython2.7 libpython2.7-minimal libpython2.7-stdlib libtcl8.6 libtk8.6
  python-attr python-funcsigs python-matplotlib-data python-minimal python-pkg-resources python-pluggy python-py python-pytest python-six python2.7 python2.7-minimal python3-attr
  python3-dateutil python3-decorator python3-joblib python3-matplotlib python3-nose python3-numpy python3-pluggy python3-py python3-pyparsing python3-pytest python3-scipy python3-ttf-bitstream-vera
Suggested packages:
  blt-demo apache2 | lighttpd | httpd libjs-jquery-ui-docs tcl8.6 tk8.6 python-doc python-tk python-attr-doc python-funcsigs-doc python-setuputils subversion python-pytest-xdist python2.7-doc
  binfmt-support python-cycler-doc diving ffmpeg inkscape libpython3 python-matplotlib-doc python3-cairocffi python3-gobject python3-pyqt4 python3-sip python3-tornado
  texlive-latex-extra ttf-staypuft python-nose-doc gfortran python-numpy-doc python3-numpy-dbg python-pyparsing-doc python-scipy-doc python3-dap python-sklearn-doc tix python3-tk
The following NEW packages will be installed:
  blt fonts-lyx javascript-common libblas3 libgfortran4 libjs-jquery libjs-jquery-ui liblapack3 libpython-stdlib libtcl8.6 libtk8.6 python python-attr python-funcsigs python-matplotlib
  python-minimal python-pkg-resources python-pluggy python-py python-pytest python-six python2.7 python2.7-minimal python3-cycler python3-dateutil python3-decorator python3-joblib
  python3-matplotlib python3-nose python3-numpy python3-pluggy python3-py python3-pyparsing python3-pytest python3-scipy python3-sklearn python3-sklearn-lib python3-tk tk8.6-tcl2
The following packages will be upgraded:
  libpython2.7 libpython2.7-minimal libpython2.7-stdlib
3 upgraded, 41 newly installed, 0 to remove and 501 not upgraded.
Need to get 33.9 MB/34.0 MB of archives.
After this operation, 122 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://us.archive.ubuntu.com/ubuntu bionic-updates/main amd64 libpython2.7 amd64 2.7.17-1-18.04 [1,053 kB]
```

Figure 3: Install sklearn

when user installs tensorflow and sklearn packages. However, in case of error you may have to install matplotlib library as well. Library can be installed with command:

```
python3 -m pip install --upgrade matplotlib
```

4 Implementation steps and analysis

Once user has executed all the commands specified in section 3, he can execute the project. In order to do that, he has to run 2 applications using python3.

- python3 simple_test_app.py
- python3 composite_test_app.py

When first file is executed, it will trigger the Simple scaling controller. Simple scaling controller will process the inputs without passing them through linear regression. As inputs are passed to ANN without rounding them of with CSC, complexity of this model is more.

```
python3 simple_test_app.py
```

```
ashish@ubuntu:~/5_auto_scaling$ python3 simple_test_app.py
[0 0 1 2 2 3 3 5 4]
(9,)
2020-04-23 09:13:55.612080: W tensorflow/stream_executor/platform/default/d
uch file or directory
2020-04-23 09:13:55.620683: W tensorflow/stream_executor/platform/default/d
ect file: No such file or directory
2020-04-23 09:13:55.620740: W tensorflow/compiler/tf2tensorrt/utils/py_util
ibraries mentioned above are installed properly.
2020-04-23 09:13:57.438870: W tensorflow/stream_executor/platform/default/d
le or directory
2020-04-23 09:13:57.439021: E tensorflow/stream_executor/cuda/cuda_driver.c
2020-04-23 09:13:57.439084: I tensorflow/stream_executor/cuda/cuda_diagnost
2020-04-23 09:13:57.440790: I tensorflow/core/platform/cpu_feature_guard.cc
2020-04-23 09:13:57.478962: I tensorflow/core/platform/profile_utils/cpu_ut
2020-04-23 09:13:57.479998: I tensorflow/compiler/xla/service/service.cc:16
2020-04-23 09:13:57.480037: I tensorflow/compiler/xla/service/service.cc:17
Train on 400 samples
Epoch 1/200
400/400 [=====] - 1s 1ms/sample - loss: 214.5736
Epoch 2/200
400/400 [=====] - 0s 28us/sample - loss: 37.1484
Epoch 3/200
400/400 [=====] - 0s 31us/sample - loss: 33.1175
Epoch 4/200
400/400 [=====] - 0s 75us/sample - loss: 20.8587
Epoch 5/200
400/400 [=====] - 0s 94us/sample - loss: 10.1403
Epoch 6/200
400/400 [=====] - 0s 75us/sample - loss: 5.9170
Epoch 7/200
400/400 [=====] - 0s 51us/sample - loss: 3.8133
Epoch 8/200
400/400 [=====] - 0s 69us/sample - loss: 2.4470
Epoch 9/200
400/400 [=====] - 0s 65us/sample - loss: 2.0046
Epoch 10/200
400/400 [=====] - 0s 57us/sample - loss: 1.6843
Epoch 11/200
400/400 [=====] - 0s 43us/sample - loss: 1.5146
Epoch 12/200
400/400 [=====] - 0s 58us/sample - loss: 1.4043
Epoch 13/200
400/400 [=====] - 0s 58us/sample - loss: 1.3426
```

Figure 4: Epoch execution in system

When simple test app is executed, data is being generated randomly by task generator. Epoch shows that data set is being learnt from model, Then from this data, task queue is generated.

```

(1, 9)
generated 0 task inside the queue
no task to process
generated 3 task inside the queue
3 task processed by the machine
generated 5 task inside the queue
3 task processed by the machine
generated 6 task inside the queue
3 task processed by the machine
generated 7 task inside the queue
3 task processed by the machine
generated 10 task inside the queue
3 task processed by the machine
generated 11 task inside the queue
3 task processed by the machine
generated 11 task inside the queue
3 task processed by the machine
generated 13 task inside the queue
3 task processed by the machine
generated 15 task inside the queue
3 task processed by the machine
generated 15 task inside the queue
3 task processed by the machine
generated 16 task inside the queue
3 task processed by the machine
generated 17 task inside the queue
the vale of data is [ 4  7  5 10  6 11  7 11  8 13  9 15 10 15 11 16 12 17]
(9, 2)
(1, 9)
the shape of X is (1, 9)
[[17.474983]]
17 task processed by the machine
generated 19 task inside the queue
the vale of data is [ 5 10  6 11  7 11  8 13  9 15 10 15 11 16 12 17 13 19]
(9, 2)
(1, 9)

```

Figure 5: Task queue

As tasks are processed new tasks are generated by task generator. Result shows that accuracy is maintained in this system.

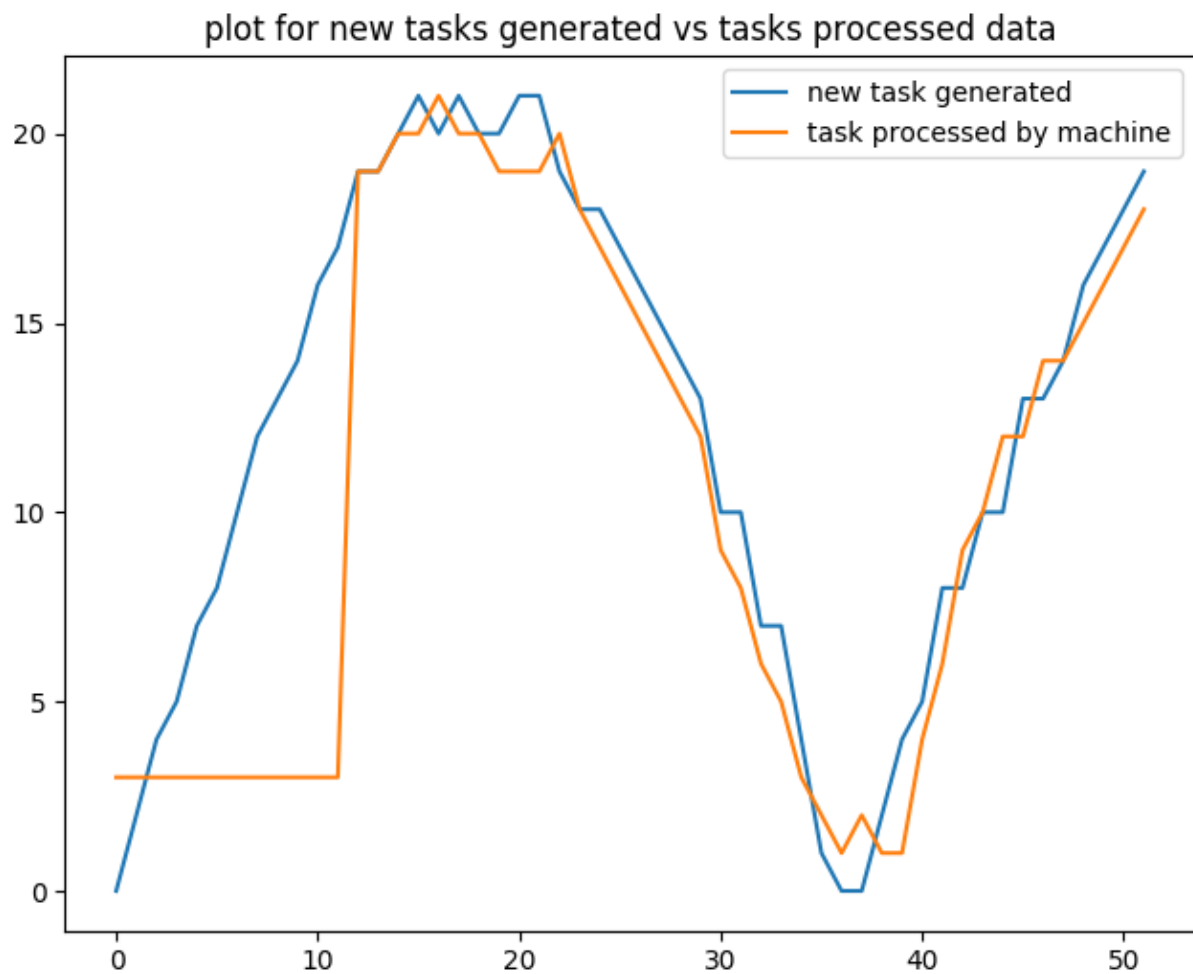


Figure 6: SSC result

4.1 The proposed CSC

In the next step, tasks generated are first passed through linear regression. Input generated is then feeded to ANN. This leads to less complexity while maintaining considerable accuracy.

`python3 composite_test_app.py`


```

ashish@ubuntu:~/auto_scaling_v1$ python3 composite_test_app.py
2020-04-09 06:35:05.900857: W tensorflow/stream_executor/platform/default/ds
uch file or directory
2020-04-09 06:35:05.902401: W tensorflow/stream_executor/platform/default/ds
ect file: No such file or directory
2020-04-09 06:35:05.902479: W tensorflow/compiler/tf2tensorrt/utils/py_util
ibraries mentioned above are installed properly.
2020-04-09 06:35:07.661959: W tensorflow/stream_executor/platform/default/ds
le or directory
2020-04-09 06:35:07.662139: E tensorflow/stream_executor/cuda/cuda_driver.cc
2020-04-09 06:35:07.662263: I tensorflow/stream_executor/cuda/cuda_diagnosti
2020-04-09 06:35:07.663401: I tensorflow/core/platform/cpu_feature_guard.cc:
2020-04-09 06:35:07.699499: I tensorflow/core/platform/profile_utils/cpu_utili
2020-04-09 06:35:07.700624: I tensorflow/compiler/xla/service/service.cc:168
2020-04-09 06:35:07.700696: I tensorflow/compiler/xla/service/service.cc:176
Train on 300 samples
Epoch 1/200
300/300 [=====] - 1s 2ms/sample - loss: 189.6874
Epoch 2/200
300/300 [=====] - 0s 165us/sample - loss: 165.3007
Epoch 3/200
300/300 [=====] - 0s 143us/sample - loss: 101.3384
Epoch 4/200
300/300 [=====] - 0s 106us/sample - loss: 63.6727
Epoch 5/200
300/300 [=====] - 0s 182us/sample - loss: 51.2088
Epoch 6/200
300/300 [=====] - 0s 88us/sample - loss: 44.6430
Epoch 7/200
300/300 [=====] - 0s 134us/sample - loss: 41.4755
Epoch 8/200
300/300 [=====] - 0s 90us/sample - loss: 37.8568
Epoch 9/200
300/300 [=====] - 0s 174us/sample - loss: 35.6349
Epoch 10/200
300/300 [=====] - 0s 147us/sample - loss: 32.8532
Epoch 11/200
300/300 [=====] - 0s 134us/sample - loss: 30.9878
Epoch 12/200
300/300 [=====] - 0s 158us/sample - loss: 28.5279
Epoch 13/200
300/300 [=====] - 0s 87us/sample - loss: 27.7659

```

Figure 7: Composite epoch

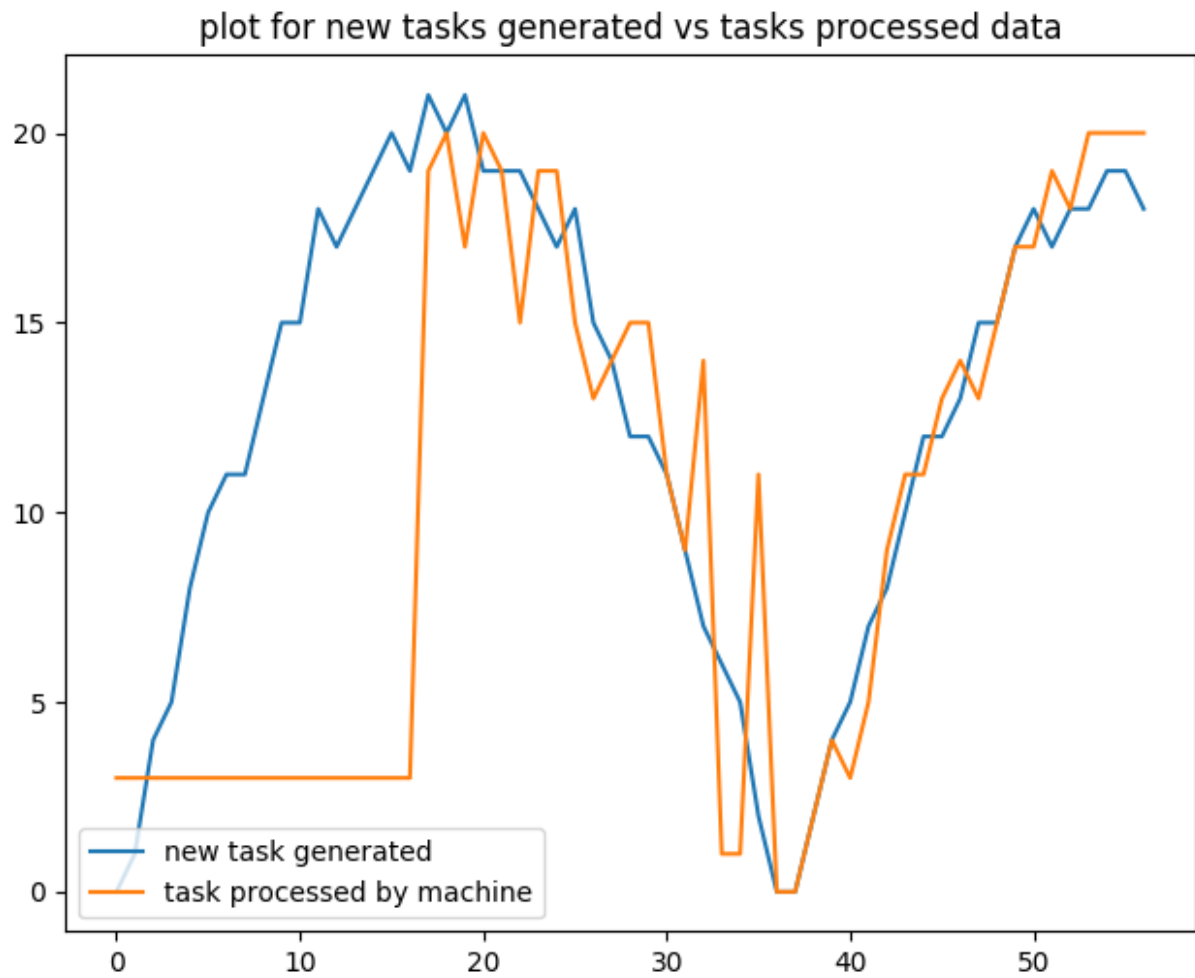


Figure 8: CSC result

References