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# **GPU-imLearn: an open-source software for imbalanced data classification based on GPU**

## **(User Manual)**

This software is free for academic use only.

This software is protected by the GNU General Public License (GPL).

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# 1. Overview

In recent years, multi-imbalance learning is becoming more and more popular, however, with the scale of data increasing fast and classification algorithms getting more complex, there is an urgent need for more efficient ways to solve the low efficiency of multi-class imbalanced data classification. we develop the "GPU-imLearn" software package and share it with the community, to boost research in this field.

The developed GPU-ImLearn software contains 6 different algorithms for multi-class imbalance learning based on GPU acceleration, 5 of them were proposed in recent years, and one(FocalBoost) was recently proposed by us. We will introduce the framework and functionalities of this software in the next sections.

## 2. Installation

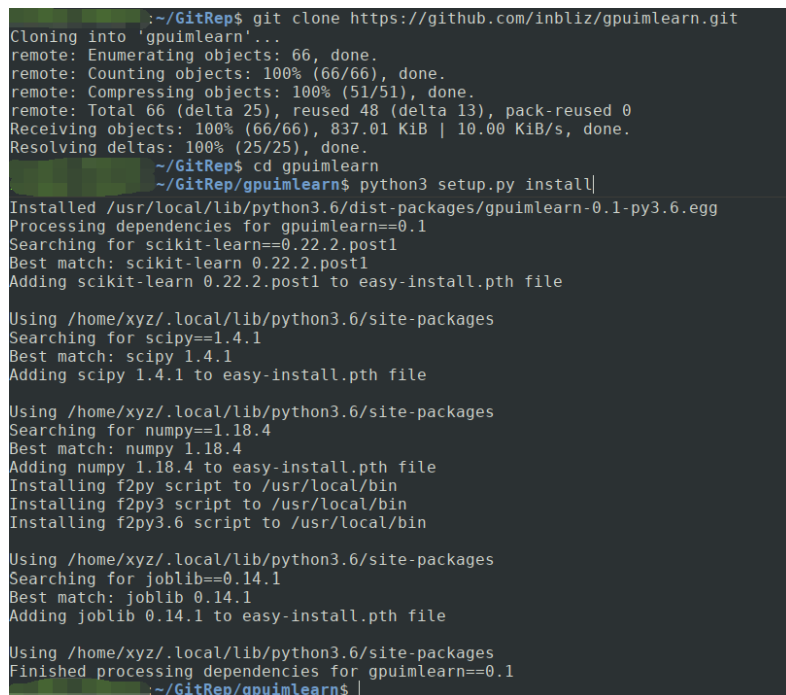
### 2.1 CUDA-imLearn

Before installation of GPU-imLearn, please ensure that CUDA 9 or above was installed correctly in your environment.

Then, you can install like this:

```
>>> git clone https://github.com/inbliz/gpuimlearn.git
>>> cd gpuimlearn/src/CUDA-imlearn
>>> python setup.py install
```

Here is a sample for installation, see figure 1.



```
~/GitRep$ git clone https://github.com/inbliz/gpuimlearn.git
Cloning into 'gpuimlearn'...
remote: Enumerating objects: 66, done.
remote: Counting objects: 100% (66/66), done.
remote: Compressing objects: 100% (51/51), done.
remote: Total 66 (delta 25), reused 48 (delta 13), pack-reused 0
Receiving objects: 100% (66/66), 837.01 KiB | 10.00 KiB/s, done.
Resolving deltas: 100% (25/25), done.
~/GitRep$ cd gpuimlearn
~/GitRep/gpuimlearn$ python3 setup.py install
Installed /usr/local/lib/python3.6/dist-packages/gpuimlearn-0.1-py3.6.egg
Processing dependencies for gpuimlearn==0.1
Searching for scikit-learn==0.22.2.post1
Best match: scikit-learn 0.22.2.post1
Adding scikit-learn 0.22.2.post1 to easy-install.pth file

Using /home/xyz/.local/lib/python3.6/site-packages
Searching for scipy==1.4.1
Best match: scipy 1.4.1
Adding scipy 1.4.1 to easy-install.pth file

Using /home/xyz/.local/lib/python3.6/site-packages
Searching for numpy==1.18.4
Best match: numpy 1.18.4
Adding numpy 1.18.4 to easy-install.pth file
Installing f2py script to /usr/local/bin
Installing f2py3 script to /usr/local/bin
Installing f2py3.6 script to /usr/local/bin

Using /home/xyz/.local/lib/python3.6/site-packages
Searching for joblib==0.14.1
Best match: joblib 0.14.1
Adding joblib 0.14.1 to easy-install.pth file

Using /home/xyz/.local/lib/python3.6/site-packages
Finished processing dependencies for gpuimlearn==0.1
~/GitRep/gpuimlearn$
```

Figure 1 installation of GPU-imLearn

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## 2.2 PyTorch-imLearn & CPU-imLearn Installation

The installation of PyTorch-imLearn and CPU-imLearn is same as CUDA-imLearn. When you are installing the CPU-imLearn, you could use it without CUDA.

```
# PyTorch-imLearn Installation
>>> git clone https://github.com/inbliz/gpuimlearn.git
>>> cd gpuimlearn/src/PyTorch-imLearn
>>> python setup.py install
```

## 3. API Reference

Each algorithm in different 3 parts (CUDA-imLearn, PyTorch-imLearn, CPU-imLearn) has 3 functions mainly: initialization, train and predict. You can use them as follows.

### 3.1 DECOC

#### model initialization:

```
clf = DECOC.DECOC()
```

#### model train:

```
clf.fit(X_train, y_train)
```

Table 3.1 DECOC.fit

Parameters	<b>X_train</b>
	The data matrix in the training dataset.
	<b>y_train</b>
	The corresponding labels of each instance in the training dataset.

#### model predict:

```
pre = clf.predict(X_test)
```

Table 3.2 : DECOC.predict

Parameters	<b>X_test</b>
	The data matrix waiting to be predicted.
Returns	<b>pre</b>
	The prediction results for X_test

### 3.2 FocalBoost

#### model initialization:

```
clf = FocalBoost.FocalBoost ()
```

---

### model train:

`clf.fit(X_train, y_train, imcls)`

Table 3.3 FocalBoost.fit

<b>Parameters</b>	<b>X_train</b> The data matrix in the training dataset.
	<b>y_train</b> The corresponding labels of each instance in the training dataset.
	<b>Imcls</b> an array specified by user, It should contain the minority classes in the dataset.

### model predict:

`pre = clf.predict(X_test)`

Table 3.4 FocalBoost.predict

<b>Parameters</b>	<b>X_test</b> The data matrix waiting to be predicted.
<b>Returns</b>	<b>pre</b> The prediction results for X_test

## 3.3 DOVO

### model initialization:

`clf = DOVO. DOVO ()`

### model train:

`clf.fit(X_train, y_train)`

Table 3.5 DOVO.fit

<b>Parameters</b>	<b>X_train</b> The data matrix in the training dataset.
	<b>y_train</b> The corresponding labels of each instance in the training dataset.

### model predict:

`pre = clf.predict(X_test)`

Table 3.6 : DOVO.predict

<b>Parameters</b>	<b>X_test</b> The data matrix waiting to be predicted.
<b>Returns</b>	<b>pre</b> The prediction results for X_test

---

### 3.4 AdaBoost.M1

#### model initialization:

```
clf = AdaBoostM1. AdaBoostM1 ()
```

#### model train:

```
clf.fit(X_train, y_train)
```

Table 3.7 AdaBoost.M1.fit

<b>Parameters</b>	<b>X_train</b> The data matrix in the training dataset.
	<b>y_train</b> The corresponding labels of each instance in the training dataset.

#### model predict:

```
pre = clf.predict(X_test)
```

Table 3.8 AdaBoost.M1.predict

<b>Parameters</b>	<b>X_test</b> The data matrix waiting to be predicted.
<b>Returns</b>	<b>pre</b> The prediction results for X_test

### 3.5 SAMME

#### model initialization:

```
clf = SAMME.SAMME ()
```

#### model train:

```
clf.fit(X_train, y_train)
```

Table 3.9 SAMME.fit

<b>Parameters</b>	<b>X_train</b> The data matrix in the training dataset.
	<b>y_train</b> The corresponding labels of each instance in the training dataset.

#### model predict:

```
pre = clf.predict(X_test)
```

Table 3.10 SAMME.predict

<b>Parameters</b>	<b>X_test</b> The data matrix waiting to be predicted.
<b>Returns</b>	<b>pre</b> The prediction results for X_test

---

### 3.6 imECOC

#### model initialization:

```
clf = imECOC. imECOC ()
```

#### model train:

```
clf.fit(X_train, y_train)
```

Table 3.11 imECOC.fit

<b>Parameters</b>	<b>X_train</b> The data matrix in the training dataset.
	<b>y_train</b> The corresponding labels of each instance in the training dataset.

#### model predict:

```
pre = clf.predict(X_test)
```

Table 3.12 imECOC.predict

<b>Parameters</b>	<b>X_test</b> The data matrix waiting to be predicted.
<b>Returns</b>	<b>pre</b> The prediction results for X_test

## 4. Usage Examples

### 4.1 DECOC

#### Usage example:

DECOC take as input two arrays: an array X of shape (n\_samples, n\_features) holding the training samples, and an array y of class labels (strings or integers), of shape (n\_samples):

```
>>> from guimlearn import DECOC
>>> X_train = [[1, 0.5], [2, 1], [1, 1], [2, 2], [1, 2.5], [2, 4.5]]
>>> y_train = [1, 1, 2, 2, 3, 3]
>>> clf = DECOC.DECOC()
>>> clf.fit(X_train, y_train)
DECOC()
```

After being fitted, the model can then be used to predict new values:

```
>>> X_test = [[1.5, 0.5], [1.5, 1.5], [1.5, 4.5]]
>>> clf.predict(X_test)
array([1, 2, 3])
```

---

## 4.2 FocalBoost

### Usage example:

FocalBoost take as input two arrays: an array X of shape (n\_samples, n\_features) holding the training samples, and an array y of class labels (strings or integers), of shape (n\_samples):

```
>>> from gpumlearn import FocalBoost
>>> X_train = [[1, 0.5], [2, 1], [1, 1], [2, 2], [1, 2.5], [2, 4.5]]
>>> y_train = [1, 1, 2, 2, 3, 3]
>>> clf = FocalBoost.FocalBoost ()
>>> clf.fit(X_train, y_train)
FocalBoost()
```

After being fitted, the model can then be used to predict new values:

```
>>> X_test = [[1.5, 0.5], [1.5, 1.5], [1.5, 4.5]]
>>> clf.predict(X_test)
array([1, 2, 3])
```

## 4.3 DOVO

### Usage example:

DOVO take as input two arrays: an array X of shape (n\_samples, n\_features) holding the training samples, and an array y of class labels (strings or integers), of shape (n\_samples):

```
>>> from gpumlearn import DOVO
>>> X_train = [[1, 0.5], [2, 1], [1, 1], [2, 2], [1, 2.5], [2, 4.5]]
>>> y_train = [1, 1, 2, 2, 3, 3]
>>> clf = DOVO.DOVO ()
>>> clf.fit(X_train, y_train)
DOVO ()
```

After being fitted, the model can then be used to predict new values:

```
>>> X_test = [[1.5, 0.5], [1.5, 1.5], [1.5, 4.5]]
>>> clf.predict(X_test)
array([1, 2, 3])
```

## 4.4 AdaBoost.M1

### Usage example:



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AdaBoost.M1 take as input two arrays: an array X of shape (n\_samples, n\_features) holding the training samples, and an array y of class labels (strings or integers), of shape (n\_samples):

```
>>> from guimlearn import AdaBoostM1
>>> X_train = [[1, 0.5], [2, 1], [1, 1], [2, 2], [1, 2.5], [2, 4.5]]
>>> y_train = [1, 1, 2, 2, 3, 3]
>>> clf = AdaBoostM1. AdaBoostM1 ()
>>> clf.fit(X_train, y_train)
AdaBoostM1 ()
```

After being fitted, the model can then be used to predict new values:

```
>>> X_test = [[1.5, 0.5], [1.5, 1.5], [1.5, 4.5]]
>>> clf.predict(X_test)
array([1, 2, 3])
```

## 4.5 SAMME

### Usage example:

SAMME take as input two arrays: an array X of shape (n\_samples, n\_features) holding the training samples, and an array y of class labels (strings or integers), of shape (n\_samples):

```
>>> from guimlearn import SAMME
>>> X_train = [[1, 0.5], [2, 1], [1, 1], [2, 2], [1, 2.5], [2, 4.5]]
>>> y_train = [1, 1, 2, 2, 3, 3]
>>> clf = SAMME. SAMME ()
>>> clf.fit(X_train, y_train)
SAMME ()
```

After being fitted, the model can then be used to predict new values:

```
>>> X_test = [[1.5, 0.5], [1.5, 1.5], [1.5, 4.5]]
>>> clf.predict(X_test)
array([1, 2, 3])
```

## 4.6 imECOC

### Usage example:

imECOC take as input two arrays: an array X of shape (n\_samples, n\_features) holding the training samples, and an array y of class labels (strings or integers), of shape (n\_samples):

---

```
>>> from gpumlearn import imECOC
>>> X_train = [[1, 0.5], [2, 1], [1, 1], [2, 2], [1, 2.5], [2, 4.5]]
>>> y_train = [1, 1, 2, 2, 3, 3]
>>> clf = imECOC. imECOC ()
>>> clf.fit(X_train, y_train)
imECOC ()
```

After being fitted, the model can then be used to predict new values:

```
>>> X_test = [[1.5, 0.5], [1.5, 1.5], [1.5, 4.5]]
>>> clf.predict(X_test)
array([1, 2, 3])
```