scikit-dyn2sel - A Dynamic Selection Framework for Data Streams

Lucca Portes Cavalheiro
Jean Paul Barddal
Alceu de Souza Britto Jr.
Graduate Program in Informatics (PPGIa)
Pontifícia Universidade Católica do Paraná (PUCPR)
Curitiba, Brazil
Laurent Heutte
Laboratoire d’Informatique, du Traitement de l’Information et des Systèmes (LITIS)
Université de Rouen Normandie
Rouen, France

Abstract

Mining data streams is a challenge per se. It must be ready to deal with an enormous amount of data and with problems not present in batch machine learning, such as concept drift. Therefore, applying a batch-designed technique, such as dynamic selection of classifiers (DCS) also presents a challenge. The dynamic characteristic of ensembles that deal with streams presents barriers to the application of traditional DCS techniques in such classifiers. scikit-dyn2sel is an open-source python library tailored for dynamic selection techniques in streaming data. scikit-dyn2sel’s development follows code quality and testing standards, including PEP8 compliance and automated high test coverage using codecov.io and circleci.com. Source code, documentation, and examples are made available on GitHub at https://github.com/luccaportes/Scikit-DYN2SEL.

Keywords: Dynamic Selection of Classifiers, Data Stream Mining

1. Introduction

Dynamic selection of classifiers (DCS) is a widely studied area in batch machine learning. Its application provided significant gains in many types of data. When developing new DCS techniques, it is essential to compare this novel method to the current state-of-art of the area. Nowadays, this is a straightforward task, thanks to deslib (Cruz et al., 2020), a library that allows the application of most DCS methods following a familiar and straightforward interface, borrowed from scikit-learn (Pedregosa et al., 2011).

When dealing with DCS in data stream mining, however, there is no such convenience. The application of data stream mining differs from batch machine learning, and thus, it is impossible to apply traditional DCS techniques as is. Common concepts in DCS are not naturally present in the streaming environment, such as the validation set, which makes the utilization of DESLIB (Cruz et al., 2020) not directly possible. In this paper, we propose scikit-dyn2sel, a framework for using and implementing DCS techniques in the data stream mining context.

©2020 Lucca Portes Cavalheiro, Jean Paul Barddal, Alceu de Souza Britto Junior, Laurent Heutte.
License: CC-BY 4.0, see https://creativecommons.org/licenses/by/4.0/
Table 1: Methods Contemplated in scikit-dyn2sel.

| DCSApply | DCSTechnique                      |
|----------|-----------------------------------|
| DYNSE (Almeida et al., 2016) | KNORA-E (Ko et al., 2008)         |
| DESDD (Albuquerque et al., 2019) | KNORA-U (Ko et al., 2008)         |
| MDE (Zyblewski et al., 2019)  | A Priori and A Posteriori (Giacinto and Roli, 1999) |
| DCS-LA (Woods et al., 1996)   |                                   |
| DCS-RANK (Sahourin et al., 1993) |                                   |
| MCB (Huang and Suen, 1995)    |                                   |
| META-DES (Cruz et al., 2015)   |                                   |

2. Structure

The scikit-dyn2sel framework is built on top of scikit-multiflow (Montiel et al., 2018) and deslib (Cruz et al., 2020), a scikit-learn (Pedregosa et al., 2011) inspired library for data stream mining. The interface of all the methods for applying DCS follows the same interface as scikit-multiflow classifiers, the essential methods are partial_fit and predict. These methods are respectively used for updating the classifiers with new data and for computing predictions.

The framework is divided into four main classes. One of these is the DCSTechnique class, which contains the traditional DCS methods implemented. The objective of this class is to output a prediction using an ensemble and a validation set, such that the latter is defined in the ValidationSet class. Some methods for applying DCS can be used directly on traditional online ensembles; however, many also contemplate the ensemble construction step, that is why each method inherits its ensemble from Ensemble. All of these classes are combined in the ApplyDCS class, which is the class that the methods for applying DCS in data streams inherit from. This class follows the same interface as scikit-multiflow (Montiel et al., 2018).

Another benefit from scikit-dyn2sel is that traditional DCS techniques available on DESLIB (Cruz et al., 2020) are not re-implemented. Instead, they encapsulated on the DCSTechniques class.

2.1 Implemented Methods

Table 1 presents all the DCS methods currently implemented in scikit-dyn2sel. The left part of the table displays the methods for applying dynamic selection techniques in data streams, and the right part displays the techniques itself.

3. Open Source

scikit-dyn2sel is open to contributions from the community. It is hosted in a public repository on Github. It is licensed under the MIT license, which is a very embracing and permissive licensing, allowing but not limited to commercial use, distribution, modification, and private use.
from skmultiflow.evaluation import EvaluatePrequential
from skmultiflow.data import SEAGenerator
from dyn2sel.apply_dcs import DYNSEMethod
from dyn2sel.dcs_techniques import KNORAE

clf = DYNSEMethod(
    HoeffdingTree(), chunk_size=1000,
    dcs_method=KNORAE(), max_ensemble_size=10)
gen = SEAGenerator()
ev = EvaluatePrequential()
ev.evaluate(gen, clf)

Figure 1: Usage example of scikit-dyn2sel.

4. Installation

The installation of the library can be done via Python package manager (pip) using “pip install scikit-dyn2sel”, or by directly cloning its GitHub repository.

5. Tests

To ensure the good operation of the framework, unit tests were written for each main method in the library. When a new contribution to the code is proposed, a continuous integration tool (CircleCi) runs the tests to ensure that if the contribution is accepted, the previously expected behavior of the methods is still respected. To measure the percentage of test coverage, Codecov is applied after CircleCi’s tests pass. A contribution is only accepted if it does not decrease the test coverage percentage of the framework.

6. Code Quality

The code is fully compliant with Python PEP8 standards, which is ensured by the Black code formatting tool (Python Software Foundation, 2018), which is also run on CircleCi after each contribution proposal. Furthermore, the static analyzer Codacy is also integrated into the Github repository, ensuring standardized code quality.

7. Usage

The usage of scikit-dyn2sel is straightforward. Since it follows the same interface as scikit-multiflow (Montiel et al., 2018), the methods can be executed with common evaluator used in the library, such as prequential (Gama et al., 2013). Figure 1 shows how this can be done using the DYNSE (Almeida et al., 2016) method.

Acknowledgments
This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

References

Regis Antonio Saraiva Albuquerque, Albert Franca Josua Costa, Eulanda Miranda dos Santos, Robert Sabourin, and Rafael Giusti. A decision-based dynamic ensemble selection method for concept drift, 2019.

P. R. L. D. Almeida, L. S. Oliveira, A. D. S. Britto, and R. Sabourin. Handling concept drifts using dynamic selection of classifiers. In 2016 IEEE 28th International Conference on Tools with Artificial Intelligence (ICTAI), pages 989–995, Nov 2016. doi: 10.1109/ICTAI.2016.0153.

Paulo Cavalin, Robert Sabourin, and Ching Suen. Dynamic selection approaches for multiple classifier systems. Neural Computing and Applications, 22, 03 2013. doi: 10.1007/s00521-011-0737-9.

Rafael Cruz, Robert Sabourin, George Cavalcanti, and Tsang Ing Ren. Meta-des: A dynamic ensemble selection framework using meta-learning. Pattern Recognition, 48, 05 2015. doi: 10.1016/j.patcog.2014.12.003.

Rafael M. O. Cruz, Luiz G. Hafemann, Robert Sabourin, and George D. C. Cavalcanti. Deslib: A dynamic ensemble selection library in python. Journal of Machine Learning Research, 21(8):1–5, 2020. URL http://jmlr.org/papers/v21/18-144.html.

Joo Gama, Raquel Sebastião, and Pedro Rodrigues. On evaluating stream learning algorithms. Machine Learning, 90:317–346, 10 2013. doi: 10.1007/s10994-012-5320-9.

G. Giacinto and F. Roli. Methods for dynamic classifier selection. In Proceedings 10th International Conference on Image Analysis and Processing, pages 659–664, Sep. 1999. doi: 10.1109/ICIAP.1999.797670.

Y. S. Huang and C. Y. Suen. A method of combining multiple experts for the recognition of unconstrained handwritten numerals. IEEE Transactions on Pattern Analysis and Machine Intelligence, 17(1):90–94, Jan 1995. ISSN 1939-3539. doi: 10.1109/34.368145.

Albert H. R. Ko, Robert Sabourin, and Alceu Souza Britto, Jr. From dynamic classifier selection to dynamic ensemble selection. Pattern Recogn., 41(5):17181731, May 2008. ISSN 0031-3203.

Jacob Montiel, Jesse Read, Albert Bifet, and Talel Abdessalem. Scikit-multiflow: A multi-output streaming framework. Journal of Machine Learning Research, 19(72):1–5, 2018. URL http://jmlr.org/papers/v19/18-251.html.

F. Pedregosa, G. Varoquaux, A. Gramfort, V. Michel, B. Thirion, O. Grisel, M. Blondel, P. Prettenhofer, R. Weiss, V. Dubourg, J. Vanderplas, A. Passos, D. Cournapeau, M. Brucher, M. Perrot, and E. Duchesnay. Scikit-learn: Machine learning in Python. Journal of Machine Learning Research, 12:2825–2830, 2011.
PSF Python Software Foundation. Black - the uncompromising python code formatter. 
https://github.com/psf/black 2018.

M. Sabourin, A. Mitiche, D. Thomas, and G. Nagy. Classifier combination for hand-printed digit recognition. In Proceedings of 2nd International Conference on Document Analysis and Recognition (ICDAR '93), pages 163–166, Oct 1993. doi: 10.1109/ICDAR.1993.395758.

Kevin Woods, W. Philip Kegelmeyer Jr, and Kevin Bowyer. Combination of multiple classifiers using local accuracy estimates. In Proceedings of the 1996 Conference on Computer Vision and Pattern Recognition (CVPR 96), CVPR 96, page 391, USA, 1996. IEEE Computer Society. ISBN 0818672587.

Paweł Zyblewski, Paweł Ksieniewicz, and Michał Woźniak. Classifier selection for highly imbalanced data streams with minority driven ensemble. In Leszek Rutkowski, Rafał Scherer, Marcin Korytkowski, Witold Pedrycz, Ryszard Tadeusiewicz, and Jacek M. Zurada, editors, Artificial Intelligence and Soft Computing, pages 626–635, Cham, 2019. Springer International Publishing. ISBN 978-3-030-20912-4.