A Hybrid COMTE-LEFTIST Time-Series Explanation Method For a Time-series Classification Bitcoin Recommendation System

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Motivations

- Bitcoin was introduced by Nakamoto [1] as a decentralized payment system.
- In this context, AI optimizes crypto trading strategies with Machine Learning and Deep Learning models.
- Standard machine learning classification algorithms often struggle with time-series data due to the complexity of temporal patterns, which is why Time Series Classification (TSC) techniques should be prioritized.
- Both LIME and SHAP face challenges in handling time-series data; however, the LEFTIST (Guillemé et al. [2]) and COMTE (Ates et al. [3]) models were developed specifically to address these issues.

The goal of this work is to present a hybrid explanation method that combines COMTE and LEFTIST.

Data and Materials

The Bitcoin closing price data was sourced from the `ccxt` library (version 4.3.58).

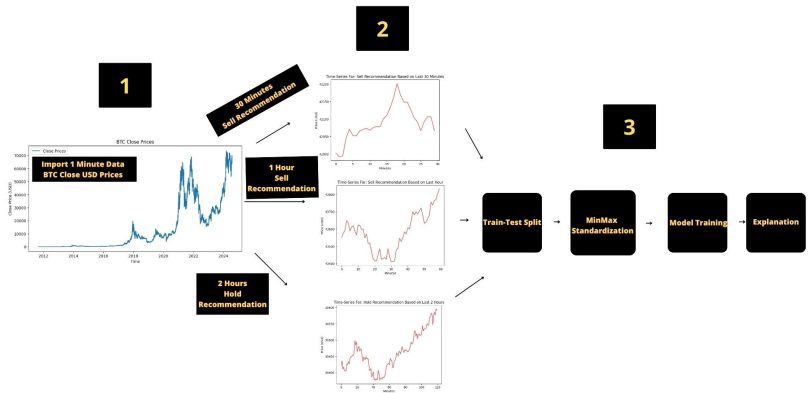

Figure: Data Preprocessing and Training Pipeline

Data and Materials II

Table: Summarization of Models

Model	Parameters	Type / Library
MRSQM	`MrSQM(strat='R', random_state=42)`	ML Time-Series / sktime
Catch22	`Catch22Classifier(random_state=3)`	ML Time-Series / sktime
Dummy Classifier	`DummyClassifier(strategy='prior', random_state=3)`	ML Time-Series / sktime
Time-series SVM Classifier	`TimeSeriesSVC(kernel="sigmoid", gamma="auto", probability=True,random_state=42)`	ML Time-Series / tslearn
Composable Time-series Forest	`ComposableTimeSeriesForestClassifier(RocketClassifier(num_kernels=100), n_estimators=10,random_state=4)`	ML Time-Series / sktime
KNN	`KNeighborsClassifier(n_neighbors=5)`	ML Tabular / sklearn
SVM Classifier	`SVC(random_state = 42,probability=True, kernel = 'sigmoid',gamma="auto")`	ML Tabular / sklearn
XGBoost Classifier	`XGBClassifier(objective='binary:logistic',random_state = 42)`	ML Tabular / xgboost
Random Forest Classifier	`RandomForestClassifier(random_state = 5)`	ML Tabular / sklearn
CNN-GRU with Attention	Conv1D; MaxPooling1D; GRU Layer; Attention Layer; GlobalAveragePooling1D; BatchNormalization; Output Layer	Deep Learning / pytorch
CNN-LSTM	Conv1D Layer; AdaptiveMaxPooling1D; Flatten Layer; Fully Connected Layer; BatchNormalization; Output Layer	Deep Learning / pytorch
Fully Conected MLP	Flatten Layer; Fully Connected Layer; Output Layer	Deep Learning / pytorch
BiLSTM	Bidirectional LSTM; BatchNormalization; Output Layer	Deep Learning / pytorch

Data and Materials III

The LEFTIST is a feature based explanation method. Whereas COMTE is based on counterfactual explanations.

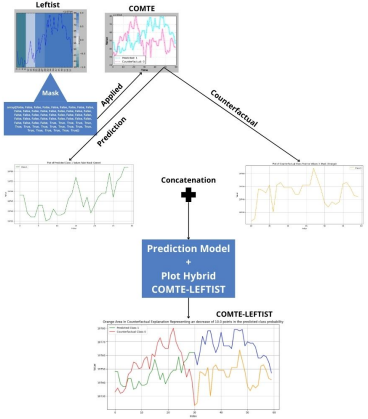

Figure: COMTE-LEFTIST Pipeline

Results

Table: Prediction Accuracy for Time Series Specific and ML Tabular Models

Time Window	Time Series Specific					Machine Learning Tabular			
	Dummy Classifier	Catch22	MRSQM	SVC	TS Forest	Random Forest	KNN	SVC	XGB
30 minutes	0.55	0.64	**0.70**	0.48	0.66	0.68	0.65	0.53	0.57
1 Hour	0.54	0.63	**0.69**	0.48	0.66	0.68	0.65	0.52	0.58
2 Hours	0.54	0.64	**0.68**	0.51	0.66	0.60	0.58	0.53	0.57

Table: Prediction Accuracy for Deep Learning Models

Time Window	Deep Learning			
	Attention CNN-GRU	CNN-LSTM	MLP	BiLSTM
30 minutes	0.64	0.64	0.56	0.63
1 Hour	0.64	0.63	0.56	0.61
2 Hours	0.64	0.63	0.58	0.59

Explanation

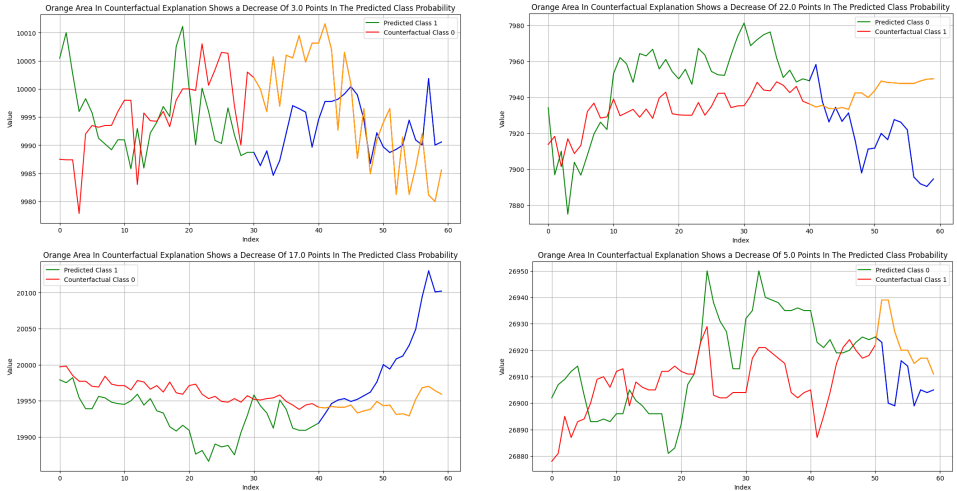

Figure: COMTE-LEFTIST Hybrid Model

Conclusion

- Hybrid explanations are key for advancing time-series explainability, addressing current limitations.
- MRSQM has achieved 70% accuracy for generating Bitcoin Sell and Hold recommendations.
- No statistically significant difference between classes of models was found. Model selection should be problem-specific.
- Future work: Deepen exploration of COMTE-LEFTIST and further enhance its explainability for time-series classification.

Bibliography I

[1] Satoshi Nakamoto. Bitcoin: A peer-to-peer electronic cash system. `https://www.bitcoin.org`, 2008. Retrieved from `https://www.bitcoin.org`.

[2] M. Guillemé, V. Masson, L. Rozé, and A. Termier. Agnostic local explanation for time series classification. In *2019 IEEE 31st International Conference on Tools with Artificial Intelligence (ICTAI)*, pages 432–439, Portland, OR, USA, 2019. doi: 10.1109/ICTAI.2019.00067.

[3] E. Ates, B. Aksar, V. J. Leung, and A. K. Coskun. Counterfactual explanations for multivariate time series. In *2021 International Conference on Applied Artificial Intelligence (ICAPAI)*, pages 1–8, Halden, Norway, 2021. doi: 10.1109/ICAPAI49758.2021.9462056.