Mphasis
The Next Applied

Quantum News Headlines Sentiment Analyzer

Whitepaper by Mphasis NEXT Labs

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1.
Introduction

World events significantly impact the behavior of financial markets, econometric analysis, policy effectiveness, risk determination and more. Such events are reported over digital channels and are amenable to be processed by tools built for Natural Language Processing (NLP) and Machine Learning (ML).

Quantum News Headlines Sentiment Analyzer applies a hybrid classical - quantum computing approach to NLP and ML on NISQ (Noisy Intermediate Scale Quantum) devices. In this paper, we have used news headlines around the COVID-19 pandemic and classified them into four categories — positive, negative, neutral and mixed.

2.
Business Drivers and Challenges

Automated analysis of free text and news articles enables businesses to contextualize and identify key findings and turn them into actionable insights. Sentiment analysis, particularly, is a useful way to understand public opinion and can help organizations navigate through pandemics such as COVID-19. While negative sentiments imply increased fear and anxiety, and hence low spending, positive sentiments engender 'revenge-commerce', wherein consumers excessively spend and, in turn, drive the economy.

Here are a few ways in which sentiment analysis can be leveraged:

- **Optimization of systems:** Negative sentiments among customers and employees lead to proactive cost and time management through process optimization. This often lends to increased efficiency.
- **Mobilization of resources:** Actionable insights gathered by analyzing sentiments around COVID-19 can supplement information from other sources and guide central agencies, healthcare providers and pharmaceutical companies to efficiently mobilize and allocate resources.
- **Stock movement predictions:** Analyzing and predicting stock market movements is an essential part of econometrics and potential investment strategies, and are, in part, driven by public sentiment. Real-time reporting, publication and analysis of news have made the system more dynamic and susceptible to change in opinion. An automated system for analysis can provide quick insights to prospective investors.
- **Increasing profitability and productivity:** Organizations can profit by analyzing various sentiments about essentials and planning production. The government can devise policies and maintain order by analyzing people's reactions to new strains, food scarcity and alleviating mass panic, etc.

3.

Factors Affecting Sentiment Analysis

Sentiment analysis is the process of computationally identifying and categorizing opinions expressed in a piece of text, especially to determine whether the writer's attitude towards a particular topic is positive, negative or neutral. To effectively leverage the capabilities of sentiment analysis for news analysis, the following factors must be considered:

- Establishing a constant stream of relevant news articles and using them effectively for analysis
- Obtaining high accuracy of predictive sentiments around key factors and features to conduct in-depth analysis for actionable insights
- Sampling sufficient datapoints (news articles) for positive and negative sentiments to avoid imbalance in datasets

4.

Why Quantum for Sentiment Analysis?

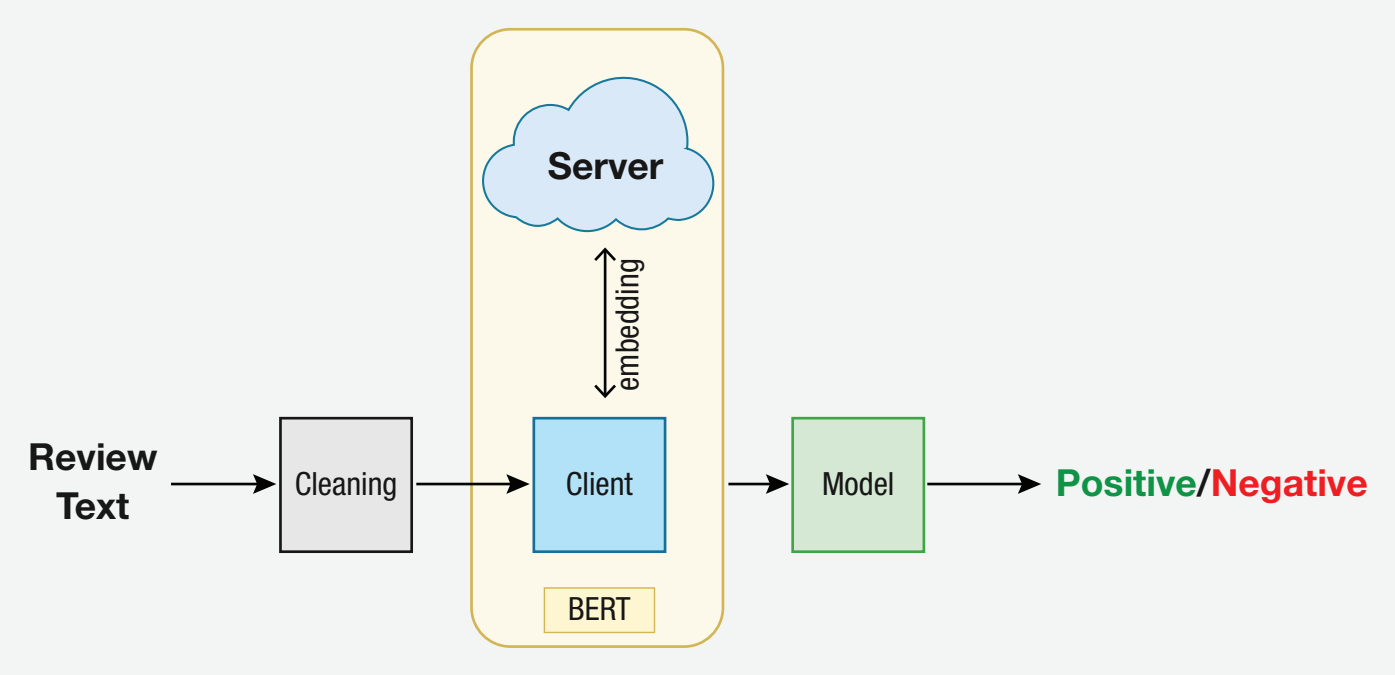
With the rapid surge in scale and complexity of opinions expressed in social media platforms, computational requirements for understanding crowd sentiments are increasing exponentially. In this paper, we use quantum theory to compare traditional sentiment analysis models with QBoost algorithms. The D-Wave quantum computer has been widely studied as a discrete optimization engine that accepts any problem formulated as Quadratic Unconstrained Binary Optimization (QUBO). In 2008, Google and D-Wave published a paper, Training a Binary Classifier with the Quantum Adiabatic Algorithm, which describes how the QBoost ensemble method makes binary classification amenable to quantum computing. The problem is formulated as linear superposition of a set of weak classifiers, and the D-Wave quantum computer is used to optimize the weights in a learning process that strives to minimize training errors and the number of weak classifiers. Quantum solvers have proved to be efficient in these scenarios, resulting in effectively reducing time-to-solution without much compromise on accuracy of classifying sentences into required classes (positive/negative). Mphasis' EON framework deals with these downsides and keeps the optimal solution closer to an optimal feasible solution.

5.

Solution Approach

We use BERT as a sentence encoder and host it as a service to map sentences into fixed lengths. BERT is an NLP model for pre-training language representations. It uses an enormous amount of free text data publicly available on the web and is trained in an unsupervised manner. In this experiment, we use an uncased 12-layered-768 hidden-12 attention head model, with dynamic sequence padding. Initially, the input text is passed through pre-processing steps to obtain a

cleaned version of input sentences. The pre-processed sentences are converted to word embeddings and uploaded to D-Wave leap using BERT-serving-client. Further, a quantum-optimized model is built using the QBoost classifier, based on a collection of weak decision tree classifiers. To use quantum annealers, first, the classification problem must be converted to Quadratic Unconstrained Binary Optimization (QUBO) problem. The estimated weights are updated while trying to reach an optimal solution. Finally, the estimated weights from the model determine the probability of either being a positive or negative sentiment.



Experiment and Results:

After converting the labels positive and negative as 1 and -1, respectivey, the results for small and large datasets are as follows:

1. Results for 2000 news headlines (Labels: -1 and 1)

Method	AdaBoost	Decision Tree	QBoost	QBoostIt
Train (acc)	0.90	1.00	1.00	1.00
Test (acc)	0.78	0.87	0.85	0.86
Time	3 s	5 s	856 ms	870 ms

*acc = accuracy

2. Results for 4000 news headlines (Labels: -1 and 1)

Method	AdaBoost	Decision Tree	QBoost	QBoostIt
Train (acc)	0.88	0.98	0.97	0.97
Test (acc)	0.85	0.1	0.90	0.91
Time	5 s	7 s	1 s	1.2 s

*acc = accuracy

Experiments were performed on two classical models namely, AdaBoost and Decision Tree, where the accuracy of models was varying around 0.78 to 1, whereas, in quantum models such as QBoost and QBoost+, the accuracies were between 0.85 to 1.

Benefits

- **High solution performance accuracy:** The training and testing accuracies are in line with classical models on both small and large datasets.
- **Faster time-to-solution:** Quantum solutions tend to converge faster than classical counterparts. Larger datasets of sentiment analysis tend to have higher savings (82.8 percent on the largest experiment) on time to classify the sentiment.

About Mphasis

Mphasis' purpose is to be the *"Driver in the Driverless Car"* for Global Enterprises by applying next-generation design, architecture and engineering services, to deliver scalable and sustainable software and technology solutions. Customer centricity is foundational to Mphasis, and is reflected in the Mphasis' Front2Back™ Transformation approach. Front2Back™ uses the exponential power of cloud and cognitive to provide hyper-personalized ($C = X2C^{2}_{TM} = 1$) digital experience to clients and their end customers. Mphasis' Service Transformation approach helps 'shrink the core' through the application of digital technologies across legacy environments within an enterprise, enabling businesses to stay ahead in a changing world. Mphasis' core reference architectures and tools, speed and innovation with domain expertise and specialization, combined with an integrated sustainability and purpose-led approach across its operations and solutions are key to building strong relationships with marquee clients. Click here to know more. (BSE: 526299; NSE: MPHASIS)

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