POLITECHNIKA GDAŃSKA

# Wykorzystanie obliczeń kwantowych w algorithmic trading

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# Czym jest algorithm trading?

Algorithmic trading, czyli handel algorytmiczny, to strategia inwestycyjna polegająca na wykorzystaniu zautomatyzowanych systemów handlowych do podejmowania decyzji inwestycyjnych na rynkach finansowych.

# Komputer kwantowy a klasyczny

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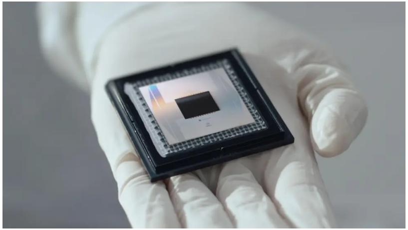
Dodatkowo komputer kwantowy może korzystać ze zjawiska splątania kwantowego, co pozwala na niemożliwe do osiągnięcia przez klasyczny komputer rezultaty.



Rysunek: Układ kwantowy Willow

# Teza badawcza

Czy wykorzystanie algorytmów kwantowych w algorithm trading daje lepsze efekty niż skorzystanie z algorytmów klasycznych.

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Do porównania wybrano 2 algorytmy klasyczne:

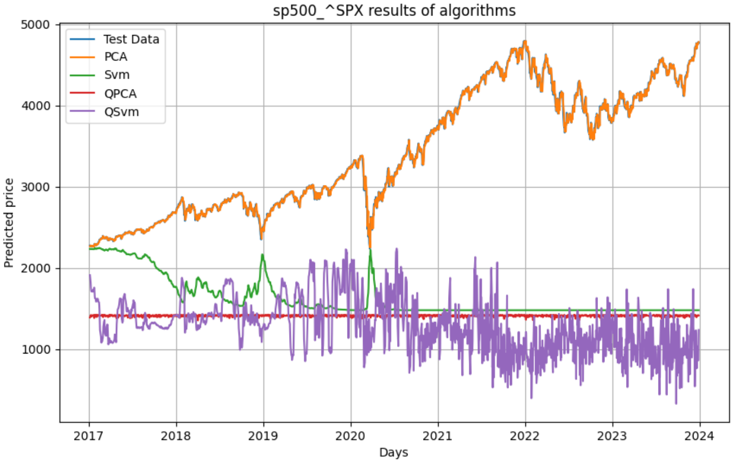
- PCA,
- SVM

oraz ich odpowiedniki kwantowe:

- QPCA,
- QSVM.

# Rezultaty predykcji

- Indeks S&P500
- zakres danych treningowych 2003-2016
- zakres danych testowych 2017-2024



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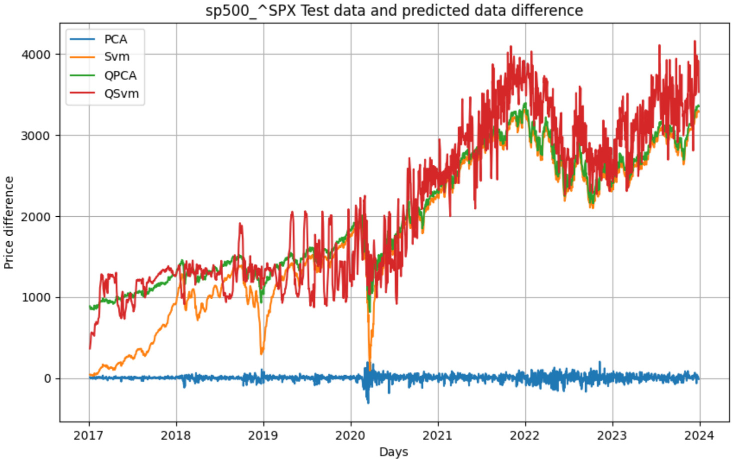

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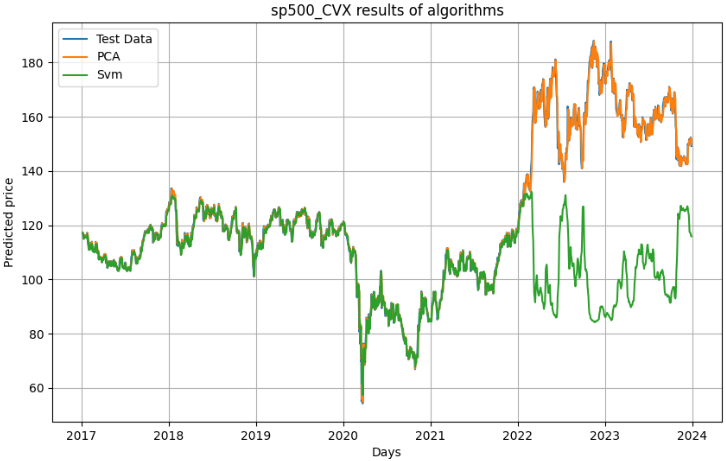
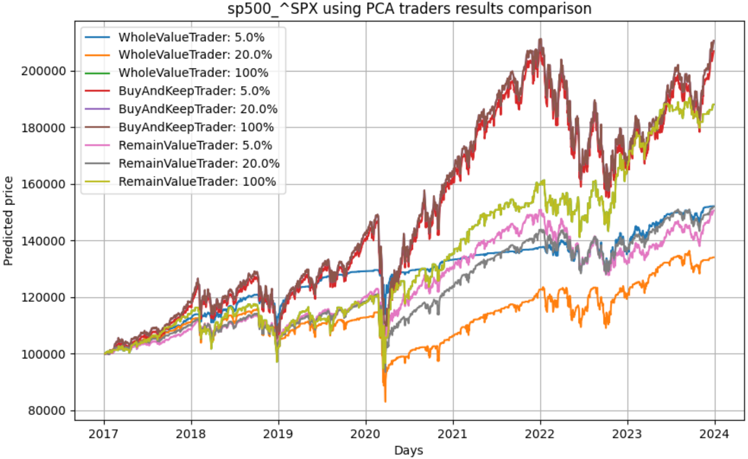
- Indeks firmy Chevron Corp
- zakres danych treningowych 2003-2016
- zakres danych testowych 2017-2024



# Rezultaty graczy giełdowych

- Indeks S&P500
- zakres danych treningowych 2003-2016
- zakres danych testowych 2017-2024



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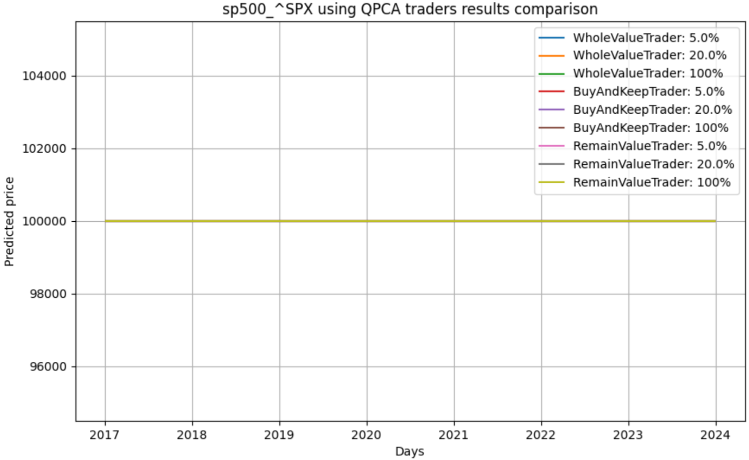

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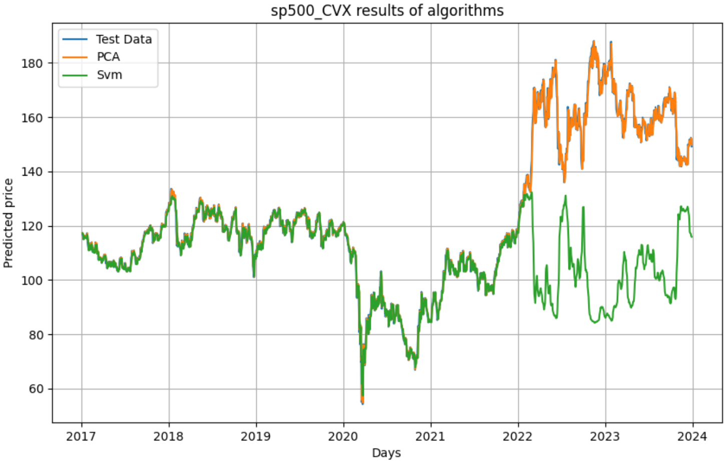

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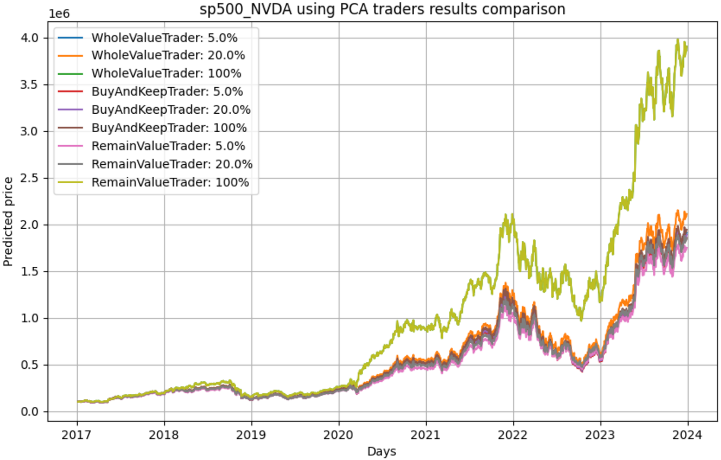
- Indeks firmy Nvidia
- zakres danych treningowych 2003-2016
- zakres danych testowych 2017-2024



# The Use of Quantum Computing in Algorithmic Trading

Paulina Brzecka, Marek Borzyszkowski, Wojciech Baranowski and Piotr Mironowicz

***Abstract*—Algorithmic trading is an investment strategy that leverages automated systems to make decisions in financial markets. Quantum computing presents opportunities to enhance these strategies by processing market data and analyzing trends with greater efficiency. This research explores implementing an agent utilizing quantum computing to make investment decisions in the stock market. The agent is evaluated using both quantum computer emulators and physical quantum hardware, comparing its performance to classical algorithms. Preliminary results show potential advantages in prediction quality and resource utilization, paving the way for further studies in quantum-enhanced financial strategies.**

***Index Terms*—Algorithmic trading, investing, trading systems, financial markets, Quantum computing, market predicting.**

## I. Introduction

Algorithmic trading has revolutionized the landscape of financial markets, significantly altering the way investment decisions are made. By employing automated trading systems, algorithmic trading allows for rapid execution of trades, often within fractions of a second, based on predefined strategies and market conditions. This ability to process vast amounts of data and make instantaneous decisions has proven to be highly effective in capturing market opportunities. However, as financial markets grow increasingly complex, traditional computational methods often struggle to keep up with the scale and intricacy of market data. The exponential increase in data volume, the need for real-time processing, and the high-dimensionality of the data pose significant challenges for classical algorithms.

Quantum computing, on the other hand, offers a promising alternative. By leveraging quantum bits (qubits) and the principles of superposition and entanglement, quantum computers can process information in parallel, potentially solving problems that are intractable for classical computers. Quantum algorithms are designed to take advantage of these quantum mechanical properties, offering the potential for faster data processing and more efficient problem-solving in areas such as optimization, simulation, and machine learning. In particular, quantum computing could address some of the limitations faced by classical computational methods in the context of algorithmic trading, where the need for speed, accuracy, and efficiency is paramount.

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P. Mironowicz, the project mentor, was with the Faculty of Electronics, Telecommunications and Informatics, Gdansk University of Technology, Gdansk, Poland.

This paper aims to investigate the implementation and evaluation of both classical and quantum algorithms for stock market prediction, with a focus on predicting asset prices based on historical data. While classical algorithms, such as Principal Component Analysis (PCA) and Support Vector Machines (SVM), are well-established and widely used in various financial applications, their quantum counterparts—Quantum Principal Component Analysis (QPCA) and Quantum Support Vector Machines (QSVM)—remain underexplored in the context of financial market predictions. The research presented in this paper seeks to fill this gap by conducting a comparative analysis of the performance of classical and quantum algorithms in a controlled environment. By exploring how these algorithms perform on historical stock market data, the paper aims to shed light on the potential advantages and challenges of incorporating quantum computing into the field of algorithmic trading.

## II. Algorithms Overview

### A. Principal Component Analysis (PCA)

Principal Component Analysis (PCA) [1] is a widely-used dimensionality reduction technique that allows for the simplification of complex datasets while retaining as much of the variance as possible. The goal of PCA is to transform a dataset into a new coordinate system, where the axes (known as principal components) correspond to the directions of maximum variance in the data. By projecting data onto a lower-dimensional space, PCA reduces the number of features needed to represent the data, making it easier to analyze and visualize. This process is particularly useful in fields such as finance, where large amounts of historical market data may include redundant or highly correlated features.

The strength of PCA lies in its ability to identify patterns in data and eliminate noise, making it a powerful tool for preprocessing in machine learning models. In the context of stock market prediction, PCA can be applied to identify key factors that drive asset prices and reduce the dimensionality of market data, thereby simplifying the problem and improving the performance of subsequent predictive models. However, while PCA is effective in capturing linear relationships in data, it may struggle to identify more complex, nonlinear patterns that are often present in financial markets. This limitation has driven the development of more sophisticated algorithms, including those that leverage quantum computing.

### B. Support Vector Machines (SVM)

Support Vector Machines (SVMs) [2] are a class of supervised learning algorithms primarily used for classification and

# Dziękujemy za uwagę!

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