ECE 473 - Course Project

Course project

Learn about a Defi protocol or concept and build some hands on experience

- Track1: AI Agents and Web3: two hot topics brought together.
- Track 2: Empirical Analyses of DeFi transactions
- Track 3: DeFi platforms, practical DeFi action actions (including trading)
- Track 4: Academic Research: fundamental progress in DeFi

Important Dates:

- Project Proposal: Apr 2, 2025 (5% of the overall grade)
- Decenter Poster Presentation Apr 16, 2025 (10%)
- Project Presentations In Class Apr 18, 2025, Apr 23, 2025, Apr 25, 2025 (10%)
- Final report + codes May 6, 2025 (17%)

Project (Track 1: AI Agents and Web3)

Choose an application you are interested in and involves AI interacting with Web3

Choose an AI agent framework

Develop the smart contracts and the AI agent

Examples in the document.

AI Agents and Web3

Web3 and AI have natural synergy

- Web3 is permissionless, decentralized, and completely digital, making it ideal for AI agents to autonomously manage wallets, execute trades, optimize transactions, and detect fraud. → decentralized autonomy → unstoppable intelligence leading to actions.

- AI can interact with smart contracts, oracles, and external data sources to trigger automated actions. → Making every “smart contract” actually smart

Use-cases of AI Agents in Defi

1 - Automated Wallet Management

- AI automates transactions, reducing human error and increasing efficiency.
- Converts natural language transaction requests (e.g., "Swap 1 ETH for USDC") into Web3 transactions.
- Can trigger transactions based on external signals, such as:
  - Social media sentiment (e.g., detecting trending assets on X/Twitter).
  - Macroeconomic indicators (e.g., inflation reports, interest rate changes).
  - Market movements (e.g., sudden price surges or drops).

Use-cases of AI Agents in Defi

2. Automated Trading & Yield Farming

- AI-powered bots analyze historical and real-time data to execute trades and optimize yield farming strategies.
- Can detect arbitrage opportunities across different DEXs and protocols.
- AI automates staking, lending, and farming, ensuring optimal risk-adjusted returns.

Real-World Examples:

- WunderTrading (wundertrading.com) –
  - Provides AI-driven trading bots that analyze past price movements to predict future trends.
- Yearn Finance (yearn.fi) –
  - Uses AI-powered vaults that dynamically allocate assets across different yield farming strategies for optimal returns.

Use-cases of AI Agents in Defi

3. Risk & Fraud Detection

- AI can monitor blockchain activity in real-time to detect anomalies, flag suspicious transactions, and prevent fraud.
- Can analyze wallet behaviors to predict and prevent hacks, and market manipulation.
- Uses machine learning models to detect unusual activity in DeFi protocols.

Real-World Examples:

- Chainalysis – AI-driven on-chain analytics to detect money laundering and fraudulent transactions (Alterya startup)
- Forta Network – The network consists of two primary components: detection bots and scan nodes. Detection bots are scripts that analyze blockchain data to detect specific conditions, while scan nodes execute these bots and publish alerts when threats are identified

Use-cases of AI Agents in Defi

4. Gas Fee & Transaction Optimization

- AI analyzes network congestion to suggest the best timing and route for transactions.
- AI-powered bots predict gas fee fluctuations and batch transactions for cost efficiency.
- AI can recommend Layer-2 solutions or cross-chain bridges for cheaper transactions.

Real-World Examples:

- Blocknative – It offers tools for mempool data analysis, transaction simulation, and gas estimation (could be possibly using AI?)

Project Track 2: Empirical Analyses

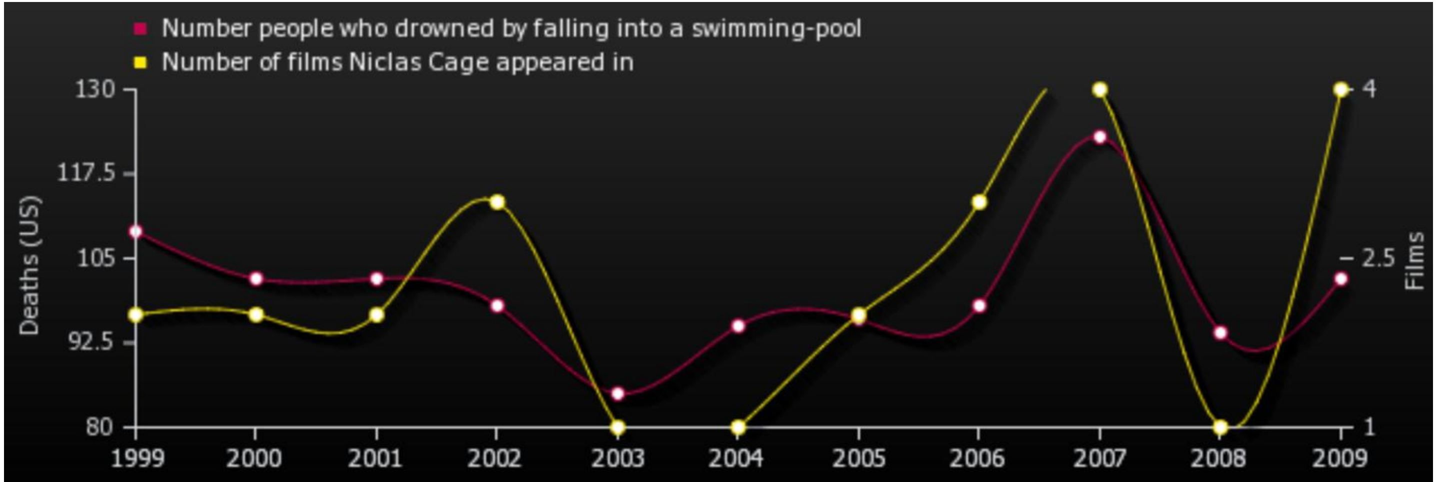
- Prices are one of the best ways to allocate resources, peer into the future and hedge risks
- Only when the model that interprets prices and signals is accurate

- **Objective:**
  - Decide a specific token/financial instrument to analyze, and what signals or features may be affecting it
  - Construct a pipeline to collect data about the pricing of that token or contract and the signals
  - Show how well the signals/feature you chose predict at least some aspects of the price of the token

Examples - Preview

- Options pricing in TradFi -> Perpetuals, PDLPs in DeFi
- Swaps in Tradfi -> Yield tokenization in Defi
- Btc, eth, sol -> macro models
- Memecoins -> sociological models

Strategy : Find features that correlate to the value of the primary token/option and explain the potential causal structure behind any surprising correlations you found



Perpetuals, PDLPs

TradFi Example: Black-Scholes Model (pricing options, risk hedging).

DeFi Counterpart: Perpetual Futures (no expiry, funding rates), Perpetual Demand Lending Pools (PDLPs).

Protocols: GMX, dYdX, Perpetual Protocol, Synthetix.

Real-world use: GMX’s GLP pool liquidity mechanism, dYdX’s decentralized perpetual trading.

Potential Analytical Method: Classical quantitative finance methods (e.g., stochastic calculus, volatility modeling).

Interesting Research Question: How accurately can traditional options pricing models predict perpetual futures' funding rate behaviors? What other features can make the model better?

Yield tokenization

TradFi Example: Interest rate swaps (fixed vs floating interest), currency swaps (IBM-World Bank 1981).

DeFi Counterpart: Yield Tokenization—Principal Tokens (PT), Yield Tokens (YT).

Protocols: Pendle Finance, Element Finance, IPOR, Voltz.

Real-world use: Pendle's yield markets (stETH), enabling fixed vs variable rate trades on-chain.

Potential Analytical Method: Time-series econometrics, yield curve modeling.

Interesting Research Question: Can yield tokenization accurately reflect market expectations for DeFi interest rates?

Macro Models

Macro Modeling (TradFi): Interest rates, inflation, monetary policy.

Crypto as Macro Assets:

- **BTC:** “Digital Gold,” hedge against inflation, stock-to-flow model.
- **ETH:** “Ultrasound money,” deflationary dynamics post-EIP-1559 and Merge, yield comparisons.
- **SOL:** Tech-equity analog, growth asset dependent on market sentiment.

Real-world events: BTC during quantitative easing (2020-2021), ETH fee-burn economics, SOL’s 2021 adoption wave and volatility in macro downturn (2022).

Potential Analytical Method: Vector autoregression (VAR), macroeconomic forecasting techniques.
Interesting Research Question: How do global liquidity conditions influence the correlation between crypto assets and traditional financial markets?

Memecoins

TradFi Example: Meme stocks (GameStop, AMC), bubbles driven by community belief, social media influence.

DeFi Counterpart: Memecoins (Dogecoin, Shiba Inu, PEPE, TRUMP).

Core Dynamics: Social contagion, narrative-driven value, reflexivity, network effects.

Real-world example: Dogecoin's rise in 2021 (market cap >$80B), Elon Musk influence, Reddit-driven rallies, Trump coin's rise and liquidations used to enrich Trump

Potential Analytical Method: LLMs for sentiment detection and analysis of Twitter, Reddit, and Telegram. Looking at when the prominent holders of coins start selling

Interesting Research Question: Can sentiment analysis of crypto Twitter (or crypto social media in general) accurately predict memecoin pump-and-dump cycles?

Data Collection & Model Formation

Data Sources: Dune Analytics, Twitter sentiment, ….

Approach: Identify specific financial instruments or tokens, collect price data, identify key signals/features.

Analysis: Quantitative (volumes, yields) vs Qualitative (social media sentiment).

Examples: See articles on the Defi Report website, Financial Times (some of them given below)

Onchain data indicates peak?

Which memecoin holders have the most conviction?

Donald Trump’s crypto project netted $350mn for him

Quiz

Canvas page for course > Assignments > Project Track - Quiz 1

Code - TSP109

Project (Track 3: DeFi Trading)

Main theme:

- Long and short
- Arbitrage
- …

May want to use:

- DEX
- Flashloans
- Bridges
- Centralized exchanges

Project (Track 3: DeFi Trading)

- Key trading strategies?
- How to stay safe?
- Which platforms to use?

Trading strategies

- Arbitrage: Profiting from price differences
  - Same DEX - find arbitrage loops
  - Different DEXes
  - Different chains
  - …
- MEV strategies
  - Sandwich attacks
  - Front running
- How to use AI
  - Train AI agents
  - Optimize the process

How to get started? – And stay safe!

- First try everything local, then go on testnet
- Never push your private key on Github (use dotenv)
- All these platforms have great docs and tutorials to start with
- Don’t code from the scratch - use existing, tested, trusted codes

Testnet is enough for the project, no need to go on mainnet

Platforms (for trade)

- Exchanges: Coinbase, Uniswap
- DEX Aggregators: 1inch, Matcha for trade execution
- Perpetual trading: dYdX

Platforms (for analysis)

- On-chain scanners: Etherscan, Dune Analytics for data insights
- DeFi Llama: tracks TVL, liquidity trends, and more
- MEV-explore: MEV and frontrunning data

Quiz

Canvas page for course > Assignments > Project Track - Quiz 2

Code - VLL617

Project (Track 4: Academic research in Defi)

Transaction fee mechanism design

How to determine the fee of a transaction?

Current Ethereum fee mechanism is EIP-1559:

- Base Fee: A base fee is now set by the protocol and adjusts dynamically based on network activity, with the base fee being burned .
- Tip: Users can also include a "tip" (also known as a priority fee) in their transaction, which goes directly to the miner, incentivizing them to include the transaction quickly.
- Dynamic Adjustment: The base fee adjusts based on the block size, with larger blocks signaling higher demand and leading to a higher base fee, and vice versa.

Important requirements:

- Incentive compatibility
- Implementable by strategic miners
- Throughput limits

Transaction fee mechanism design (suggested papers)

Transaction Fee Mechanism Design

- Introduces two property for the transaction fee mechanism design
  - Miner Incentive Compatibility: Prevents miners from manipulating transaction selection for profit.
  - Off-Chain Agreement Proofness: Prevents collusion between miners and users to bypass fees.
- Paper shows EIP-1559 satisfies these two properties

Dynamic transaction fee mechanism design:

- Analyzes dynamic users: a dynamic user makes decisions over time, considering not just immediate inclusion in the next block but also the tradeoff between paying higher fees for faster confirmation versus waiting for a lower fee in future blocks.
- Shows EIP-1559 is not incentive compatible when the users are dynamic.

Automated Market Making (suggested papers)

ZeroSwap: Data-driven Optimal Market Making in DeFi ,Adaptive Curves for Optimally Efficient Market Making:

- Even Though static curves can elicit the price they lead to LP loss due to arbitrage.
- This problem is addressed by adapting market prices to trader behavior, captured via the classical market microstructure model of Glosten and Milgrom

The Geometry of Constant Function Market Makers: This paper develops a geometric framework for Constant Function Market Makers (CFMMs),

Optimal Automated Market Makers: Differentiable Economics and Strong Duality

- The literature on the design of AMMs has mainly focused on prediction markets with the goal of information elicitation.
- They instead focus on designing AMM with the goal of profit maximization

Borrow Lending Markets

Thinking Fast and Slow: Data-Driven Adaptive DeFi Borrow-Lending Protocol, AgileRate: Bringing Adaptivity and Robustness to DeFi Lending Markets

- Static interest rate curves lead to inefficient utilization especially when the market moves very fast
- Use machine learning method to adapt to the demand and supply changes in an online manner

Attacks on dynamic defi interest rate curves

They demonstrates attack on PID based interest rate controller

MEV market extractable value

[Computation of Optimal MEV in Decentralized Exchanges]

- Batch auctions are believed to be more resistant to Maximal Extractable Value (MEV) compared to AMMs.
- Contrary to the general belief, the paper demonstrates that batch auctions are not entirely MEV-proof.
- Block builders (validators or miners) still have the power to insert, delete, or selectively include transactions, which allows them to extract MEV.

[F3B: A low-overhead blockchain architecture with per-transaction front-running protection]

- Encrypt the transactions when sending to the mempool
- A committee can collectively decrypt the transactions only when their place in the blockchain becomes fixed.

References

- TLDR : An interesting academic Defi conference to check out: https://www.thelatestindefi.org/
- EC workshop , blockchain and Defi: https://ec24.theodiamandis.com/
- ACM CCS workshop: https://defi.security/

Quiz

Canvas page for course > Assignments > Project Track - Quiz 3

Code - SRK674

Happy Coding!