Research conducted by Gilberto Guadiana
Supervised by Professor Katherine Compton
Sponsored by the 2021 McCormick Summer Research Fellowship
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Implementing NFT Technology for Collaborative Casual Creators

Overview

This summer I worked on investigating non-fungible tokens (NFT) technology built on the Ethereum blockchain network with the supervision of Professor Katherine Compton. NFTs are codified ownership deeds of digital assets, and one can consider Ethereum to be a distributed computing network that provably executes computer code as written without modification. I created web applications using JavaScript, Python, and Solidity (used for developing Ethereum applications) that implemented NFT technology and allowed groups to create and own original, collaborative artwork. Refer to Appendix A for core deliverables including all code written.

Phases and Results

1. NFT Brownie Tutorial

At the start of the project, I began by exploring the affordances of NFTs, like allowing users to increase their sense of belonging in a group and show off their ownership of digital assets. Discussions with Professor Compton helped me identify how you can leverage the affordances of NFTs within popular casual creators, like The Sims or Minecraft. I selected Drawphone [1], a party game where players create drawings and others guess what they drew, to adapt. After designing my NFT implementation on paper, I worked through a tutorial [2, 3] that covered how to make the backend for NFTs. Once I became familiar with Solidity, the Brownie development framework, and Python needed, I began attempting to adapt Drawphone. Following issues with deploying my own instance of the game on a server, I pivoted to adapting a JavaScript casual art tool I made in Professor Compton's Generative Methods class that allows you to draw on a canvas with drawing tools (Figure 1).

2. Collaborative Art Tool

I adapted the casual art tool to allow you to connect with other players and draw on the same canvas in real time (Figure 2). The Collaborative Art Tool uses PeerJS [4] to connect through WebRTC, and Professor Compton helped with providing a template that I used as starter code [5]. My goal was to have the application allow users to upload their artwork to the decentralized database IPFS [6] and create NFTs that gave ownership of the created artwork to each owner. I struggled to add the NFT functionality to this application because I was unsure of how to run Python scripts through a server without access to a command line, which the NFT Brownie Tutorial used. To get around this, I redid Collaborative Art Tool using Flask [7] that lets you run Python and JavaScript together on a server. This worked up to a point, but I was stuck on how to connect to IPFS through a server.

Once the application was functional, excluding the NFT portion, I tested the application and simulated the NFT functionality. Figure 3 shows artwork that came out of a user test during this time. The user tests showed me that users enjoyed being able to draw together, but with no direction of what to draw and the "low quality" of the art produced, users were not very interested in keeping their artwork in the long-term or even have ownership of it. As I integrated feedback from the users to make the drawing experience better, Professor Compton let me know that I was moving away from the NFT part of the project and helped me think about how to test for user interest in the affordances of NFTs.

3. NFT Truffle Tutorial

After being stuck on connecting IPFS to the Python/JavaScript/Flask application, I followed a tutorial that showed me how to make NFTs and connect to IPFS through the Truffle framework, JavaScript and other JS libraries [8]. During this time, I reflected on the results of the user tests and decided to design a new application that would center the NFT functionality instead of the drawing experience. I conceptualized a turn-based application that would allow users to have ownership over each phase of a collaboration. Users would take turns uploading a file for the next stage of the artistic collaboration. Once a user submits a turn, the application would upload the file to IPFS and create an NFT of the artwork from that turn that each collaborator owns. After completing the tutorial, I now had the tools necessary to make a working application.

4. Collaborative Minter: Art Functionality

I built the Solidity/JavaScript/Truffle application and called it Collaborative Minter (Figure 4). The application uses a master factory contract to deploy all collaborations on the Ethereum blockchain. The application calls all of the blockchain functions using the web3 JS library [9]. Once I got it working and deployed on a website through Heroku, I tested the application. Figure 5 shows a collaboration worked on by two people. Figure 6 shows how the final phase looks like on OpenSea, an NFT marketplace.

5. Collaborative Minter: Composite NFT and Sales Functionality

After successfully testing Collaborative Minter, I extended the application to allow collaborators to create a composite NFT. Collaborators can spend, burn, all of the NFTs from each phase and the application creates a new NFT that displays all stages of the artwork together in a sequence. Professor Compton suggested the burning of the NFTs in order to preserve the scarcity of the artwork. I also created a transaction system so that users could bid on the artwork made through the application. Users submit the NFTs they want to buy along with the price, and all collaborators need to agree for the sale to be successful. The application would then execute the sale by splitting the proceeds from the sale between the collaborators and transferring ownership of the NFTs to the buyers. In addition, I implemented a mechanism that gives collaborators 10% royalties from any secondary sales. I based some of the sales functionality on a multi-signature wallet tutorial [10]. I drafted provisional implementations for this phase's functionality. However, this phase is not fully tested. One issue that came up during this phase is that the application was too large to be on the Ethereum network, so I implemented a Solidity library to reduce the size of the smart contract, application, itself.

Possible Extensions

Next steps to this research include fully testing the functionality of Collaborative Minter developed in the last phase of this research and improving the user interface for managing transactions. Collaborative Minter could be extended to allow for collaborations outside of digital artwork. Other extensions include modifying Collaborative Art Tool to have working NFT functionality. Additionally, the Solidity code of the applications could be optimized to lower costs of the application.

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Figures

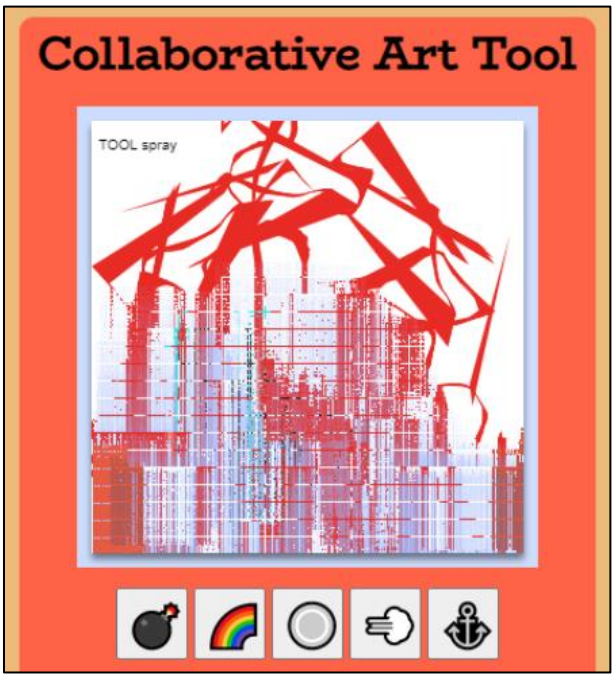

Figure 1. Casual art tool application snapshot.

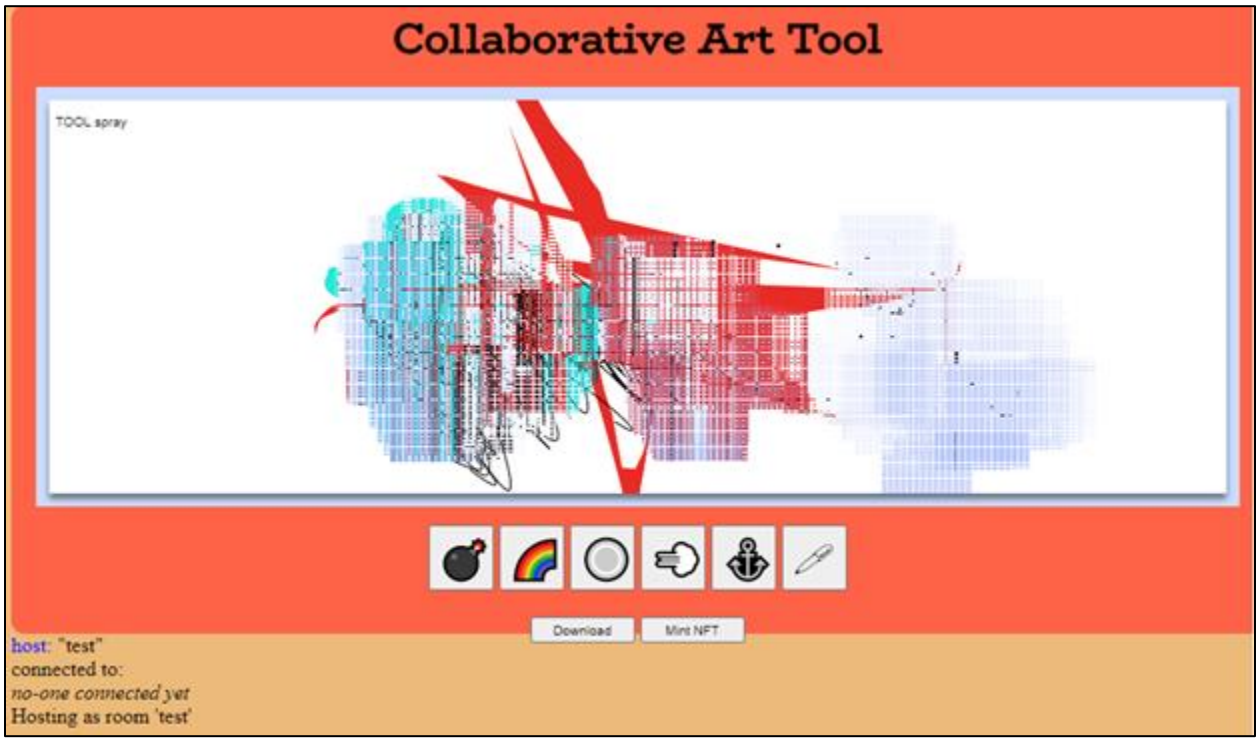

Figure 2. Collaborative Art Tool application snapshot.

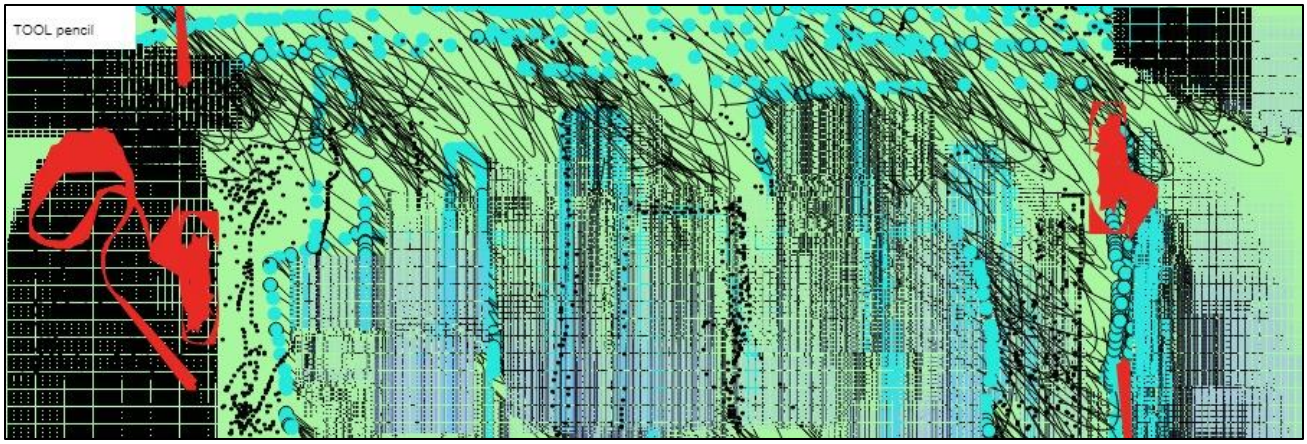

Figure 3. Collaborative artwork from user test by three people using Collaborative Art Tool.

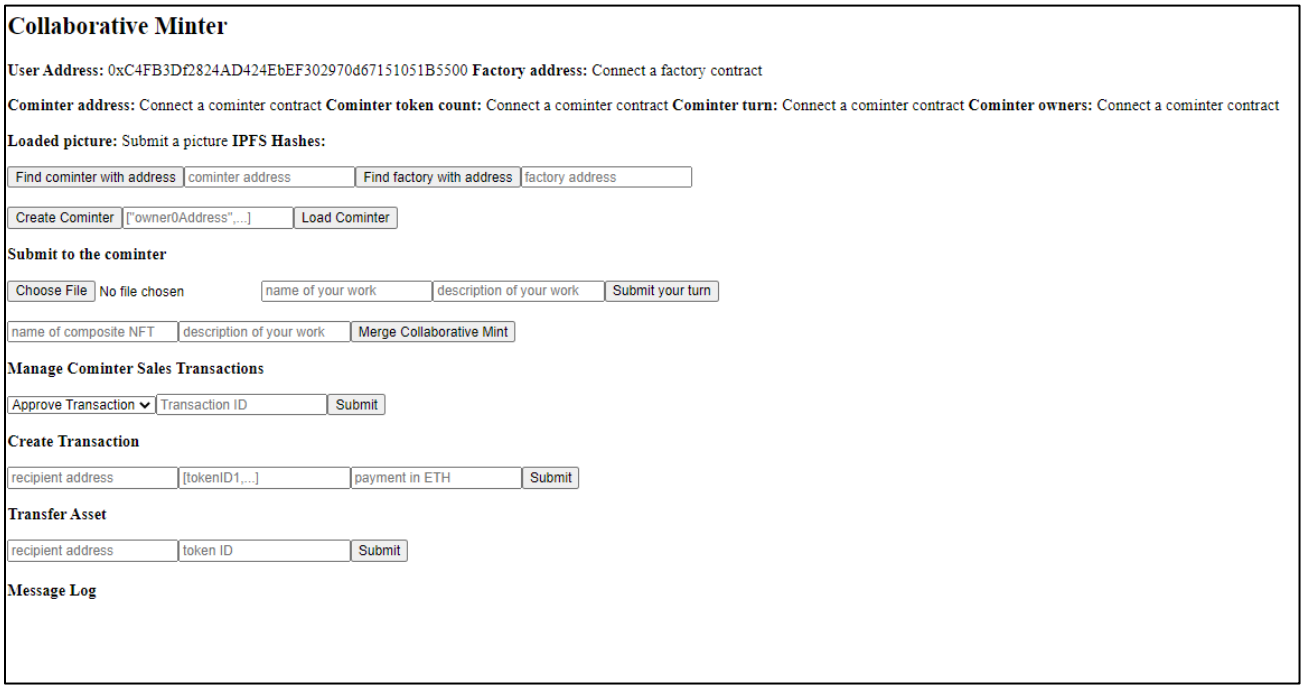

Figure 4. Collaborative Minter interface snapshot.

Figure 5. Collaborative artwork from two people using Collaborative Minter

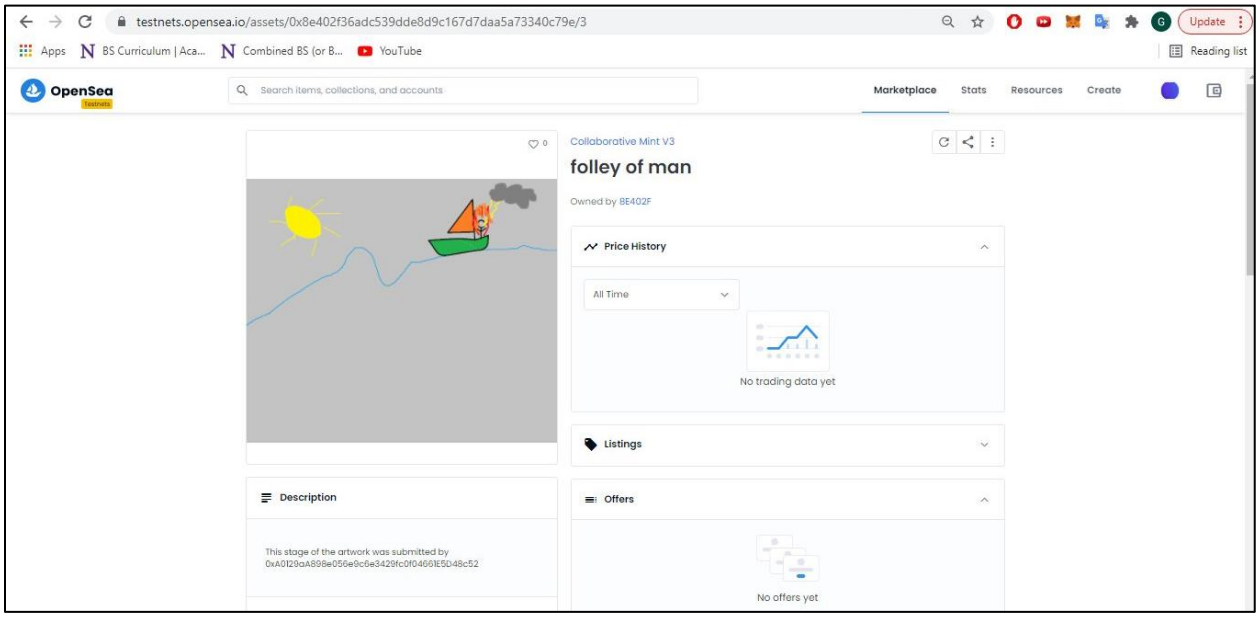

Figure 6. NFT from Collaborative Minter rendered on NFT marketplace OpenSea.

References

[1] https://github.com/tannerkrewson/drawphone
[2] https://www.youtube.com/watch?v=p36tXHX1JD8&ab_channel=PatrickCollins
[3] https://github.com/PatrickAlphaC/nft-mix
[4] https://peerjs.com/
[5] https://github.com/galaxykate/codoodle
[6] https://ipfs.io/
[7] https://flask.palletsprojects.com/en/2.0.x/
[8] https://www.youtube.com/watch?v=pTZVoqBUjvI&ab_channel=DappUniversity
[9] https://web3js.readthedocs.io/en/v1.5.2/
[10] https://www.youtube.com/watch?v=Dh7r6Ze-0Bs&ab_channel=SmartContractProgrammer

Appendix A: Core Deliverables

1. GitHub repository available at https://github.com/gguadiana100/Blockchain-Summer2021-Research
2. Code walkthrough of Collaborative Minter available at https://www.youtube.com/watch?v=8SPv8jnL5IM&feature=youtu.be
3. Thank you message to Neil and Wendy Sandler available at https://twitter.com/gilberto__g/status/1417209553217855491
4. Progress report article available at https://gilbertguadiana.medium.com/collaborative-nfts-summer-research-project-beginnings-and-first-user-test-efcf8c93c87e?source=social.tw