<u>POL 495 Assignment 2</u>
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1. I re-read all my readings from Assignment 1 and have thoroughly understood all the articles.

2. The main premise of the article, "On the Relative Effectiveness of Coping Strategies for Inadequate Public Water Supply: A Behavioral Experimental Study," showcases how public water supply systems involve two major social roles: a user and a provider.

   Part 1: Introduction
   The dynamic between a user and provider is crucial in understanding how public water supplies work. There are many ways in which users and providers can both navigate these social roles. For instance, the article discusses how a user can find alternate ways of water supply (other than the centralized one) where they can petition, appeal and voice their opinions. And as Abubakar discusses, this will lead to improved infrastructure quality as providers want to avoid extra costs of dealing with user discontent. There were also various pros and cons to having a centralized provider discussed in the article. There were other studies that looked at one or the other in terms of the provider, but this article takes note how the behavioral responses and interactions between users and providers were not looked at and studied. For instance, delving deep into the effects of user-level strategies and the relationship between the user and provider affecting infrastructure quality was not thoroughly studied in previous articles. Conditional cooperation and Hirschman's exit-voice strategy are together useful for understanding these types of interactions. The article points out that there are only a few studies noted to have used this strategy for water supply challenge specifically. The key components of the experiment are the users' exit, voice strategy and the combination of those managed by providers. Also, how the mutual interaction between the user and the provider (and the social outcomes) affect and are affected by water conservation strategies and decisions made.

   Part 2: Experimental Design
   The main focus of the experimental design is to focus on the action situation where the adequacy of the water supply system is tested. This system can be unreliable if providers decide to not fulfill the requirement of system maintenance. This is a deliberate decision in order to receive short term profits. The other way it is unreliable is if the user decides to stop paying the fees to the providers. This is a reciprocal issue and critical in maintaining mutual social satisfaction or conditional cooperation. This is a controlled behavioral experiment, following standard experimental economics. The vicious cycle or

social trap which causes unreliable water supply is captured and showcased through this experiment in terms of farmers and providers having choices and payoff structures.
The main examination of the experiment: was to examine how different coping strategies impact this social trap as a society, and how these strategies affect user-provider interactions at individual levels. For each treatment, human decisions are observed and compared with paying fees and the infrastructure quality. Details of the experiment are also provided in other documentation provided by Dr. Yu where I have gone through the method of the experiment in further detail. Overall, there are 10 baseline rounds and 10 treatment rounds.
Experiment:

First Round:
Players: 4
How stakeholders interact in use and maintenance of public infrastructure.

Farmers:

- Take water from shared irrigation infrastructure to grow crops. This gives them their earnings to use irrigation infrastructure.
- They need to pay a fee to the provider who is in charge of maintaining the irrigation structure.
- Farmers can hold payments and keep fees as earnings instead

Provider:

- Must decide how to use the collected fees.
- The provider can either invest the fees to maintain the infrastructure or keep the collected fees as its earnings.
- When the provider makes an investment, the earning is the amount of leftover fees that remains after investment.
- More water is available for farmers to grow if irrigation infrastructure is maintained.

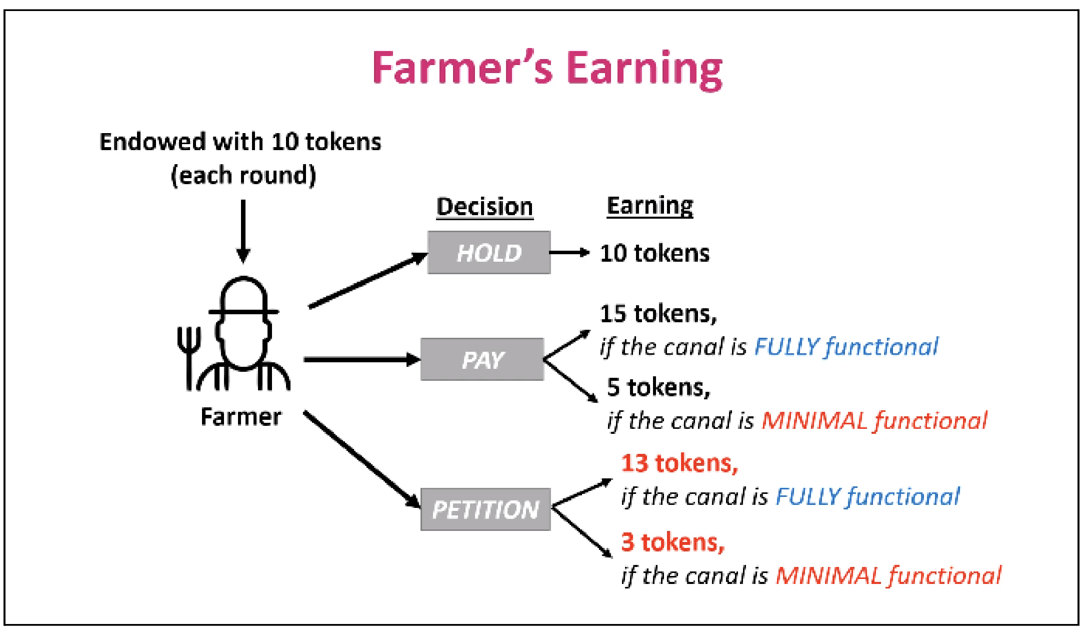
The 4 players will play the game multiple times or rounds. There are 3 farmers and 1 provider. Each player is randomly assigned one of the roles as a provider or a farmer. The irrigation infrastructure is fully functional or minimally functional depending on the decisions made.
If fully functional, 15 tokens are invested for maintenance. If not, it is minimally functional.
Each farmer receives 10 tokens and can choose to either hold this to earn the money. The other option is that the farmer pays 10 tokens to the provider. Once he chooses to pay the provider:

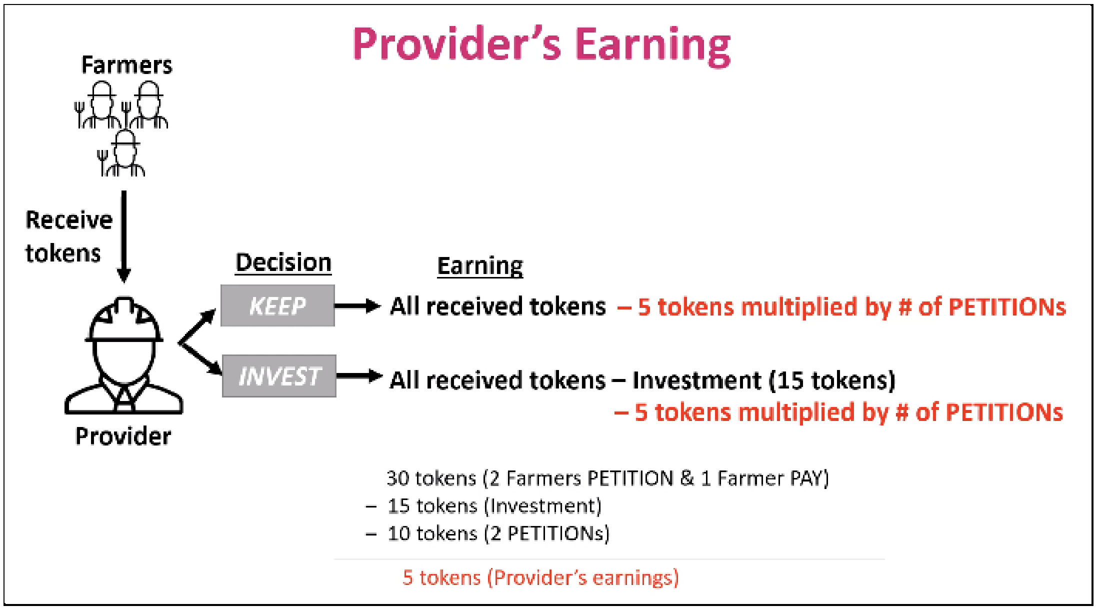
- The irrigation infrastructure is fully functional, the farmer will earn 15 tokens.
- If it is minimally functional, the farmer will earn 5 tokens and the provider collects tokens paid by the farmer.

The provider decides what to do with the tokens:
- Keep for themselves as earnings
- Invest in the water irrigation
- It takes 15 tokens to make needed investment to irrigation infrastructure
- Provider's earnings cannot be less than 0

There is also a time constraint: one minute.

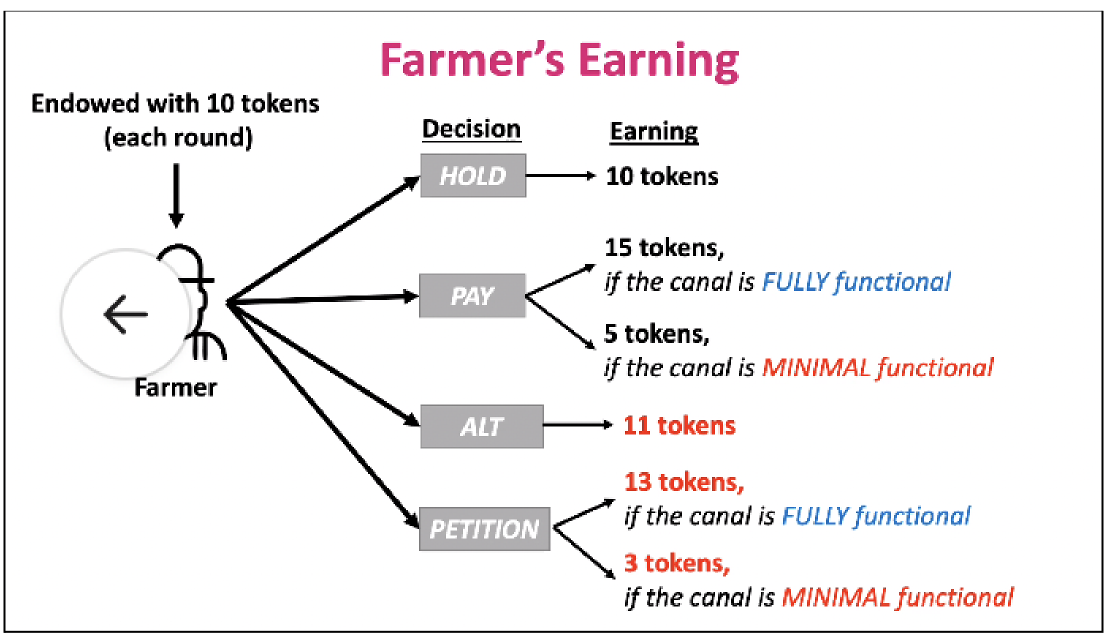
Second Round:
Farmers can:
- Hold payments
- Pay 10 tokens to the provider to use the public irrigation system
- Petition the providers to improve the infrastructure while still paying the providers 10 tokens to use the water.
    - Costly to farmers because they are wasting their time and energy and 2 tokens will be deducted from their earnings.
    - Costly to providers because the provider has to spend time and energy to handle the petition and 5 tokens will be deducted for each petition.

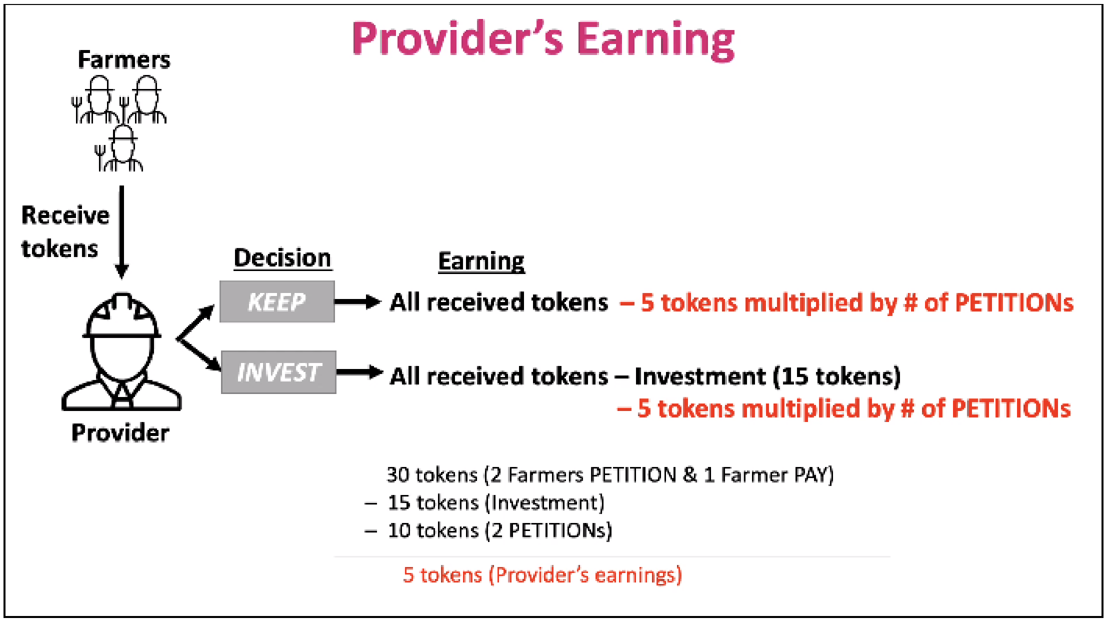




Third Round:
Farmers have 4 options for this round:

- Hold payments of 10 tokens
- Pay 10 tokens to the provider to use the public irrigation system
- Does not pay provider and invest in alternative water sources (private owned)
- Petition to improve infrastructure





3. Video recording of the actual experiment being conducted. While watching this video, I thought it was interesting to see that the quiz questions required you to know all the details carefully before proceeding to the actual experiment. You needed to answer all the questions correctly before playing the game.
   Over the course of the game, the graphics change to show how each payment and decision made impacts the quality of the irrigation infrastructure.
   As the second round begins, I think the addition of having a chat is a great option and shows that you can have some time to come to a consensus and discuss how the rounds will work. After the chat was enabled, it was important to note how there was an improvement in the irrigation infrastructure quality overall as long as all participants followed through and paid. However, when one farmer didn't pay, a lot of them didn't pay the next round as well. It showed a lot about the social structure between farmers and providers and how the interactions between farmers can contribute to differences in payment and water irrigation.

4. I researched some papers in Google Scholar and identified papers that incorporated machine learning and artificial intelligence into experiments. In total, I read 3 different articles that incorporated this.

   One of the papers I read that stood out to me and gave me a great introduction to this is "The Behavioral Economics of Artificial Intelligence: Lessons from Experiments with Computer Players," written by Christoph March. The article discusses how experimental economic research is utilizing computer players and AI to help shape the research and experiments now more than ever. In summary, it is also interesting to note how human behavior changes when it is known that the other players are computers. They act more selfish and tend to exploit the players. There are a few factors in taking note of AI in experiments.

- First, AI can be used to identify behavioral variables that affect behavior.
- Second, difficulties in implementing AI can help us understand common limitations of human cognition.
- Behavioral economics is necessary to understand and predict how automation and AI can overcome and exploit human limitations.

There are many important questions that will arise in terms of AI and how the agents in the experiments will work in the field and how the interactions between the machine and humans will form. Understanding how human behavior will change and strategies will translate to HCI is important in predicting patterns and outcomes in economic behavior and experiments using AI.

In Section 3.3 Public Good Games, the author discusses how computers or CP interact with humans and vice versa. This section is relevant to the water irrigation experiment since they fall under the same categories. The conclusion of this section is that CPs reduce the impact of human altruistic behavior and show how humans try to take advantage of the machine. The contributions are 50% lower and human subjects act more selfishly.

The article also talks about different ways CPs are designed to follow in the experiment. They can be categorized as:

- Fixed type: CPs draw actions randomly based on the domain
- Adaptive algorithms: repeated game strategies like tit-for-tat
- Mimic Human Subject: depends, but CP can draw a full sequence of choices or CPs mimic human subjects in the game.

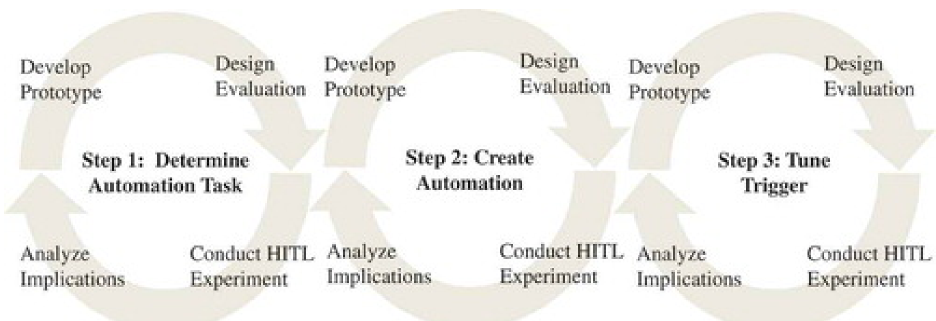
Overall, there are many pros and cons to using AI in experiments and it can be noted that CPs increase experimental control and help in testing behavioral economics. However, it should also be noted that real world interactions and decisions made by humans do not coincide with AI and CPs automated to perform their tasks and decisions.

The next few papers I examined used many different ML models to help CPs analyze data and perform decisions and patterns based on this. Some of the ML models used are random forest classifiers, Gradient Boost, and decision trees. The goal of the decision-tree models is to help establish a model that predicts the value of the target variable based on several inputs.

Overall, the basic structure follows that data is divided into training and testing. The training data helps with understanding behavior and how the experiment takes place. This training data is analyzed and ran in various models. The model that fits the training data is taken and the predictions and observed behavior is utilized in the testing data. (towards data science)

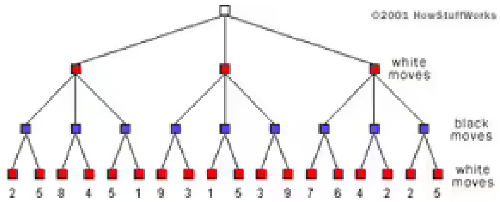
A paper that is established as experimental economics and uses random forest classifiers and Natural Language Process modeling is “Using machine learning for communication classification,” by Stefan P. Penczynski. The author discusses how text is analyzed and communication transcripts are studied and analyzed to understand behavior and obtain insights. Text analysis is represented by a bag-of-words model and classification methods combining NLP and ML models like random forest classifiers.
The random forest model classification had regression and classification. The results show that machine learning and NLP can help with the researching and going through experimental economic studies. The cost of implementing a model is also not high. This is a great example of how automation and ML can be economical in research projects and can help improve consistency in the experiment.

Another paper that showed automation to help with user engagement is an article called “Creating Effective Automation to Maintain Explicit User Engagement,” by Bindewald and Miller. The article discusses how Human-centered automation strives to provide work environments in which humans and machines collaborate cooperatively to balance system performance while maintaining adequate human engagement. There are main designs that need to be made in order to effect adaptation. Automation helps with increasing effectiveness and time in terms of performing the experiment. They describe the process outlined through this diagram.



5. After going through the experiment again and understanding how automation in experimental designs work, I had a better understanding of what needed to be done. I came up with a few ideas. In all of these articles, the articles didn’t delve into how computer automation was working with users as well as “learning” and wanted to figure out a specific example on exactly the methodology I would use to go about automating an experiment. I decided to research the basics and delve deep into how chess automation works.

As the skill of the player increases, the computer seems to almost learn and analyze players' moves and guide their strategies accordingly.
The way automation works is exactly what I am learning in my CS 471 Artificial Intelligence class. The approach is first a three-level tree diagram:



From there we use the minimax algorithm and alpha beta pruning, which I learned its effectiveness on Pacman. I know how this game theory works and after learning about this again in terms of chess, I can visualize it helping with the automation for the experiment.
For example, in terms of the irrigation experiment, we can use this chess analogy and say that the farmers are the human chess players and the providers are the CP. Using this analogy, we can use:
i. Decision trees to help figuring out the accuracy of the model and learning behavior for the CP to model
ii. Incorporate minimax and alpha beta pruning into the algorithm of the provider/ CP so that the provider is also trying to attain the optimal path while following a path that the CP has learned from machine learning.
iii. A more complex stage of the experiment would be to have different levels of difficulty set for farmers and the provider/CP will react in ways that are more ambitious and possibly choose greedy paths. This can be done by changing the alpha beta pruning levels and figuring out parameters that we can change in order to limit or increase the level of strength of the provider/ CP. For instance, CP would have

- Limited time to respond in easier rounds
- Conditional cooperation and real-time learning (to be more empathetic or to be more selfish)
- Have a goal set and only have actions planned to perform the end goal regardless of human consequences/ farmers lives. The goal can differ from monetary greed to maintenance of proper infrastructure.

Personally, I don't think there is only one particular way to automate the provider's role as there are so many variables and factors to consider. I do think that the overarching theme would be to perform machine learning on a model and using game theory in AI like zero-sum game or minimax algorithms to help model the role of the provider keeping parameters as factors that can be changed.

6. Just based off of looking at the raw data, I was not able to identify any key elements in the data and how providers are really interacting with the farmers. However, once I

perform preliminary data analysis to check how the user and providers interact, I understand the basic shape or similarities and patterns that can be derived from the data. This is outlined in detail in POL 495 Summary Report of Code and the Final Report.

Articles:

1. https://arxiv.org/pdf/1907.02100.pdf
2. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3485475
3. https://link.springer.com/article/10.1007/s10683-018-09600-z
4. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.416.503&rep=rep1&type=pdf
5. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6775758/
6. https://www.tandfonline.com/doi/full/10.1080/10447318.2019.1642618
7. https://pubs.aeaweb.org/doi/pdf/10.1257/aer.91.5.1521