Developing Strategies for Expert Crafting in Final Fantasy XIV - Proposal

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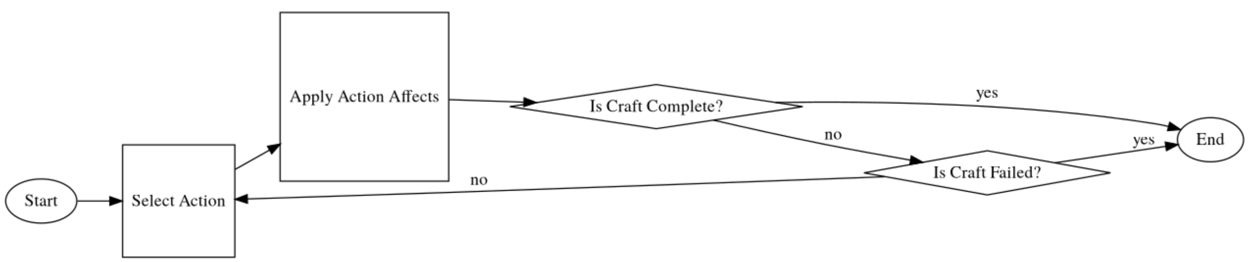
Problem Statement

Final Fantasy XIV is a massively multiplayer online game developed by Square Enix. As part of its gameplay, players can craft items. They do this by using skills to increase the item's quality and to make progress toward its completion. This system is popular enough and has enough depth that they have recently created a form of "competitive" crafting.

The crafts that players synthesize for this purpose are called "expert crafts." They are much more difficult than normal crafts, have a modified set of rules, and can only be synthesized for the purpose of competition. Players must increase the craft's quality to a minimum value and complete the craft without breaking it, or the item is worthless. Competitors have ten days to get as many points as possible.

Our goal is to simulate the expert crafting environment and to create an AI that will find the most effective way to complete these crafts. By training the AI, we may be able to identify common ways that it handles certain scenarios effectively.

Problem Analysis



State Space

Attribute	Max value
Material Status	5
CP	572
Durability	11
Progress	11126
Quality	82400
Buff - Inner Quiet	11
Buff - Waste Not I/II	8
Buff - Manipulation	8
Buff - Innovation	4
Buff - Veneration	4
Buff - Name of the Elements	3
Buff - Final Appraisal	5
Buff - Great Strides	3
Buff - Muscle Memory	5
Buff - Observe	2

Which results in `146,194,199,352,115,200,000` or 146 Quintillion possible states.

State Transition

During each turn of a craft, one action is performed until the craft is either complete or failed. Currently there are 30 actions available, consisting of actions that primarily increase Progress, actions that primarily increase Quality, and Buff actions which provide multi-turn effects. Most actions consume CP to perform, which means that most `paths` to solutions will have a fairly fixed depth. Of these 30 actions, some have prerequisites that will remove them from consideration while simulating.

The process of calculating the effects of each action on the environment will be carried out on each member of the population in our genetic algorithm. This is necessary because the environment is sequential, and changing even one action will have a ripple effect.

State Evaluation

Any states where Durability has a value of zero and either the value of Progress is less than 11126 or the value of Quality is less than 58000 are failure states. Any states where the Progress is 11126 and the Quality is less than 58000 is also a failure state.

Our heuristic will calculate state values by calculating the percentage of the maximum by which they would increase Progress or Quality, then divide that result by the Durability consumed plus proportion of the CP

$$h(s) = \frac{\frac{progressGained}{totalProgress}}{durabilityCost + \frac{cpCost}{cpTotal}}$$

cost to max CP. As an equation:

Characteristics

The crafting environment in Final Fantasy XIV is fully observable, so it follows that the AI's environment will be fully observable. The AI is the only agent operating on the environment, so it is a single-agent environment. The environment is stochastic: each step, there is a random chance for materials to take on a particular quality, which applies multipliers to the actions the AI can take. Additionally, there are some actions which have a chance to fail. Each state's actions are affected by previous actions taken by the AI, so the environment is sequential. The game is turn-based, and there are no changes between percepts, so the environment is static. Every value is represented as an integer, so the environment is discrete.

Dataset

Thankfully, since the game the AI is playing is from an MMO Game, the community has procured all of the required data entries for each Item, Action, and Buff can readily be accessed at here and here. We can take this data, with some additional annotations and use it to accurately simulate the crafting mini-game, and if were stream-line the sanitizing of this data, our simulator can be easily updated for future versions of the game and more refined datasets.

Implementation Strategy

By treating this problem as a Fuzzy Constraint Satisfaction Problem [1], we can approach this using a genetic algorithm [2]. We will generate some population of sequences of actions, and will preform selection, mutation

[1] Z. Ruttkay, "Fuzzy constraint satisfaction," Proceedings of 1994 IEEE 3rd International Fuzzy Systems Conference, Orlando, FL, 1994, pp. 1263-1268 vol.2, doi: 10.1109/FUZZY.1994.343640.

[2] R. Kowalczyk, "On solving fuzzy constraint satisfaction problems with genetic algorithms," 1998 IEEE International Conference on Evolutionary Computation Proceedings. IEEE World Congress on Computational Intelligence (Cat. No.98TH8360), Anchorage, AK, USA, 1998, pp. 758-762, doi: 10.1109/ICEC.1998.700147.

and crossover on these until the best solution appears to have converged. To prevent problems with local maxima, we may have a larger mutation rate, or allow for multiple steps of mutations to take place at a single time. We might also be able to treat dominating sequences as elites [3] and keep them in an external population to add more variation to the population. Due to the calculation of the heuristic being read-only on global state data, we can maximize the multi-threaded-ness of the algorithm to maximize performance.

Deliverable

The final deliverable project will contain at least the following:

1. An expert crafting simulator that is as accurate as possible to the real game.
2. An AI that can play a single round of expert crafting.
3. A refined dataset that can be updated easily and refined based on public/community data.

The following are stretch goals and may or may not be in the final project due to scope or time constraints:

1. An AI that plays set number of crafts over a set number of simulated time-frames that can be compared to the public leader-boards.
2. A GUI describing the AI search tree and allow for a user to follow contingencies for chance based actions to still achieve high scoring crafts

Evaluation

An individual craft can be *scored* based off of the final craft quality and the number of steps it takes to get to that result, and if the craft fails the score will be 0. The formula we will use is the score yielded by the result divided by the number of steps it took to get to that result (which will be 0 if the craft breaks or does not meet the minimum quality threshold).

To validate if our AI is playing the game well enough, we can compare the score of our simulated craft to the official leader-boards for crafts, as well as perform some qualitative testing in game. If we get to the point where we can simulate crafting for the same amount of time competitors did, we can compare the score of our AI to the scores of top players directly instead of extrapolating.

Schedule

The first problem that needs to be tackled is processing, sanitizing, and categorizing the community data sources to create a singular database of all possible actions, buffs, and calculations that exist in the game. After this is complete, work can be started on the simulator, which will take a starting environment, and allow an agent to perform actions until the craft is complete. The data should be done being aggregated and we should have a fair amount of the simulation environment done by November 16.

After we have finished the simulation environment, we can implement our AI. We will develop a genetic algorithm and heuristics to create sequences of actions as genomes, evaluate their fitness, and use mutations and crossover to come up with an acceptable sequence of actions. This should be done by November 30.

Once we have a working AI, we can start performing test runs compared against other players' scores and optimizing to achieve the highest scores possible. We should have these metrics by December 8.

[3] M. Sailaja Kumari, Sydulu Maheswarapu, "Enhanced Genetic Algorithm based computation technique for multi-objective Optimal Power Flow solution," International Journal of Electrical Power & Energy Systems, Volume 32, Issue 6, 2010, pp. 736-742, ISSN 0142-0615, doi: 10.1016/j.ijepes.2010.01.010.