

Investigation of Different Visualization Techniques for the Multi-Objective Reinforcement Learning Results

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Background

Multi-Objective Reinforcement Learning gets a vector reward after every action compared to single reward in a reinforcement learning.

Nile River Management Problem contains 3 countries:

- Egypt wants to minimize their water deficits and the frequency below minimum water level of High Ashwan Dam (HAD).
- Sudan wants to minimize their water deficits
- Ethiopia wants to maximise their energy production from the hydroenergy power plant

Research Question

How can you present the outputs of the multi-objective reinforcement learning algorithm to the decision makers?

| Visualization Type | Clarity Mean | Clarity Median | Clarity StDev | Usefulness Mean | Usefulness Median | Usefulness StDev | Most Useful | Worst Useful | Overall Mean |
|---------------------------|--------------|----------------|---------------|-----------------|-------------------|------------------|-------------|--------------|--------------|
| Bubble Chart | 3.1875 | 3 | 1.0468 | 3.375 | 3.5 | 1.0247 | 0 | 3 | 3.2813 |
| Stacked Bar Chart | 4.25 | 4.5 | 0.9309 | 3.875 | 4 | 1.2042 | 5 | 1 | 4.0625 |
| Heat Map | 4 | 4 | 1.0954 | 3.875 | 4 | 1.0247 | 2 | 1 | 3.9375 |
| Spider Plot | 2.625 | 2 | 1.2583 | 2.6875 | 3 | 1.0145 | 0 | 11 | 2.6563 |
| Pairwise Plot | 3.5 | 4 | 1.1547 | 3.9375 | 4 | 1.1815 | 4 | 0 | 3.75 |
| Parallel Coordinates Plot | 4 | 4 | 0.6325 | 4 | 4 | 0.8944 | 5 | 0 | 4.75 |

Methodology

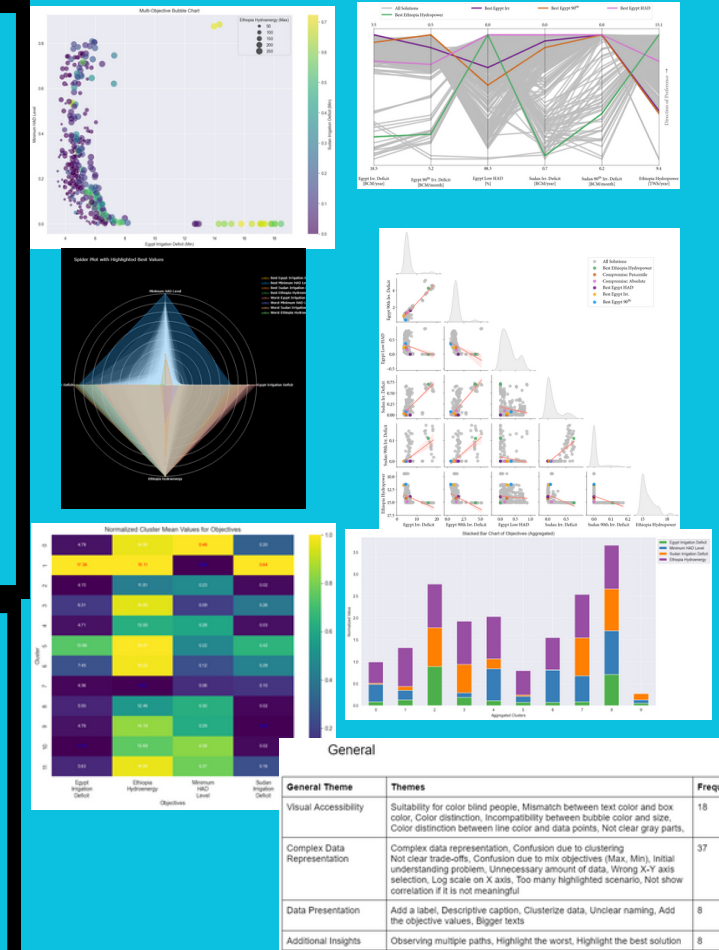
- Implementation of 4 visuals: Bubble Chart, Stacked Bar Chart, Heat Map, Spider Plot
- Choosing 2 example visuals: Parallel Coordinates Plot, Pairwise Plot
- Clustered and full data visuals were implemented
- Making user evaluation: Multiple choice, open-ended, comparison questions
- Quantitative Analysis: ANOVA, Chi-Square Test and Basic Statistics
- Qualitative Analysis: Thematic Analysis

Results/Analysis

- Data was collected from 16 computer science students
- Stacked Bar Chart had the highest clarity and average rating. Improvement - Confusion due to mix objectives. Highest standard deviation for usefulness
- Parallel Coordinates Plot had the lowest standard deviation for both clarity and usefulness. Highest usefulness score. Worst values can be highlighted too.
- Spider Plot had the lowest values for both clarity and usefulness, and the highest standard deviation for both sub-criteria. Colors can be more distinct
- Chi-square test for clustered vs full data points: 0.0. So, no preference between those options
- ANOVA test showed that there are preference among the visuals for clarity and usefulness.

References

- Van Moffaert, K., & Nowé, A. (2014). Multi-objective reinforcement learning using sets of pareto dominating policies.
- Sari, Y. (2022). Exploring trade-offs in reservoir operations through many objective optimisation: Case of Nile River Basin



Future Work

- Bigger sample size for chi-squared test
- Better visualization options, such as video records can be shown