Graph Games: A Human Computing Game Framework

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Abstract

Graph Games is a framework intended to leverage the power of human intuition for solving computationally difficult problems. This summer we:

- Added more features to the framework to attract and retain players
- Researched other problems to add to the Graph Games framework
- Implemented three new games based on three of these problems:
  - Power Houses, based on the problem of Dominating Set
  - Power Lines, based on the problem of Vertex Cover
  - Portal Forger, based on the problem of Graph Bandwidth
- Released Graph Games to a group of beta testers to obtain feedback on these changes.

NP-Complete Problems

- Solutions are easy to verify
- Difficult to find solutions
- Solving one NP-complete problem solves them all
- Can be applied to many real-world situations:
  - Network and operating system scheduling
  - Automation of electronic design fabrication
  - Deadlock resolution
  - Many others

Background

Human Computing

- Uses human intuition for difficult computational tasks
- The bigger and more diverse the group, the better the results
- Human Computing Games present problems to people as games
- Games engage people, making them more likely to spend time solving problems
- Casual, online games are an ideal platform for this

Clinical Computing

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Future Work

Survey Research – We recently released Graph Games to the public, as well as an accompanying survey about players’ gaming experiences. We hope the results will make Graph Games even more appealing and enjoyable for users.

More Insightful Puzzles – As the success of the Graph Games project hinges on its ability to provide useful results for both practically and theoretically important puzzles, we would like to add more of these puzzles to see how the Graph Games community handles them.

Algorithm Development – Players and developers have already uncovered several problems with our current algorithms, and we hope to continue developing them by studying player solutions and adding games that encourage users to stump our algorithms.

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Want to Play? Come join us at http://graphgames.computinggames.org

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Graph Games

Graph Games began as a simple applet designed to present puzzles to players based on several NP-complete problems related to graph pebbling. Last year’s work extended this prototype by redesigning the framework to make it more extensible. This year we added three new games based on the NP-complete problems graph bandwidth, dominating set, and vertex cover.

New Features

- Graph Games

The Graph Games title screen.

The new and improved Graph Games play screen interface.

Achievements

- Beating one of each type of game
- Getting the highest score on a particular puzzle
- Spending a long time or making a lot of moves on a puzzle

Global points

- Awarded based on several criteria:
  - How well a player solves a puzzle
  - How difficult the puzzle is
  - If anyone has beaten the puzzle before
  - Allow players to compete across games

Unlocking puzzles

A puzzle before and after being unlocked.


def power_lines()

def power_houses()

def portal_forger()

Power Lines

Power Lines is based on the vertex cover problem, where a solution is defined as any set of nodes that are connected to every edge in a graph. Power Lines represents this as a grid of power substations, with the goal of activating substations until power is supplied to every power line in the grid. The fewer substations a player uses, the greater their score.

Power Houses

Power Houses is similar to Power Lines, as it is based on dominating set, a problem analogous to vertex cover. In dominating set, a solution is defined as any set of nodes that are connected to every other node in a graph. Clicking on a house places a wind turbine by that house, supplying it and its neighbors with power. Player’s scores are based on the number of turbines they use.

Portal Forger

Portal Forger is based on the NP-complete problem of graph bandwidth, where a solution consists of mapping consecutive, distinct integers to every node on a graph. The bandwidth of such a solution is defined as the greatest difference between the integer values of any two nodes in that graph. The best solutions are those that result in the lowest bandwidths.

Portal Forger portrays the graph bandwidth problem as a network of connections between portals in space. Players must place stabilizers on portals to ensure safe travel between them, with the energy cost to run them based on the difference between the portals’ addresses. The goal is to use as little energy as possible by grouping the addresses of the portals as closely together as possible. Players are rewarded for lower energy levels, by keeping every energy level on the graph lower than a small value.