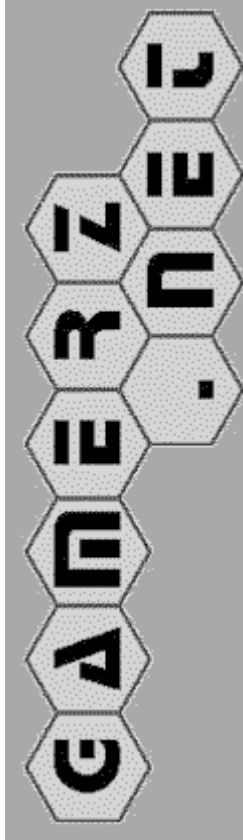


A Cluster Analysis of Richard's PBEM Server

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For G4G11, March 2014.



Introduction

The goals of this paper are twofold. First, it is my intention to share with the larger community knowledge of one of my personal favorite places on the Internet, Richard's PBEM Server ("Richard's PBeM Server"), a play-by-email server founded by Richard Rognlie in 1994! Secondly, I would like to make use of the openness of the platform to apply machine learning techniques to see what patterns can be discerned from user behavior, since Richard's server keeps records on games played going back to its foundation.

History of the server

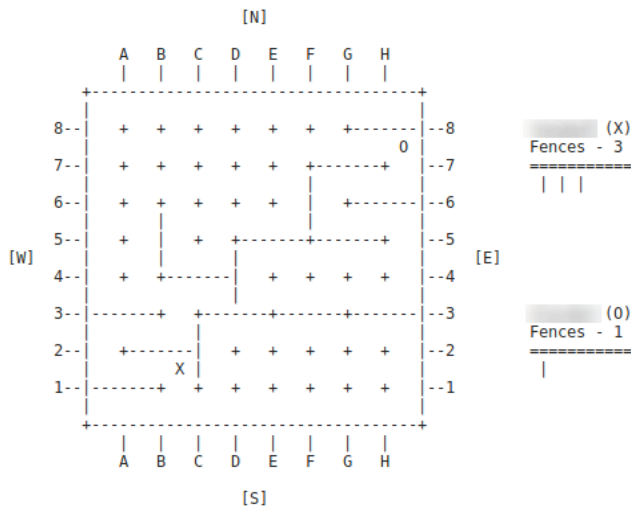
Richard's server was founded in 1994 as means to play games by email in an automated fashion. Richard had previously been able to play Trax on a server at UC Berkeley, but the availability was not complete and the set-up did not automate tasks such as maintaining the user database. Gamerz was launched with the ability to play Trax (TraxGame) and Twixt. Before the first public announcement, the list also included Hex, Abalone and C++Robots (since relegated to its own implementation).

In 1998 Richard wrote: "[PBMServ] currently supports 50+ games, 1200+ users and 3500 requests/day" ("PBMServ History"). It is apparent from the experiments below that it has only continued to build. My personal history with the site started in 2001 when I became addicted to playing the game Zèrtz, which I had recently bought (Zèrtz).

Games

The range of games is broad but the emphasis is on abstract board games such as backgammon, chess, go, etc. The distinguishing feature of the server is that each of the games has its board drawn purely in ASCII characters and therefore is suitable for playing with any email reader in existence. In the figure below, a game of Quoridor is shown in progress.

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Rules at: <http://www.gamerz.net/pbmserv/quoridor.html>
 Graphics: <http://www.gamerz.net/pbmserv/Quoridor/Quoridor.php?731&html>

There are variants of traditional games, such as a large number of variants on the game of Backgammon (also called Hit), such as Moultezim and Plakoto, which are traditional variants on the game popular in other countries (Tzannes).

There are more modern games such as the games of Project GIPF by Kris Burm. In addition to abstract games there are card games such as Spades and Hearts, and some less traditional games such as Werewolf (also known as Mafia).

The server has been set up as a platform and allows for the addition of new games. Therefore a dedicated group of developers has sprung up to add new games to the server on a volunteer basis (if not previously mentioned, everything on the site is without cost). A relatively recent (in server time) addition to the site has been a graphical front end to allow games to be played via the web. This front end is completely integrated with the more traditional mail server and it is perfectly possible to mix and match with one player using the graphical interface and one email

or even to have one player alternate between the two methods.

make display
small
plain, large
plain, small
zertz+11 games
all games
zertz+11 ratings
zertz+11 challenge
zertz+11 help
report bugs
log in

Zertz+11 game 601

plays player1,
 plays player2

The last move was Bb1.g5, player2 to move

Click or enter move

--special move--

<< <<
 player1 player2
 1 Bb4.g4 2 Gd5.g1
 3 Bb1.g5

An exciting trend has been having game developers bring their games to Gamerz as a means of exposing them to an audience of fans. The prolific designer Cameron Browne, author of Connection Games and Hex Strategy, has added over forty games currently only playable online on the server. Most of the games he

designed himself, but Yavalath has the distinction of having been designed by a computer (Evolutionary Game Design).

The games he has added include Druid², Mambo, Dragons, and a two-player game, Conway, based on John Conway's Game of Life (Mathematical Games)³

To continue a non-exhaustive list, Doug Zander has contributed Power Drain, Luke Pebody contributed Cooper Young and Mark Ballinger and I brainstormed Haggis as an adaptation of the Sid Sackson game Haggie (Sackson).

The Experiment

The experiment was conducted by downloading from the server ratings for 255 different games (there were actually even more data files than this, but I immediately excluded a handful of games, largely experimental, which had no complete games). Later, after working with the data I made the decision to cut off games with fewer than 50 completed games, which trimmed the list by 75 to leave 180 games to cluster. The excluded list included many interesting games (including two I had coded myself), but I was worried that the statistics would be too noisy. Ironically, the last game to make the cut (i.e., have over 50 games completed) was called Borderline.

Then there were the users whose behavior I tracked. There were in all 2362 distinct users. At first I weeded out all users who had only played one type of game, but later decided that this pruning would lead to unexpected effects in the distance metric used and so I reversed that decision, i.e., every game was represented by a vector with 2362 dimensions. The most prolific user on the site (in terms of breadth) had completed games in 176 different categories.

The statistics yielded for each user, games won, lost, drawn and the user's rating (discussed more below). To simplify matters, the only data kept was the total number of games completed (wins + losses + draws). Using a technique similar to the "bag of words" technique for document classification ("Bag-of-words Model"). Each game was then associated with an N-dimensional vector where each dimension represented a distinct user, i.e., each game was expressed as a bag of users.

Some users are huge fans of certain games and I wanted to make sure that these superfans did not drown out the contributions of their peers, so I stepped in and made a further arbitrary decision to cap the number of games played by a single user at 20 (the number of games necessary to be an "established player" on the server).

² To the insistent commenters on Boardgamegeek, everyone realizes that the druids did not actually build Stonehenge and they certainly did not put down stones willy-nilly for the purpose of walking over them.

³ **Achievement unlocked:** obligatory John Conway reference.

The reason for this cap was that the next step was to normalize the vectors to unit length. Without taking that step, it would quickly be the case that some games were essentially only represented by a few dedicated fans. Before I made this adjustment, there were some games deemed close that seemed implausible given the nature of the game (not that there were no surprising correlations in the final results).

Next, the problem was to consider how close games were to each other. I used the “cosine distance” which is simply:

$$1 - x \cdot y$$

for normalized game vectors x and y . Since the components of every game vector are guaranteed to be non-negative, the result is always a number between 0 and 1. To be equivalent (distance zero) two games would have to be played by exactly the same group of players in the same proportion.

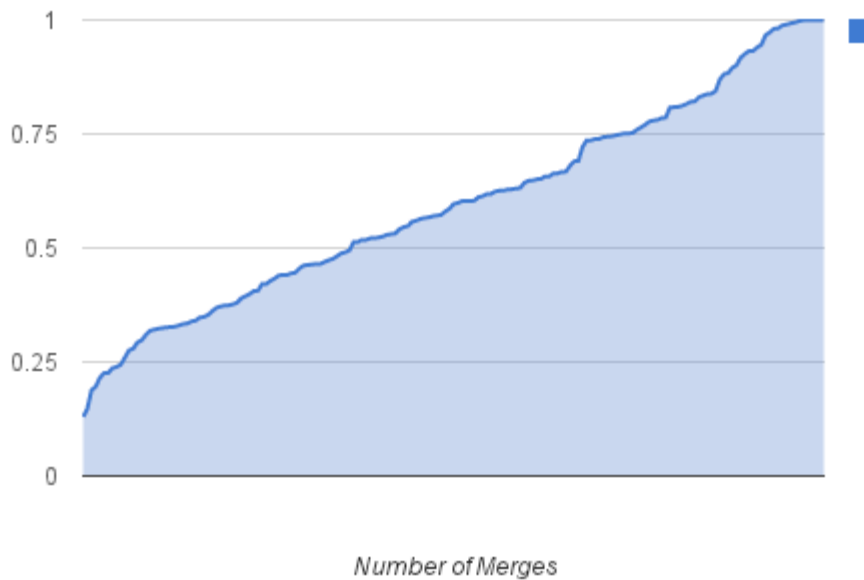
Two sets of games were considered to have distance equal to the diameter of the combined set, i.e., the furthest distance achievable by a pair of points in the combined set. By using this criterion instead of trying to compute centroids of clusters, the program never actually had to perform the normalization or dot product calculation after the initial run and all the clustering operations were able to operate based on a lookup table.

Clustering was done by agglomeration. The starting point was a list of 180 clusters with each containing one game, and then the program recursively removed the closest pair of clusters from the list and replaced them with a new cluster formed from their union. This new cluster required expanding the lookup table of distances to account for the distance of this new cluster from all existing clusters, however in this setup, this could be obtained by setting the distance of a cluster to the new cluster to be the maximum of the distances from that cluster to its two subcomponents.

Results

This graph marks the progress of the algorithm as it successively combined clusters to form new clusters. Therefore, the left edge of the graph corresponds to the situation of having a set for every game and the rightmost extreme corresponds to the result of combining all 181 games into a single cluster. At each point in the progression, the program kept track of the diameter of the newest formed cluster. The hope was that there would be a logical point of inflection in this graph, which would be true if there were really discrete clusters such that merging to that point would entail relatively little gain in error and combining beyond that point would mark a sharp trend upwards. The actual data, however, showed a much smoother transition, which meant there was not necessarily an obvious stopping point or ideal number of clusters.

Cluster radius as clusters are merged.



Here are the results of the clustering algorithm when it was allowed 20 distinct clusters. The choice to stop at 20 was arbitrary, but it was the first level of aggregation that put the Project GIPF games into their own cluster, and 20 was approximately the number of different hand-curated categories used by Richard Rognlie in the game descriptions on the server's front page.

Cluster (number of plays)	Notes
<p>Cluster 1 Total Plays (147460) Backgammon (87554) Scramble (16291) Plakoto (13795) Moultezim (10445) Hypergammon (9447) Nackgammon (4269) Deadgammon (2325) Lingo (1729) Grandgammon (1605)</p>	<p>Backgammon variants and word games. I found it surprising that the algorithm lumped these two together...</p>
<p>Cluster 2 Total Plays (28694) Othello (4258) Go (3895) Pente (3417) TwixT (2490) LoA (2476)</p>	<p>Most of these are established abstract games with a long history.</p>

<p>Hex (2156) Amazons (2063) Wari (1560) Havannah (890) Gomoku (790) Phutball (645) Draughts (615) Hexxagon (606) Hexade (533) Dama (432) Epaminondas (426) NMM (389) Connect4x4 (383) FireAndIce (355) Emergo (315)</p>	
<p>Cluster 3 Total Plays (23617) Renju (22461) Ninuki (1039) S-Pente (117)</p>	<p>Renju (RenjuNet)] has a significant fan base all its own. It is the professional version of the game gomoku (five in a row).</p>
<p>Cluster 4 Total Plays (14965) Trax (7864) Conhex (1597) Quoridor (1366) Gonnect (1270) Druid (966) Akron (622) Unlur (574) Stymie (321) Oust (126) Crossway (94) Jungle (83) Batalo (82)</p>	
<p>Cluster 5 Total Plays (8491) Chess (4003) DarkChess (1366) OmegaChess (973) DoubleChess (646) ProgressiveChess (342) QuickChess (327) RennChess (237) AvalancheChess (129) Chex (123) Amoeba (100) Bughouse (90)</p>	<p>Chess and its variants...</p>

GrandChess (87) Capablanca (68)	
Cluster 6 Total Plays (6852) Zertz (2629) Zertz+11 (971) Yinsh (817) Tzaar (716) Dvonn (711) Punct (543) Gipf (393) Tamsk (72)	Project GIPF
Cluster 7 Total Plays (6544) Mambo (850) Yavalath (595) Y (481) Margo (472) Mutton (419) Halves (364) Holo (355) Lambo (243) Dragons (218) Chameleon (180) Palago (171) Forms (164) Chroma (150) Che (149) Limit (134) Osbo (130) Thoughtwave (127) Antipod (110) Boche (109) Jade (106) Gates (105) Mono (105) Orbit (86) Sonar (81) Dna (80) Cross (73) Trichet (68) Star (64) Ndengrod (63) Blobs (62) Visavis (61) Trilbert (61) TimeVectors (56)	Many games by Cameron Browne.

Malaka (52)	
Cluster 8 Total Plays (6040) ToW (1203) Abalone (660) ROthello (420) ChineseCheckers (395) Ataxx (391) K-Pente (380) Neutron (366) Tanbo (352) Connect4 (349) Gravity (261) Checkers (244) Susan (239) Rings (195) Plotto (193) Hexbo (178) Connectris (125) MaxCheckers (89)	
Cluster 9 Total Plays (5439) Yacht (2670) Warship (1385) CooperYoung (785) Toot (402) Sudoku (115) Chaos (82)	
Cluster 10 Total Plays (4609) Wizard (1682) Perudo (1177) MHearts (524) Cathedral (489) Spades (312) Blackout (169) WarpAndWeft (91) Conway (83) Hive (82)	This includes many of the card games although it mixes in pure abstracts such as Cathedral.
Cluster 11 Total Plays (3731) Shogi (1696) ChuShogi (1036) TenjikuShogi (566) Xiangqi (433)	Shogi and most of its variants (although Minishogi has a cluster of its own).
Cluster 12 Total Plays (3204)	

CoNeutron (1948) Robots (1197) Koan (59)	
Cluster 13 Total Plays (2452) Fanorona (376) Powerdrain (332) Alak (246) Socolot (228) Blackbox (224) Breakthrough (219) Psycho (209) NCBackgammon (162) Stack (111) Tumble (107) Pitch (102) Survival (76) Focus (60)	Many of these are the games of Doug Zander
Cluster 14 Total Plays (2434) Dots (816) Spangles (657) Andantino (387) Oddthello (129) Quadrature (122) Plotto5 (108) Entropy (82) Connexions (77) Qubic (56)	
Cluster 15 Total Plays (1517) Octi (615) OctiLite (330) RazzledazzleX (311) Octi3base (183) Razzledazzle (78)	
Cluster 16 Total Plays (911) Stratego (261) Hnefatafl (213) DoubleMoveChess (209) Trinim (176) Borderline (52)	
Cluster 17 Total Plays (416) Reversi (144) Majorities (86)	

Projex (66) Quadrex (62) LoopTrax (58)	
Cluster 18 Total Plays (223) Onyx (147) Accasta (76)	
Cluster 19 Total Plays (152) Terrace6x6 (89) Terrace (63)	
Cluster 20 Total Plays (104) MiniShogi (104)	

Further Exploration

There were several facets of gameplay that were not explored by this analysis. For one thing, the popularity measure was only conducted using the metric of games completed. The data contained in addition the ratings (see <http://www.gamerz.net/pbmserv/ratings.html>). This information could potentially be used as a different source of information, although it would probably be necessary to restrict to “established” players, i.e., those with at least twenty games played, as ratings tend to be highly noisy before that point.

One different problem that has occurred to me is whether one can determine from a ratings distribution the relative degree of skill in a game or decide whether there are tiers of players. Elwyn Berlekamp distinguishes levels of knowledge that characterize played of Dots and Boxes based on specific revelations. It has been my experience that Zèrtz exhibits a similar phenomenon, especially since on the smaller board it is possible to lose the game on the first move against a knowledgeable opponent.

Another factor not taken into consideration was the length of time games had been available on the server. This obviously gave a bias towards games that had been around longer. For newer games there is a recently implemented “history” command, which is more granular than the “ratings” command used here. It would have helped take that into account.

Lastly, games take differing lengths of time, which means that number of games is not necessarily the best metric to use. Time spent playing may be a better metric or number of moves played.

Conclusion

This concludes the exploration of Gamerz. The list of games is large and grows larger and larger over time as long as there are individuals willing to extend it.

Acknowledgements

The author would like to thank the developers who participate in building and extending Gamerz and in particular: Cameron Browne, Jonathan Bush, John Williams, and Doug Zander, whose comments led to great improvements in this paper. Most of all, the author would like to thank Richard Rognlie for giving me in his words many happy opportunities to reduce my productivity.

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