Games Research Today: Analyzing the Academic Landscape 2000-2014

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ABSTRACT
In this paper we present an analysis of the academic landscape of games research from the last 15 years. We employed a data driven approach utilizing co-word and co-venue analysis on 48 core venues to identify 20 major research themes and 7 distinct communities, with a total of 8,207 articles and 21,552 unique keywords being analyzed. Strategic diagrams and network maps are applied to visualize and further understand interrelationships and underlying trends within the field.

Categories and Subject Descriptors
K.2. [**History of Computing**]: Theory, People

General Terms
Theory

Keywords
Games research; bibliometric study; co-word analysis; co-venue analysis

1. INTRODUCTION
Since the turn of the century, games research has both become an established domain of study and broadly diversified the range of topics explored under the heading of "games". While this expansion can be viewed positively for the field as a whole, the large number of venues and topics can become overwhelming for researchers trying to understand where their work best fits and should be published. Some studies have tried to reduce this confusion by identifying paradigms of games research with respect to particular domains and venues [9, 15, 24], but little has been done to investigate the field as a whole.

In the absence of data analysis, there has been an anecdotal understanding among some game researchers—such as with [3, 4]—that there are two overarching communities within the field, one with research focused on technical approaches to understanding and developing games (e.g. artificial intelligence, computational modeling, visualization, graphics research, etc.) and another addressing non-technical aspects of games with a range of research approaches from the humanities, arts, design, and social sciences (e.g., narrative, user experience, virtual worlds, role play, design, philosophy, etc.). However, a clear analysis of the interrelations and synergies among sub-communities and research themes that comprise the current academic landscape remains undocumented. In this paper, we present our efforts at mapping the topology of games research from the first part of this century.

We collected and analyzed publications from 48 core publication venues of games research from the years 2000 through 2014. Our analysis utilizes co-occurrence methods and community detection techniques to provide a comprehensive overview of the field. With co-word analysis we identified 20 distinct research themes, and through co-venue analysis we also determined 7 communities for these themes. We also note conferences and journals that act as bridges between communities. Results are visualized using co-occurrence analysis artifacts such as strategic diagrams and keyword network maps. Finally, we conclude with a discussion of the current state of the games research field.

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2. RELATED WORK
While our work is among the first of its kind targeting the games research community as a whole, there has been similar work tracing the progress of other research fields such as Human Computer Interaction [17], ubiquitous computing [18], library and information science [11, 14, 16, 25], consumer behavior [19], software engineering [10], biology [1, 8], and education [21]. Drawing from this past work, we use popular techniques such as co-word analysis to examine the current academic landscape of the games research field.

2.1 Co-word and Co-venue analysis
Co-word analysis is a widely used bibliometric approach that identifies interactions and hierarchies among problems, concepts, and ideas in a network [6, 7]. It builds upon the assumption that an article's keywords provide a summary of its content, and thus can be utilized to reduce a large space of descriptors (i.e., article text) to a network graph of smaller related spaces (i.e. keywords) [8]. Keywords are associated with a paper, and two keywords associated with the same paper are connected to form a network graph of keywords. The co-word network can then be analyzed for clusters to identify a set of closely related themes [18]. A similar approach can be used for co-venue analysis where venues are associated with authors, and two venues where the same author has published are linked to form a network graph of venues. A co-venue network can be analyzed for clusters to identify a set of closely related venues, or communities. This approach visualizes the interrelated concepts and is easier to understand while maintaining vital information necessary for analysis [10].

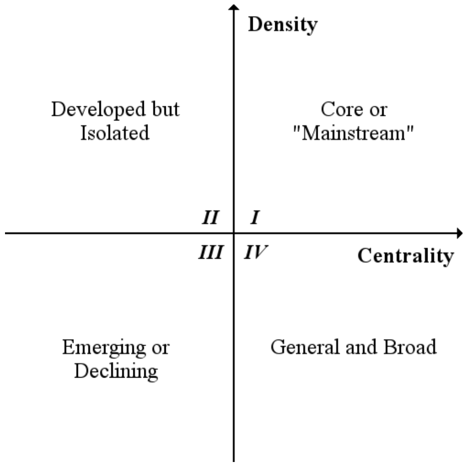

Figure 1. Strategic diagram characterizations based upon density and centrality.

Ultimately, network analysis can be used on network graphs to describe a field of research. It segments the graph into clusters of nodes, and each cluster corresponds to a research theme or community within the field. Depending on how nodes and clusters are linked (e.g., co-word, co-author, co-venue, etc.), different network characteristics can be utilized to describe a research field in vastly different ways [17]. The network characteristics we are concerned with in our analysis are:

- Centrality: the degree of interaction a cluster has with other parts of the network [18]. It essentially measures the strength of the links from one research theme or community to other research themes or communities, and is an indicator of the significance of a theme or community in the development of an entire field [19]. As a cluster obtains more strong links in a network, the more central it's position becomes [20].
- Density: the measurement of a cluster's development [19]. It can be understood as the strength of all internal ties (edges) linking together nodes that make up a theme or community [13]. Density provides a good representation of a cluster's ability to maintain itself and grow over time [6]. As a cluster increases in density, the more coherent it becomes and the more likely it is to contain inseparable nodes [18].
- Bridges: bridges between two nodes provides communication and facilitates flow among otherwise isolated regions of the network [17, 20].

Utilizing centrality and density, a strategic diagram can be created to better visualize and understand the maturity and cohesion of network clusters [14]. Strategic diagrams have been used widely in previous co-word analysis work [1, 14, 16–19, 25] where the density and centrality of clusters are plotted on a two-dimensional grid. The x-axis of the grid shows how strongly a cluster is connected to others and the y-axis shows a cluster's development.

A cluster's location within a strategic diagram characterizes it in the context of the whole discipline [6] (Figure 1). In quadrant I, clusters are both coherent and central to the field as a whole. These mainstream clusters represent the focus of a large portion of the network. While clusters in quadrant II are also coherent, they tend to be specialized and separate from the overall focus. Clusters in quadrant III are in flux, representing emerging or declining portions of the network. Finally, quadrant IV contains clusters that represent a common, broad focus or have not yet matured but have the potential to be a primary network focus.

Table 1. Expert generated list of core games research journals.

Journal
Computers in Entertainment (**CIE**)
Eludamos. Journal for Computer Game Culture (**Eludamos**)
Entertainment Computing
Game Studies
GAME The Italian Journal of Game Studies (**G|A|M|E**)
Games and Culture (**G & C**)
IEEE Transactions on Computational Intelligence and AI in Games (**TCIAIG**)
International Computer Games Association Journal (**ICGA**)
International Digital Media and Arts Association (**iDMAa**)
International Journal of Arts and Technology (**IJART**)
International Journal of Computer Games Technology (**IJCGT**)
International Journal of Game-Based Learning (**IJGBL**)
International Journal of Gaming and Computer-Mediated Simulations (**IJGCMS**)
International Journal of Role-Playing (**IJRP**)
International Journal of Serious Games (**IJSG**)
Journal of Game Design and Development Education (**JGDDE**)
Journal of Game Development (**JOGD**)
Journal of Gaming & Virtual Worlds (**JGVW**)
Journal of Virtual Worlds Research (**JVWR**)
Simulation & Gaming (**S&G**)
The Computer Games Journal (**TCGJ**)
Well Played

3. DATA

To understand different games research communities, we obtained meta-data of research papers in a set of core publication venues vetted by field experts. The meta-data contains titles, authors, published venues, keywords, and citations. This allows us to establish relationships between papers and within communities.

3.1 Core Venue Identification

The first step in the data collection process was identifying core games research venues. Having consulted with leading researchers among major game research groups in the US—such as UCSC, NCSU, NYU, and NEU—we identified 21 core games research journals (Table 1) and 27 core games research conferences (Table 2) that researchers often publish in and refer to for new games research.

Since our data collection is done using electronic means, we do not account for venues that do not publish their papers in dedicated online proceedings. We feel this exclusion is reasonable since modern games research is conducted via electronic medium. In fact, almost all of games research venues release their articles, or at least the meta-data, online. We also excluded major interdisciplinary venues that have published games research related papers—such as AAAI, SIGCHI and SIGGRAPH—since their primary focus is not games research itself and the core games research venues primarily cover the same topics. This exclusion is acceptable according to Bradford's law of scattering [5] since a relatively small core of venues will account for as much as 90% of the literature while attempts to gather 100% will add venues and articles at an exponential rate [12].

Table 2. Expert generated list of core research conferences.

Conference
AAAI Spring Symposium on AI and Interactive Entertainment (**AAAISAIIE**)
ACM SIGRAPH Sandbox Symposium (**Sandbox**)
Advances in Computer Entertainment Technology (**ACE**)
Artificial Intelligence and Interactive Digital Entertainment (**AIIDE**)
Computational Intelligence and Games (**CIG**)
Digital Games Research Association Conference (**DIGRA**)
European Conference on Games Based Learning (**ECGBL**)
Foundations of Digital Games (**FDG**)
Future Play
Games Learning Society (**GLS**)
Gamification
Intelligent Narrative Technologies Workshop (**INT**)
Intelligent Technologies for Interactive Entertainment (**INTETAIN**)
International Computer Games Conference (**CGAMES**)
International Conference on E-Learning and Games (**Edutainment**)
International Conference on Entertainment Computing (**ICEC**)
International Conference on Interactive Digital Storytelling (**ICIDS**)
International Conference on Virtual Storytelling (**ICVS**)
International Games Innovation Conference (**IGIC**)
International Simulation and Gaming Association Conference (**ISAGA**)
Meaningful Play
Serious Games Development and Applications (**SGDA**)
Technologies for Interactive Digital Storytelling and Entertainment (**TIDSE**)
The Philosophy of Computer Games
Under the Mask
Workshop on Network and Systems Support for Games (**NetGames**)

3.2 Collection and Completeness Verification

We contacted publishers of each venue for approval to batch download articles from their repositories, and used a data crawler to automate the collection process. However, for some venues publications are only stored in PDF format. In such cases, we hand-collected articles and used scripts to convert them into text before running an additional script to extract meta-data.

In order to confirm the completeness of our collection process, we conducted a verification step that randomly selects two papers from each venue and checks for their existence in our database. To make sure that the random selection is fair, for each venue, we use the following retrieval URL to obtain the list of papers:

```
https://scholar.google.com/scholar?as_public
ation=<venue_name>&as_ylo=2000&as_yhi=2014
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The value "<venue_name>" above is replaced by the names of the venues, such as DIGRA, FDG, etc. The first two entries in the retrieved list for each venue are used in our test set, and the verification process shows that we have collected 86.17% of the articles from our core games research venues.

3.3 Cleaning the Data

The data set collected originally suffered from entry duplication and articles that were prematurely reported or not peer-reviewed, such as extended abstracts, abstracts only, and panels. These articles were detected and removed. Another issue was the appearance of editors' names in the co-author list of papers. In particular, some online repositories show editors' names alongside with authors, which caused inconsistencies when batch downloaded. Potential editors in the data were identified by having more than 5 publications in a year. We then verified whether the potential editors were actually editors or instead authors and removed them accordingly. After the data was cleaned, we were left with 8,207 papers from the games research field in the last 15 years.

3.4 Keyword Generation

Over a third of the papers in the dataset we collected did not originally contain keyword information. This was due to incomplete data sources or lack of keywords in the original publication. Since keywords are essential pieces of information to connect papers in the same research community (and vital for our co-word analysis), we implemented an algorithm to generate keywords from paper titles and abstracts. Below are the steps for each paper missing keywords:

1. Create *a keyword candidate pool* of existing keywords from the papers in the database.
2. Create a *2-gram candidate pool* by extracting 2-grams from titles and abstracts of all papers in the database.
3. Manually screen out inappropriate 1- and 2-grams which are either meaningless or semantically too general to be good keywords, such as "recent years" or "considerable amount".
4. Split titles and abstracts into phrases. Treat the phrases as keywords if they already exist in the keyword candidate pool.
5. For papers with less than 3 phrases set as keywords, the valid 2-grams from their titles and abstracts are set as keywords.

Our justifications for the above generation steps are as follows:

1. Existing keywords cover N-grams well, for $N \leq 2$.
2. 1-grams include too many frequently used words, which are generally not very useful. (e.g., "Game", "Player", etc.).
3. Keywords are rarely long phrases, thus N-grams where $N \geq 3$ are unlikely to be keywords.

This process automatically generates and tags keywords for most papers without keywords in our database, however it still leaves about 50 papers without any appropriate keywords. We asked the researchers from our venue identification task to identify keywords for these papers based on domain knowledge.

We would also like to note that Rake [22] is one of the widely used algorithms for keyword generation. However, since the algorithm adopts a scoring scheme that linearly combines the scores of word pairs in candidate keywords, it tends to return high scores for long phrases even though the frequency of such phrases appearing altogether within one context is low. This led us to use the modified algorithm above which is based on Rake.

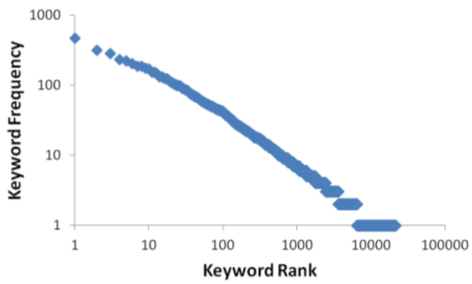

Figure 2. Power-law distribution of keyword frequency with logarithmic scale. Power-law distributions should appear similar to a straight line when using a logarithmic scale.

4. ANALYSIS AND RESULTS

4.1 Research Themes from Co-Word Analysis

To improve accuracy of the co-word analysis, we manually standardized keywords with a frequency greater than 10 through synonym mergence (e.g., "MMOG" and "Massively Multiplayer Online Game") and plurality mergence (e.g., "Educational Game" and "Educational Games"). As a result, from the 8,207 articles collected, a total of 21,552 unique keywords were identified with frequencies up to 466.

The frequency of keywords in the last 15 years of games research follows a power-law distribution with an alpha of 2.28 and R^2 of 0.92 (Figure 2). This indicates a scale-free network structure where a small number of popular nodes (i.e., keywords) act as hubs connecting other concepts; these hubs in turn shape the network reflecting the overall intellectual structure of games research through keywords [17]. The scale-free property of the network also suggests that major research themes and influences can be detected using a small subset of the most popular keywords [25]. We therefore selected keywords that appeared more than 18 times in the dataset, covering 25% of the total keyword frequency. This resulted in the 264 most frequent keywords for co-word analysis (Figure 3).

We then constructed a weighted co-word network graph where each keyword is represented by a node and an edge of weight n is added between keywords that appeared together on n papers. Research themes were determined using Blondel et al's community detection algorithm on the network [2]. A total of 20 clusters (research themes) were detected from the 264 most frequent keywords (Table 3).

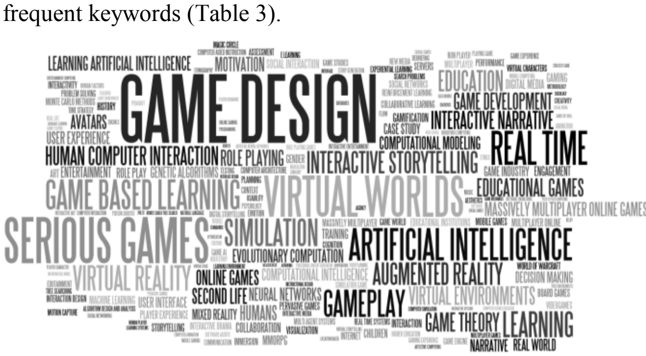

Figure 3. Keyword cloud visualizing the 264 most frequent keywords used in games research papers

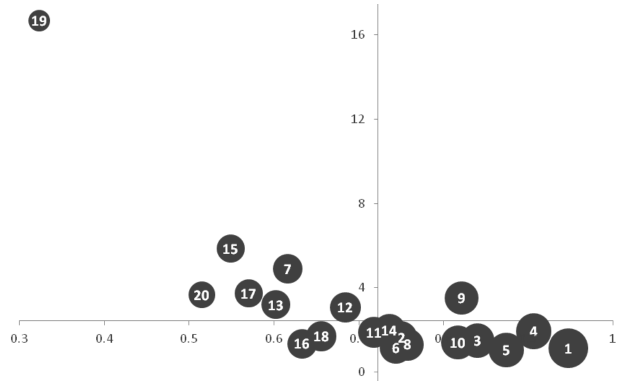

Figure 4. Strategic diagram for games research themes.

For each research theme, Table 3 shows:

- Keywords: the 10 most frequent keywords that constitute the theme. The three most frequent keywords are shown in bold and summarize the general topics of the theme.
- Size: the total number of keywords encompassing the theme.
- Frequency: how often a keyword from this theme will occur on average.
- Centrality: the strength of a theme's interaction with other themes [13]. A localized version of this metric is calculated using a K-step reach of 2.
- Density: the strength of the links tying together keywords within a theme (i.e., internal cohesion) [13].

Based on cluster centrality and density of the 20 themes in Table 3, we constructed a strategic diagram to visualize the maturity and cohesion of each theme (Figure 4). The origin of the diagram is set to the average cluster centrality and density (i.e., 0.7229, 2.4245). C19 was excluded from the calculations since its values were a large enough outlier to notably skew the averages.

Finally, to better understand and visualize the interactions between games research themes in Table 3, we created a granular network map of keywords [17, 18] (Figure 5). In the network map, each keyword is represented as a node and keywords that appear on the same paper are linked together. The size of a node in the figure is proportional to the frequency of the keyword and nodes of the same color belong to the same theme. To reduce visual clutter, only the two most frequent keywords from each research theme are used while links between keywords are shown if their correlation coefficient is above 0.33. A downside of this visual reduction is that the exclusion of weaker links can cause clustered nodes to appear disconnected. For instance, "Interactive Narrative" and "Interactive Storytelling" in Figure 5 appear separated, however this is not the case. It is simply because multiple weaker links between the two are not included.

Table 3. Major themes in games research. The cluster ID, top keywords, size (S), frequency (F), centrality (C), and density (D).

ID	10 Most Frequent Keywords	Size	F	C	D
T1	**Game Design**, **Serious Games**, **Game Based Learning**, Educational Games, Game Development, Motivation, Case Study, Engagement, Gamification, Collaborative Learning	38	67.74	0.947	1.138
T2	**Interactive Storytelling**, **Interactive Narrative**, **Role Playing**, Real World, Multiplayer Online, Massively Multiplayer, Interactive Drama, Game World, Non Player, Digital Storytelling	24	47.88	0.750	1.641
T3	**Real Time**, **Virtual Reality**, **Virtual Environments**, Virtual Characters, Game Engine, Motion Capture, Time Strategy, Animation, Virtual Storytelling, Computer Animation	20	51.00	0.840	1.500
T4	**Virtual Words**, **Massively Multiplayer Online Games**, **Second Life**, Online Games, Avatars, Social Interaction, Gender, Multiplayer, World of Warcraft, Ethnography	20	63.30	0.906	1.942
T5	**Gameplay**, **User Experience**, **Entertainment**, Player Experience, Immersion, Usability, Flow, Interface, Ludology, Game Environment	18	43.11	0.874	1.059
T6	**Narrative**, **Art**, **Interactivity**, Emotion, Aesthetics, Music, Agency, Interactive Art, Affective Computing, Interactive Systems	14	37.57	0.744	1.154
T7	**Game Theory**, **Evolutionary Computation**, **Computational Intelligence**, Genetic Algorithms, Search Problems, Standards, Optimization, Trees Mathematics, Mathematical Model, Statistics	14	45.01	0.616	4.901
T8	**Augmented Reality**, **Mixed Reality**, **User Interface**, Pervasive Games, Mobile Games, Magic Circle, Mobile, Ubiquitous Computing, Mobile Gaming, Location Based	13	50.23	0.757	1.321
T9	**Artificial Intelligence**, **Decision Making**, **Planning**, Context, Cognition, Game AI, Multi-Agent Systems, Real-Time Systems, Human Player, Measurement	12	54.75	0.821	3.515
T10	**Human Computer Interaction**, **Digital Media**, **Interaction Design**, New Media, Psychology, Interactive Media, Human Factors, Interface Design, Level Design, Gesture Recognition	12	42.92	0.817	1.409
T11	**Simulation**, **Role Play**, **History**, Experiential Learning, Cooperation, Representation, Modeling, Negotiation, Participation, Simulation Gaming	12	48.17	0.718	1.894
T12	**Learning Artificial Intelligence**, **Training**, **Machine Learning**, Reinforcement Learning, Learning Systems, Game Playing, Data Mining, Sport, Predictive Models, Feature Extraction	11	39.18	0.684	3.073
T13	**Servers**, **Internet**, **Computer Architecture**, Mobile Computing, Delay, Peer to Peer Computing, Media, Tiles, Cloud Computing, Scalability	10	31.50	0.602	3.200
T14	**Learning**, **Education**, **Children**, Storytelling, Creativity, Teaching, Reflection, Tangible Interfaces, Educational Technology, Survey	10	59.10	0.736	2.000
T15	**Humans**, **Neural Networks**, **Software Agents**, Testing, Navigation, Computer Simulation, Artificial Neural Networks, Games of Skill, Robots	9	44.56	0.549	5.861
T16	**Interaction**, **Communication**, **Role Playing Games**, Player Behavior, Content Creation, Personality, Fun, Multi-Touch	8	29.88	0.633	1.357
T17	**Educational Institutions**, **Computer Aided Instruction**, **Software Engineering**, Software, Computer Science Education, Technological Innovation	6	31.17	0.570	3.733
T18	**Collaboration**, **Board Games**, **Social Networks**, Multiplayer Games, Social Media	5	46.20	0.656	1.700
T19	**Monte Carlo Methods**, **Tree Searching**, **Algorithm Design and Analysis**, Monte Carlo Tree Search	4	38.00	0.323	16.667
T20	**Computational Modeling**, **Visualization**, **Engines**, Databases	4	50.00	0.515	3.667

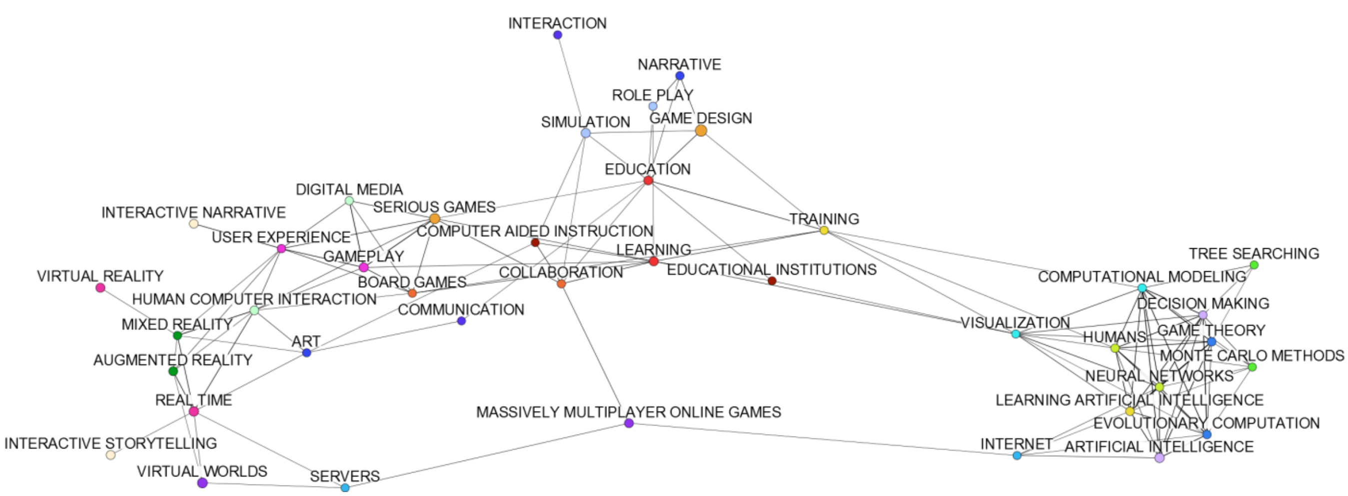

Figure 5. Keyword network map (line represents link between two keywords with Pearson correlation coefficient ≥ 0.34).

4.2 Communities from Co-Venue Analysis

Using a similar approach to our co-word analysis, we constructed a weighted co-venue network graph where each venue is represented by a node and an edge of weight n is added between venues that had n authors publish in both venues. Communities were again determined using Blondel et al's community detection algorithm on the network, and a total of 7 clusters (research communities) were detected from the 48 venues (Table 4). In addition to the most frequent keywords, centrality, and density of each research community, Table 4 also shows venues that comprise each community. Venues are ordered from greatest to least by the total number of unique authors that have published at that venue.

We also wanted to see which venues were most likely bridges between communities. As a result, we calculated the betweenness centrality for all venues in the network since nodes with high betweenness centrality play a role as bridges between other portions of the network [16]. The venue with the highest betweenness centrality for each community is shown in bold. We then constructed a strategic diagram to visualize the maturity and cohesion of each research community (Figure 6). The origin of the diagram is set to the average centrality and density of the communities from Table 4 (i.e., 0.9393, 17.5656).

Lastly, to better understand and visualize the interaction between games research communities, we constructed a granular network map of venues (Figure 7). In the network map, each venue is represented as a node in the graph and venues that have had the same author publish are linked together. The size of a node in the figure is proportional to its degree and nodes of the same color belong to the same theme. To reduce visual clutter, only four venues with the highest number of authors from each research theme are used while links between venues are shown if their correlation coefficient is above 0.33. Again, this visual reduction has the same downsides as the visual reduction used for the keyword network map.

Table 4. Communities in games research. Cluster ID, conferences, keywords, centrality (C), and density (D) are shown.

ID	Conferences	5 Most Frequent Keywords	C	D
C1	**DIGRA**, S & G, JVWR, G & C, iDMAa, The Philosophy of Computer Games, JGVW, Game Studies, Eludamos, Under the Mask, ISAGA, G|A|M|E, IJRP	**Virtual Worlds**, **Simulation**, **Game Design**, Second Life, Role Playing	0.971	6.744
C2	ACE, **ICEC**, Edutainment, CIE, Intetain, Entertainment Computing, IJCGT, NetGames	**Augmented Reality**, **Real Time**, **Virtual Reality**, Game Design, Virtual Environments	0.975	37.786
C3	IJART, Sandbox, IGIC, **FuturePlay**, CGames, Gamification, JGDDE	**Game Design**, **Serious Games**, **Education**, Computer Aided Instruction, Human Computer Interaction	0.976	4.762
C4	CIG, AIIDE, **FDG**, TCIAIG, ICGA, INT	**Artificial Intelligence**, **Game Theory**, **Humans**, Evolutionary Computation, Computational Intelligence	0.976	27.933
C5	**ICIDS**, ICVS, TIDSE, AAAISAIIE, JOGD	**Interactive Storytelling**, **Interactive Narrative**, **Real Time**, Interactive Drama, Digital Storytelling	0.884	15.300
C6	**GLS**, Meaningful Play, IJGCMS, TCGJ, Well Played	**Game Design**, **Gameplay**, **Educational Games**, Real World, Case Study	0.907	9.100
C7	ECGBL, **IJGBL**, SGDA, IJSG	**Game Based Learning**, **Serious Games**, **Game Design**, Learning, Educational Games, Education, Assessment	0.886	21.334

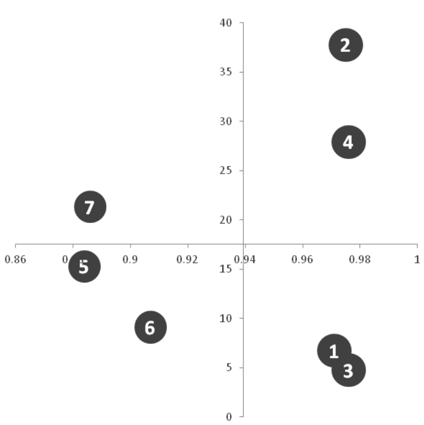

Figure 6. Strategic diagram for games research communities.

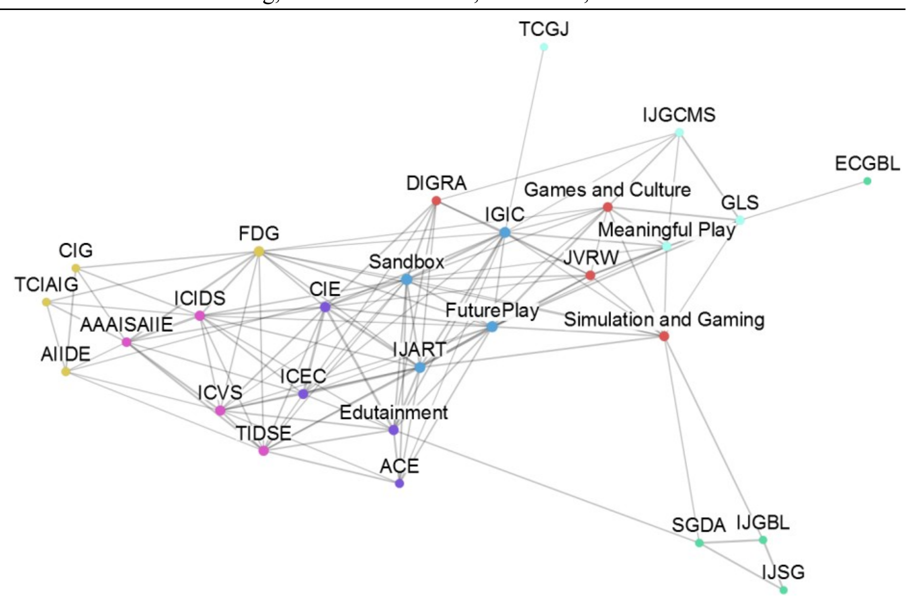

Figure 7. Venue network map (line represents link between two venues with Pearson correlation coefficient ≥ 0.34).

5. DISCUSSION

We took a data driven approach, using co-occurrence of keywords and venues to identify major research themes and communities in the last 15 years, and to understand how these communities and themes interact. This data driven approach circumvents the pitfalls of subjectively or intuitively trying to map the field, using research that has been conducted and published as the basis for analysis. Ultimately, while previous work has been focused on specific communities and paradigms within games research, our work provides a big picture overview of the landscape to offer insights on common researcher questions such as to which communities, themes, and venues their work applies and where they should publish.

5.1 Connecting the Overarching Communities

Our results appear to support anecdotal evidence for the separation of research with a technical focus (clustered around the right side of Figure 5, and in the top left quadrant of Figure 4—e.g., Artificial Intelligence, Decision Making, Neural Networks, etc.) from other games research topics. Similarly, technically focused communities and venues in Figure 7 fall more towards the left side (e.g., venues clustered in C4 and C5—see Table 4) while less technically focused ones fall more towards the right (e.g., C6 and C1). The two venues often anecdotally cited as the larger umbrella conferences—FDG and DiGRA—fall near the center of the venue network map (Figure 7) as we would expect, with FDG left of center indicating a greater presence of technical papers.

The data also shows that education has established itself as one of the central research topics within the games research field, with keywords such as “Serious Games”, “Game Based Learning”, “Education”, “Educational Games”, "Computer Aided Instruction", "Collaborative Learning", etc. relating to many different research themes (T1, T11, T14, T17) and communities (C3, C6, C7) at different levels of development—as illustrated in the strategic diagrams for Figures 4 & 6. Education related keywords such as serious games or game based learning are also among the most frequently used keywords and make up the largest cluster (T1) in the network.

5.2 Too Many Venues?

One recent debate that has appeared on the Digital Games Research Association Gamesnetwork mailing list is the question of whether there are too many venues for games research [4]. Forty-eight core games research venues is a large number for a relatively young field and we have noted a comparatively small number of major communities in Table 4. However, there is a large number of research themes in Table 3, suggesting that many small and emerging sub-communities are encompassed within the larger ones presented here. Additionally, the strategic diagram in Figure 4 suggests that the games research field is still rapidly evolving since many themes and corresponding sub-communities are still isolated from the field (e.g., Monte Carlo methods in T19) or have the potential to become a primary focus of games research (e.g., augmented reality in T8). We hope that our presentation of communities and trends through this paper can provide data-driven insights that might inform the conversation about venues.

5.3 Where Should I Publish?

For many researchers, the large number of venues raises the question of appropriate locations to publish their work. This depends largely on what communities and themes their research best matches and the interdisciplinary nature of their work. The venue network map in Figure 7 illustrates the layout and strong connections between venues and communities. Venues and communities that are more central to the network tend to cover a wider range of research and accept more interdisciplinary work, while more peripheral venues and communities tend to be focused on specific research themes. Therefore, the more interdisciplinary a researcher's work is among communities in Table 4, the more beneficial a venue with high betweenness centrality (more central to the network in Figure 7) from one of the related communities is. Conversely, research that is very focused within a specific community may benefit from more peripheral venues within that community. For instance, FDG in C4 might be a better venue for submissions of AI work making use of narrative theory while CIG in C4 would likely be a better venue for submissions of focused AI work using neural networks in games.

Notably, the clustering of venues is not as focused with respect to research themes since there are many venues that publish interdisciplinary work, spanning a diverse range of topics. Looking at the strategic diagram in Figure 6 and corresponding communities in Table 4, a distinction between the breadth of venues can be understood. For instance, between the two larger umbrella conferences in Figure 6, FDG (C4) is shown to be more focused and mainstream than DiGRA (C1). Considering FDG tends to have a stronger technical focus while DiGRA is more broad, this distinction seems appropriate.

6. LIMITATIONS AND FUTURE WORK

One of the main limitations of this study is that it does not account for games research works published in non-core venues—such as AAAI, SIGCHI, CogSci, and SIGGRAPH—since it is difficult to auto-detect games research papers published in these venues and existing methods to do so vary greatly in their success. Additionally, accounting for papers in non-core but known games research venues does not solve the general challenge of collecting all games research papers. There are other interdisciplinary venues that occasionally publish games papers and tracking every single one of these venues and papers would be infeasible. However, we do feel these exclusions are reasonable considering Bradford's law of scattering, which demonstrates that almost all of a community's literature can be accounted for using a small set of core of venues.

Another limitation to note is that our co-venue analysis cannot determine the impact of a particular venue within its community or the games research field as a whole. This is because (on top of being subjective) many other factors contribute to the clout of a venue besides its centrality, connectedness, or size. As a result, the collection of additional meta-data for analysis—such as acceptance rates—would be necessary.

Lastly, a limitation and direction for our future work is the lack of an analysis of the evolution of the field. While our analysis presented here provides a strong overall look at the current state of the field over the past 15 years, the subtle nuances of how and when communities have emerged, grown, merged, and declined is difficult to grasp using just co-word analysis. We have begun analyzing the co-evolution of the games research field using the Evo-NetClus model [23], since it is ideal for better understanding how games research has changed and what direction it might go in the future.

7. CONCLUSION

In this paper, we presented an overview of the landscape of games research over the last 15 years. Our findings identified 20 major research themes and 7 distinct sub-communities. The results validated the commonly held assumption that games research has different clusters of papers and venues for technical versus non-technical research, and identified interactions and synergies between these research clusters. We hope the data driven approach used can provide insight and aid further discussions and questions that researchers may have about the field as a whole.

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