

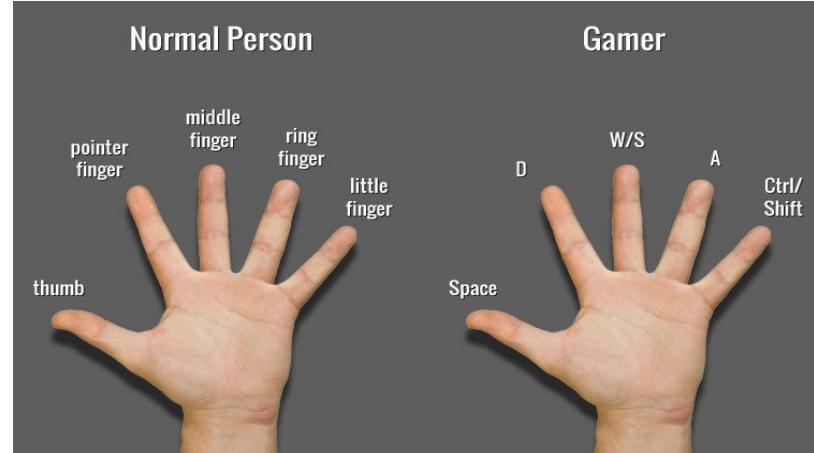
PLAY WHAT YOU LIKE!

- RAVI KIRAN SELVAM
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Recap

ONE STOP PLACE TO KNOW WHAT YOU LIKE,
WHICH WORKS FOR YOU, WHERE TO GET!

KNOWLEDGE GRAPH ABOUT VIDEO GAMES,
THEIR MINIMUM REQUIREMENTS, PURCHASE
SOURCE



Game Knowledge Graph - Overview



Key Statistics:

- 1,189,934 triples are present in the KG
- 58,606 game nodes
- 11,761 games have minimum requirements
- 17,773 games have seller and price information

Use Cases



Find Cheapest Purchase Source

Personalized Game Recommendations

Visualize Game properties and understand its distribution

Find Games supported by your System

Can My PC Run It?

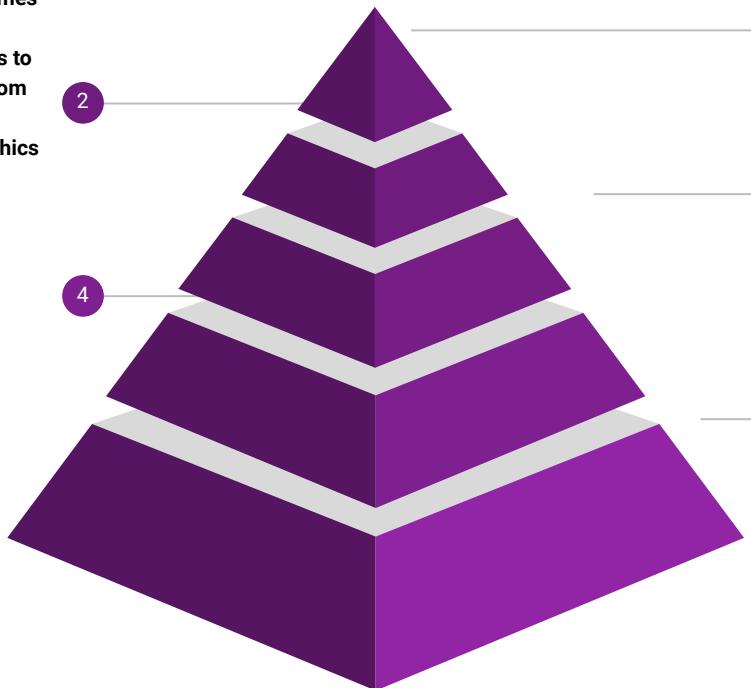
Workflow

Entity Linking

1. Link games from IGDB to games from G2A
2. Link G2A game requirements to CPU and GPU information from techpowerup
3. Link the Processor and Graphics information to Benchmark Scores

SPARQL QUERIES, Visualization

1. Based on user input, generate custom queries
2. Visualize the class properties



Crawling

1. IGDB.com - Crawl Games, Platforms, Enterprises information
2. G2A.com - Crawl information about the device requirements and game seller information
3. Techpowerup.com - Crawl CPU and GPU information

Ontology Mapping

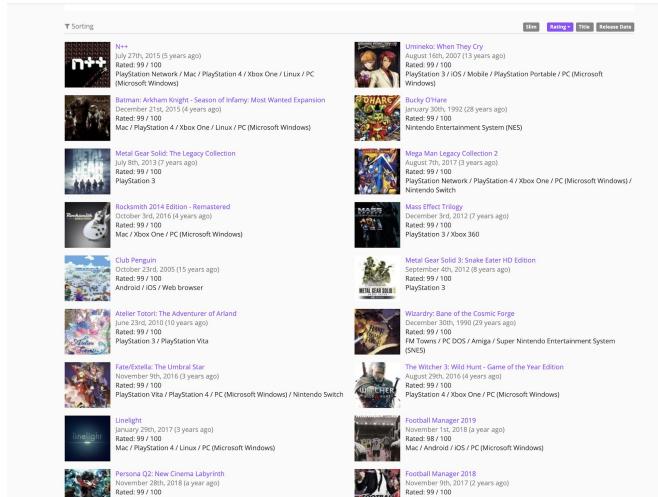
1. Define custom ontology classes and properties
2. Reuse the existing ontologies if available
3. Generate Triples

Game Recommendations

1. Filter based on highest rating
2. Filter based on the users hardware specifications
3. Use Cosine similarity between embeddings to recommend games

Crawling Challenges

Crawl Infinite Scrolling Pages



This screenshot shows a search results page for GPU components. At the top, there is a search bar labeled "Refine Search Parameters" and a "Refine Search Parameters" button. Below the search bar is a table with columns for Manufacturer, Release Date, Direct, Mobile, Verification, and GPU. The table lists various GeForce models with their specific details. A large arrow points from the search bar area down towards the table.

| Manufacturer | Release Date | Direct | Mobile | Verification | GPU |
|-----------------|------------------------|------------------|---------------|--------------|------------------|
| All | All | All | All | All | TMUs / ROPs |
| GeForce FX (26) | All | All | All | All | All |
| Memory Type | Memory Size | Memory Bus Width | Bus Interface | Slots | Power Connectors |
| All | All | All | All | All | All |
| TOP | Recommended Resolution | | | | |
| All | All | | | | |
| Sort by: | Name | | | | |
| Reset Filter | or type to Search... | | | | |

| NVIDIA | | | | | | | |
|----------------------------------|----------|----------------|------------|----------------------|-----------|--------------|-----------------------|
| Product Name | GPU Chip | Released | Bus | Memory | GPU clock | Memory clock | Shaders / TMUs / ROPs |
| GeForce FX5100 | NV34A1 | Mar 6th, 2003 | AGP 8x | 64 MB, DDR, 64 bit | 200 MHz | 166 MHz | 4 / 2 / 4 / 4 |
| GeForce FX5200 | NV34A2 | Mar 6th, 2003 | AGP 8x | 128 MB, DDR, 128 bit | 250 MHz | 200 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5200 | NV38C1 | Mar 6th, 2003 | AGP 8x | 128 MB, DDR, 128 bit | 250 MHz | 200 MHz | 2 / 0 / 4 / 2 |
| GeForce FX5200 LE | NV34A2 | Mar 17th, 2003 | AGP 8x | 128 MB, DDR, 64 bit | 250 MHz | 166 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5200 PCI | NV34B1 | Mar 6th, 2003 | PCI | 256 MB, DDR, 128 bit | 250 MHz | 200 MHz | 4 / 2 / 4 / 4 |
| GeForce FX5200 Rev.2 | NV34B1 | Mar 6th, 2003 | AGP 8x | 128 MB, DDR, 64 bit | 250 MHz | 200 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5200 Ultra | NV34A2 | Mar 6th, 2003 | AGP 8x | 128 MB, DDR, 128 bit | 325 MHz | 325 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5200 Ultra Mac Edition | NV34A2 | Mar 6th, 2003 | AGP Pro 8x | 128 MB, DDR, 128 bit | 325 MHz | 325 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5500 | NV34B1 | Mar 17th, 2004 | AGP 8x | 64 MB, DDR, 128 bit | 270 MHz | 166 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5500 PCI | NV34B1 | Mar 17th, 2004 | PCI | 256 MB, DDR, 128 bit | 270 MHz | 200 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5600 | NV31 | Mar 6th, 2005 | AGP 8x | 128 MB, DDR, 128 bit | 325 MHz | 250 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5600 Ultra | NV31 | Mar 17th, 2003 | AGP 8x | 128 MB, DDR, 128 bit | 400 MHz | 400 MHz | 4 / 1 / 4 / 4 |
| GeForce FX5600 XT | NV31 | Mar 17th, 2003 | AGP 8x | 128 MB, DDR, 128 bit | 235 MHz | 200 MHz | 4 / 2 / 4 / 4 |
| GeForce FX5600 XT PCI | NV31 | Mar 17th, 2003 | PCI | 64 MB, DDR, 128 bit | 235 MHz | 200 MHz | 4 / 2 / 4 / 4 |

Crawl Tables

Data Cleaning & Normalization

Clean GPU data and extract the Model and its number

Minimal requirements

Processor

Intel Core i5-3330 | AMD FX-4300



Graphics

NVIDIA GeForce 760 | AMD Radeon R9 270 | (2GB VRAM)

GeForce GTX 470
Radeon HD 6970

DX11 Compatible GeForce 760 or AMD HD 8800 or higher with 4GB of RAM →

GeForce 760
AMD HD 8800

Normalize Units to a common unit

Memory (GB, KB etc)



MB

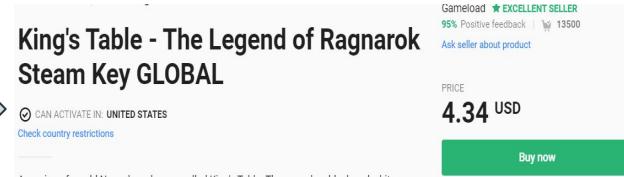
Clock Speed (MHz,
KHz, GHz etc)



MHz

ER Games - Challenges & Evaluation

G2A.com



IGDB.com

01

Total Pairwise Comparisons ->
2,037,203,166

- Blocking (trigram blocking)
- Total Comparisons after Blocking ->
3,870,531

```
mgn5_idb_games_5162,mgn5_g2a_games_with_requirements_1772,0
mgn5_idb_games_7023,mgn5_g2a_games_with_requirements_7369,0
mgn5_idb_games_9358,mgn5_g2a_games_with_requirements_9218,0
mgn5_idb_games_10408,mgn5_g2a_games_with_requirements_11529,0
mgn5_idb_games_2,mgn5_g2a_games_with_requirements_7834,0
mgn5_idb_games_99,mgn5_g2a_games_with_requirements_281,0
mgn5_idb_games_505,mgn5_g2a_games_with_requirements_5280,1
mgn5_idb_games_719,mgn5_g2a_games_with_requirements_9043,1
mgn5_idb_games_1591,mgn5_g2a_games_with_requirements_7834,0
mgn5_idb_games_334,mgn5_g2a_games_with_requirements_7448,1
mgn5_idb_games_338,mgn5_g2a_games_with_requirements_12009,1
mgn5_idb_games_340,mgn5_g2a_games_with_requirements_20431,1
mgn5_idb_games_544,mgn5_g2a_games_with_requirements_3297,0
mgn5_idb_games_2261,mgn5_g2a_games_with_requirements_4359,0
mgn5_idb_games_4,mgn5_g2a_games_with_requirements_5940,0
mgn5_idb_games_1926,mgn5_g2a_games_with_requirements_12818,0
mgn5_idb_games_3231,mgn5_g2a_games_with_requirements_26390,0
mgn5_idb_games_10643,mgn5_g2a_games_with_requirements_14946,0
mgn5_idb_games_11258,mgn5_g2a_games_with_requirements_5940,0
mgn5_idb_games_6,mgn5_g2a_games_with_requirements_1158,0
mgn5_idb_games_2781,mgn5_g2a_games_with_requirements_4146,1
```

Game ER Task - Metrics

1 Blocking Efficiency

0.001899

2 Accuracy

0.84

3 F1 Score

0.7617

ER CPUs and GPUs - Challenges & Evaluation

Minimal requirements

Processor AMD FX-6350 / Core i5 6600K

Graphics AMD Radeon HD 7850 2GB / nVidia GeForce GTX 660 2GB

Memory 8GB RAM

Disk space 50GB available space

System 64-bit Windows 7, Windows 8.1 and Windows 10

CPU Linking

GPU Linking

| | | | |
|---------|---------|---|----------------|
| FX-6350 | Vishera | 6 | 3.9 to 4.2 GHz |
|---------|---------|---|----------------|

| | | | |
|--------------|---------|---|----------------|
| Core i5-6600 | Skylake | 4 | 3.3 to 3.9 GHz |
|--------------|---------|---|----------------|

| | | | |
|----------------|----------|---------------|--------------|
| Radeon HD 7850 | Pitcairn | Mar 5th, 2012 | PCIe 3.0 x16 |
|----------------|----------|---------------|--------------|

| | | | | |
|-----------------|-------|---------------|--------------|----------------------|
| GeForce GTX 660 | GK106 | Sep 6th, 2012 | PCIe 3.0 x16 | 2 GB, GDDR5, 192 bit |
|-----------------|-------|---------------|--------------|----------------------|

G2A.com

Techpowerup.com

CPU ER Task - Metrics:

Accuracy: 0.8333333333333334

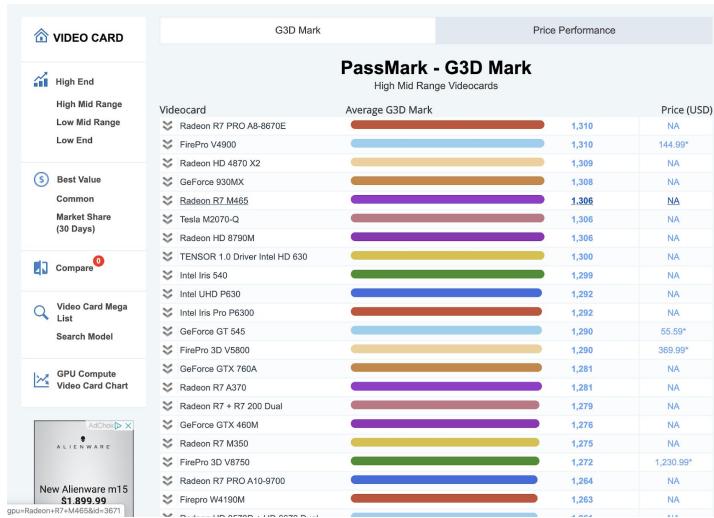
F1 Score: 0.7368421052631579

GPU ER Task - Metrics:

Accuracy: 0.8249663333333334

F1 Score: 0.7826086956521738

GPU Comparison Challenges



The more the G3D mark, the better is the performance of the GPU!

Downstream GPU comparison task
- Metrics

Problem: G3D mark is not known for all GPUs.

GPU G3D mark prediction task
- Metrics

Regression results:
R² value = 0.9244652682628763
Adjusted R² value = 0.9164942664212703

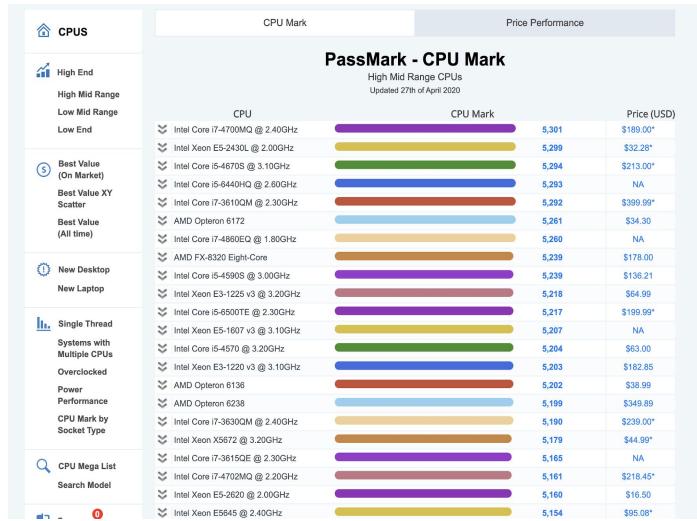
Classification results:
Precision = 0.8798842257597684
Recall = 0.9339477726574501
F1 score = 0.9061102831594635

Solution: Train a regression model and predict the G3D mark for unknown GPUs.

Most Important GPU Features: (Obtained using Random Forest Regressor)

1. Pixel Shader
2. ROPs
3. GPU Clock Speed
4. Memory Clock Speed
5. TMUs

CPU Comparison Challenges



The more the CPU mark, the better is the performance of the CPU!

Downstream CPU comparison task
- Metrics

Problem: CPU mark is not known for all CPUs. (Same problem as for GPU)

CPU mark prediction task
- Metrics

```
[ ] r2_score(y_test,y_pred_unnormalized)
```

```
0.9420142988634452
```

Accuracy: 0.9736842105263158
Recall: 1.0
Precision: 0.9444444444444444
f1 score: 0.9714285714285714

Solution: Train a regression model and predict the CPU mark for unknown CPUs.

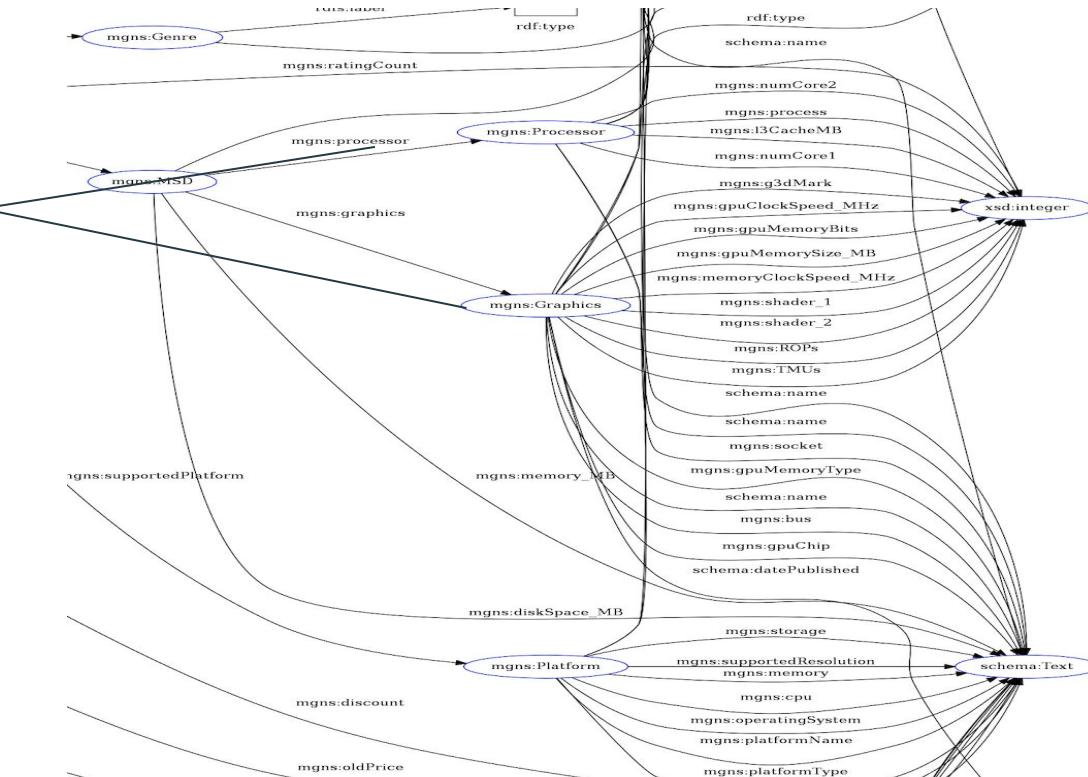
Most Important CPU Features: (Obtained using Random Forest Regressor)

1. Process
2. TDP
3. Socket
4. Number of Cores
5. Clock Speed

Ontology Mapping Challenges

Defining Custom Class Ontologies for,
• MSD
• Processor
• Graphics!

Defining Custom Properties for various classes,
• hasGenre
• hasMSD
• supportedPlatform
• ROPs and a lot more!



Game Node Embeddings

fastText

fastText pre-trained embeddings - 300 dims

Encode the sentence by averaging of the individual Word Embeddings

Game Name Embedding

Game Summary Embedding

Genre, Theme Embedding

Game Mode Embedding

0.2

0.2

0.4

0.4

Game Node Embedding

Encode the game node by weighted averaging of the individual Game Component Embeddings

Weights

Game Recommendations



1

Filter by game rating

Among all the games, filter only the games that have rating ≥ 80 .

2

Filter by device configuration

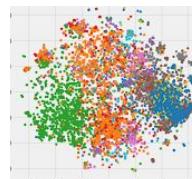
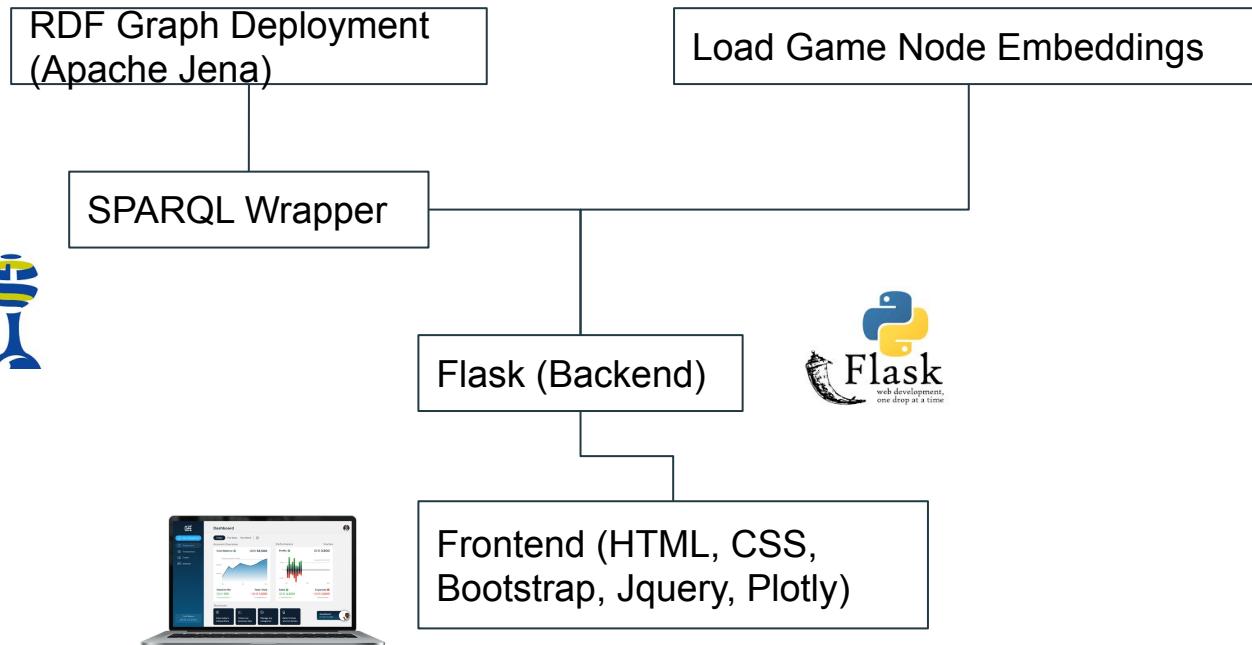
Among those games, filter only the games that can be played in the user device.

3

Rank the top-5 games

Use the Game node embeddings and compute the cosine similarity between the current game and all other games and rank them to make recommendations!

Web Application Overview



User Interface - I

Game Page

Please enter your device configuration

Available Hard Disk Space:
512 GB

Available RAM:
8 GB

Processor:
Core i3-5000

Graphics Card:
Geforce 800M

Register your device configuration!

Successfully stored the device configuration!

Search our Game and Requirements - KG

Game Name:

Released Year: 2017

Minimum Rating: 80

Supported Platforms:

Developer:

Publisher:

Seller:

Genre: Adventure

Theme:

Game Mode:

Min Price:

Max Price:

Min Discount:

Max Discount:

Show all games
 Show games supported by my device
 Show games not supported by my device

Search

User enters his device configuration

Results

| game_id | game_name | released_year | genre | rating_value |
|-----------------------------------|--|---------------|-----------------------------------|--------------|
| http://inf558.org/games#img_1025 | Dragon Quest XI: Echoes of an Elusive Age | 2017 | http://inf558.org/games#adventure | 84.0 |
| http://inf558.org/games#img_1063 | What Remains of Edith Finch | 2017 | http://inf558.org/games#adventure | 85.0 |
| http://inf558.org/games#img_11160 | Yakuza Kiwami 2 | 2017 | http://inf558.org/games#adventure | 96.0 |
| http://inf558.org/games#img_1134 | Assassin's Creed: Origins | 2017 | http://inf558.org/games#adventure | 84.0 |
| http://inf558.org/games#img_1157 | Dark Souls III: The Ringed City | 2017 | http://inf558.org/games#adventure | 93.0 |
| http://inf558.org/games#img_12678 | A Hat in Time | 2017 | http://inf558.org/games#adventure | 85.0 |
| http://inf558.org/games#img_12760 | The Evil Within 2 | 2017 | http://inf558.org/games#adventure | 83.0 |
| http://inf558.org/games#img_12849 | Assassin's Creed: Origins - Gold Edition | 2017 | http://inf558.org/games#adventure | 90.0 |
| http://inf558.org/games#img_12917 | Hitman: Game of the Year Edition | 2017 | http://inf558.org/games#adventure | 90.0 |
| http://inf558.org/games#img_12927 | Assassin's Creed: Origins - Deluxe Edition | 2017 | http://inf558.org/games#adventure | 90.0 |

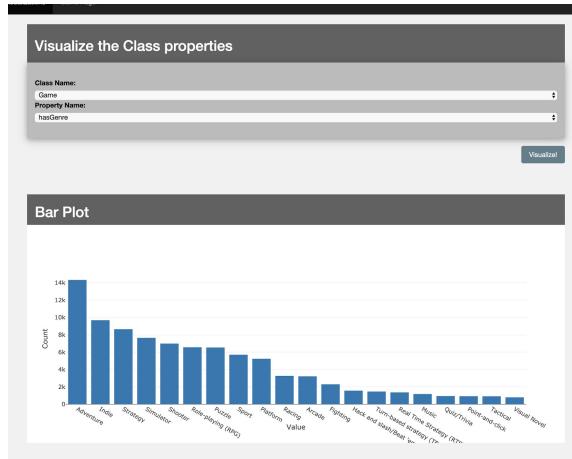
Showing 1 to 10 of 75 rows

Prev 1 2 3 4 5 ... Next

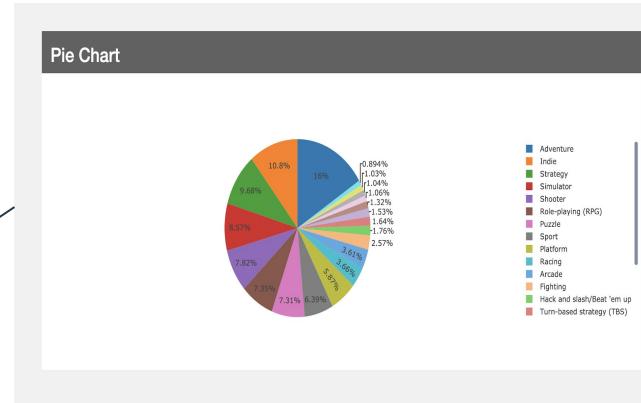
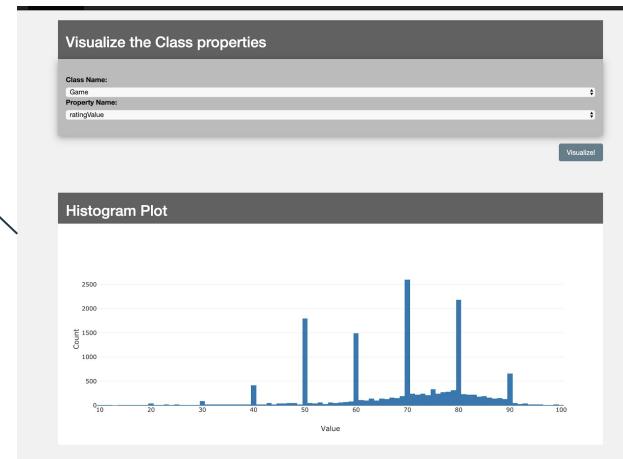
Searching the Game KG

Results table with pagination and sorting capabilities

User Interface - II



Visualizing Continuous valued property



Visualizing Discrete valued property
(Top-20 most occurring values)

User Interface - III

Empyre: Lords of the Sea Gates

Game Summary: <:p>"Featuring a top-down isometric presentation, Empyre: Lords of the Sea Gates will rekindle old-school PC RPG fans with feelings of some of the classic story driven RPGs of the 90s. While the combat should feel familiar to veteran players, there's a new twist in that the game uses a hybrid Real Time/Turn-based System. Players can enter a "Planning Mode" where they choose actions for each character in their party while combat is paused, and when entering into the "Action Mode" all characters will perform simultaneously, giving players complete control over their party while presenting a streamlined combat system that eliminates waiting for each character to act in sequence."</p>

Released Year: 2017

Supported Platforms: PC (Microsoft Windows)

Developers: Coin Operated Games

Publishers: Coin Operated Games

Game Modes: Single player

Genres: Role-playing (RPG), Strategy, Adventure

Themes: Historical, Fantasy

Rating: Not Available

Seller: Keys_with_guarantee

Price: 25.29 USD

Discount: 19.0 % OFF

Purchase Link: <https://www.g2a.com/en-us/empyre-lords-of-the-sea-gates-steam-key-global-i10000155945001>

Game Minimum Requirements:

- 4096 MB RAM, 10240 MB HDD, Processor = FX-4300, Graphics card = GeForce GTX 650 Ti (or)
- 4096 MB RAM, 10240 MB HDD, Processor = FX-4300, Graphics card = Radeon R7 240

User Device Configuration:

- 8192 MB RAM, 524288 MB HDD, Processor = Core i3-530, Graphics card = GeForce 800M

Game Information

Recommended Games that works on the User Device

Game Minimum Requirements:

- 4096 MB RAM, 10240 MB HDD, Processor = FX-4300, Graphics card = GeForce GTX 650 Ti (or)
- 4096 MB RAM, 10240 MB HDD, Processor = FX-4300, Graphics card = Radeon R7 240

User Device Configuration:

- 8192 MB RAM, 524288 MB HDD, Processor = Core i3-530, Graphics card = GeForce 800M

More to consider:

Drakensang: The River of Time
games#mig_354

Warhammer Quest 2: The End Times
games#mig_49541

The Witcher 2: Assassins of Kings
games#mig_6080

Avadon: The Black Fortress
games#mig_3078

The Legend of Zelda: Oracle of Seasons
games#mig_1126

Cheapest Seller & Purchase Link