

School of Informatics



Informatics Research Review Natural Language Processing-based Recommender System in Games

██████████
January 2021

Abstract

This review briefly introduces the common recommender system in real life. The background of game design and recommender system in education and games areas is discussed. The literature review dive into several core papers related to recommender system in games and natural language process and find the usefulness of these two kinds of technology. The literature review also includes evaluation for core papers. The conclusion part briefly summarize the findings in this review and propose a research title that can be discussed in the future.

Date: Friday 29th January, 2021

Supervisor: ██████████

Contents

1	Introduction	1
1.1	Game design	2
1.2	Recommender system	3
1.2.1	Recommender system in education	3
1.2.2	Recommender system in games	5
2	Literature Review	6
2.1	Recommender system in games	6
2.2	Natural language processing	8
3	Summary & Conclusion	9

1 Introduction

With the implementation of machine learning in the field of artificial intelligence from theory to practice, machine learning is widely used in a variety of industries, among which recommender system is an extremely important application branch. In short, the recommender system analyzes the user's data and summarizes the most frequently occurring parts as the user's preferences [1]. In short, the recommendation system analyzes the user's data and summarizes the most frequently occurring parts as the user's preferences. Examples of practical applications of recommender systems are actually quite common in real life. Take the most common shopping platform Amazon for example, its system often pushes ads related to items that users have viewed or bought. For example, if a user has bought paper and cosmetics, he/she will see similar images of paper or cosmetics on his/her Amazon homepage, and he/she will be able to click on these images to browse for the corresponding products. Furthermore, the images of the different types of products are presented in sections, so if the user is browsing a large enough number of products, it is likely that his/her homepage will present all the recommendations of the products he/she is interested in. All of these functions can be roughly treated as if they were implemented by a recommender system. All users will be asked when they sign up for an Amazon account if they want to share their personal data with Amazon to receive customized advertising services, or they can uncheck this service in the account settings screen.

The above examples are common in real life, especially in these difficult times when the Covid-19 is rampant and the need for online shopping is increasing rapidly. However, this review will mainly focus on the recommender system in specific games and explore the possibility that NLP(Natural language processing) technology in it. The topic contains three main parts of this review: NLP, recommender system, game. More specifically, this review will dive into the recommender system in games and NLP technology to explore the possibility of NLP in improving the efficiency and accuracy of the recommender system in games. In order to provide a more concise definition of the topic. These key words need to be explained in more details. The recommender system in the game is somewhat vaguely defined and has a wide range of referents. It can even refer to the game platform to recommend players to play what game, similar to the shopping platform, the game platform can develop the appropriate advertising recommendation strategy to recommend the player's favorite game genre based on the games

played and the games viewed by the player [1]. Nonetheless, the recommender system in games here focus on in-game content recommendations in this review. A general understanding is that the system can decide what to play next depending on the player's level and preferences. More complicated content recommender system will be mentioned below where appropriate. NLP is primarily concerned with the analysis of text entered by the player. The original idea behind this topic was to combine NLP technology with language learning games by analysing the player's input text to deduce the player's language level in order to create the next game at the player's level. Therefore, this review will not delve too deeply into NLP techniques, but instead will simply analyze the input text for grammar, spelling, sentence structure and other more elementary language analysis [2].

To summarise the above paragraph, the scope of the review will be limited to content recommender system in games, basic NLP for short text or sentence. The review will not explore a wide range of recommender system and complicated NLP techniques such as semantic or sentiment analysis.

The rest of the introduction will give the background and concludes with the general findings of the review. The background of the review will cover game design, recommender system and brief natural language processing.

1.1 Game design

In today's internet society, game is a topic that cannot be escaped, and since the 21st century, the game industry has grown rapidly. With the gradual improvement of the game industry, an increasing number of people want to join this sunrise industry. One simple reason why the game industry has developed so rapidly is that the rapid growth of the Internet has given rise to Internet-dependent online games, which have greatly enhanced human connectivity, allowing people to socialise and play alongside each other in a virtual world. Players can live as a different version of themselves in the virtual world than they would in the real world. This attractive virtual world has given rise to a huge money-grabbing game industry. The game industry was no longer just small games made by small studios with their own hobbies. It had a complete theory of game output, in which the core gameplay mechanics were involved: game design [3].

Game design theory allows game designers to have a strong sense of purpose, such as periodically setting difficult levels to make players feel challenged. Game design is not only about designing games in a superficial sense, it also includes psychological and even behavioural studies of players. The game designer will also set up different types of games to suit the needs of different types of people. There is a term for this classification of games called game genres [3]. For example, action games are for players who like quick reactions but casual games are for casual players who want to play games to relax. Traditionally various genres of games have been used to keep players entertained and relaxed, but in recent years a new genre of game has attracted a lot of attention. Rather than focusing on entertainment and engaging gamers, this genre looks at non-entertainment applications. It can be a simulation of the real world(e.g. simulations) or it can train the player in a certain skill(e.g. military applications, medical applications, etc). The name of this genre of games like their actual content, called Serious Games [4]. Some evidence already suggests that serious games can be a great help to people in real life. Serious medical games with a content recommender system can greatly reduce the boredom of patients in rehabilitation and make them more active in rehabilitation [5]. In addition to the several areas of application for serious games mentioned above, there are

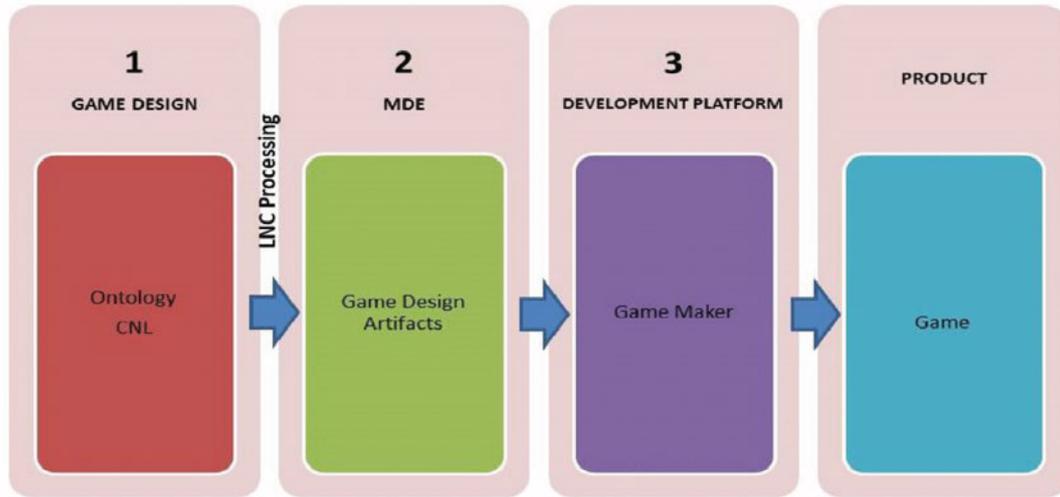


Figure 1: GameDesign [3]

also social and public policy applications and educational applications. Unlike other types of serious games, educational games should not only be educational but also a bit entertaining so that players do not feel bored while playing them. These games are mainly aimed at younger children or teenagers who are still in the learning stage, but they can also help adults to learn some knowledge.

	Serious Game Category
1	Medical applications
2	Educational applications
3	Social and public policy applications
4	Business and management applications
5	Military applications
6	Simulations

This review will not dive into game design which is the support evidence that shows the prospects of serious games especially educational games. This review will cover the applications on general games and explore the possibility of serious game in the future.

1.2 Recommender system

Recommender system is used in a wide range of areas, this review will only focus on the gaming and education areas.

1.2.1 Recommender system in education

Due to the increasing integration of mobile applications, apps on mobile phones can cover many aspects of people's lives. These apps includes some educational apps such as math questions searching app or fun learning games [6].

This kind of system can be applied in a great number of courses such as Maths, English(or other language courses), Physics, etc.This system can choose to teach new lessons or to review what

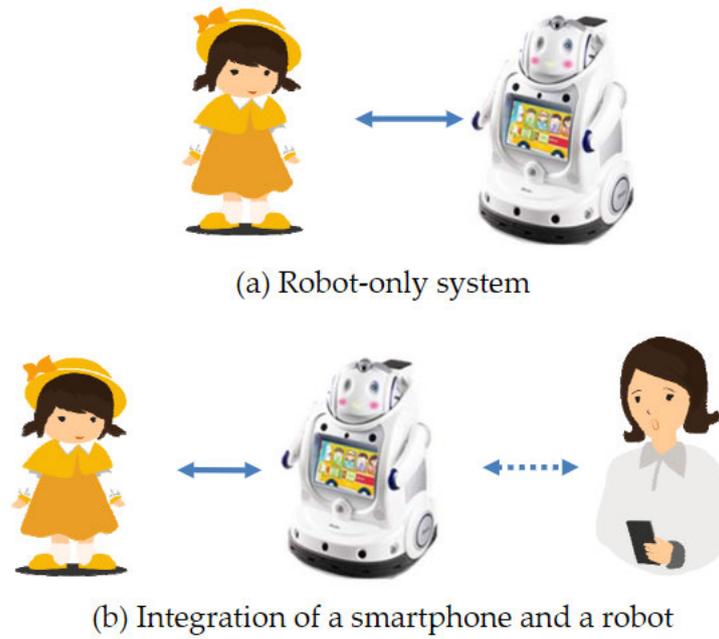


Figure 2: One example of education applications implemented by recommender system [6]

has been learned depending on the children’s level of receptiveness, or to create a learning plan that is appropriate to the children’s actual level. At the same time, the children will not find the after-school homework for a particular lesson difficult or easy, as the recommender system controls the difficulty of the homework (dynamic difficulty).

Recommender system can greatly enhance the children’s learning or play experience, and can also provide advice and summaries for teachers, parents and education stakeholders [7].

The following figure 3 shows a real platform for children learning. It is clear from this figure that children can practice their different types of intelligence in different parts of the system. Therefore, recommender systems are well established and widely used in the education area, and these applications can greatly improve the learning efficiency of students and deepen the understanding of teachers and parents about their children [7].



Figure 3: Home screen [7]

Another reason for the widespread use of recommender system is the challenge teachers face in

teaching their students the increasingly complex knowledge. Teachers will have to use a mix of different e-learning methods supported by recommender system to teach the increasingly complex knowledge[8].

1.2.2 Recommender system in games

As mentioned before, recommender system has been applied in on video game platform. However, it is important to note that the content recommendation system here is based on out-of-game user preference data, rather than actual in-game content recommendations [1].

In-game recommender systems have actually been developed for some time, and now content recommendation algorithms can greatly expand the resources available in the game as well as the complexity of the game itself, and they can even change the content of the game based on the player’s comments about the game (by determining the sentiment of the comments) [9]. Furthermore, this kind of recommender system that allows for customisation of content and game mechanics allows for more engaging and challenging tasks to be chosen by players, which allows for greater player engagement than traditional manual design and creation of game tasks [10].

A more specific application is the item recommender system in MOBA games, which recommends the most suitable equipment for the player based on the current game progression (game situation, character selection of the player and the opponent, player’s proficiency with the character, etc) [11]. This system is a great convenience for beginners who are not very familiar with the game system, allowing them to follow the relatively correct progression of the game as far as possible without knowing anything about it. The equipment recommender system learns from veteran players’ changes to the default kit and gives all players a wide range of options.

The following figure 4 shows the index terms of the paper discuss the applications of recommender system in MOBA games [11]. It is clear from the figure that recommender system and information retrieval has strong linkage. IR (information retrieval) is also known as an important technique in Natural Language Processing area [12]. That is the reason why I would like to combine NLP and recommender system in games.

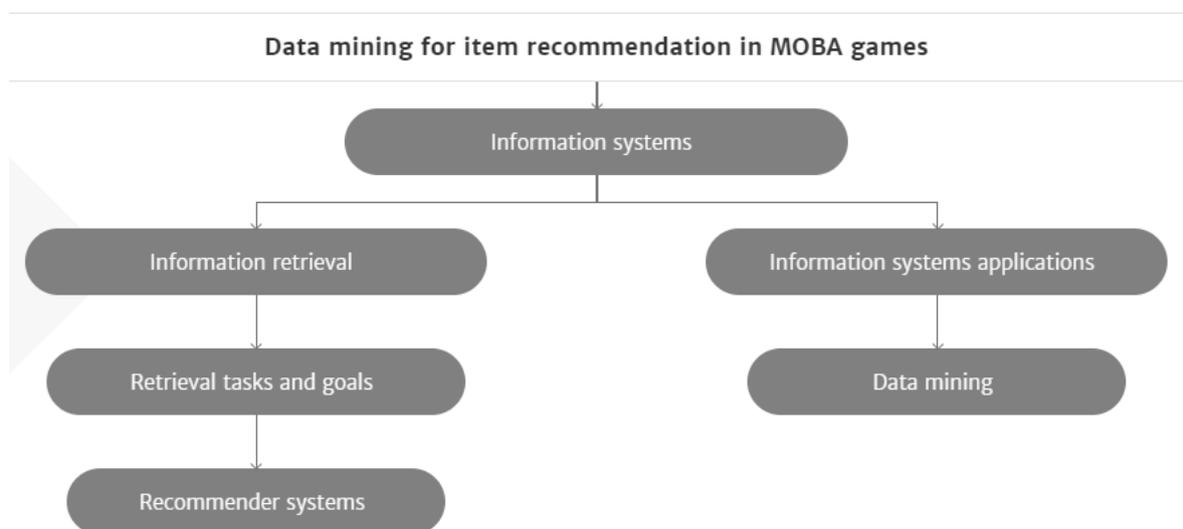


Figure 4: Index term [11]

Since game-based learning is a recently emerging learning method. Researchers are also studying and evaluating the advantages and disadvantages of this new learning method compared to traditional learning methods [13]. According to the evidence, the game learning approach needs to be regulated to prevent abuse that could lead to students becoming addicted to games or unable to access traditional education. Game-based learning is still a great and fun way to learn knowledge but it can not occupy the entirety of the classroom [13]. Educators should not only adopt a mix of different e-learning methods, but also adopt a hybrid teaching methods that combines game-based learning and traditional learning to make learning more fun and effective.

To summarise, the general findings of the review is that recommender system is already widely used in games, not only in the popular online video games, but also in serious games and especially in educational games. Branching techniques of NLP - Information related technology such as information retrieval - can also help recommender system to improve its efficiency and accuracy. The sources in these areas are not too much but they are not difficult to find. The next section will discuss about several core papers related to these areas.

2 Literature Review

2.1 Recommender system in games

According to the study of recommender system in board games, the board game is no longer as homogeneous as the original chess. The board game is being released so quickly that human and even recommender system technology itself has become somewhat unable to keep up with its iterative pace [14]. Customers sometimes have no idea how to choose these board games. In order to solve the problem, this study aimed to design a recommender system evolving from information system. This system will recommend the most suitable game for customers depending on their interest and previous playing history(i.e. which type of board games they prefer to play before).

The recommender system here is not an in-game recommender system in the traditional sense but it is also not a product category recommender system like the advertisement system on Amazon, it can be understood as a task recommender system within a larger game system. This game systems contains multiple board game tasks and players should choose which to play next according to the recommendation from the recommender system. This recommender system works in a similar way to the educational game mentioned above that develops children's intelligence in various areas (see that in figure 3).

They have selected a large enough amount of data on a reliable and authoritative website, including player reviews of individual games, as well as data on the content of the games themselves [14]. These data would be used in their three experimental scenarios.

The first experiment focus on players. Player ratings for each board game will be recorded in the database and there are several different mathematical ways to handle these data. Therefore, the system can learn different preferences of different players, thus giving recommendation to players who have similar images [14].

The second experiment focus on board games themselves. This kind of system is called content-based recommender system which would basically provide recommendations depending on their game contents. The system would analyze and learn the specific contents of the board games from the dataset via two types of machine learning-based methods such as kNN(k-Nearest-

Neighbor) [14]. Then, the system would give a score for each board games according to their game mechanics, playfulness and other dimensions. The final result would be a descent list from the game with the highest score.

The final experiment is the hybrid methods of the above two approaches. This method takes into account not only the scores of each board game, but also each player's rating for each game to arrive at a combined result [14]. This method looks more rigorous than the first two ways but the actual result is not the optimistic solution.

In the evaluation stage, they split the dataset into training data and test data and use several kinds of information retrieval evaluation methods such as Precision@k, Recall@k, nDCG and AP to evaluate the experimental results. The final evaluation concludes that one method in content-based recommender system has the best performance [14]. This result also demonstrates the importance of content recommender systems in games. This is also the reason why game designer prefer to use content recommender systems in games.

This paper generally has a good premise that is the quick releasing of board games and choose reliable data. The methodology including three ways from human, game and hybrid method is critical. The conclusion part is contained in evaluation part. Although the result is summarized, it would be nice to have the summary in a separate paragraph and provide some suggestions for future work.

While the evidence above illustrates the importance of content recommender system, the following paper discusses the difficulty and robustness of content recommender system.

Another study of recommender system in a hot MOBA online game Dota2 is close to us. There are two terms that need to be explained at first. MOBA is the abbreviation of Multiplayer Online Battle Arena which is a type of online video game with more than one player in the same map. This type of game has strong combat attributes, which has given rise to the equipment system. Different equipment has different characteristics and effects, and different equipment on different characters can also lead to different situations. In short, the equipment system has a huge impact on the progress of the game, so players need to be very careful when choosing their equipment.

The aim of the study is to design an item(equipment) recommender system in Dota2 which would be quite helpful for beginners or non-profession players. They selected data (item plan) from skilled players matches and pre-process those data. Therefore, the dataset for study consists of training data(75%) and test data(25%) [15].

In the experiment stage, they used training data to fit two classifier(Rule-Based Classifier and Logistic Regression Classifier) and predict the result for test data via corresponding machine learning model.

The method of evaluation is to compute the accuracy for each experiment. The accuracy is computed by how many item plans meet expectations. The results show that logistic classifier has better performance [15]. Despite the interference of many other factors, knowing only the character and itmes still gives relatively good results, suggesting that the content recommender system in the game is not greatly influenced by context. In other words, the content recommender system in games is not so difficult to implement. It only depends on several major aspects so the robustness of the system is good.

To evaluate this paper, the premise and methodology is critical enough. However, the evaluation scheme using only one method (i.e. accuracy), may be less convincing and it would be better to

use multiple methods to evaluate the results of the experiments. The conclusion is better than the first paper of this section since it has some suggestions for future work.

The two articles above provide a good overview of the importance and robustness of content recommender systems in games and provide much evidence for future research.

2.2 Natural language processing

Information retrieval is a technique for searching information in a specific database and returning the search results to the user [16]. In an easy to understand explanation, similar to the mechanism of the search engine google, the user enters a query containing the information they want to search, the system matches and retrieves the corresponding information in the database based on the query and returns the results.

The ideal information retrieval system is one in which users are free to express the information they need and the various details within that information, and in which the system can truly understand the meaning of that information and search for it [16]. The information here is somewhat similar to the papers in this IRR, with the most central papers and other related papers that we need to really understand in order to draw some conclusions. The information retrieval also need to understand all of the information instead of only receiving the basic query and processing it.

The combination of natural language processing and IR systems makes it easier for the system to understand the input, allowing the user to enter information in natural language, which is processed by NLP and thus accurately matched in the database [16].

A study of information retrieval explains in more depth the need to combine natural language processing and information retrieval systems. This study focus on short text conversation which is a common scenario in daily life. Due to the poor performance of the automated answering systems on the market, they would like to design a short text conversation with IR approach that can automatically respond human and complete some short text conversation [17].

They start from the definition of short text conversation and analyze the situation of short text conversation on social media. After that, they set up a problem-solving scheme including problem definition and system architecture for retrieval-based short text conversation. They used a variety of ways to select and process the data set. In the experiment stage, they designed a sufficient number of models types and used dataset to train those models. In the evaluation stage, they summarized the experimental results for each model/method and pointed out the parts of the experiment that were completed well and the parts that failed. The study concludes that the retrieval-based model performs well in these experiments and there are several more directions of short text conversation can be explored [17].

The overall paper provides sufficient evidence and critical premise, methodology, evaluation and conclusion. It has very detailed design scheme, data processing, experimental procedures, and evaluation processes. The conclusion also give a final result of what method has the best performance. This study can also prove that natural language processing is of great in understanding human's text.

Another paper is about a more piratical application of NLP in an English learning platform. The study starts from the related work showing that the urgent need for such a learning platform in the market and describes the system architecture (figure 5) [18].

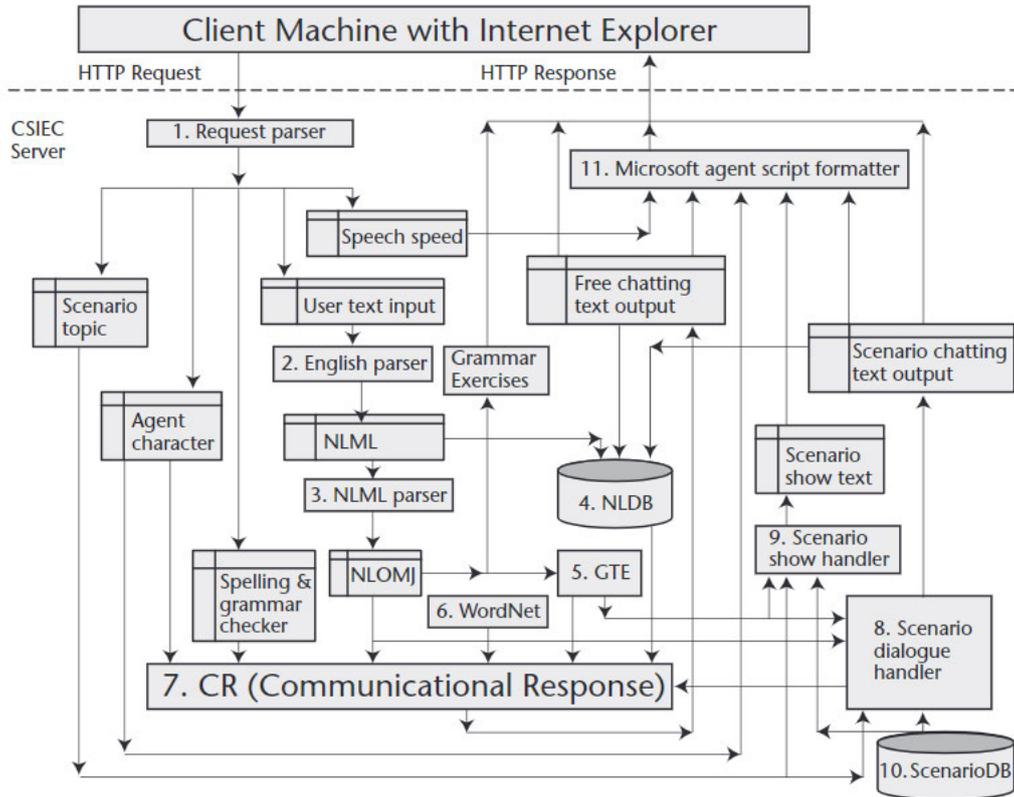


Figure 5: System architecture [18]

Then, they tested the system performance in different scenarios. For example, the system has a couple of exercises such as listening exercise and speaking exercise. The system would automatically provide some suitable exercises for students and respond them if they have done the exercises by typing or speaking aloud. Also, they have several ways/models to give exercise to students, respond to their answers, give feedback and scoring [18]. These models will not be discussed in details in this review since they are quite technical. Finally, the study concludes the success of NLP in English learning platform and notes that there are still some difficult problems in NLP field need to be solved in order to improve the efficiency and accuracy of NLP [18].

The premise and methodology of this study is clear but more statistic evidence should be provided in the evaluation stage so that readers will be more convinced by the findings.

The above two articles indicates that the high usefulness of NLP and IR. NLP technology can be applied in a great number of fields, among which education is a significant part for social development.

3 Summary & Conclusion

This review indicates that the usefulness of recommender system in many fields especially in games and education areas. And the educational games with recommender system already exist. There is some evidence to suggest that recommender systems have had some success in educational games and have a promising future, but there is still a need for regulations to

govern them.

NLP technology is also widely used and has applications in the education area such as online English learning platforms that require interaction with students. The combination of NLP technology and recommender systems in educational games is bound to improve the ease of use and efficiency of educational games.

The commonalities between those works are the usefulness of new techniques. With the application of new technologies in a number of areas, previously inefficient software or platforms are bursting with new energy. This also shows the importance of recommender system and NLP.

In the future, there should be more possibilities to implement a natural language processing-based recommender system in educational games. Students can speak and type words, the system can process these words via NLP and give appropriate feedback. At the same time, recommender system can analyze the specific level of each student and tailor their learning plan according to their skills level. Due to the usefulness and existed applications of recommender system in educational games and NLP technology, the whole education industry will benefit from this kind of efficient educational game.

References

- [1] Germán Cheuque, José Guzmán, and Denis Parra. Recommender systems for online video game platforms: The case of steam. In *The Web Conference 2019 - Companion of the World Wide Web Conference, WWW 2019*, pages 763–771. Association for Computing Machinery, Inc, 5 2019.
- [2] Andhik Ampuh Yunanto, Darlis Herumurti, Siti Rochimah, and Imam Kuswardayan. English education game using non-player character based on natural language processing. In *Procedia Computer Science*, volume 161, pages 502–508. Elsevier B.V., 2019.
- [3] Kleber Tavares Fernandes, Marcia Lucena, and Eduardo Aranha. A strategy for the development of computational thinking from game design specifications. In *Proceedings - IEEE 19th International Conference on Advanced Learning Technologies, ICALT 2019*, pages 386–388. Institute of Electrical and Electronics Engineers Inc., 7 2019.
- [4] Carol M. Forsyth, Arthur Graesser, and Keith Millis. Predicting Learning in a Multi-component Serious Game. *Technology, Knowledge and Learning*, 25(2):251–277, 6 2020.
- [5] Carina S. González-González, Pedro A. Toledo-Delgado, Vanesa Muñoz-Cruz, and Pablo V. Torres-Carrion. Serious games for rehabilitation: Gestural interaction in personalized gamified exercises through a recommender system. *Journal of Biomedical Informatics*, 97, 9 2019.
- [6] Gu Min Jeong, Chang Woo Park, Sujeong You, and Sang Hoon Ji. A study on the education assistant system using smartphones and service robots for children regular paper. *International Journal of Advanced Robotic Systems*, 11(1), 4 2014.
- [7] Almudena Ruiz-Iniesta, Luis Melgar, Alejandro Baldominos, and David Quintana. Improving children’s experience on a mobile EdTech platform through a recommender system. *Mobile Information Systems*, 2018, 2018.
- [8] Thorsten Sommer, Valerie Stehling, Max Haberstroh, and Frank Hees. What Are Teachers’ Requirements for Remote Learning Formats? Data Analysis of an E-Learning Recommendation System. In *Lecture Notes in Networks and Systems*, volume 47, pages 207–216. Springer, 2019.
- [9] Rishabh Joshi, Varun Gupta, Xinyue Li, Yue Cui, Ziwen Wang, Yaser Norouzzadeh Ravari, Diego Klabjan, Rafet Sifa, Azita Parsaeian, Anders Drachen, and Simon Demediuk. A Team Based Player Versus Player Recommender Systems Framework for Player Improvement. In *ACM International Conference Proceeding Series*. Association for Computing Machinery, 1 2019.

- [10] Rafet Sifa, Raheel Yawar, Rajkumar Ramamurthy, Christian Bauckhage, and Kristian Kersting. Matrix- and Tensor Factorization for Game Content Recommendation. *KI - Kunstliche Intelligenz*, 34(1):57–67, 3 2020.
- [11] Vladimir Araujo, Felipe Rios, and Denis Parra. Data mining for item recommendation in MOBA games. In *RecSys 2019 - 13th ACM Conference on Recommender Systems*, pages 393–397. Association for Computing Machinery, Inc, 9 2019.
- [12] Julia Hirschberg and Christopher D. Manning. Advances in natural language processing, 7 2015.
- [13] Venera-Mihaela Cojocariu and Ioana Boghian. Teaching the Relevance of Game-based Learning to Preschool and Primary Teachers. *Procedia - Social and Behavioral Sciences*, 142:640–646, 8 2014.
- [14] Michael Ion, DIMITRIS Sacharidis, and Hannes Werthner. Designing a recommender system for board games. In *Proceedings of the ACM Symposium on Applied Computing*, pages 1465–1467. Association for Computing Machinery, 3 2020.
- [15] Wenli Looi, Manmeet Dhaliwal, Reda Alhajj, and Jon Rokne. Recommender system for items in DOTa 2. *IEEE Transactions on Games*, 11(4):396–404, 12 2019.
- [16] Elizabeth D. Liddy. Enhanced text retrieval using natural language processing. *Bulletin of the American Society for Information Science*, 24(4):14–16, 1998.
- [17] Zongcheng Ji, Zhengdong Lu, and Hang Li. An Information Retrieval Approach to Short Text Conversation. 8 2014.
- [18] Jiyoun Jia. An AI framework to teach english as a foreign language: CSIEC. *AI Magazine*, 30(2):59–71, 2009.