

# Heuristic evaluation of video games in Smart TV environments

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## Abstract

With the growth in the number of apps from different contexts in cloud software repositories, usability has become one of the key aspects to improve application competitiveness and end-user productivity. Usability can be included in the software development process both in the design phase and in the evaluation phase, where one of the most widespread formal methods is the heuristic evaluation, in which a group of evaluators inspect the usability of a software product taking into account a set of specific heuristics, in order to identify usability problems associated with the heuristics, which are rated by the evaluators according to the parameters of severity, frequency and criticality. In order to extrapolate the heuristic evaluation to other contexts such as Smart TV environments, this article proposed as a contribution the development of a heuristic evaluation on a video game deployed on a Samsung Smart TV, which involved the participation of 3 evaluators who inspected the video game according to Pinelle's usability principles for video games. This work is intended to serve as a reference regarding the application of the heuristic evaluation method in software deployed in different environments.

**Keywords:** heuristic evaluation, Smart TV, usability, video game, usability.

## I. INTRODUCTION

With the increase in the number of applications deployed in cloud app stores, one of the most relevant aspects to improve software competitiveness in the market and user productivity in the interaction is usability [1]–[5]. According to ISO 9126, usability is an attribute that defines software quality, along with other relevant attributes such as: functionality, reliability, efficiency, maintainability and portability [6]–[10]. In the same sense, according to ISO 9241-11, usability can be defined as the extent to which a software product can be used by specific users to achieve specific objectives with effectiveness, efficiency and satisfaction in a specified context of use [11]–[14].

The articulation of usability in the software development process can be done in the design phase through the incorporation of heuristic principles, or in the evaluation phase through the application of formal inspection methods such as heuristic evaluation or through user tests developed in a usability laboratory [15]. Heuristic evaluation is an efficient

and economical evaluation method in which a group of evaluators inspect the compliance of a set of heuristic principles on a given software, in order to obtain a list of usability problems and rate them taking into account parameters such as severity, frequency and criticality [16], [17]. The above, in order to determine the usability problems that should be prioritized to improve the quality of the evaluated software.

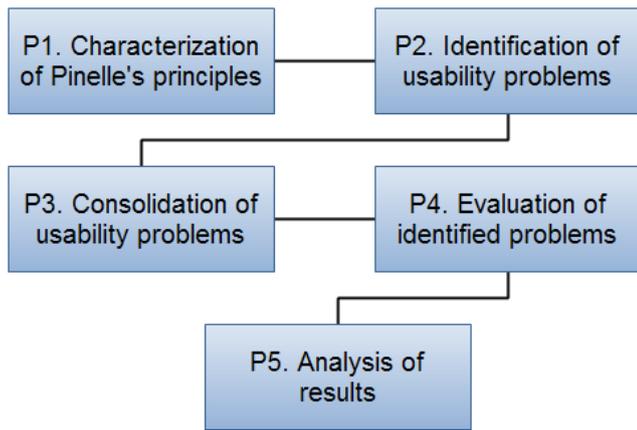
Although the heuristic evaluation method has been widely spread in the context of general-purpose applications, making use of Nielsen heuristics, its use has not been evidenced in other specific contexts such as video games or applications deployed in Smart TV environments, taking into account usability heuristics specific to the applications of such contexts. In this paper we propose as a contribution the application of the heuristic evaluation method in the analysis of usability problems of video games deployed in Smart TV environments. The heuristic evaluation was performed using the 10 usability heuristics proposed by Pinelle, which were obtained from the review of common usability problems within the GameSpot portal [18]–[20]. Specifically, a heuristic evaluation was developed on the Urban Ninja video game, which was installed on a Samsung Smart TV. The heuristic evaluation presented in this paper is intended to serve as a reference as an effective method to be applied in the evaluation of video games on different platforms, from the perspective of usability. Similarly, the methodology used in this paper is intended to serve as a reference for the extrapolation of heuristic evaluation to other types of applications deployed in non-conventional environments.

The rest of the article is organized as follows: Section 2 presents the methodology considered for the development of this work. Section 3 describes the results obtained from this research, which includes the development of the different phases considered in a heuristic evaluation of the Urban Ninja video game installed on a Samsung Smart TV. Finally, Section 4 presents the conclusions and future work derived from this research.

## II. METHODOLOGY

For the development of the present research, an adaptation of the methodological phases that make up a heuristic evaluation was carried out [21]. Thus, 5 methodological phases were considered in this work: characterization of Pinelle's usability principles, identification of usability problems in the Urban Ninja video game, consolidation of usability problems,

evaluation and/or rating of identified problems and finally analysis of results (see Figure 1).



**Fig. 1.** Methodology considered

In phase 1 of the methodology, Pinelle's 10 usability principles were explored in order to determine the purpose and scope of each of these heuristics, as well as their extrapolation to the context of video games deployed in Smart TV environments. Once the Pinelle principles had been characterized, in phase 2 of the methodology, each of the evaluators carried out an individual inspection of the Urban Ninja video game in order to identify usability problems associated with the Pinelle heuristic principles. Based on the inspection carried out by each evaluator in phase 2, in phase 3 the evaluators proceeded with the consolidation and discussion of the usability problems, in order to reach a consensus regarding the unfulfilled principles in the different problems identified. In phase 4, the evaluators rated the consolidated problems on a scale of 0 to 4, according to the parameters of severity and frequency. Similarly, in this phase the criticality of each problem identified is obtained from the sum of severity and frequency. Finally, in phase 5, from the ratings assigned by each evaluator, the average and standard deviation of severity, frequency and criticality are obtained. In the same way, problem rankings are obtained according to severity, frequency and criticality, which allow to guide the videogame development team on those problems that have a higher priority to be solved, in order to improve the usability of the software product. Lastly, a set of recommendations are proposed as an alternative to the solution of the problems identified in the heuristic evaluation developed on the Urban Ninja video game.

**III. RESULTS AND DISCUSSION**

This section presents the results obtained in this research, which includes the development of the different phases of the heuristic evaluation. Thus, this section first presents a brief description of the Urban Ninja video game and Pinelle's usability principles. Subsequently, the consolidated list of problems, the rating assigned by the evaluators to the problems identified and the analysis of the results obtained from their rating are presented. Finally, a set of recommendations obtained for the different usability problems considered in the evaluation are presented.

The heuristic evaluation developed and described in this paper was performed on the Urban Ninja video game, which was

downloaded from the Samsung Smart TV app store. The main character of the video game is a ninja, who must run over the roofs of the buildings of a city avoiding collisions with the different obstacles he encounters on his way (see Figure 2). To control the movement of the ninja, the player must use the up and down buttons on the Smart TV remote control. The game also has a main menu that allows you to start the game, check the ranking of scores, review the game credits and exit.



**Fig. 2.** Urban Ninja video game

As previously mentioned, the heuristic evaluation was performed using Pinelle's 10 heuristic principles, which are described in Table 1 and were inspected in the Urban Ninja video game [18], [19].

**Table 1.** Pinelle's heuristics

Heuristic	Description
H1. Provide consistent responses to the user's actions.	The video game must respond predictably to different user actions. Character movements, collisions and physical laws have a behavior that is consistent with the real world.
H2. Allow users to customize video and audio settings, difficulty and game speed.	The video game must allow the user to configure audio and video options, game speed and difficulty level.
H3. Provide predictable and reasonable behavior for computer controlled units.	The video game's controlled units (enemies, interactive objects, etc.) have a predictable and reasonable behavior, keeping consistency with the real world.
H4. Provide unobstructed views that are appropriate for the user's current actions.	The video game must provide unobstructed views. The cameras used in the video game must adapt to the movement of the character.

H5. Allow users to skip non-playable and frequently repeated content.	The game must allow the user the option to skip frequent and repetitive content that is presented at different times during the video game.
H6. Provide intuitive and customizable input mappings.	The video game controls or inputs must be intuitive, conventional and easy to configure.
H7. Provide controls that are easy to manage, and that have an appropriate level of sensitivity and responsiveness.	The sensitivity of the video game controls must be adequate and depending on the type of video game it is possible to configure it.
H8. Provide users with information on game status.	Sufficient information about the game state (levels, lives, scores, enemy) should be provided using visual indicators, which help to understand the objectives of the video game.
H9. Provide instructions, training, and help.	The video game must provide the necessary help instructions to operate it and optionally include a training level.
H10. Provide visual representations that are easy to interpret and that minimize the need for micromanagement.	The different visual representations used by the game should be easy to interpret and should be consistent with real-world information.

Once Pinelle's heuristics were characterized, the 3 evaluators participating in the heuristic evaluation identified and consolidated the usability problems present in the Urban Ninja video game, which are shown in Table 2.

**Table 2.** Consolidated list of usability problems

<b>Id</b>	<b>Usability problems</b>	<b>Unfulfilled principles</b>
P1	The video game does not allow the configuration of multimedia options (enable or disable background music and/or audio effects).	H1
P2	Before starting the game, a message with the game instructions is always displayed.	H5
P3	The video game controls are intuitive, but not customizable.	H6

P4	The sensitivity of the controls is not adequate and cannot be adjusted.	H7
P5	The game does not have a status bar and does not show the score obtained, the current level or the time elapsed since the start.	H8
P6	Instructions are presented every time the game is started, but not in the main menu.	H9

From the consolidated list of problems, each of the evaluators proceeded to rate the severity, frequency and criticality of each problem. Severity evaluates the gravity of the usability problem and its scale is between 0 and 4, where 0 indicates that there is no usability problem, while 4 means that the problem is catastrophic. Frequency evaluates how often a user may encounter the identified problem and is scaled between 0 and 4, where 0 indicates that the problem occurs less than 1% of the time, while 4 indicates that the problem may occur more than 90% of the time. Criticality is obtained from the sum of severity and frequency, so its scale is between 0 and 8 [21]. Details of the severity and frequency rating scales are presented in Table 3.

**Table 3.** Severity and frequency rating scale

<b>Rating</b>	<b>Severity</b>	<b>Frequency</b>
0	It's not a usability problem	<1%
1	Cosmetic usability problem. Does not need to be resolved unless extra time is available on the project.	1-10%
2	Minor usability problem, whose solution has a low priority.	11-50%
3	Major usability problem, whose solution should have a high priority.	51-90%
4	Catastrophic usability problem, whose solution is imperative for the product to be released.	>90%

Taking into account the list of problems in Table 2 and the rating scale in Table 3, Table 4 shows the ratings assigned by each of the evaluators in terms of severity, frequency and criticality for each of the problems identified in the heuristic evaluation.

**Table 4.** Problem ratings

<b>Id</b>	<b>E1</b>			<b>E2</b>			<b>E3</b>		
	<b>S</b>	<b>F</b>	<b>C</b>	<b>S</b>	<b>F</b>	<b>C</b>	<b>S</b>	<b>F</b>	<b>C</b>

P1	2	2	4	2	2	4	2	2	4
P2	1	3	4	2	3	5	2	3	5
P3	1	1	2	1	1	2	1	1	2
P4	2	2	4	2	2	4	1	1	2
P5	3	3	6	3	4	7	3	2	5
P6	1	1	2	2	2	4	1	0	1

By averaging the ratings of the 6 problems identified in terms of severity, frequency and criticality, it is possible to obtain the results shown in Figure 3. According to the results in Figure 3, it can be seen that the most severe problem is P5, while the least severe is P3. Similarly, Figure 3 shows that the most frequent problems are P2 and P5, while the least frequent problems are P3 and P6. Likewise, it is possible to observe in Figure 3 how the most critical problem is P5, while the least critical problems are P3 and P6. In this sense, it is important to prioritize in the development of the Urban Ninja video game, the inclusion of a status bar that allows to visualize the score, the level and the time, in order to improve the immersion and the understanding of the objectives of the video game.

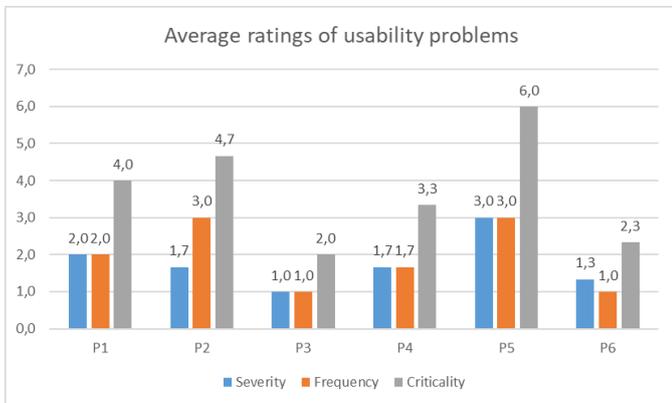


Fig. 3. Average ratings of usability problems

The prioritization of the problems at the criticality level can be seen more clearly in Table 5, which shows the ranking of the problems identified according to criticality, including the priority associated with each problem according to the average obtained at the criticality level.

Table 5. Ranking of problems according to criticality

Id	Criticality	Priority
P5	6.0	High
P2	4.67	Medium
P1	4.0	Medium
P4	3.33	Low
P6	2.33	Low
P3	2	Low

On the other hand, when applying the standard deviation to the ratings assigned by the evaluators in terms of severity, frequency and criticality, the results shown in Figure 4 are obtained. It is possible to observe, according to the results of Figure 4, that in problems P1 and P2 the standard deviation of the problems for severity, frequency and criticality is 0, since in these problems there was total coincidence in the evaluators' ratings. Similarly, in the case of problem P2 there was coincidence in the frequency rating assigned by the evaluators, while in the case of problem P5 there was coincidence in the rating assigned by the evaluators to severity. It is also important to mention that the maximum standard deviation for severity is 0.6, for frequency is 1.0 and for criticality is 1.5.

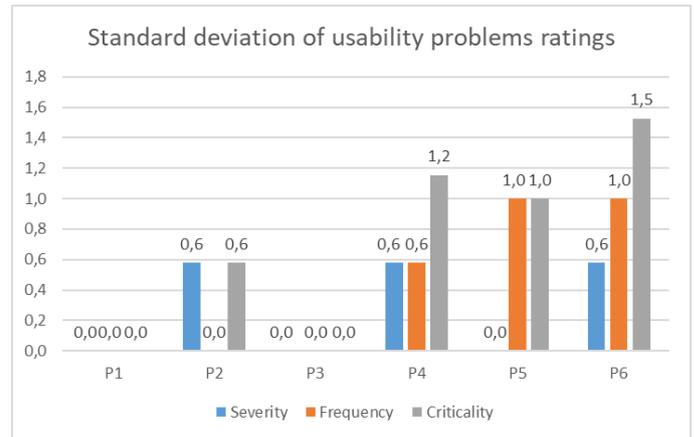


Fig. 4. Standard deviation of usability problems ratings

Finally, based on the evaluation results, Table 6 presents a set of recommendations to improve the usability of the Urban Ninja video game, which are described for each of the 6 usability problems determined.

Table 6. Recommendations obtained for the Urban Ninja videogame

Id	Recomendaciones
P1	It is recommended to include in the video game the option to enable or disable background music and/or sound effects.
P2	It is recommended to remove the message that appears before starting each game and to include an option to consult the instructions in the main menu.
P3	It is recommended that the video game provide the flexibility for the user to customize the interaction controls, taking into account the buttons available on the remote control.
P4	It is recommended to include an option in the main menu to adjust the sensitivity of the controllers, in order to improve the response of the video game character.
P5	It is recommended to include a status bar in the video game, in which the level, the score and the time elapsed in the game are shown. The above in order to facilitate the understanding of

	the objectives of the video game and improve the user's immersion in it.
P6	It is recommended to include an option in the main menu that allows consultation of the video game controls, as well as their customization.

Complementing the above, as a positive aspect of the video game, it is important to mention that the different interfaces make use of the same range of colors, allowing a consistent and recognizable design for the player.

#### IV. CONCLUSIONS

Heuristic evaluation is one of the most widespread usability evaluation methods, characterized by its simplicity and effectiveness. Mainly, heuristic evaluation has been spread in desktop applications or web applications, having as a challenge its adaptation to other contexts that have gradually gained ground in the field of interactive applications, as is the case of software deployed in Smart TV environments. In this paper we proposed as a contribution the development of a heuristic evaluation of usability on video games deployed in Smart TV environments. The heuristic evaluation developed is intended to serve as a reference to apply this evaluation method in other non-conventional contexts of interactive applications.

For the conduct of the heuristic evaluation presented in this article, the 10 usability heuristics proposed by Pinelle were used, which proved to be suitable to be extrapolated to other contexts such as Smart TV environments, in order to identify usability problems. Thus, in the case of the heuristic evaluation developed, a total of 6 usability problems were identified that do not comply with Pinelle's heuristic principles, of which 1 has a high priority, 2 have a medium priority and 3 have a low priority. The heuristic evaluation performed on the Urban Ninja video game deployed on a Samsung Smart TV, allowed determining that the usability problem with high priority to be solved corresponds to the non-inclusion of a game status bar that allows the presentation of the level, score and time. The solution to this usability problem will allow the end user to become more immersed and understand the objectives of the video game in a clearer way. Other aspects that have a medium priority and that can help to improve the interaction with the video game, are the inclusion of an option to enable and disable background music and sound effects, as well as the suppression of the message that appears every time a game of the video game is going to be started.

Finally, this work proposed a set of recommendations associated with the 6 usability problems identified, which are intended to guide the video game development team on the functionalities to be included and the elements to be adjusted in order to improve end-user interaction, as well as to contribute to the competitiveness of the application in the Smart TV application store.

As a future work derived from this research, we intend to propose a set of usability criteria associated with each heuristic and corresponding to the environment of video games deployed on Smart TV environments. It is also intended to complement

the heuristic evaluation conducted with a user test developed in a usability laboratory, in order to determine additional usability issues.

#### REFERENCES

- [1] K. Radle and S. Young, "Partnering usability with development: how three organizations succeeded," *IEEE Softw.*, vol. 18, no. 1, pp. 38–45, Jan. 2001, doi: 10.1109/52.903164.
- [2] C. Dinkel, D. Billenstein, D. Goller, and F. Rieg, "USER-ORIENTED OPTIMIZATION OF THE GUI OF A FINITE ELEMENT PROGRAMME TO ENHANCE THE USABILITY OF SIMULATION TOOLS," *South-East Eur. Des. Autom. Comput. Eng. Comput. Networks Soc. Media Conf. SEEDA\_CECNSM 2018*, Nov. 2018, doi: 10.23919/SEEDA-CECNSM.2018.8544936.
- [3] D. Hering, T. Schwartz, A. Boden, and V. Wulf, "Integrating usability-engineering into the software developing processes of SME: A case study of software developing SME in Germany," *Proc. - 8th Int. Work. Coop. Hum. Asp. Softw. Eng. CHASE 2015*, pp. 121–122, Jul. 2015, doi: 10.1109/CHASE.2015.22.
- [4] M. Heikkinen and H. Maatta, "Design driven product innovation in enhancing user experience oriented organisational culture in B-to-B organisations," *2013 IEEE-Tsinghua Int. Des. Manag. Symp. Des. Bus. Innov. TIDMS 2013 - Proc.*, pp. 127–135, Dec. 2014, doi: 10.1109/TIDMS.2013.6981226.
- [5] G. Çetin and G. Mehmet, "A measurement based framework for assessment of usability-centricness of open source software projects," *SITIS 2008 - Proc. 4th Int. Conf. Signal Image Technol. Internet Based Syst.*, pp. 585–592, 2008, doi: 10.1109/SITIS.2008.106.
- [6] M. Baklizi and S. Alghyaline, "Evaluation of E-Learning websites in Jordan universities based on ISO/IEC 9126 standard," *2011 IEEE 3rd Int. Conf. Commun. Softw. Networks, ICCSN 2011*, pp. 71–73, 2011, doi: 10.1109/ICCSN.2011.6013778.
- [7] M. D. Dzulfiqar, D. Khairani, and L. K. Wardhani, "The Development of University Website using User Centered Design Method with ISO 9126 Standard," *2018 6th Int. Conf. Cyber IT Serv. Manag. CITSM 2018*, Mar. 2019, doi: 10.1109/CITSM.2018.8674325.
- [8] H. W. Jung, S. G. Kim, and C. S. Chung, "Measuring software product quality: A survey of ISO/IEC 9126," *IEEE Softw.*, vol. 21, no. 5, pp. 88–92, Sep. 2004, doi: 10.1109/MS.2004.1331309.
- [9] C. Santos, T. Novais, M. Ferreira, C. Albuquerque, I. H. De Farias, and A. P. C. Furtado, "Metrics focused on usability ISO 9126 based," *Iber. Conf. Inf. Syst. Technol. Cist.*, vol. 2016-July, Jul. 2016, doi: 10.1109/CISTI.2016.7521437.
- [10] D. D. J. Suwawi, E. Darwiyanto, and M. Rochmani,

- “Evaluation of academic website using ISO/IEC 9126,” *2015 3rd Int. Conf. Inf. Commun. Technol. ICoICT 2015*, pp. 222–227, Aug. 2015, doi: 10.1109/ICOICT.2015.7231426.
- [11] P. Weichbroth, “Usability of mobile applications: A systematic literature study,” *IEEE Access*, vol. 8, pp. 55563–55577, 2020, doi: 10.1109/ACCESS.2020.2981892.
- [12] N. Kerzazi and M. Lavallee, “Inquiry on usability of two software process modeling systems using ISO/IEC 9241,” in *Canadian Conference on Electrical and Computer Engineering*, 2011, pp. 000773–000776, doi: 10.1109/CCECE.2011.6030560.
- [13] V. F. Martins, M. De Paiva Guimaraes, and A. G. Correa, “Usability test for Augmented Reality applications,” 2013, doi: 10.1109/CLEI.2013.6670668.
- [14] F. Henrique Yoshiaki Nakagawa, A. Salvany Felinto, and M. Toshio Omori, “Inclusion of teaching slides in games: Analysis of the efficiency, effectiveness and satisfaction,” *IEEE Lat. Am. Trans.*, vol. 11, no. 6, pp. 1372–1377, Dec. 2013, doi: 10.1109/TLA.2013.6710386.
- [15] D. M. Delgado Agudelo, D. F. Girón Timaná, G. E. Chanchí Golondrino, and K. Márceles Villalba, “Propuesta de una herramienta para la estimación de la satisfacción en pruebas de usuario, a partir del análisis de expresión facial,” *Rev. Colomb. Comput.*, vol. 19, no. 2, pp. 6–15, 2018, doi: 10.29375/25392115.3438.
- [16] F. Paz, F. A. Paz, J. A. Pow-Sang, and L. Collantes, “Usability heuristics for transactional web sites,” in *ITNG 2014 - Proceedings of the 11th International Conference on Information Technology: New Generations*, 2014, pp. 627–628, doi: 10.1109/ITNG.2014.81.
- [17] T. Wahyuningrum, C. Kartiko, and A. C. Wardhana, “Exploring e-Commerce Usability by Heuristic Evaluation as a Complement of System Usability Scale,” Oct. 2020, doi: 10.1109/ICADEIS49811.2020.9277343.
- [18] G. E. Chanchí, M. C. Gómez Álvarez, and W. Y. Campo Muñoz, “Criterios de usabilidad para el diseño e implementación de videojuegos,” *Rev. Ibérica Sist. e Technol. Informação*, no. E26, pp. 461–474, 2020.
- [19] D. Pinelle, N. Wong, and T. Stach, “Heuristic Evaluation for Games: Usability Principles for Video Game Design,” in *Proceeding of the twenty-sixth annual CHI conference*, 2008, pp. 1453–1462.
- [20] G. E. Chanchí, M. C. Gómez, and W. Y. Campo, “Propuesta de un videojuego educativo para la enseñanza-aprendizaje de la clasificación de requisitos en ingeniería de software,” *Rev. Iber. Sist. e Technol. Inf.*, no. E22, pp. 1–14, 2019.
- [21] M. Inga, L. Zemanate, and G. Chanchí, “Evaluación Heurística De Usabilidad Sobre El Sistema Gestor De Base De Datos (SGBD) De Sevenet De La Industria Licorera Del Cauca (ILC),” in *Avances y Experiencias Innovadoras en Computación e Informática*, Pasto, Colombia: Universidad CESMAG, 2020, pp. 231–247.