A New Way to Generate Urban Environments for Video Games Using the Architectural Impression Curve Method

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Abstract. One of the most important elements influencing the perception of the game is a properly designed space that accompanies the gameplay. Designing a level in such a way that it provides the viewers with the impressions assumed by the designer at a given moment of the game, and thus becomes visually engaging or merely a background, is a task requiring adequate preparation, experience, and many simulations. We have proposed a new way of generating urban space using the architectural method of the impression curve. In developing the tool, we defined the individual values of the impression curve in spatial form and its accompanying relationship, so that the game environment corresponds to the user's experience at the adopted scale. We analyzed the levels, generated with our tool based on the defined impression curves, by a group of users who produced their impression curves as part of their exploration of the space. Our method indicated a different take on modular and generative spatial design than has been done to date, and the effectiveness of the proposed solution. Our discovery will allow further development of the use of the impression curve method in video games and link it to currently studied methods of the gameplay curve or audio curve, as components responsible for the appropriate control of player engagement and activity.

Keywords: Virtual environment, Level design, Impression curve, Urban space generation

1 Introduction

Level design is a fundamental and intricate phase in the game development process, playing a crucial role in shaping the player's experience. The virtual environment, within which a game unfolds, is not merely a background element but an active component that significantly influences both narrative delivery and

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player immersion. The deliberate structuring of space to evoke specific emotions, guide the player's perception, and align with gameplay objectives is a complex challenge. Achieving the desired effect requires careful planning, extensive design work, and a deep understanding of spatial composition.

Traditionally, game levels and environments intended to facilitate storytelling or enhance player experience are manually crafted by skilled level designers. This approach ensures that every detail—from layout and lighting to object placement—contributes to the intended gameplay dynamics and emotional impact. When designing a level tailored to a specific game concept, mechanics, or playstyle, numerous factors must be analyzed and seamlessly integrated into a coherent framework [18]. The interplay of aesthetics, functionality, and player psychology dictates the success of the final design.

In recent years, the field of Procedural Content Generation (PCG), including the automated creation of game levels, has been gaining traction as an alternative or complementary approach to manual design. The advancement of PCG techniques has led to the development of various algorithms and methods capable of generating diverse virtual spaces. However, despite the progress in this domain, algorithmically generated environments frequently fall short in delivering the depth of immersion achieved by handcrafted levels. Many procedural techniques focus on efficiency and variability but often lack the nuanced spatial storytelling elements that define high-quality level design [6].

The present study explores whether it is feasible to develop a tool that integrates spatial characteristics defined by the Kazimierz Wejchert impression curve as a guiding parameter for procedural environment generation. To achieve this, a generator was designed based on a modular system structured around an urbanized setting—specifically, a street environment. The generated virtual space was composed of individual modules that reflected values corresponding to the impression curve scale, thereby aiming to replicate human spatial perception in a controlled manner.

To validate this approach, a series of test environments were procedurally generated, each structured to align with varying impression curve values. Subsequently, experimental tests were conducted to assess the effectiveness of the method and verify whether it successfully produces immersive, perception-driven spatial compositions. The findings contribute to the ongoing discourse on bridging procedural generation techniques with human-centered design principles, offering insights into the potential for more immersive and narratively cohesive automated level design.

2 Related works

Since the designed tool incorporates subjective parameters such as emotions and impressions, it becomes essential to establish a quantifiable framework that translates these intangible experiences into measurable values. One of the methodologies introduced in architectural studies that aligns with this need is the impression curve, a concept developed by Kazimierz Wejchert [20]. This tool is

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based on a ten-grade scale used to assess variations in spatial perception over time or distance, typically presented in graphical form. By assigning specific characteristics and spatial features to numerical values, Wejchert's approach provides a structured method for analyzing urban environments, with particular emphasis on streets as dynamic, spatiotemporal sequences.

The impression curve has traditionally been employed to evaluate the attractiveness and perceptual qualities of streets, public spaces, and other elements of urban landscapes. It has been widely used in architecture and urban planning as a means to analyze human reactions to spatial arrangements and their aesthetic impact [9, 3]. Furthermore, it has found application in real estate valuation, where spatial perception plays a role in determining property desirability [12]. Despite its broad use in the analysis of real-world environments, the application of the impression curve to virtual spaces remains a relatively unexplored domain [16]. Early research efforts in this field, as presented in [14, 15], provided the first indications that the impression curve could serve as a valuable tool in the design and evaluation of digital environments. More recent studies further support this idea, demonstrating that it is possible to apply the impression curve in the assessment of virtual spaces at various stages of level design in video games [2]. This highlights its potential as a quantitative method for evaluating spatial immersion and user experience in digital environments.

Architecture and level design share many common principles and design methodologies, as indicated in [17]. The author of this study not only identifies the parallels between these fields but also explores the transfer of architectural concepts and spatial planning techniques to the design of virtual environments. One of the key factors influencing the level of immersion in a video game is spatial simulation [13]. In both real-world and digital environments, individuals instinctively construct cognitive maps of their surroundings, gradually memorizing distinctive elements and using them for navigation. This process, fundamental to human spatial perception, is equally applicable to virtual worlds, where the arrangement of objects, pathways, and landmarks influences how players interact with and explore their surroundings. The way in which space is structured significantly impacts the player's ability to navigate and their motivation to explore, reinforcing the importance of intentional level design.

A well-designed game environment, much like an urban setting, can subtly guide player movement and encourage exploration through careful placement of visual cues and suggestive design elements. A clear example of this approach is Disneyland, where architectural and spatial design are deliberately employed to direct visitors' paths and enhance their overall experience [11]. Similarly, in video game level design, the application of architectural knowledge enables the creation of spaces that feel realistic, engaging, and intuitive to explore. Beyond realism, this approach allows games to serve as immersive representations of distant, lost, or even entirely fictional locations, reinforcing the idea that video games can act as experiential tools for exploring environments that might otherwise be inaccessible [10].

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The studies presented above underscore the significant impact of architectural techniques on increasing player immersion and shaping the perceptual experience of digital spaces. Prior research confirms that the impression curve can be successfully applied to the evaluation and validation of virtual worlds, offering a structured and quantifiable method for assessing spatial design and user engagement. By integrating architectural analysis with level design methodologies, future research can further refine these approaches, bridging the gap between real-world spatial perception and the immersive potential of digital environments.

3 Modular Approach

The problem of generating urban spaces can be divided into four stages, each of which is carried out using different methods: space planning, which involves the division into streets and designated areas for buildings, the generation of the external appearance of buildings, the internal spatial division of structures, and the distribution of details and furnishings within the generated environment [4]. These stages contribute to the overall realism and functionality of the virtual space. However, evaluation criteria typically focus on aspects such as realism, scale, variety, performance, or algorithm control, while the degree of player immersion is often not taken into account [7]. Most research in this area emphasizes the development of techniques for procedurally generating cities and buildings, analyzing performance, the degree of control over the process, and the runtime efficiency of algorithms. While these aspects are essential for optimizing generation methods, they do not sufficiently address the influence of the generated space on gameplay and player experience, as seen in studies such as [19, 1, 8]. In this paper, the criteria for verifying the performance of the system will be based on how closely the players' impressions, expressed on the ten-point scale of the impression curve, correspond to those assumed at the stage of space generation.

The layout and generation of buildings are carried out using two primary methods: employing objects that represent entire building models or constructing objects from smaller modules. Another possible approach involves algorithms that directly operate on a grid-based system [1]. The first method is the most straightforward in terms of implementation but is also the most time-consuming. Designing an entire building as a single model requires considerable manual effort, particularly when a diverse set of structures is needed to maintain the visual variety of the environment. While procedural algorithms can modify the geometry of pre-existing models to introduce variation, they do not provide complete control over the resulting forms. This limitation is problematic for an urban environment generator that relies on specific perceptual guidelines, such as the impression curve, as an input factor. To address this issue, the modular approach to building generation was adopted.

Authors in [5] classified modular construction methods based on the type of modules used, identifying three main categories. The first type consists of small, indivisible modules that serve a specific function but cannot exist independently

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within a scene. Examples of such modules include windows, pillars, or doors, which must be combined with other elements to create a complete structure. The second type, referred to as the "box" concept, defines modules as larger architectural units that incorporate a greater level of detail and do not necessarily require integration with additional components. Some of these modules can function as standalone objects, appearing in the generated environment without further modification. The third type is a hybrid approach that combines elements of the first two categories, offering larger modular components composed of smaller, indivisible objects. Although this method allows for the creation of complex and unique architectural forms, it also presents challenges related to computational efficiency and design constraints.

For the design of the urban space generator, the "box" concept was selected due to its ability to balance control over architectural details, the level of variation in structures, and the efficiency of module creation. Research conducted in [5] indicates that this approach provides an optimal compromise between maintaining a detailed and recognizable architectural style while allowing for procedural diversity in the generated space. By adopting this method, the generator can produce urban environments that align with predefined perceptual expectations, ensuring that the spatial experience conforms to the intended values of the impression curve. This structured approach facilitates the creation of immersive and coherent virtual spaces while maintaining a level of flexibility that supports both design efficiency and user engagement.

4 Methodology

The aim of the research was to verify the performance of the generator and the modular structure for defining space developed within it, as well as to verify the application of the impression curve as a set of data shaping a reliable space at the stage of advanced blockout without human intervention. To the generator, 49 base modules were prepared, which were then additionally modified by adding additional decorative elements, thus obtaining 210 modules that will be used to generate buildings. Based on the quantisation of grades prepared by Kazimierz Wejchert in [20], individual modules received scores. To further reduce the probability of the occurrence of a sense of boredom with the environment, which is reflected in the scale by a downgrading, an additional system based on probability was used, according to which a given module can be assigned multiple assessments with a numerical chance of their occurrence within a given rating. This allowed the scores to be blurred in such a way that modules designed for lower scores could also appear within higher scores, but with correspondingly lower probability. This allowed more realism and more modules to be matched to a particular grade. The division of modules according to their function was also introduced - base or ground level (always present and being level 0), floors (levels above 0), roof/ceiling (being the tip of the building). A given module has a selected value of the impression curve based on its complexity. Examples of designed modules can be seen in Figure 1.

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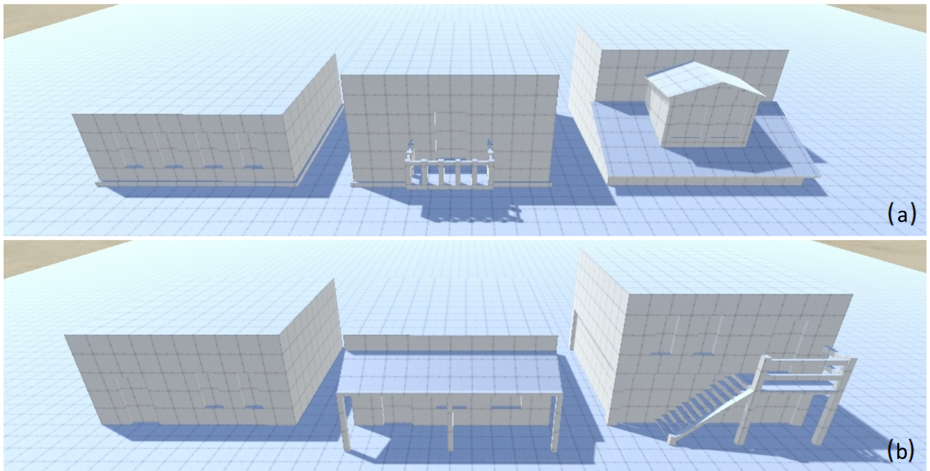

Fig. 1. (a) Examples of modules serving as a base, (b) examples of modules serving as floors. Examples of modules from which buildings are constructed.

As the impression curve tool works best with linear spaces, the street was used as a form of urban environment. Twenty-two street structure templates were also designed and assigned to specific grades based on theories from the field of architecture. All models are based on simple geometry only, as it is already possible to use the impression curve at this level design stage [2]. Additional input for the application was also the determination of the acceptable quantity of one module. This allows adjustment of how many times the same modules can be used in a particular grade. Lower grades had larger values, while higher grades had smaller and smaller values, to avoid a situation where many modules are repeated and create a feeling of monotony.

A test application was prepared for the research. The character, which is controlled by the player, uses a first-person camera. To maintain the linearity of the test, additional restrictions were introduced so that the user can only move along a dedicated section of the street, even if the street has additional openings or branches. Each level consists of generated sections of street and is on average 50 units in length, with an evaluation of the environment taking place halfway through. The player moves at a speed of 5 units per second - so assuming the player does not stop and moves in the right direction all the time, they reach the next point in about 10 seconds.

The environment has three levels (referred to as L1, L2 and L3 hereafter), different impression curves were used to generate each level. All three streets consist of 7 fragments generated by the program and evaluated during the experiment. The values of the impression curve from which each level was created are as follows: L-1 - 1, 3, 4, 4, 5, 3, 2; L-2 - 4, 3, 5, 6, 6, 8, 7; L-3 - 4, 5, 7, 9, 10, 8, 5. The choice of three levels with slightly different values and curve shapes allows the different courses of the impression curve to be examined.

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5 Generator implementation

The functioning of the generator is based on a structured data system in the form of an object that stores information about all predefined modules. Each module is characterized by a set of parameters that determine its properties and placement rules within the generated environment. These parameters include the type of module, its dimensions, window styles, and specific impression curve values within which the module can appear, along with the associated probability (weight) for each value. Additionally, the structure contains information about whether the module has alternative versions, which may differ in terms of detail, as well as which walls of the module contain additional decorative elements such as windows, balconies, or protruding architectural features. The module manager also incorporates a set of predefined street templates, each of which has associated ratings that determine its probability of selection. Within each street template, there are designated building placement areas that include constraints on the types of modules that can be selected for that location. These constraints specify the allowable module sizes and define which walls of the buildings can contain decorative elements. By enforcing these constraints, the system ensures that adjacent buildings do not have overlapping side-wall decorations, preventing visual inconsistencies and maintaining architectural coherence in the generated environment.

The generator operates by processing the impression curve values provided as input and selecting corresponding street templates based on their assigned evaluation scores. Once a street template is chosen, the system proceeds to generate buildings within the designated areas by sequentially selecting their base, main structure, and roof. At each step of this process, only modules that are compatible with the given evaluation criteria and impression curve values are considered. Additionally, the probability weight assigned to each module influences its likelihood of being selected, meaning that modules with higher weights for a particular impression curve value have a greater chance of being used in the final generated environment.

To maintain variety and prevent excessive repetition of specific modules within a single street, the generator tracks the number of times each module has been selected. This mechanism ensures that no module appears more frequently than permitted by the predefined program parameters for a given impression curve evaluation. The described sequence of operations is applied iteratively to each of the impression curve values provided as input to the generator, resulting in a procedurally assembled urban space that aligns with the intended spatial perception and design objectives.

6 Procedure

There were 36 participants in the study, the vast majority of whom ($n = 33$) were aged between 16 and 27 years old. Each participant knew the basics of computer use, was familiar with computer games and common control schemes.

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The experiment was conducted remotely. An important assumption was that the subject had no information regarding the impression curves used to generate the levels, and each level was passed only once without repeating the experiment.

At the beginning of the test, an introductory screen was displayed to familiarize the participant with the details of the experiment. The message provided information regarding the number of levels, the purpose of each level, and a brief explanation of the evaluation procedure. Additionally, the participant was informed about the evaluation scale, with an important clarification that a score of 1 corresponds to a simple and uninteresting environment, while a score of 10 represents a highly engaging space rich in detail and architectural dominants.

Once the participant acknowledged the message, they were allowed to explore the virtual street environment. Upon reaching the designated evaluation point, movement was restricted, although the participant retained the ability to look around freely. The evaluation process commenced as soon as the participant confirmed their readiness by pressing the designated button. Following the evaluation, movement was re-enabled, allowing the participant to continue exploring.

Reaching the end of the street triggered progression to the next level. In cases where the completed stage was the final one, a concluding screen was displayed. Upon completion of the experiment, a CSV file was generated, recording the participant's ratings for each of the three tested levels. Examples of the generated street segments evaluated during the study can be seen in Figure 2.

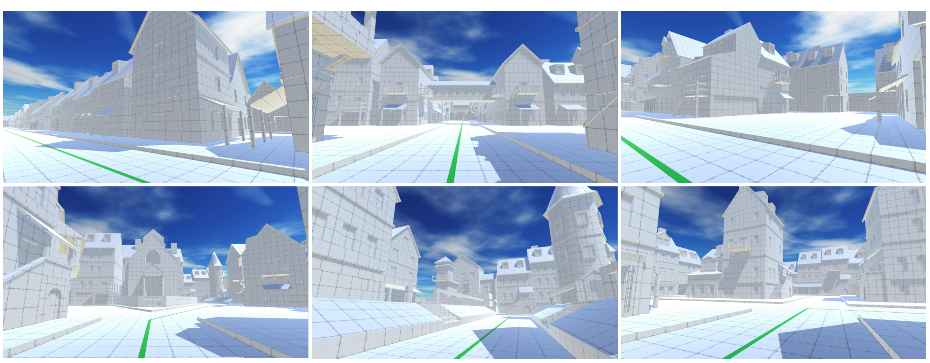

Fig. 2. Sample screenshots showing street fragments that were generated with the implemented system and were evaluated during the study. Fragments generated sequentially from grades: 4, 8, 6, 9, 10, 8. Screenshots from the application showing the generated street sections.

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7 Results

Before the results could be analyzed, they had to be properly processed so that comparisons could be made between the results and the values used in the generator. The impression curve represents subjective values of impressions, but according to research, individual elements in space influence the observers' feelings to the same or similar extent. This means that it is possible to use individual impression curve plots to prepare an averaged result [20, 2].

measuring point	1	2	3	4	5	6	7
L-1							
original value	1	3	4	4	5	3	2
average	3.81	4.58	5.64	5.42	6.33	4.42	3.53
standard deviation	1.647	1.498	1.566	1.479	1.528	1.422	1.481
L-2							
original value	4	3	5	6	6	8	7
average	5.11	4.44	6.28	6.92	6.81	7.75	7.11
standard deviation	1.021	1.257	1.304	1.320	1.350	1.441	1.429
L-3							
original value	4	5	7	9	10	8	5
average	5.11	5.5	6.75	9.14	8.81	8.44	6.42
standard deviation	1.286	1.236	1.187	0.787	1.023	1.383	1.233

Fig. 3. Summary of the values used to generate the street, the mean scores of the experimental participants and the standard deviation for each level.

Due to the inherently subjective nature of the experiment, the ratings provided by individual participants exhibited variations both in scale and in the range of values used. Some participants utilized the entire spectrum of available ratings, while others predominantly assigned lower or higher scores, limiting their evaluations to a narrower subset of the scale. Additionally, there were noticeable differences in the way ratings fluctuated throughout the experiment. In many cases, participants provided scores that followed a relatively stable and linear pattern of increase or decrease. However, for some individuals, the assigned ratings appeared more inconsistent, with abrupt changes in values, leading to greater fluctuations between subsequent evaluations.

To analyze the collected data, the mean and standard deviation were calculated for each evaluation point across all three tested levels. The summary of the original values used for generating the street fragments, along with the computed statistical measures, is presented in Fig. 3. The observed standard deviations confirm the diversity in rating tendencies among participants, reflecting the subjective differences in how individuals perceived and evaluated the generated spaces. Notably, the standard deviations appear to be higher for the first level, which may indicate that participants initially lacked a clear reference point for how to appropriately distribute their ratings along the scale. As

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the experiment progressed, this variability tended to stabilize, suggesting that participants gradually developed a more consistent internal framework for assessing the environments. This pattern highlights the importance of contextual familiarity in subjective evaluations, where early assessments may be influenced by uncertainty or a lack of comparative reference, gradually adjusting as users gain more experience with the task. Examples of the street sections evaluated by participants, representing the lowest, intermediate, and highest grades used in the experiment, are shown in Figure 4.

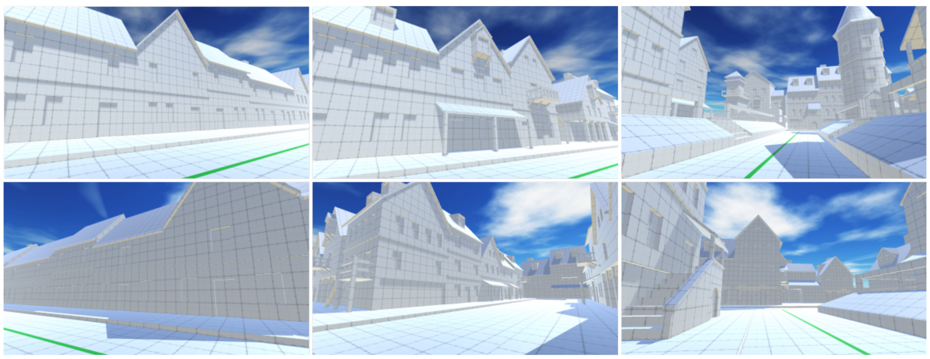

Fig. 4. Examples of points where participants in the study were asked to evaluate the space.All of the points presented were then used in the questionnaire. Extracts with the lowest, intermediate and highest grade are presented. The fragments generated sequentially from the grades: 1, 5, 10, 1, 5, 10. Screenshots from the application showing the generated street sections.

8 Discussion

The impression curve is a tool influenced by the subjective feelings and predispositions of the observer. Depending on the individual, the rating scale may vary and be used to a different extent. This means that as a criterion by which to confirm the effectiveness of the implemented generator, it cannot be used only whether the average of the samples observed during the experiment is close to the original value of the curve at a given point.

In this regard, additional criteria have also been adopted in terms of which the effectiveness of the solution will be tested:

- The same trend of ratings between points was observed. This means that the monotonicity of the averaged curve is the same as the impression curve from which the level was generated.
- The numerical change in mean scores between points is like the numerical change in scores from the impressions curve used.

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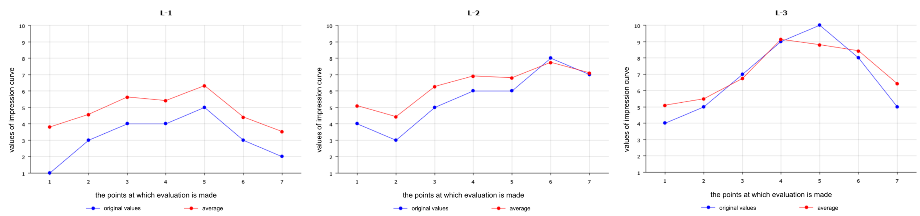

Fig. 5. Comparison of the course of the original impression curve and the average impression curve for the conducted research

– The global extremes are at the same points.

Fig 6 highlights where the trend of the averaged curve differs from that assumed. However, it is worth noting that two of these differences relate to two street sections that were generated using the same value. The system used the same values, which means that the user had to travel twice as long a route generated using the same rules and the same pool of available modules for the grade. The author in [20] pointed out that a lack of change in the structure of the space or in the amount of detail negatively influences the feeling, so that a decrease in such places, although different in trend from the assumed one, is not accepted as an anomaly.

section	1 – 2	2 – 3	3 – 4	4 – 5	5 – 6	6 – 7
L-1						
trend - original curve	increase	increase	**constant**	increase	decrease	decrease
trend - averaged curve	increase	increase	**decrease**	increase	decrease	decrease
L-2						
trend - original curve	decrease	increase	increase	**constant**	increase	decrease
trend - averaged curve	decrease	increase	increase	**decrease**	increase	decrease
L-3						
trend - original curve	increase	increase	increase	**increase**	decrease	decrease
trend - averaged curve	increase	increase	increase	**decrease**	decrease	decrease

Fig. 6. Comparison of the trend between individual points between the original and the averaged impression curve.

Analysing the change in scores between individual sections of the averaged impression curve against the change in values for the original curve allows us to see how effective and accurate the implemented system is in controlling the player's feelings. The calculated numerical changes are shown in Fig 7. A difference of at least 0.5 was taken as the difference between the expected value and the averaged value, which can be considered significant. This is due to the previously mentioned elements such as different rating scales among users. The first point where the calculated difference is relatively large is the very beginning of the first level. This is most likely since the players had no reference point

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section	1 – 2	2 – 3	3 – 4	4 – 5	5 – 6	6 – 7
L-1						
change in grades- original curve	**2**	1	0	1	-2	-1
change in grades - averaged curve	**0.77**	01.06	-0.22	0.91	-1.91	-0.89
difference (absolute value)	**1.23**	0.06	0.22	0.09	0.09	0.11
L-2						
change in grades- original curve	-1	2	1	0	**2**	-1
change in grades - averaged curve	-0.67	1.84	0.64	-0.11	**0.94**	-0.64
difference (absolute value)	0.33	0.16	0.36	0.11	**1.06**	0.36
L-3						
change in grades- original curve	**1**	**2**	2	**1**	**-2**	**-3**
change in grades - averaged curve	**0.39**	**1.25**	2.39	**-0.33**	**-0.37**	**-2.02**
difference (absolute value)	**0.61**	**0.75**	0.39	**1.33**	**1.63**	**0.98**

Fig. 7. Comparison of the numerical change of scores between the different points. A positive value means an increase by a given value, while a negative value means a decrease.

at the beginning of the experiment and each participant took a different input threshold for the ratings. The largest discrepancy in the change in the value of the ratings between the different points was observed in the third level, which contained not only the highest ratings but also the largest increases or decreases between them. One reason may be the assumed length of the street, which was too short to express such large differences in player sentiment when the ratings are already at a high level. This also means that the system should not only take into account the mere trend between grades through a different pool of modules, the frequency and multiplicity of their occurrence or the structure of the space, but should also take into account the intensity of change.

While this study focused exclusively on the spatial geometry of urban environments, it is important to acknowledge that additional factors such as lighting, textures, sound design, and gameplay context also significantly influence the player's perception of space. These elements were intentionally excluded to isolate the effects of spatial structure, but their impact has been described in prior work, particularly in [2]. This provides a foundation for future studies aiming to integrate multiple sensory and contextual elements into impression-based procedural generation.

9 Conclusions

The research presented here indicates that implementing an urban space generator using impression curve values as input is possible, and furthermore, using geometry alone to represent urban objects is sufficient to predict the player's feelings, confirming previous research in this area. Further improvements to the performance of the system and additional research could be conducted. Some of the potential improvements that were highlighted after analyzing the results include:

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- Considering the values of the previous street fragment for additional space modifications to create smoother transitions and maintain continuity between segments.
- Implementing additional rules for the generator when the impression curve used as input contains several consecutive points with the same value to avoid repetitive spatial structures.
- Generating additional decorations and environmental elements for higher-rated segments to enhance detail richness and improve player perception of space.

An important addition to the research will be an analysis of the influence of player characteristics, such as player type and player motivation and prior experience with design or architecture, on the alignment of the assigned ratings with the shape of the original impression curve. Understanding these variations could provide insights into how different users perceive and evaluate virtual spaces, potentially refining the application of impression curves in procedural urban environment generation. This direction represents an opportunity for further development in integrating architectural principles into virtual spatial design.

References

1. Alkaim, A.: Procedural generation for architecture (2015)
2. Andrzejczak, J., Osowicz, M., Szrajber, R.: Impression curve as a new tool in the study of visual diversity of computer game levels for individual phases of the design process. In: International Conference on Computational Science. pp. 524–537. Springer, Springer International Publishing (2020)
3. Antoszczyszyn, M.: Methodology of spatial perception and proxemics learning in szczecin architecture faculty. General and Professional Education **2018**(1), 7–16 (2018)
4. Cogo, E., Prazina, I., Hodzic, K., Haseljic, H., Rizvic, S.: Survey of integrability of procedural modeling techniques for generating a complete city. In: 2019 XXVII International Conference on Information, Communication and Automation Technologies (ICAT). pp. 1–6. IEEE (2019)
5. Fenech, B., Carter, J.: Approaches to modular construction for real-time game environments. Tech. rep., University of the Sunshine Coast, Queensland (2017)
6. Johnson, M.R.: Integrating procedural and handmade level design. In: Level Design Processes and Experiences, pp. 217–242. AK Peters/CRC Press (2017)
7. Kelly, G., McCabe, H.: A survey of procedural techniques for city generation. ITB Journal **14**(3), 342–351 (2006)
8. Kim, J.S., Kavak, H., Crooks, A.: Procedural city generation beyond game development. SIGSPATIAL Special **10**(2), 34–41 (2018)
9. Mordwa, S.: Krzywa wrażeń dla ulicy piotrkowskiej w Łodzi (2009)
10. Porreca, R., Geropanta, V., Abril, K., Giordanelli, D.: Gaming as a disembodied experience of the city: from assassin's creed to'smart learner'. SCIRES-IT-SCIentific RESearch and Information Technology **10**(2), 117–130 (2020)
11. Rogers, S.: Everything i learned about level design i learned from disneyland. In: Game Developers Conference (2009)

ICCS Camera Ready Version 2025
To cite this paper please use the final published version:
DOI: 10.1007/978-3-031-97573-8_6

12. Senetra, A., et al.: Wpływ metodyki oceny walorów krajobrazowych na wyniki szacowania nieruchomości. Acta Scientiarum Polonorum Administratio Locorum **9**(2), 113–128 (2010)
13. Swink, S.: Game feel: a game designer's guide to virtual sensation. CRC Press (2008)
14. Szrajber, R.: Impression curve and the gameplay curve as an attempt to record the player's experience (2014)
15. Szrajber, R.: Architecture in video games - seeing or experiencing (2017)
16. Szrajber, R.: Architecture in virtual worlds as a field of research. In: Badania Interdyscyplinarne w Architekturze 2. vol. 1, pp. 55–66. Silesian University of Technology, Wydzial Architektury Politechniki Slaskiej (2017)
17. Totten, C.W.: Architectural Approach to Level Design. CRC Press (2019)
18. Upton, B.: Pt and the play of stillness. In: Level Design Processes and Experiences, pp. 185–204. AK Peters/CRC Press (2017)
19. Viitanen, H.: Procedural city generation tool with unity game engine (2016)
20. Wejchert, K.: Elementy kompozycji urbanistycznej. Arkady (1984)

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