THE RELATIONSHIP BETWEEN SPATIAL CONFIGURATION AND SPATIAL BEHAVIOR IN ONLINE GAME SPACE

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Abstract

This study aims to identify factors influencing people's recognition of space in virtual reality. Our study subject is the on-line game of the World of Warcraft (WOW). Virtual space in games is different from common virtual space. Game users access a game and share its space to enjoy various contents. It can be said that virtual environment in games is different from the ones realized in other existing studies in that game users are exposed to virtual space for a relatively longer period, they know it well, and they can move by watching key maps.

Through this study, we will learn to predict how users of virtual space act in that space when we are designing a virtual space, and also to understand which factors of space recognition influence users in their space recognition activities in virtual space. In addition, we will be able to learn what kind of influence key maps have on people's behaviors.

For research method, first, an appropriate subject space in the WOW was selected and the traffic volume of game users appearing in that space was examined. Then space syntax analysis was used on space realized in games to measure global integration, local integration, depth, and distance, after which the relationship between the analyzed syntactic properties and the traffic volume was closely examined. In addition, a survey was conducted on game users in order to understand how much impact the key map had on deciding their walking path.

The regression analysis of the syntactic properties and the traffic volume indicates that global integration had the highest correlation, followed by depth, distance, and local integration. These results are contrary to existing studies, in which local integration is shown to have the highest correlation. The reason for this seems to be that in the real environment, people recognize space while walking and, based on that recognition, they decide on the next walking path, whereas game users move after recognizing the spatial structure to their target in virtual reality, made possible by their use of the key map.

Introduction

Finding factors that influence people to recognize space and clarifying their mutual relation is an important tool in understanding the relationship between human beings and architectural environments. In this context, the study of the relationship between space and spatial behavior is continuously progressing.

Until now, the setting of the architectural environment for a study has progressed concerning two aspects mainly. The first is a behavioral study that examines the actual environment that people encounter, and the second is a study in which a virtual space is created and the reactions of its users are analyzed.

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As the importance of virtual reality (VR) is gradually becoming apparent, more studies are being carried out even though they are as yet limited. However, discussions of spatial recognition and behavior of human beings VR studies have been unsatisfying until now. Even studies of VR itself are limited in that VR is something that is created arbitrarily as an experimental space to substitute for actual reality.

Dalton (2001)[i] proved that human beings select a path with the smallest degree of deviation from the direction they are heading by using a VR environment with various degrees of parting roads as the experimental subject. Saif (2005)[ii] created an actual spatial configuration in VR, and found out that the examination subjects recognized the spatial configuration of VR in a way similar to that by which they recognized actual reality. However, this kind of study has as its subject an experimental space in which the participants are made to use a space that they have not yet encountered.

On the other hand, the graphic environment of computer games is gradually becoming closer to that of reality, and currently almost all games are in 3D and thus offer environments that are very similar to reality. In particular, many users connect simultaneously onto online games and they enjoy various contents by sharing the game space. Also, by being in contact with the game space not merely for one or two hours but by being active in it for a very long time, they learn the spatial configuration of the game. In other words, a living environment is being created, and people are moving within that environment.

With this in mind, the methods that most VR studies choose – studies in which a VR is created and the reactions of the participants in that space are examined – can be said to be quite different from each other in terms of the amount of exposure to the environment or in the degree of learning that occurs in the virtual space of games. Generally, virtual space has meaning in that it gives users a chance to study in advance, but this point seems to be missing in existing studies on VR.

In other words, the users' frequency of exposure and level of learning regarding the virtual environment may be said to be much more limited than their spatial knowledge of real space. Considering that the exposure time in a game space is relatively longer and that there is more learning involved, and also considering that users can move by looking at the key-map, it may be said that game space is different from the VR created and used in existing studies.

If how users recognize virtual space and act in this game space is clarified, then how the people using that space will act could be predicted when planning or designing virtual spaces. In addition, what kind of spatial configuration factors a person is influenced by when perceiving virtual space can be closely examined.

In this context, the purpose of this study is to analyze what characteristics of spatial configuration influence the behavior of space usage by analyzing spatial behavior in virtual realities created in games.

Contents and Method of Study

Contents of Study

The study was carried out in the following way to verify the influence of spatial configuration characteristics on space usage behavior and the role of a key-map in spatial behavior. First, online games that are currently in use were selected as the subject of the study. Second, a survey was done on the frequency of key-map use and at which times it was used in order to look at the influence of key-maps on users of the game. The survey was conducted through a mailing system in the game and given to arbitrary users who were at level 20 or higher, which showed their degree of expertise in the game. Third, such things as Integration, Integration (3), Control, and Point Depth were calculated using Space Syntax techniques, with the space created in the game as the subject. At this point, the movements of the users of the game were examined, which were then reflected on the creation of an axial line. The Point Depth was calculated based on the axial line of the space where most of the users first enter and meet. Fourth, the behavioral patterns of the users in virtual space were discovered by surveying the traffic of the users. The standard for measuring the traffic was to use the axial line that was previously drawn up as the center point, and each position was examined for 10 minutes. Fifth, the distance from the standard point that was used when analyzing the Point Depth to the point of traffic measurement was found. Sixth, the correlations between traffic volume and Integration, Integration (3), Control, Point Depth, and Distance, which were found previously, were analyzed using statistics.

Subject of Study: World of Warcraft Online Game

“World of Warcraft” (WOW) was selected as the game case study. The reasons for selecting WOW as the study subject game were as follows: First, this game has many users. Its formal online service started over three years ago and many users have been using it for a long period of time.

Second, because roads and buildings in the game space are composed in the same proportions as they would be in reality (refer to Figure 1), the users can perceive virtual reality using the same standards found and used in reality.

Third, numerous alternative plans exist in selecting the course of movement, and users are frequently forced to select a course of movement because target buildings are distributed in all directions. Here, the target building refers to a target that a user seeks for a special purpose, such as a hotel, a weapon store, a necessities store, a castle gate, or an auction house.

WOW is a multi-play online role-playing game[iii] that was developed in 2004 by the software development company Blizzard Entertainment[iv]. It is based on the computer strategy simulation game Warcraft, which was developed in 1994 and recorded the greatest number of sales ever in the history of the computer game industry. This game can be played simultaneously by thousands of players, and the servers are divided largely into two types, regular and war, by the countries to which the users belong. Of the two types, the players select the service that most fits their taste, choose a race from among the eight races, and then select one of the nine various types of jobs, after which they can begin playing. A player’s main purpose is to explore dungeons by carrying out the given quests in a virtual continent called “Azeroth,” and the player carries out activities such as transferring, chatting, fighting, selling, and buying in the game.

Figure 1:

WOW play screen

The users of WOW play by selecting one of the two races that are at war with each other, and the members of each race enjoy the game independently since exchange, chatting, or the course of movement between the races are blocked. In this study, race A, which is one of those races, is chosen and analyzed. WOW has 38 servers, but since the number of simultaneous users for each server is limited, the users that connect afterwards must wait until the connected users end their game when the number of users reaches the server capacity. Thus, at the times during which the number of users is at its maximum, the same number of users always exist in the game and that state is maintained for a long period of time in popular servers. In investigating traffic, since all places cannot be measured at the same time, it is desirable to have a constant number of people crossing the target location. It is also good to have a situation in which the ratio of the races is close to 1, and thus have no special events such as war or terror. The server "Elun," which satisfies the two conditions, was selected as the subject server. On the Elun server, 1,397 users belonging to race A and 1,533 users belonging to race B play during the evening time (18:00-24:00) when the users are most crowded and the ratio between the races is 1.1, which is ideal[v]. The server is managed independently by country, and the Korean server was chosen as the subject in this study.

Azeroth is composed of 46 regions, and of those, there are 31 activity regions for race A, shown in Figure 2. Each region can be divided largely into three parts, and they are classified as big cities (L1, L2, L3), small cities (S1~25), and port cities (P1~3). S9 only has air routes that connect with the cities of race B, so air routes are not shown in Figure 2.

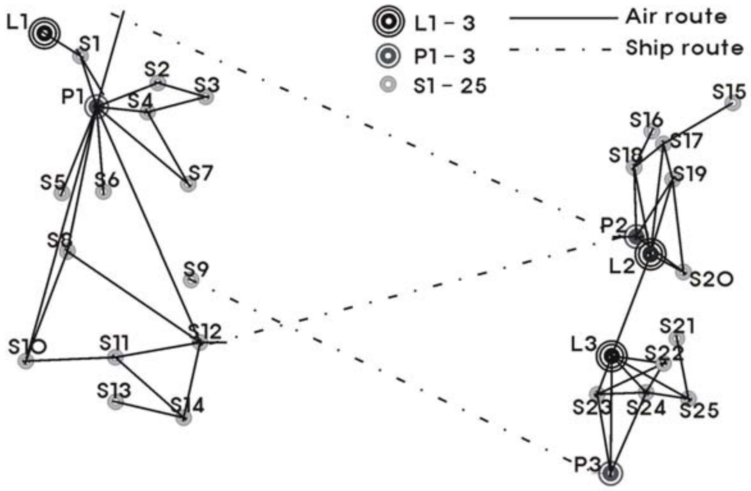

Figure 2:

The transfer routes of race A in the Elun server

Small cities act as the center points of each field, and port cities act as major points of transportation. On the other hand, big cities are places where users gather, and are suitable for examining the spatial behavior of users because cities are where the target buildings needed in the game are concentrated, and so they act as nodes at which people gather and transfer to other regions. There are three big cities that race A uses: L1, L2 and L3. L3 is selected as the subject location for this study because it has many users, and does not have an inflow that is difficult to predict, such as "return home" – which is a uni-directional magic function by which a user can instantly be transported to a hotel that the user chooses within the game. The transfer methods (see Table 1) that users can use within the game include moving by walking or by riding a horse in L3, and these are like walking in real life. The only difference between walking and riding a horse is in transfer speed, but there is no change in the game screen shown to users. Crossing L3 diagonally takes about four minutes while walking, and real time and the time of WOW are the same. For transportation by air, the flight time takes two minutes for the closest distance and about 30 minutes for the furthest distance.

Table 1:

Transportation methods in the game

Transportation method	Speed	Transfer Route	Others	Allocation Interval
Walking	100%	Free will	Basic movement	-
100 gold horse	160%	Free will	Level limit 40	-
1,000 gold horse	200%	Free will	Level limit 60	-
Air transportation method	400%	Service section	A small transportation fee	-
Boat	Instantaneous transfer	Service section	Board at a port city	5 minutes
Return home	Instantaneous transfer	Selected hotels	Only one hotel can be selected	1 hour
Summon	Instantaneous transfer	Place of summoning	Special skill of the black magician Two helpers needed	-
Portal	Instantaneous transfer	Big city magician district	Special skill of the magician Usage possible only for colleagues of the magician that activated the portal	-

In L3, buildings that play major roles within the game and NPCs (Non-Player Characters)[vi] that must be encountered are dispersed throughout the game. Each user uses L3 to visit various places based on need, to meet each NPC as a requirement to accomplishing quests, or as a gateway to get out to the field. Figure 3 is the image of a map that unfolds on the screen while using the key-map as an image of L3.

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Figure 3:

Map of L3

A Survey on the Usage of the Key-Map

A survey was carried out to discover the effect of key-maps on users that play the game. As shown in Figure 4, the surveys were sent out to and retrieved from a great number of unspecified users at level 20 or higher by using the mailing system provided within the game.

Figure 4:

The sending out and retrieval of surveys

When a text mail is sent out to the ID of the user who will be doing the survey by using mailboxes installed at numerous spots within the game, as in Figure 4, the user receives an indication that mail has arrived, and goes to a nearby mailbox to read the mail. All of this happens within the game. The delivery time of the mail is a few minutes, and is based on the distance between the users exchanging mail. Also, limiting the level of users to 20 or higher is done to exclude users who are inexperienced in recognizing the existence of and in using the key-map, since their playing time in the game is short. It normally takes about a week for a user to reach level 20. We sent out emails to 130 users and received a total of 50 replies, which was a 38% response rate.

Space Syntax Analysis

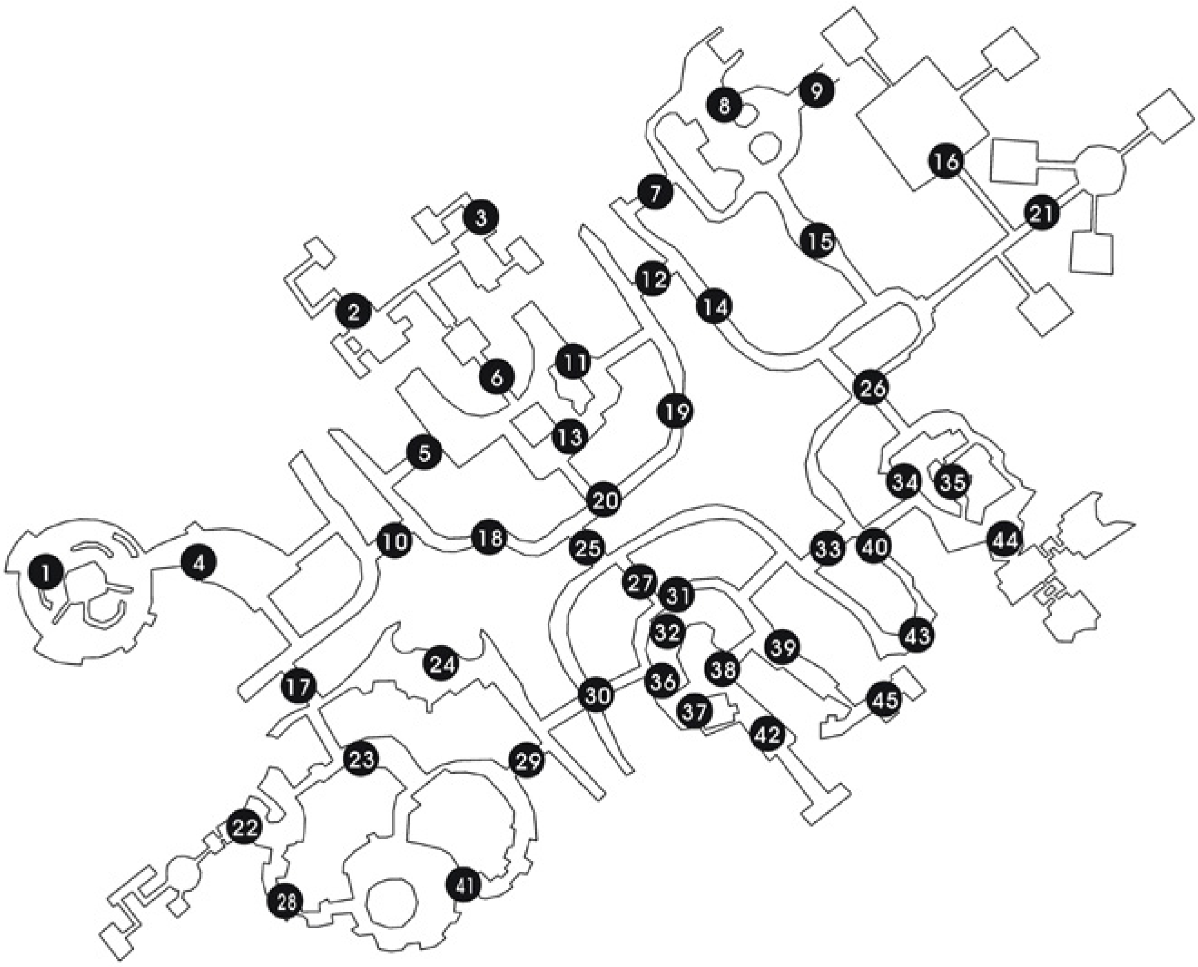
To analyze the spatial configuration of the game space, an axial line was made by using the aerial map of the entire WOW (Figure 2) and the map of L3 (Figure 3). Also, in drawing axial lines, the behavior of users in the subject location of the study was observed and referenced in order to reflect the spatial behavior of users more accurately. After drawing the axial lines, its syntactic properties were analyzed by using the Axman program. When calculating the value of the Point Depth, the axial line number of 39 in Figure 5 was established as the origin. The origin is a spot where users arrive when they come to L3 to go into it, and the spot is a location that almost all users pass through.

Traffic Measurement

The times when the server capacity is full are measured and the traffic is measured for a period of 10 minutes at each of the 45 places in Figure 5. Each location is the center point of each of the axial lines that were previously drawn up in 3.4. A virtual line is drawn perpendicular to the direction in which users move in each location, and then the number of people passing through that line is counted.

Figure 5:

Location of Traffic Measurement

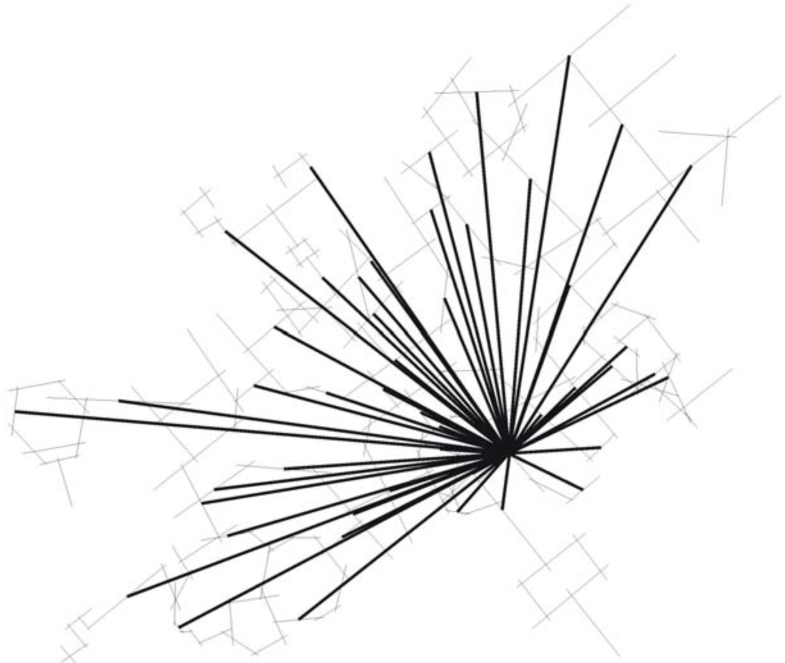


Distance Analysis

Distance is measured in a straight line from the origin to the center point of each axial line, in other words, until the traffic measurement point, as in Figure 6. The origin is set at point 39 in Figure 5, as with the Point Depth in 3.4, and the value of the origin is 0. The value is calculated by having the distance from the origin to the furthest measurement location as 100. Thus, the calculated value is not an absolute number but a value that is proportionally derived.

Figure 6:

The distance from the origin to each location



Comparative Analysis

Based on the traffic measurement results, the correlations between traffic and Integration, Integration(3), Depth, Distance and Control are compared and analyzed. A regression analysis is carried out using StatView 5.0.1, a statistics program. The amount of traffic is set as the dependent variable, and Integration, Local Integration(3), Depth, Distance and Control are set as the independent variables.

Analysis

A Survey on the Usage of Key Maps

When a user manipulates a key-map in the game, a map for the space in which the user is currently located appears on the screen. The user can find out his or her standing location as well as the direction of orientation. Buildings and roads are all marked on the key-map, but the map does not mark any of the other users or NPCs. Therefore, the application of the key-map is predicted to have a great influence on users' recognition of spatial configuration and their behavior. A survey was carried out on game user behavior as it relates to key-map usage, and the results are as follows.

On the question asking about the frequency of the key-map use, "How often do you use the key-map?" 21 people replied "very often", which was 42% of the total number of respondents. Twelve people replied "often", which was 24% of the total, 12 replied "regularly," which was 24%, 3 replied "rarely," which was 6%, and 2 replied "never", which was 4%.

Next, to the question, "When do you use the key-map?" four possible answers were given: "always before moving", "when I do not know the road that I want to take", "after getting off from aerial transportation or out of boats", and "never." As for the replies, 20 people chose the first answer, which was 40% of the total, 28 chose the second answer, which was 56%, none of the respondents chose the third answer, and 2 chose the fourth answer, which is equal to the number of people that said in the first question that they did not use key-maps.

The survey results show that 42 % of the users used the key-map very frequently, and 24% of the users used it frequently or regularly, which shows that 90% of the users of the game appropriately used the key-map. Concerning the usage of the key-map, 40% of the users habitually pressed the key-map to examine the route even though they had been there many times and knew the path well, and 56% of the users mainly used it when they could not remember the road or were not sure.

As shown in the survey analysis results above, the influence of the key-map can be said to be absolute. The users that get help from the key-map can move by looking at the entire spatial configuration, and thus have a great advantage in finding paths. They can not only recognize the entire spatial layout beforehand, but they can also plan the transfer route ahead of time.

Space Syntax Analysis

Figure 7 shows the results of the Space Syntax analysis. The accessibility of each axial line is expressed in the colors of the rainbow spectrum in the analysis data. The color red means that accessibility is at its highest, and as it changes to purple, it shows that accessibility is decreasing. Of the four images, Integration(whole) of the entire region shows the analysis values for all routes, and Integration, Integration(3), and Point Depth show the enlargement of a section in L3.

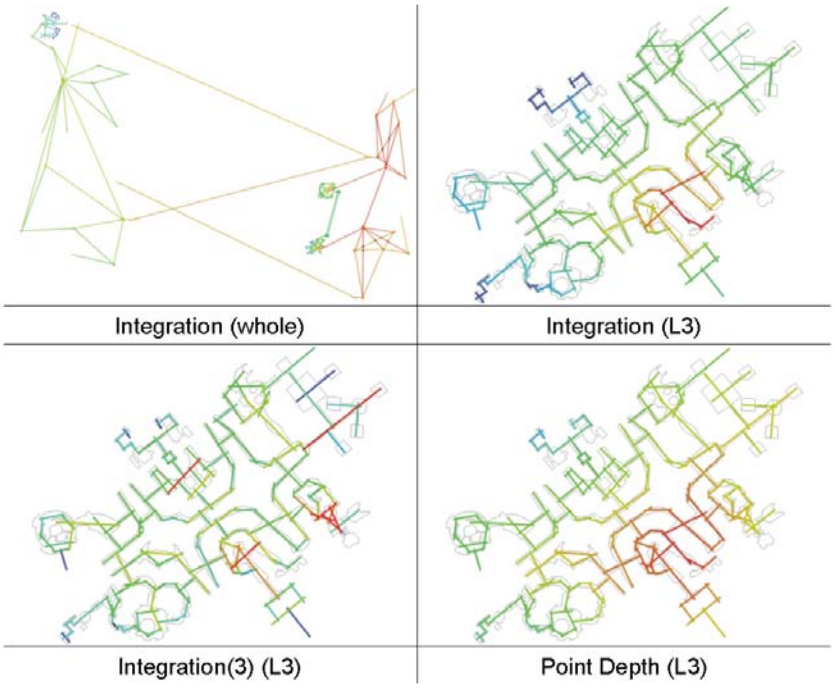


Figure 7:

Results of Space Syntax analysis

Primarily, when examining Integration, the spot in which visitors are flown to in the center square shows the highest accessibility, and as they get further from the square it can be seen that accessibility becomes lower. Specifically, it can be seen that accessibility decreases as users go toward the Northwest region rather than toward the Southeast region.

The results of Integration(3) analysis show spots at which the accessibility is high and those at which it is not, spots that appear sporadically, and the analysis shows that the center square (which provides a large space), parts of the North space, the lower regions of the Southwest, and the long path section on the West side all have high accessibility.

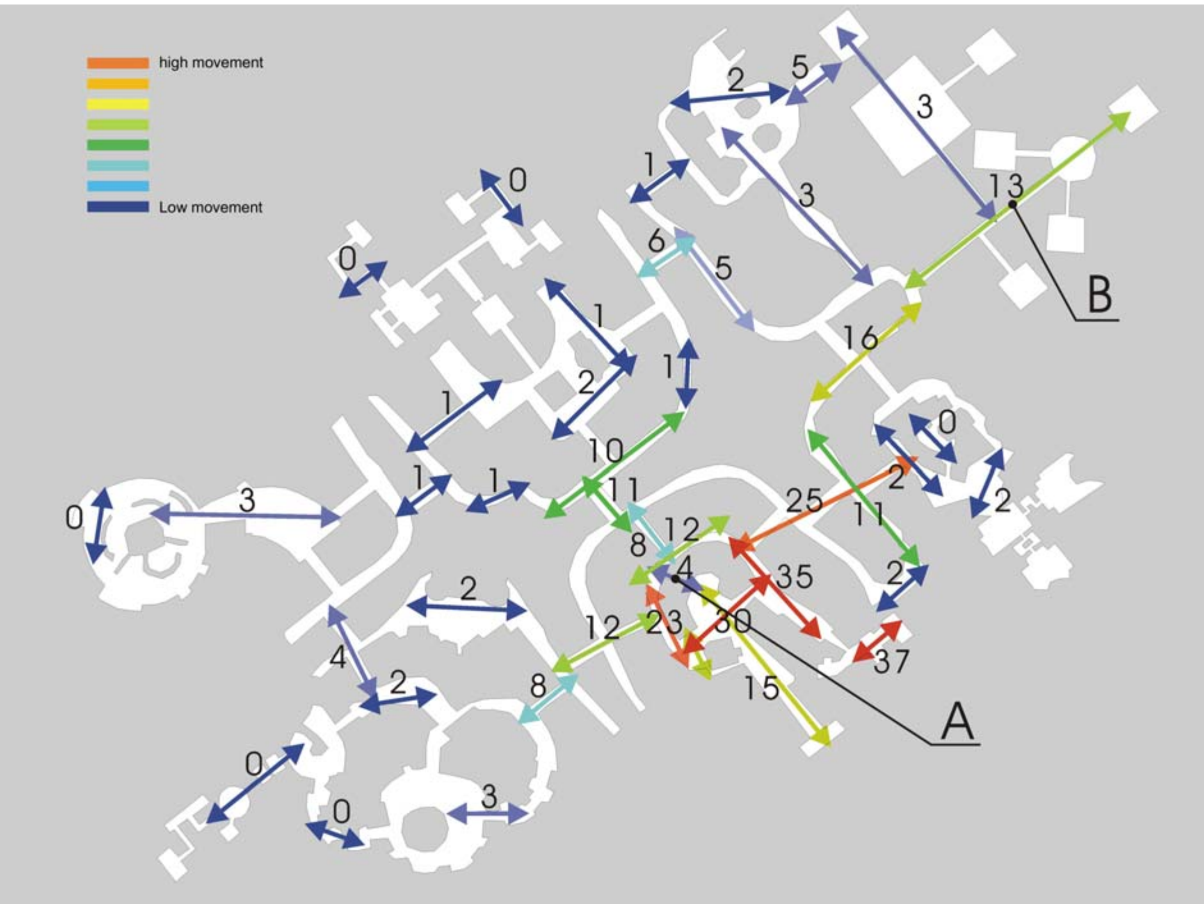
When the results of Point Depth analysis are examined, they generally appear similar to the results of Integration analysis, and as one gets further from the origin point, the accessibility is shown to become gradually lower.

Traffic Analysis

Traffic research in the game space was measured for four hours from 8PM until 12PM. At the same time, it was confirmed that the number of users in the game during the measured time period remained consistent by checking every 10 minutes to see if there were people that were waiting to enter the game. The traffic for each location is shown in Figure 8. The places that recorded the highest traffic were points 39 and 45, which are locations that users encounter first when arriving at L3 by the air-route, with a traffic of 35 and 37 people in ten minutes for points 39 and 45, respectively. On the other hand, six of the 45 locations did not have a single user pass by, and this shows that in L3, there is a mixture of locations that people use frequently and do not use at all.

Figure 8:

Results of measuring pedestrian volume

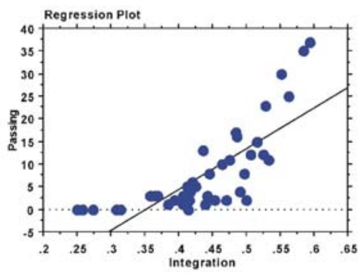


In addition, location A in Figure 8 seems to have recorded a number much lower than the traffic volume nearby because many users did not know there was a hidden path between the buildings. Also, because location B is the entrance to the location where a specific event takes place and many people come for that event, it shows a high traffic volume.

Analysis of the Correlation Between Spatial Configuration-Type Characteristics and Traffic Volume

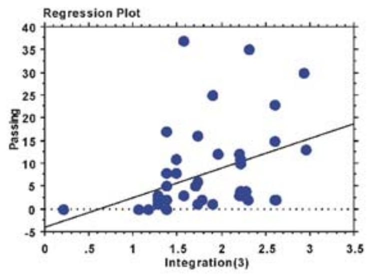
When the results of the correlation between syntactic properties of spatial configuration and traffic volume are summarized through space syntax analysis, they are as follows. The results of simple regression analysis of traffic volume and Integration show that R = 0.769 and R^2 = 0.592 (P < 0.0001), which reveal that there is a high correlation. On the other hand, the relationship between traffic volume and Integration(3) was R = 0.389 and R^2 = 0.151 (P=0.0083), which, unlike Integration, was analyzed to have a very weak correlation. The relationship between traffic volume and Point Depth appears as R = 0.677, R^2 = 0.458 (P<0.0001). Therefore, it had a lower correlation than did Global Integration, but it had a much higher correlation than did Integration(3). The relationship between traffic volume and Control showed a low correlation, with R = 0.232 and R^2 = 0.054 (P = 0.1251), and lastly, the relationship between traffic volume and Distance was R = 0.646 and R^2 = 0.417(P< 0.0001), which was shown to be the third highest correlation following that of Integration and Point Depth.

The Correlation Between Traffic Volume and Integration



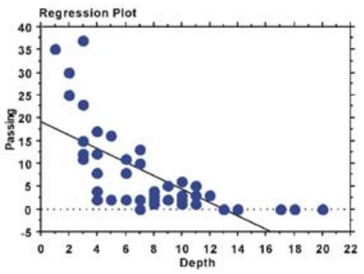
Y = -31.757 + 90.276X

The Correlation Between Traffic Volume and Integration



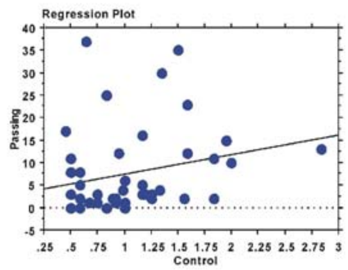
Y = -4.013 + 6.482X

The Correlation Between Traffic Volume and Point Depth



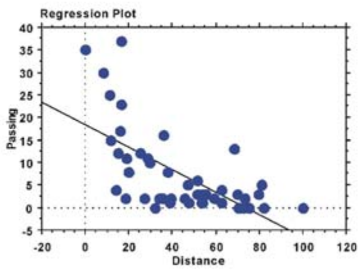
Y = 19.186 – 1.478X

The Correlation Between Traffic Volume and Control



Y = 2.958 + 4.405X

The Correlation Between Traffic Volume and Distance



Y = 18.464 – 0.251X

Figure 9:

Results of measuring pedestrian volume

Each scattergram in Figure 9 visually shows the regression analysis results. The traffic volume, which is an independent variable, is located on the Y-axis, and the dependent variables are on the X-axis. Also, as the points marked on the line become denser, it shows that there is a stronger correlation. The r-squared values show the correlation as quantitative numbers, and it appears that Integration had the strongest correlation with traffic volume. Table 2 shows the correlation between traffic volume and each of the variables.

	Global Integration	Local Integration	Depth	Control	Distance
All gates	0.592	0.151	0.458	0.054	0.417
Excluding gates with a traffic volume of 0	0.690	0.080	0.541	0.029	0.400

Table 2:

The r-squared values of Traffic Volume and Each of the Variables (R^2)

Integration usually became higher when the user perceived the entire space, and this seems to be caused by users grasping the layout of the map beforehand and moving by using the key-map. Point Depth and Distance appeared as factors showing the next highest correlations, and it was demonstrated that Integration (3) and Control had almost no correlation.

Next, the correlation in pedestrian volume measurement was analyzed by excluding locations at which the pedestrian volume was measured as 0. Locations with a pedestrian volume of 0 appeared as sections in the outer regions with low accessibility and in spots that do not have very low accessibility but are located in a corner. This means that the difference between a high and low pedestrian volume with regard to locations with high and low accessibility is greater than the difference in the accessibility of those locations. Additionally, it is believed the transfer routes in the corner sections are not used because they have relatively lower accessibility compared to the alternative paths. These results show that when users grasp the entire composition of the game beforehand and move after choosing their transfer route, the chance of selecting an alternative path with low accessibility becomes substantially lessened. As a result, it can be seen that the correlation (R^2) between Integration and pedestrian volume becomes very high, to 0.690, as shown in Table 2. In other words, it can be verified that the frequency of use of the corner regions, which have a much lower accessibility, is almost nonexistent because spatial behavior in the game is conducted after viewing the key-map. Based on this, the key-map is seen to play a major role in finding paths by helping the users to recognize the general spatial configuration in a virtual environment.

Conclusions

In this study, the formal factors of a game space and their correlations to traffic volume in that game space were researched. The results of analysis show that when a person moves in a game space, they are influenced by the syntactic properties of spatial configuration, and this especially appears to be closely related to Integration. In other words, the results show that there is a tendency to move in a direction where there is less directional change, rather than going a short distance from where one currently is to one's destination, based on the premise that one knows the location and transfer route of where one plans to go beforehand.

In studies interpreting the amount of traffic in real space, the integration that was calculated by taking into account the depth of three nearby spaces (i.e. integration (3)) is known as the most predictive factor. However, opposite results are shown in game space. The reason for this seems to be that, unlike reality, where space is perceived by moving around in it and also where the transfer route is decided based on that perception, the characteristics of a game causes a participant to perceive the spatial configuration to the target destination first, before moving toward that destination. Hence, the game user learns the entire formation of the space beforehand, and then moves. This suggests that the behavior of people who use a space after receiving help in the form of navigation, an information map, or a sketch in real space can be predicted. It can be expected, then, that the movement of people will be influenced the most by Integration, not only in games where key-maps exist, but also in real life, if they can learn the necessary spatial configuration beforehand using such devices as Navigation. It was shown that when many alternatives exist in path finding, people select the plan with the highest degree of Integration, and that the key-map greatly decreases the extent to which an alternative path with low accessibility is chosen. For example, major tourist places or buildings such as museums provide a tourist map or an interior plan for the users. In these cases, the users recognize the spatial configuration and move accordingly using a guidebook, which plays the same role that a key-map in a game does. It may be inferred that the spatial behavior of users in these cases show behavior patterns that are different from those of other normal users. Therefore, it is important to provide users with a high level of spatial configuration recognition, and to do this, it may be said that, in the planning stage, there is a need to plan in such a way that will raise the level of Integration.

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vi. NPC is not a character that a user controls but a character that moves according to the rules of the game.