ASSA: An Intelligent Agent-Simulation for Shop-Around Behavior

– Focusing on Its Performance Evaluation --

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Abstract: Policy exploration of downtown revitalization gets becoming important in also Japan. This paper deals with a modeling and simulation project of downtown visitors' shop-around behavior by intelligent 'heavy' agent approach, mainly based on artificial intelligence ideas. In this context, our agent is 'naturalistic and wise', in short, he/she behaves bounded rational in short term, but intellectually in long term, by devising and implementing planning (dynamic scheduling), learning and adaptation functions. In this paper, first, we explain the architecture of ASSA model, referring existing researches. In ASSA, each visitor agent makes and remakes his/her schedule to visit shops, based on time-constraints and shop-preferences, chooses alternative visits when he/she fails an errant, and takes impulse stop to shops and detour actions when he/she has enough time. A series of the activities of the day affects his/her next planning and so on. ASSAver.3 pursues a dynamic simulation of 'naturalistic and intelligent' shoppers' behaviors. Next we report a development and implementation of ASSAver.3 at Asunal Kanayama, a small shopping mall, and Osu shopping street complex district, Nagoya, Japan, based on detailed observation surveys. Then we show a framework of evaluation suitable for our modeling approach, including redundancy indicators on shop-visits and walk-length and similarity analysis of their shop-visit sequences. So, last we show valid-check results in a several cases of the simulation performances from several aspects.

Keywords: Intelligent Agent Approach, Shop-Around Behavior, Planned Action, Improvised Action, Performance Evaluation

1. INTRODUCTION

In large modern cities, the behavior patterns of visitors to downtown have become increasingly diversified. For this reason, when we plan to promote a 'lively' commercial district, it is important to analyze pedestrians' micro behavior, based on the bottom-up approach. In such an analysis, visitors' shop-around behavior within the commercial district is the key factor to focus on, because, it is clear that each pedestrian's shop-around behavior consists of multiple levels of activity; at first planned action in accordance with a preference pattern of the visitor, and later improvised action, such as the search for alternative shops or information acquisition. Furthermore, the behavior patterns of visitors are closely related to the agglomeration of shops and their spatial layout in a commercial district. Accordingly, development of a simulation model of pedestrian shop-around behavior in a commercial district can be a useful tool for analyzing the composition of a commercial district.

One of the major characteristics of pedestrian shop-around behavior is premeditation and improvisation. That is, each pedestrian ranks the shops they will visit and plans a proposed route before the visit, whilst in the commercial district they will respond flexibly and change their plan according to the situation. In the construction of our shop-around behavior model we considered it important to place emphasis on incorporating this key characteristic. Therefore, our model evolved into a non-Markov model that inevitably differed from the existing models using the Markov chain (For example, Borgers & Timmermans, 1986). Moreover, Agent-Based Social Simulation (ABSS) involving an autonomous individual with intelligence, was selected as the best technique to reproduce these behaviors (Arentze, Pelizaro & Timmermans, 2005, Dijkstra, Timmermans & Vries, 2007, Zhu and Timmermans, 2008).

Taking into account the above points we are developing the ASSA (Agent Simulator for Shop-Around) project, so we have upgraded its version, ver.1 including the functions of Planned Action and Improvised Action (Alternative Visit), ver.2 including impulse visit, and ver.3 including also detour action.

The most important points for checking the validity for such kinds of intelligent agent models are criteria. In this paper, focusing on this theme, we especially propose a framework and indicators that are devised in order to check the performances on several functional aspects of the model, then, evaluate the simulation performances through illustrating examples and by comparing with actual survey data applied these indicators. Not only in the case of Asunal Kanayama, a small shopping mall but referring the case of Osu shopping street complex, downtown Nagoya, we examine the performances of simulations from multi-facet aspects, in comparison with features of the visitors' attributes, preferences and actions and so on.

2. ASSA(AGENT SIMLUATOR OF SHOP-AROUND) PROJECT

2.1 Decomposition of Downtown Visitor's Shop-Around Behavior

The first feature element of the downtown visitor's behavior model that we aspire to develop is the function of time allocation or scheduling for visiting shops under limited time allowance (time-budget). Implementing scheduling function in itself is an antithesis of Markov model, but it does emphasize time constraint, and this is an application of intelligent planning function for the agent. Shop-around behavior, as referred to in this paper, has been explained in cognitive science (For example, Roth & Roth, 1979). The second feature element is the handling of dynamic updates of an agent behavior, including mainly rescheduling. This also relates to intellectual functions like adaptation and learning. Data-fitting oriented evaluation would be the third feature element of our model.

Here, we would like to introduce what we call agent simulator of shop around behavior (ASSA). We have investigated shop-around behavior of visitors in downtown Nagoya 12 times thus far. During our surveys, we asked for the walking routes, shops visited, and whether the visits to the shops were planned in advance. According to the redundancy analysis as mentioned at 4.4, the shop-around behavior within a survey area, including the routes taken and the distance traveled, is not necessarily optimized.

With this in mind, we have decided to breakup shop-around behavior into planned and improvised. We further divided improvised action into alternative visit action, impulse action (Table 1). Planned action is an action performed according to a schedule. Alternative Action, which is defined as an improvised action, is an action of visiting a shop that was not part of the original plan because the planned errand was not completed in the shop visited (Kaneda & Yoshida, 2010). This concept was not specifically differentiated in Markov based shop-around behavior model.

Table 1: Layer-Decomposition of Downtown Visitor's Shop-Around Behavior

<table>
<tr><th colspan="2" rowspan="2">Agent's Action</th><th colspan="2">Information Processing</th><th rowspan="2">On Schedule Plan</th></tr>
<tr><th>On Shop-Visit</th><th>On Path</th></tr>
<tr><td colspan="2">Planning & Decision Action</td><td>Planning a Visit-Order</td><td>Planning Path</td><td>Forming</td></tr>
<tr><td colspan="2">Planned Action</td><td>Visiting Planned Shop in turn</td><td>Following Planned Path</td><td>Keeping</td></tr>
<tr><td rowspan="2">Improvised Action</td><td>Alternative-Visit Action</td><td>Choosing Same Category's Shop when Failed Errand</td><td>Modifying Path</td><td>Inserting</td></tr>
<tr><td>Impulse Action</td><td><u>Impulse-Visit (Stop) Action:</u> Dropping in Non-Planned Shop if Time Available</td><td><u>Impulse-Detour Action:</u> Walking Non-Shortest Path if Time Available</td><td>Re-forming</td></tr>
</table>

We will now explain this in more detail using an example as shown in Figure 1. A boy leaves his home with a plan to buy a book and to go to his dentist appointment at noon. The original plan of the boy was to go to the dentist after buying the book at the nearby bookshop. When he visits the bookshop (Planned Action), he discovers that the book is sold out (failure to complete his errand). After considering the time constraint and the distance to the next closest bookshop, he decides to go to the next closest bookshop (Alternative Visit). He was able to buy the book at the next bookshop (errand completed). He hurries to the dentist’s office because the dentist appointment is approaching (Planned Action). Because the dentist appointment took shorter than anticipated (errand completed), the boy decides to take a detour to enjoy window-shopping and stops at a cafe (Impulse Visit) before going home. In this example, although redundancy was added to the original schedule, there were no changes made to the basic structure, like changing the sequence of the errands. If there was no time available to visit the second bookshop after discovering that the book was sold out in the first bookshop, the boy would have gone to the dentist first, and then went on to buy the book. If this was the case, he would have performed rescheduling.

Figure 1: Explanation of Layer Decomposition of Visitor's Behavior in Downtown

2.2 COMPONENTS OF ASSA

ASSA is designed to include the following three submodels: (A) Planning Model at home; (B) Shop-Around Model in the commercial district; and (C) Travel Model between home and the district (See Figure 2).

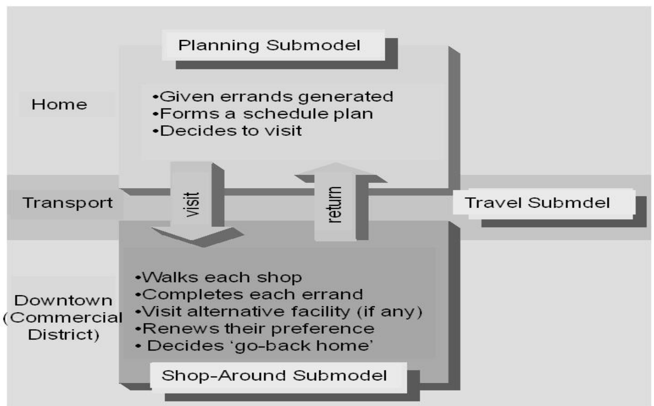

Figure 2: Concept of ASSA's Agent Behavior Model

(A) Planning Submodel

The Planning Submodel consists of the following 4 modules:

(1) Errand Generation Module: generates errands that the agent is to carry out in the commercial district.

(2) Commercial District Visit Decision Module: makes decisions concerning the visit according to the number of errands.

(3) Time-Budget Generation Module: generates a time-budget that consists of the downtown visit day and the possible time-bands for the downtown visit.

(4) Plan-Making Module: generates a schedule plan to complete the set of errands under the constraints of the time-budget.

(B) Shop-Around Submodel

The Shop-Around Submodel consists of the following 4 modules:

(1) Trip to Shop Module: moves each agent in the commercial district through a path.

(2) Errand Achievement Module: decides the complete or failure of an errand that the agent attempts.

(3) Alternative Visit Action Module: if the agent fails to complete the errand a decision is made whether to carry on with the errand, search for an alternative shop, or modify the plan.

(4) Post-Action Processing Module: A decision is made concerning the return to home and preferences are updated.

(C) Travel Submodel

The Travel Model between Home and Commercial District expresses a round-trip between home and the commercial district. In the case of a visit to the commercial district, when the agent has left home and the time set for transportation T has elapsed, the agent appears at the inflow point to the commercial district, which was set in Plan Making module. Conversely, when the agent leaves the commercial district, the agent moves to the exit point that was set in the post-behavior processing model, and after the time set for transportation T has elapsed, the agent arrives home. The time set between home and the commercial district T is set in accordance with the agent’s place of residence..

The current ASSA verion sets the following assumptions:

(1) The city model has only one monopole commercial district, and there is no other prominent commercial district in any other district.

(2) Direct interaction between agents does is omitted.

(3) All agents already know all shops and routes.

The future development aims to improve these assumptions.

2.3 Some detailed features of each ASSA version

Here, we focus on mainly Shop-Around Submodel (Figure 3).

(A) Features of ASSAver.1 and ver.2

ASSAver.1 deals with only planned actions and alternative actions (task completion / failure is represented as fixed probability for each errand). It was developed with rescheduling function in case of failure to complete a task. Moreover, the tight assumption set that all of the 'path planning' is always optimized by Dijkstra method.

In ASSAver.2, Impulse Visit is defined as "an impromptu visit to a shop in the commercial district, that is neither Planned Action nor an Alternative Visit." Impulse Visit expresses the completely spontaneous behavior of an agent. Each of impulse visit is determined probabilistically when visiting each street, based on street-appeal, each shop-preference and remaining time by e-greedy method (in much details, see Yoshida & Kaneda, 2007a, 2008a, 2008b, Kaneda & Yoshida, 2008).

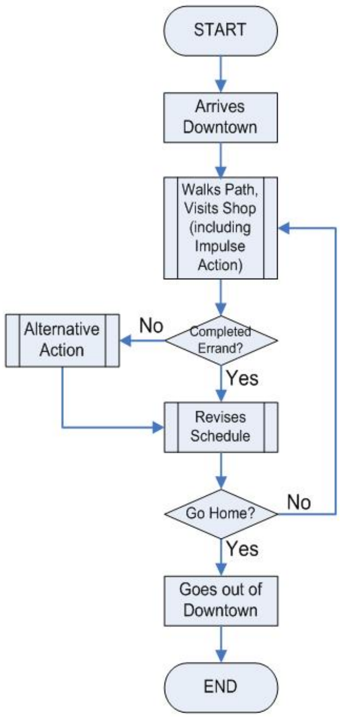

Figure 3: Behavior Algorithm of Downtown Visitor Agent in ASSA

(B) Features of ASSAver.3

ASSAver.3 deals with two kinds of Detour actions; one is relaxation of the optimality of ‘path planning’, and the other is about Impulse Detour.

(1) Detour at Planning Making Module:

As mentioned previously, detour behavior at planning stage occurs during the route planning action. Therefore, we have removed the optimality assumption of ‘path planning’ in (1-4) in ASSAver.1. This relaxation means that when the visitor deliberately selects a longer route, even though the visitor knows the shortest route, based on considerations such as safety, degree of congestion, or preference towards particular streets. In order to implement the above behavior model, we weighted each agent relative to each link in the network of commercial districts. With this weight applied, each agent would select psychological or emotional shortest route as opposed to the physical shortest route. Therefore, even though agents themselves believe that they planned to take the shortest routes, the actual routes planned would be longer routes in the planning action. The weight applied to each link was determined by adding randomization item to preference values against facilities possessed by each agent.

(2) Impulse Detour Action Model:

Impulse detour action is positioned opposite to improvisation. It is a planned route departure behavior and so on, which is a higher-order function. Softmax method (refer to Takadama [19] for the details of the method) that uses Boltzmann distribution was used to model the behavior. Modeling followed the steps described below. First, when visiting a commercial district, locations that are different from the original destination are selected at random. Next, the values of the selected locations are calculated based on the distance between the current location and the selected locations, and the weight of each location (the weight for each selected location is same as the detour planning action model). Based on these values, probability to select each location is determined using Boltzmann distribution, which uses γ from previously mentioned equation 2-6 as the temperature parameter. Note that we have decided that impulsive detour behavior will not occur if β as shown in equation2-4 is less than 0.1.

3. PERFORMANCE EVALUATION FRAMEWORK

3.1 Evaluation Focus

To evaluate the characteristics of the above designed model, we analyze the simulation results taking into account the following five points.

a) General evaluation

(1) Analysis of aggregated behavior

(2) Analysis of statistics

b) Individual function evaluation

(3) Illustration of agent's individual behavior

(4) Analysis of similarity of visit sequence

(5) Analysis of redundancy

3.2 Illustration of Agent’s Individual Behavior

From the data obtained by the simulation we extract the individual behavior results for each agent, and then graphically express them on the map. There are two focal points: shops visited and walking routes. To observe the shops visited, attention is paid to the following four points: locations, visiting order, planned or unplanned visits, task success or failure. Based on our observations, we check whether each designed function is working: validity of a plan drawn up by an agent in the Planning & Decision Action; implementation of the plan in the Planned Action; occurrence of Impulse visits in the Impulse Action; and occurrence of alternative visits in the Alternative-Visit Action. Walking routes are assessed mainly by paying attention to whether agents have deviated from the shortest route, and we check the normal planning and implementation of a planned route, and the occurrence of detours from the planned route.

3.3 Analysis of Similarity in Visit Sequence

We compare shop visiting patterns for each sample from the simulation and the survey so as to verify how closely the following points resemble each other: the shops visited, visiting order, and the number of shops visited (Joh, Arentze & Timmermans, 2001 as existing approach).

For verification, the concept of Levenshtein distance is introduced. To be specific, an agent sample and survey sample are corresponded one-to-one, between the visit sequences, the Levenshtein distance is calculated by assigning a cost of 1 for each insertion, deletion and substitution, and this result is used as an indicator to assess to what extent the result of agent behavior has reproduced shop visits by a real pedestrian. Concerning the visit sequence of a certain agent, we select survey samples whose gender and age belong to the same category, and from among them, one survey sample whose Levenshtein distance is the shortest is used, and an average and variance of the shortest Levenshtein distances as a whole are obtained to conduct variance analysis. In addition, the percentage of sample pairs with a Levenshtein distance of 0 − meaning the visit sequences are identical − is also used as one indicator.

In this case it is important to note that the Levenshtein distance is determined according to the one-to-one correspondence results of the data and survey sample; therefore, the average and variance of Levenshtein distance for the whole sample changes according to the correspondence determination method. Consequently, to maintain the validity of this indicator, a method to find a solution that is objectively acknowledged as the optimum sample pair must be adopted. For this problem, it was decided to consider the problem as an application of a stable marriage. If we regard “a man” in this problem as an agent sample, “a woman” as a survey sample, and the “ranking” as the Levenshtein distance from the marriage partner, by matching stable couples with samples, it is possible to find the optimum sample pair. However, there is a plurality of solutions for stable coupling; therefore, a plurality of solutions is calculated by changing the permutation of samples, and a solution that gives the minimum average value of the shortest Levenshtein distance is adopted.

3.4 Redundancy Analysis of Walk Length

In both the simulation and survey attention is paid to what degree the behavior result and the scheduled plan deviates from the optimum geographical distance solution, and by comparing them, behavior and planning characteristics in the model are verified. The similarity analysis of visit sequences in the previous section pays attention to the visiting order and examines the degree of similarity between samples, whereas this analysis focuses on geographical distance and compares the degree of deviation from the optimum route distance. For verification, detour behavior indicators consisting of the following three levels are adopted, as proposed by Arakawa & Kaneda (2002, See also Figure 4).

· Level 1 indicator: This indicator expresses the degree of deviation between the actual distance walked between shops and the shortest distance between shops. This indicates redundancy concerning a route between shops and can be interpreted as a detour.

· Level 2 indicator : When the shortest route distance between a shop planned to be visited (hereinafter planned-visit shop) and the next planned-visit shop is regarded as a benchmark, this indicator represents how much the shortest route distance between the shops actually visited deviates. This indicates redundancy concerning an unplanned visit, and when this value is high, it can be interpreted as behavior having been extended to include unplanned visits to shops some distance away, so as to fulfill a new task within the district.

· Level 3 indicator : When the route distance of the shortest sequence between planned-visit shops is regarded as a benchmark, this indicator shows how much the shortest route distance of the actual visit sequence between the planned-visit shops deviates. This indicates redundancy concerning a plan for the shops visit sequence, and it can be interpreted that the lower the value, the more efficient the sequence taken.

By using hierarchical decomposition of pedestrian behavior in 2.2, these indicators can be reinterpreted as follows: the Level 1 indicator shows how often a detour from the planned route occurs in the Impulse-Detour Action; the Level 2 indicator shows how often Impulse visits occur in the Impluse-Visit Action, and how often alternative visits and route revision occur in the Alternative-Visit Action; and the Level 3 indicator shows the degree of deviation between the plan made by a pedestrian in the Planning Action and the optimum solution. Accordingly, comparison of the results of agent behaviors with that of survey samples using these indicators allows us to verify the following: characteristics of detours from the planned route in the Level 1 indicator; characteristics in the combination of Impulse and alternative visits in the Level 2 indicator; and the efficiency of a plan in the Level 3 indicator.

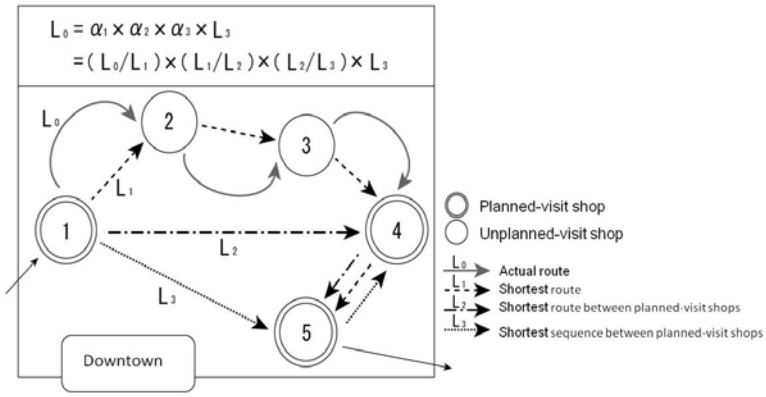

Figure 4: Explanation diagram of redundancy indicators

(Alpha1: Level 1 indicator, Alpha2: Level 2, Alpha3: Level 3)

4. EVALUATION OF SIMULATION PERFORMANCE

By employing the above-mentioned simulation model we conducted simulation experiments and evaluated the experiments using the evaluation framework. Here, we show two examples from the commercial district in Nagoya City: Asunal Kanayama, a three-storied shopping mall with 60 shops, 4 categories (28 commodity stores, 15 café and restraints, 15 services and 2 wagons), and Osu district, a shopping street complex district with 685 shops, 8 categories (café and restraints, groceries, households goods, electrics, cloths, parks and temples, second-hands, others). The latter is modeled as a network with 36 street-nodes. We have already detailed survey data in the both cases (See Misaka et.al (2010) and Oiwa et.al (2005)). Visitors are categorized by 2 gender groups , 3 age groups and other properties such as living places and visit frequency.

In Kanayama Simulation Case, 3000 agents' performances during 120 holidays had been stable after the trial 30 holidays, so this average is considered. In Osu Case, 2500 agents' performances during 120 days after the trial 10 holidays is considered.

4.1 Overall Performance of ASSA

Table 2 shows comparisons between survey data and the simulation results obtained using ASSAver.1, 2 and 3. Please note that the simulators used time distance expression, whereas the actual physical distance traveled was extracted from the route drawn on the maps of the surveys, making comparison between the two impossible. Therefore, the distance traveled is shown only as reference. Free walking speed is generally said to be between 1.2 m/s and 1.5 m/s. If the simulation data is converted into distance using these values, the distance traveled fall in the range of 172m to 216m, 65m to 81m, and 238m to 297m. Observing other values, it is evident that the duration of visiting a commercial district is shorter by approximately 14 minutes and the facilities visited is less by about 0.7 facilities. The simulations showed realistic values for planned facility visits.Table 2: Aggregated performance of ASSA series in Kanayama Case

Table 2: Aggregated performance of ASSA series in Kanayama Case

	ASSAver.1	ASSAver.2	ASSAver.3	Survey
Ave. Stay Time (min.)	54	70	80	94
Ave. Walk Time (m) /time (min.)	2.4min	0.9min	3.3min	147m
Ave. # of Visited Shops	1.07	1.85	2.11	2.84
Ave. # of Planned-Visit Shops	0.74	0.71	0.61	0.63

Here, we pay attentions for one agent behavior in Osu Simulation Case. This agent is a younger age woman sample who comes from <middle distance> by train. From her plan, we can see that the agent plans to visit five shops: clothing shops <A>, <B>, <C>, <D> and an electric appliances shop <E>.

After this agent had entered the district, she actually first visited a clothing shop <U> (1). The agent walked by way of a street that is not the shortest route to shop <A>, the first planned-visit shop; therefore, it can be recognized that the detour behavior function worked. Next, the agent visited a secondhand goods complex <V> (2), which again was not included in the plan, and as a result of these unplanned visits, the agent changed her plan and chose to visit <E> (3), which she had planned to visit at the very end of her trip. In the three shops – <E> (3) and the subsequently visited <D> (4) and <C> (5) – the agent successfully fulfilled all her tasks, but in <B> (6), she failed to fulfill her task. As an alternative shop she chose <W> (9). Before visiting <W> (9), she visited <A> (7), which she had planned to visit earlier, and then made an unplanned visit to another clothing shop <X> (8). In <W> (9) the agent fulfilled the task that she failed at (6), and then made unplanned visits to yet more clothing shops <Y> (10) and <Z> (11) and then went home. From these observation results, we can read that each main function shown in Table 1 was working in a complex way. In addition, the behavior of impulse visiting several

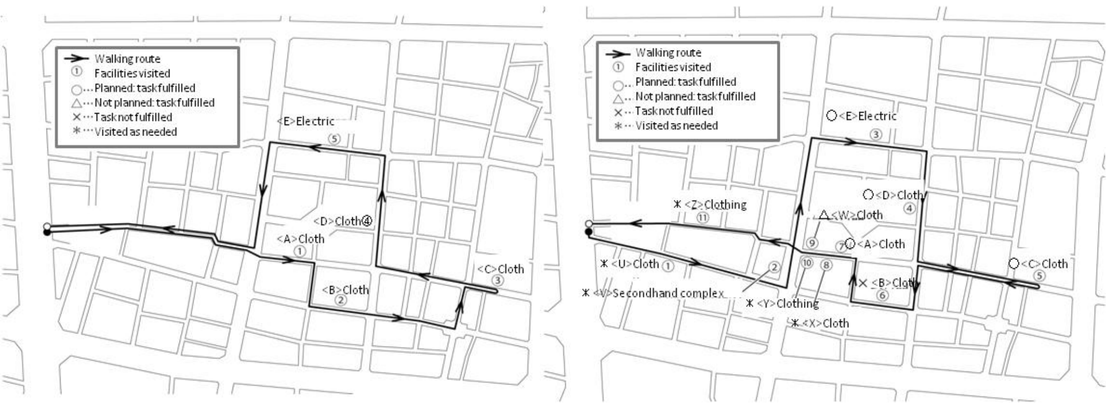

Figure 5: An Agent’s behavior in Osu Case (Left: plan, Right: performance)

clothing shops in sequence is characteristic of the young age women that actually visits the district; from this point, we can confirm that the model is capable of rescheduling a behavior pattern that is unique to an attribute.

Next, Figs. 6a and 6b show the results of aggregated behavior analysis with a focus on pedestrian passage percentage distribution. With regard to the ground floor section, it is apparent that the simulation result almost matches the survey. On the 2nd and 3rd floors, the simulation shows fewer visits than the survey; to remedy this point the following factors can be applied: to weaken the negative effect of distance when shops are selected; to improve parameters for the preference of shops and streets; and to adjust the negative effect of visiting higher levels in multistory shops.

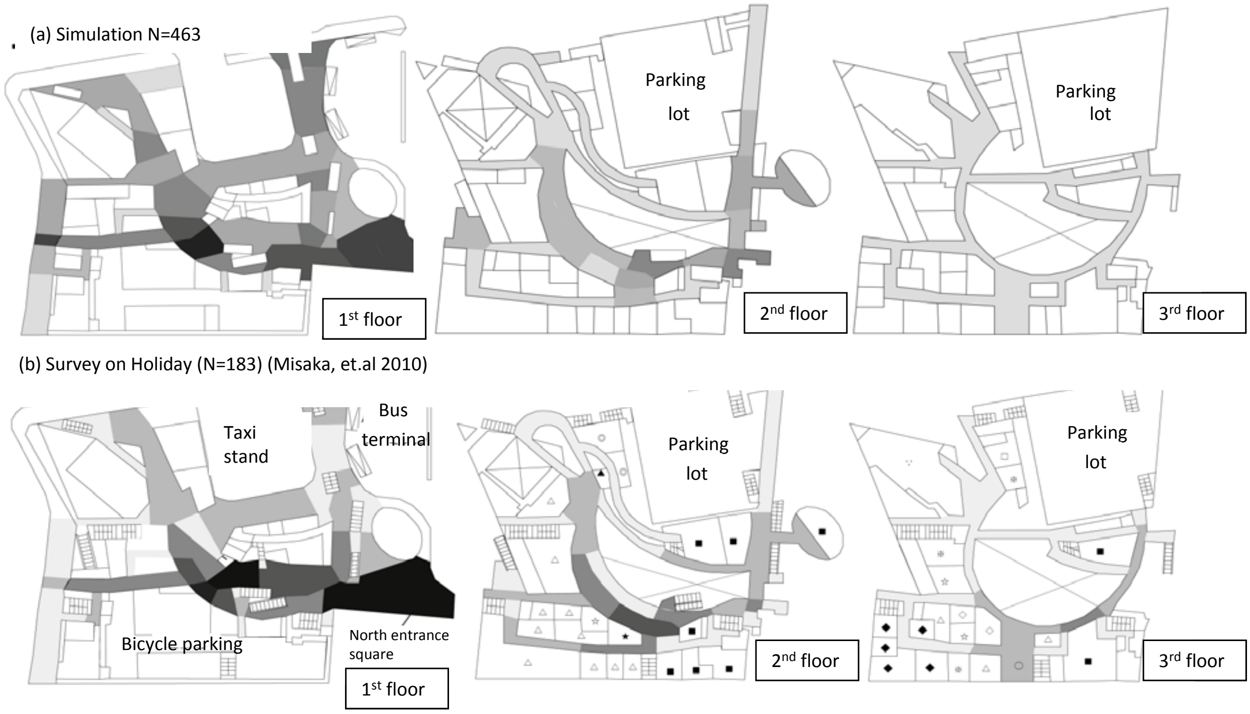

Figure 6: Pedestrian spatial distribution of Kanayama Case

4.2 Results of Individual Function Evaluation: Asunal Kanayama

Table 3 shows the verification results of visit sequence similarity. As a whole, the average value and variance value of the shortest Levenshtein distance (hereinafter, the shortest LD) were 2.03 and 1.96 respectively. This means that when one sample is selected at random from the simulation and the survey, the number of steps required for producing identical visit sequences is 2.03 times on average. In addition, the percentage of full match sample pairs whose visit sequences are the same, accounted for 22.09% of the whole (hereinafter, referred to as the EM ratio). When the result was examined according to attributes, the older man category showed the highest evaluation for the shortest LD average value; this indicates that agents in this category had good average similarity within the category. In the evaluation with a focus on the EM ratio, the middle-aged man category had the highest percentage; this indicates that agents in this category were the best at completely reproducing the visit sequence within the category. Compared to women agents, men agents in any age group had high similarity to the survey; when the results were examined according to age group, similarity of the young age group tended to be lower compared to other age groups. Women account for the majority of visitors to Asunal Kanayama; therefore, with regard to this group further improvement in similarity is needed.

Table 3: Results of similarity analysis of visit sequence in Kanayama Case

	Number of samples		Average of the shortest LD	Standard deviation of the shortest LD	EM ratio (%)	Test
	Total	249	2.03	1.96	22.09	NE
Gender	Men	57	1.67	1.56	28.07	*
	Women	192	2.14	2.08	20.31	
Age	Younger	54	2.65	2.24	14.81	*
	Middle age	129	1.83	1.74	20.16	
	Older	66	1.92	2.14	31.82	
Six attributes	Younger: Men	11	2.00	1.91	9.09	NE
	Younger: Women	43	2.81	2.26	16.28	
	Middle age: Men	27	1.74	1.48	33.33	
	Middle age: Women	102	1.85	1.79	16.67	
	Older: Men	19	1.37	1.35	31.58	
	Older: Women	47	2.15	2.32	31.19	

4.3 Redundancy : Asunal Kanayama

Table 4 shows the results of redundancy analysis. In the Level 1 indicator, the simulation showed higher values in Group 3, with agents tending to take more detour behavior than found in the survey. In the Level 2 indicator, compared to the survey, the simulation result showed higher values in Group 1; compared to the survey the simulation showed less evidence of Impulse and alternative visits. Moreover, the number of planned-visit shops were examined and compared to the survey, the simulation result showed a large difference in the occurrence percentage of improvised behavior. In the Level 3 indicator, because of the small number of survey samples, only the simulation result was analyzed; however, it was possible to confirm the efficiency of the plan made by an agent, and that the rearrangement of the plan due to the occurrence of improvised behavior was affected by the number of shops visited and the number of planned-visit shops, whereas they were not affected by such attributes as gender, age, and frequency.

Table 4: Results of redundancy analysis in Kanayama Case

Level 1 indicator		Simulation N(people)	Simulation Group1	Simulation Group 2	Simulation Group3		Survey N(people)	Survey Group 1	Survey Group 2	Survey Group3	
		575	243	131	201		111	38	40	33	*
Number of planned-visit facilities	0	181	45	37	99	**	62	18	21	23	
	1 or more	394	198	94	102		49	20	19	10	
Number of facilities visited	0 or 1	279	132	37	110	**	46	16	11	19	*
	2 or more	296	111	94	91		65	22	29	14	
Frequency of visit (per week)	1 or more	457	180	108	169	*	50	20	17	13	
	Less than 1	118	63	23	32		61	18	23	20	
Duration of stay (minutes)	Up to 30	124	36	19	69		33	11	9	13	
	Less than 120	158	64	46	48	**	39	16	12	11	
	120 or more	293	143	66	84		39	11	19	9	
Level 2 indicator		N(people)	Group1	Group 2	Group3		N(people)	Group 1	Group 2	Group3	
		575	278	151	146		111	33	34	44	**
Gender	Men	165	96	29	40	**	18	6	5	7	
	Women	410	182	122	106		93	27	29	37	
Number of planned-visit facilities	0	181	63	32	86	**	62	15	15	32	**
	1 or more	394	215	119	60		49	18	19	12	
Number of facilities visited	0 or 1	279	245	17	17	**	46	26	12	8	**
	2 or more	296	33	134	129		65	7	22	36	
Frequency of visit (per week)	1 or more	457	223	121	103	**	50	19	16	15	
	Less than 1	118	45	30	43		61	14	18	29	
Duration of stay	Up to 30	124	81	17	26		33	16	8	9	
	Less than 120	158	75	34	49	**	39	8	14	17	
	120 or more	293	122	100	71		39	9	12	18	
Level 3 indicator		N(people)	Group1	Group 2	Group3		N(people)	Group 1	Group 2	Group3	
		394	209	54	131		49	33	9	7	*
Gender	Men	118	66	10	42						
	Women	276	143	44	89						
Age	29 or younger	128	62	22	44						
	30 to 49	135	78	15	42						
	50 or older	131	69	17	45						
Number of planned-visit facilities	1	333	200	35	98	**					
	2 or more	61	9	19	33						
Number of facilities visited	0 or 1	185	120	13	52	**					
	2 or more	209	89	41	79						
Frequency of visit (per week)	1 or more	326	170	43	113						
	Less than 1	68	45	11	18						
Duration of stay	Less than 120	134	77	14	33						
	120 or more	260	132	40	88						

- Group1: (-159%)
- Group2: (160-239%)
- Group3: (240%-)

Due to the small number of samples, testing was not possible.

**5% significant difference *10%significant difference

5. CONCLUSION

In this paper, we showed the features of ASSA (Agent Simulator for Shop-Around) project, especially focusing on performance evaluations from several aspects of the proposed shop-around pedestrian agent. The key of our approach emphases on the improvisation of the downtown visitor's behavior under the time-budget constraints, in comparison with existing Markov type models. So it needs that new kinds of performance framework of criteria including such visit-sequence similarity and multi-level walk-length redundancy as well as rich illustrations. The results of simulations suggest the potential of our approach to simulate 'naturalistic and intelligent' shop-around visitor's behavior, though some problems for tune-up parameters still remains.

As future issues, the following areas can be stated: to further improve the usefulness of the model based on the verification result; and to develop and reconstruct the evaluation framework.

Acknowledgements

We would like to thank Ms. Mingji Cui.

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