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# A Platform for Analyzing Access-friendly Transportations for Elderly People Using GIS on Agent-based Model

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***Abstract*— In this research, we construct a platform for analyzing access-friendly transportation for elderly people using GIS on agent-based model. Our interest is related to an aging world population and well-being of elderly people. We use GIS data of Ibaraki city Japan and study the outing rate of elderly people. We defined the number of times of outing per seven days as outing rate. The simulation is performed 63 times. It is comparable to 63days (nine weeks). As the results of simulation showed that the utility of experience from reaching destination and achieving their aim was more effective for next decision of old-old than that of young-old.**

## I. Introduction

BACKGROUND of this aim is related to an aging world population and well-being of elderly people. Especially the ratio of Japanese elderly population is the most distinctive among the world [3]. In order to live a life worth living, it is important that elderly person can move easily to their destination. According to a report [2], there are strong relations with Subjective Well-Being (SWB) and opportunities of going out. In general, SWB is defined as the index that she/he evaluates the feeling of happiness and satisfaction of her/his own life. As the result of her research, a case of having many opportunities of going out showed high value of SWB. Also, communication with others enhanced a sense of well-being [4]. In this research, we aren't go into details of SWB, however, we discuss about utilities of their experience. The utilities are similar idea on this point of SWB.

Elderly people are categorized two groups, young-old (aged 65-74 years old) old-old (over75 years old). And that tendency going shopping is vary greatly depending on age. The citizens aged over 60 in Japan tended to rarely go out. On the other hand, less than 60 years showed tendency to often go out [1]. In this research, tendency going out are arranged by different from young-old and old-old.

### *A. Background of Construct Platform*

Last year, we presented the result of optimized combination of local bus and DRT (Demand Responsive Transport) for elderly person using a simple model at WEHIA 2013. However, to solve several practical problems, we should revise our model from some aspects. One is modified field. GIS data should be implemented to revised model to deal with solving regional issue. The other is, function of decision making should be revised by implementing some mental factors. We use GIS data of typical Japanese city and study outing rate of elderly people.

### *B. Outline of Ibaraki City*

A lot of Japanese people were concentrated around urban area by rapid economic growth in the1960's. Many residential areas called New Town were supplied by prefecture or government in the suburbs of urban area. And the car has been main transportation for residents in a long time. More than a decade ago, a lot of their children moved to more convenient place for live. The population is rapidly aging at New Town. And peoples who lives in new town let go of their car by their aging. Therefore, bus plays an important role in the aging society. One of a New Town named Sunny Town is on Ibaraki city in Osaka. Sunny Town was created 121 hectare in 1970's. In this research, we treat Ibaraki city and build a model.

Ibaraki city lies north and south about 17 kilometers, and east and west about 10 kilometers. According to the report of questionnaire of Ibaraki citizens (2013), elderly people who live the mountains area (35.7%) and hilly terrain area (21.8%) represent higher population aging rate than downtown (19.2%). And the ratio of going out at people over 70 years of the mountains area (every day 24.4%) and hilly terrain area (every day 36.0%) is lower than that of downtown (every day 52.4%). That is, people who live in the mountains area and hilly terrain area feel awkward to use of public transportations. Therefore, we construct a platform using GIS for analyzing access-friendly transportation for elderly people.

## II. Outline of a Model

### *A. Decision of people*

In this research, for the sake of such improvements, we introduce the people's behavior is provided by the function for four variables as follows:

$$Dt=f(Tt,Wt,At,Ut), \quad (1)$$

where *Dt* is the value of elderly people's willingness of going out, *Tt* is time factor, *Wt* is the value of weather condition factor, At is the value of age factor, *Ut* is the value of utility on trip.

*1) Time factor*

Time factor is represented the length of time which is required reaching at peoples' destination from his home and returning his home. In our model, it is assumed to be used always the bus when the people move to shopping center, hospital and so on... If a person is going to move to shopping, he calculates the time it takes to walk to nearest bus stop, next bus schedule of the nearest bus stop, arrival time to the destination: shopping center, and the last bus from the destination to his home. The result of this calculation is used in decision making. If there is no schedule of the last bus, he decides cancellation of his trip.

*2) The variable of weather condition factor*

The variable of weather condition factor is represented that depending on the weather conditions, people will decide adjustment of schedule, transportation way, or cancellation of his trip [10]. And a literature survey shows the change of decision affected by weather change [11]. In this research, people's willingness to go out is given 40 percent in case of rain. And people's willingness to go out is given 60 percent in case of a good weather condition.

*3) Age factor*

Age factor is represented relations age between willingness of go out. Aged over 60 has gradually decreased in motivation of outdoor activity [1]. In this research, we treat the category of young-old and old-old. The ratio of willingness to go out on young-old and old-old are given each 60 percent and 40 percent.

*4) The value of utility on trip*

The value of utility on trip are represented that people receive a lot of satisfaction from achievement of his activities. For example, if he achieved his aim (shopping), his utility (degree of satisfaction) becomes high. In this research, Utility is changed by past (inexperienced) status and present (experienced) status. And the utility is referenced in the utility table. The utility is determined by the time spent at the destination. The utility is using the value of one tenth of the time experience. People is going to use 60 minutes at the library, 30 minutes for shopping and 40 minutes at the hospital,. The concept of time of shopping and library are based on [13]. The concept of time of hospital is based on [14].

In addition, the utility factor adds on shortage percent of the age factor. If value (e.g. 6) of utility is increased, the value is translated to additional percentage (e.g. 6%) of age factor. That is, the value of the utility is added to percentage of the willingness in age factor.

*5) Outing rate*

We defined the number of times of outing per seven days as outing rate. Outing rate is calculated as follows:

Outing rate is divided total number of times of outing in seven days by seven.

## *B. About GIS data*

In our simulation, we use the data from the questionnaire results by Ibaraki City, which includes the actual status of the usage of bus schedule, citizen requests for service.

In this research, we implement the data of GIS to our model. The data of OpenStreetMap (OSM) is used for geographic information of Ibaraki City. OSM is provided that everyone can use easily on the internet. And we convert this data (osm formats) to shapefile formats using QGIS. In addition, we get coordinate data from shapefile formats using software "GIS Data Converter for artisoc". Loading this coordinate data, we use a part of program from GIS sample model which is provided by KKE Inc (see Fig.1). Lines represent road, river, and railway and so on. Dot represents people. In this simulation, local bus passes regular root and pick up peoples at bus stop and drop the people off at bus stop on the near destination.

Enlargement of a Residential Area

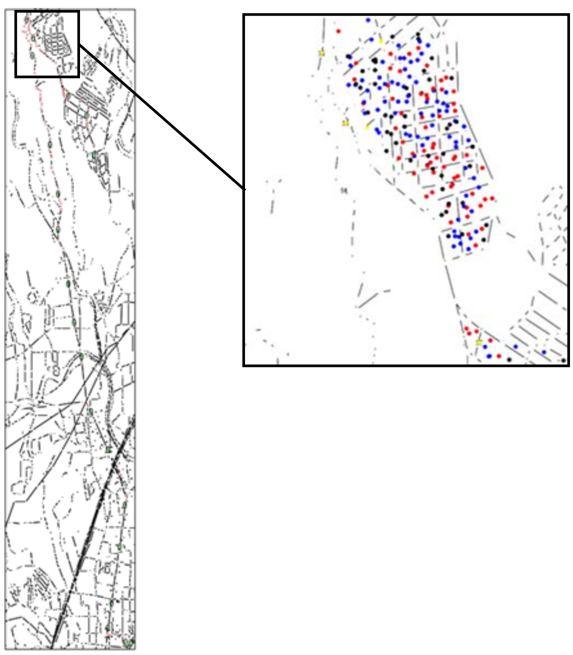

Fig. 1 Outline of Our New Model

## *C. The Role of Agents*

Types of agent are as follows:

1) People agent: People agent differs in age. Population density is referenced on a map of Ibaraki city. The site of residential area is high density. The behavior of people agent is decided by function (1). People agent interacts himself for

decision making of achieving his trip. Total number of people agents is 1,000.

2) Local bus agent: local bus agents run downtown to hilly terrain area. The numbers of 80 buses run per a day. Travel distance is about 8.5 km. Bus speed is 18.2km/h (from downtown to a residential area), 20.4km/h (from a residential area to downtown).

3) Local bus stop agent: The number of 38 Local bus stop agents is located along the highway.

Simulation is performed 63 times. It is comparable to 63days (nine weeks). Utility of each people agent is taken over to the next time. Utility make up for the decrease of motivation going out associated with age. One trip using bus is limit of this model. One round trip is maximum number per a day.

*D. Outputs of Agent Based Simulation*

Data rerated to local bus agent

1. Time series of total fare (revenue) and the average number of people agent who used bus.

2. The number of people agent in each bus

TABLE I.
OUTING RATE OF YOUNG-OLD UNDER GOOD WEATHER CONDITION

| **Weeks** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **6th** | **7th** | **8th** | **9th** |
|---|---|---|---|---|---|---|---|---|---|
| Average of Outing Rate | 50.57 | 64.76 | 75.42 | 76.94 | 77.66 | 77.83 | 77.59 | 77.06 | 77.42 |
| Maximum | 100.00 | 100.00 | 75.38 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Minimum | 0.00 | 0.00 | 75.38 | 28.57 | 28.57 | 28.57 | 28.57 | 28.57 | 28.57 |
| Standard Deviation | 21.31 | 20.84 | 75.44 | 16.48 | 16.04 | 14.94 | 16.08 | 16.34 | 14.84 |

TABLE II.
OUTING RATE OF OLD-OLD UNDER GOOD WEATHER CONDITION

| **Weeks** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **6th** | **7th** | **8th** | **9th** |
|---|---|---|---|---|---|---|---|---|---|
| Average of Outing Rate | 22.91 | 31.89 | 38.98 | 50.30 | 59.31 | 69.23 | 73.00 | 76.56 | 76.91 |
| Maximum | 71.43 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Minimum | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 14.29 | 14.29 | 14.29 |
| Standard Deviation | 16.68 | 20.02 | 21.96 | 23.19 | 23.20 | 21.90 | 18.12 | 16.54 | 16.79 |

TABLE III.
OUTING RATE OF YOUNG -OLD UNDER RAINFALL CONDITION

| **Weeks** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **6th** | **7th** | **8th** | **9th** |
|---|---|---|---|---|---|---|---|---|---|
| Average of Outing Rate | 22.48 | 27.68 | 31.52 | 33.24 | 35.92 | 37.52 | 39.11 | 38.99 | 38.58 |
| Maximum | 71.43 | 85.71 | 85.71 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Minimum | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Standard Deviation | 16.48 | 18.81 | 18.25 | 18.75 | 19.33 | 18.21 | 18.66 | 19.32 | 18.82 |

TABLE IV.
OUTING RATE OF OLD -OLD UNDER RAINFALL CONDITION

| **Weeks** | **1st** | **2nd** | **3rd** | **4th** | **5th** | **6th** | **7th** | **8th** | **9th** |
|---|---|---|---|---|---|---|---|---|---|
| Average of Outing Rate | 10.55 | 12.68 | 13.34 | 16.56 | 18.90 | 20.99 | 23.72 | 26.20 | 29.65 |
| Maximum | 57.14 | 71.43 | 57.14 | 71.43 | 71.43 | 85.71 | 85.71 | 71.43 | 85.71 |
| Minimum | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Standard Deviation | 11.32 | 13.96 | 14.22 | 15.84 | 15.94 | 16.38 | 18.79 | 18.73 | 18.72 |

Data rerated to People agent

1. The number of people agent which didn't use bus
2. The number of people agent which used bus
3. Outing rate of people agent

## III. The Results of the Simulation

### *A. The Results of Outing Rate*

Outing rate was the ratio of experience times of going out within 7 days. If a person went out 3 times in 7 days, the outing rate is calculated to be 42.86 percent.

Each peoples' outing rate was shown in TABLE I to IV. Fig.2 and Fig.3 shows that people agent which use bus after a week. The graph shows increase, same or decreases as compared with the first week.

The outing rate of young-old under good weather condition was represented in TABLE I. First week of an average of outing rate was 50.57 percent. And final week of an average of outing rate was 77.42 percent. Comparing the number of first week and that of final week, an average of outing rate was increased 26.86 percent.

The outing rate of old-old under good weather condition was represented in TABLE II. First week of an average of outing rate was 22.91 percent. And final week of an average of outing rate was 76.91 percent. Comparing the number of first week and that of final week, an average of outing rate was increased 54.00 percent. This extension percentage of difference on degree of change in case young-old and old-old, in case of old-old was larger.

Therefore, in case of young-old, people agent which increased outing opportunity was shown range among 70 and 80 percent (see Fig.2). On the other hand, in case of old-old, people agent which increased outing opportunity was shown more than 90 percent (see Fig.3).

The outing rate of young-old under rainfall condition was represented in TABLE III. First week of an average of outing rate was 22.48 percent. And final week of an average of outing rate was 38.58 percent. Comparing the number of first week and that of final week, an average of outing rate was increased 16.10 percent.

The outing rate of old-old under rainfall condition was represented in TABLE IV. First week of an average of outing rate was 10.55 percent. And final week of an average of outing rate was 29.65 percent. Comparing the number of first week and that of final week, an average of outing rate was increased 19.11 percent.

Therefore, in case of young-old, people agent which increased outing opportunity was shown less than 70 percent (see Fig.4). On the other hand, in case of old-old, people agent which increased outing opportunity was shown more than 70 percent (see Fig.5).

Compared with case under good weather condition and under rainfall condition, outing rate was increased at case old-old rather than that of young-old.

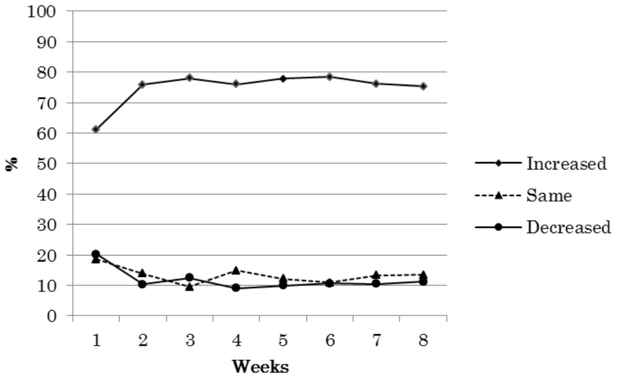


Fig. 2 Bus Users' Shifts Based on Comparisons with First Week (Young-Old, a Case of Good Weather Condition)

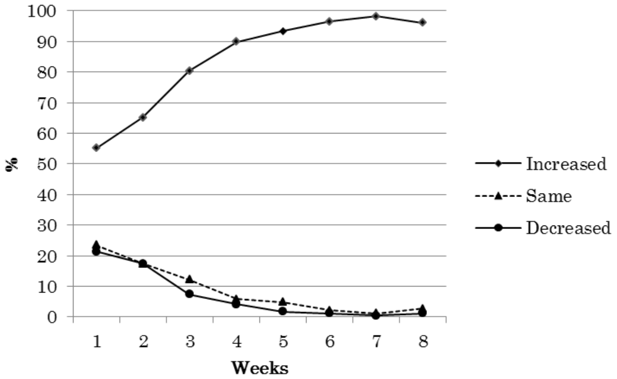


Fig. 3 Bus Users' Shifts Based on Comparisons with First Week (Old-Old, a Case of Good Weather Condition)

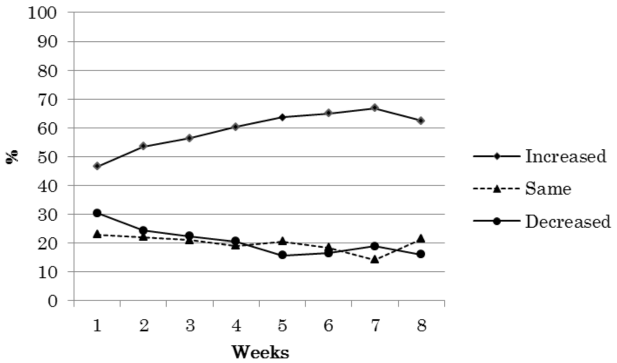


Fig. 4 Bus Users' Shifts Based on Comparisons with First Week (Young-Old, a Case of Rainfall Condition)

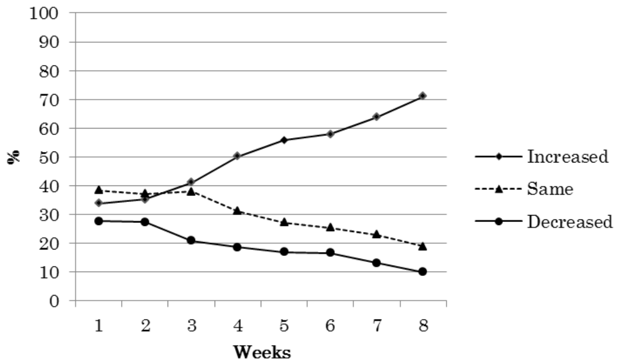


Fig. 5 Bus Users' Shifts Based on Comparisons with First Week (Old-Old, a Case of Rainfall Condition)

### *B. Case of Rainfall Condition*

The repeat times of people agent under good weather condition were shown in Fig6. According to a polygonal curve of young-old, the range of repeaters was within 32 to 56. Maximum number of repeater (67 people agents) was 45 times.

According to a polygonal curve of old-old, the range of repeaters was within 8 to 49. The range was the number of 17 times wider than that of young-old. Maximum number of repeater (27 people agents) was 37 times.

From height of a polygonal curve of young-old, a lot of repeaters were concentrated around 45 times. On the other hand, a polygonal curve of young-old was not so high and wide. That is, there were together with high and low repeaters.

On the other hand, in case of under rainfall condition was shown in Fig7. According to a polygonal curve of young-old, the range of repeaters was concentrated within 5 to 36. Maximum number of repeater (63 people agents) was 22 times.

From polygonal curve of old-old, the range of repeaters was within 1 to 27. Maximum number of repeater (42 people agents) was 12 times.

The features of under rainfall condition were that most people agent existed near distance from the origin in Fig.7. The number of repeaters was fewer than in case of good weather condition. And a polygonal curve of old-old in case of under good weather condition was wide. However, a polygonal curve of old-old in case of under rainfall condition was not so wide.

From the number of repeaters, we were able to confirm that repeaters increased under good weather condition and decreased under rainfall condition.

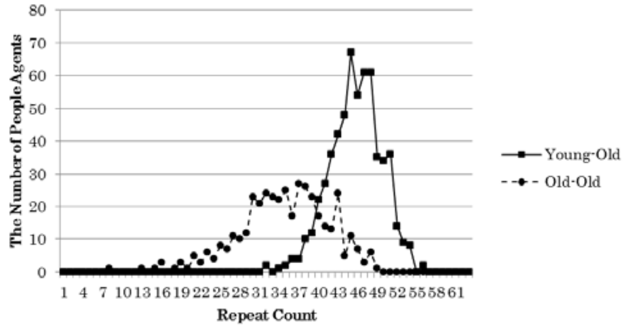


Fig. 6 The Number of People Agent which Repeater of Bus (Case of Good Weather Condition)

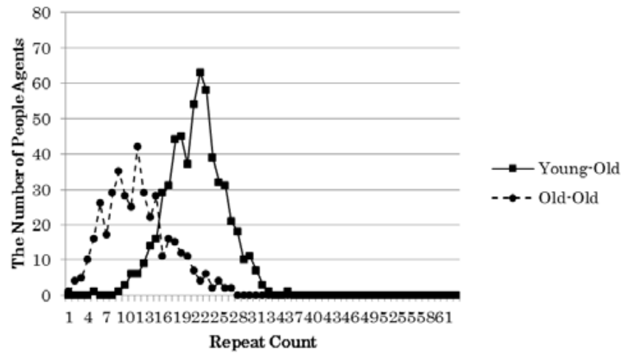


Fig. 7 The Number of People Agent which Repeater of Bus (Case of Rainfall Condition)

## IV. Conclusion

As the result of the simulation, during the first week, young-old was using the bus relatively well. For this reason, the ratio of young-old of people agent which used local bus more than first week was significantly less than the old-old.

That is, utility did not affect enough to the next decision-making in case of young-old.

The finding is that the utility of experience from reaching destination and achieving their aim was more effective for next decision of old-old than that of young-old.

And, looking at this results from another perspective (policies of bus management), we understood that many people agent used local bus agent over and over again, local bus agents became well-established transportation. And we understood total fare was increased by getting many people agents who were repeaters.

The result implies that one of the policies may work well. For example, the bus company gives opportunity (e.g. discount, free) of riding bus for some people who has never use the route of bus or has been out of use for long years, the people is able to renew his awareness of buses' convenience. This policy requires a lot of initial costs. However, if utility of people increase, use of local bus will become well-established. And initial cost will be able to pick up from fare. Especially, from the aspect of outing rate, the policy is able to affect well for people of old-old.

Notice that, our model has no alternative way of transportation. Therefore, our offer is limited to only people who has no alternative way.

For future work, we will implement three cases which are mountains area (north side), hilly terrain area (center) and downtown (south side). And we will reflect data from previous study [5], [7] to new mental factor. And we will implement transportation's cost and the condition of budget constraints might be required in our model. We are going to carry out revised our model and discuss our simulation results at ESSA 2014.

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