On Generic Properties of Extended Environment Values

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Abstract: This paper proposes the integrated scheme of moving demand by using the form of environment values for multiple categories of landmarks. It has become possible to seek the optimum solutions for the users to select the most convenient trajectory on the basis of connected and autonomous technologies for vehicles. Then the prediction of the various EV (environment values) and the recommendation of them by using NMF (Nonnegative Matrix Factorization) is one of the easiest realizations. Secondly, the PFLOW (people flow) based simplification of environment values and related city structures are described. Finally, NMF and PFLOW based EV optimization will be shown with simple examples

Keywords: Environment value, nonnegative matrix factorization, people flow

1. Introduction

In this article, we are going to newly propose the concept of the environment values which is considered as the extended notion of multi attributes utility functions along the spatio-temporal trajectories of human movements. From the viewpoints of the environment values above, we are investigating the people flow around the major landmarks of domestic small areas and also of abroad. Here, we can alleviate the target accuracies of spatio-temporal prediction as compared with the conventional risk prediction problems. However, we cannot obtain the inference rules and the learning data sufficiently in order for demand prediction with spatio-temporal trajectories and the environment values alone. Therefore, we focus on the people flow which has been supposed to be activated by the common situations although they are the past data and introduce the possible solutions for the prediction even when the learning data.

For example, in the next generation, it is believed that the car sharing will be the prospective industry especially backed up by connected vehicles and various ADAS technologies. But the recommendation of the route should be determined not only by currently developed AI based IoT but also by new demand prediction technology. In this paper, the latter technologies are proposed based on the latest analysis of people flow and the spatio-temporal movements in view of generic properties and the specific properties. Practically this is possible even if the target system does not have big data by using NMF (Non negative Matrix Factorization). Moreover, it is enabled by new model of PFLOW and demand prediction with land mark model. This is simplified by multi EEV (Extended Environment Value) space in which PFLOW trajectories are organized. In this process multi-utility functions are maximized using EV potentials subject to practical constraints such as time, space, capacity, season, weather, cost and energy. These are all mathematically expressed by Green functions and the analysis is well approximated by NMF and NTF combined by multivariate linear regression theory on the basis of sparse modelling technologies. And when the EV potentials are transformed to the real acquisition of users, it will raise the positive values of human convenience properties. When it is negatively raised it will degrade the human convenience properties.

From the viewpoints of EV above, we are investigating the people flow around the major landmarks in a provincial city. Here, the targeted spatio-temporal accuracies highly weighted in the risk prediction problems are now rather alleviated. However, spatio-temporal trajectories so far and the current EV acquirement would not reach the sufficient learning data and inference rules which re required for the moving demand predictions. Then in this research, we focus on the people flows which are supposed to be activated by the common situations even if they are the past data.

2. Environment Values

2.1 What are the environment values ?

To get every valuable information and material along the spatio-temporal trajectory is considered as the environment value (EV). There are various EVs that can lead the people flows as follows:

(1) Energy: to get energy and pay, use in order to move and continue to work. To eat, supply, and charge, etc. To consume the energy is always needed to work.

(2) Environment: to see, use, get useful information, to enjoy and appreciate something is also the property of the environment.

(3) Excursion; to enjoy the movement along the trajectories under the various environment is also the source of the EV. You can enjoy the spatio-teporal trajectoires on the feeling of excursion.

(4) Experience: to get every experience can lead the movement along the trajectories. You can get and pay the experiences of your own. The rout and the scene which users want to experience is the typical style.

(5) Economy: to get the special benefit of the LM

(6) Exercise : practice in mental domain, train in physical domain and mental domain.

(7) Expert : this makes the target LM is well known.

(8) Emergency: this makes the EV positive or negative

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rapidly.

(9) Expectation : this makes the target LM is well expected

(10) Extension: this makes the target LM is used for wide area of usages.

(11) Engineering: this makes that target LM is well accessed by technical instruments.

(12) Electronics: this makes the target LM is well facilitates with electronics devices.

(13) Entertainment: This is just enjoying as the name suggests. Under the constraints of time like above, time values limited by aging subject to physical age and mental age will make the use's own view of values even if others are not evaluating them. People like to spend much more time for other than books and TVs. The reasons to live are the most important things. For example, how much time do you spend for cleaning up house? To pay money is changed to climbing mountains, going abroad, enjoying diving, concert, skiing, buying the brand name products, going to the interesting landmarks, etc.

Each EV is not independently calculated from the other EV. Each EV has the effective spatio-temporal domain ST and the coverage of ST depends on the situation Q. Low EV means the effectiveness of the GET(EV) is low. Different person has different EVs.

$$X = \sum_{t=t1}^{t2} EV\_GET\{trajectory(real\_space, virtual\_space), situation\} \quad (1)$$

Where, *X* means the event occurrence data matrix which row dimensions express the target environments of EV. For example, the landmarks are the easiest descriptions. The column dimensions express the target vectors of optimization. These are get by function EV_GET which is dependent on the real space EV acquisition behaviors and virtual space EV acquisition behaviors along the trajectory. EV_GET varies under the conditions of situation. Therefore the EVs are also effective for the virtual spatio-temporal trajectories in the mental world of the users.

2.2 Modeling of EV

Practically, in ITS related points of views, the optimization problem of *EV_GET* is subject to the following condition :

$$\{\text{road, time, cost, comfort, security, jam, sightseeing resource, etc.}\}$$

Ordinarily, the desire for EV is ambiguous unless the specified image of plan is made in advance. For example, "I want to go somewhere, but I don't know the detail of the sightseeing menu." Then the strong recommendations are required to get the indefinite EVs. Mobile coffeehouse, mobile bar, mobile office, mobile restaurant are considerable applications in ADAS systems and the public transportations.

$$X = \sum_{t=t1}^{t2} EV\_GET\{trajectory(real\_space, virtual\_space), situation\} \quad (2)$$

$$= AB^T = \left(\sum_{\forall a \in E\$} A_a\right)\left(\sum_{\forall b \in Q\$} B_a\right)^T$$

Cruise property is one of the positive factors to raise the EV. If the users can roughly estimate the EV_GET journey, it will contribute to raise the EV, but completely knowing the journey is negative to EV in view of experience of extraordinary which is the important factor of fun.

$$EVofFun = Extraordinary + Expected \quad (3)$$

$$\mathrm{NMF}(EVofFun) = \mathbf{A}(EVofFun)\mathbf{B}(EVofFun)^{\mathrm{T}} \quad (4)$$

Combination of plural NMFs are appropriate to describe the composite problems such as

$$NMF = (a_1, a_2, \cdots)(NMF_1, NMF_2, \cdots)^T \quad (5)$$

NMF_i is decomposed to A_iB_i which includes the factor components each of which will well describe the problems.

$$EV\_Satisfactory = EV\max - Congestion - Crowdness + Weather \quad (6)$$

Sometimes, most effective EV is congestion like below.

$$NMF(EV) = \text{-}Congestion \quad (7)$$

The degree of satisfaction will be strongly affected by the three factors above. When the congestion occurs, the *EV_Satisfactory* will decrease drastically. Then the plural recommendations of trajectories are required to avoid the negative factors. Class of factors is defined as below.

$$\{festival, event, typhoon, construct, \cdots\}$$

For one user, the size of event matrix will be determined. The row size of *X* is *I* which corresponds with the number of EV landmarks where the user will visit on the assumed trajectories. Namely the size of the *X*, A, R are $I\times J$, $I\times R$, $J\times R$, respectively. Under this condition, we will iteratively calculate the matrix decomposition until we get the following form;

$$X = AB^T \quad (8)$$

Here, R describes the number of the factors.

Each component of A, B will be updated by the next formula:

$$a_{ir} \leftarrow a_{ir} \frac{\sum_{j=1}^{J} x_{ij} b_{jr}}{\sum_{j=1}^{J} \hat{x}_{ij} b_{jr}}, \quad b_{jr} \leftarrow a_{ir} \frac{\sum_{j=1}^{J} x_{ij} a_{ir}}{\sum_{j=1}^{J} \hat{x}_{ij} a_{ir}} \quad (9)$$

by using this equation, *mth* stage of recurrent calculation is expressed as follows:

$$X_m = A_m B_m^{\ T} \quad (10)$$

Where, usually, X_m does not completely conform to the value *X*, *t*he difference between *X* and X_m will continue to be evaluated through the recurrent calculation.

$$E_m = X - X_m \quad (11)$$

By using NMF, we can express the EV demand prediction. Now the trajectory which can acquire the EV potential on N landmarks is searched for optimum. For each landmark, totally M EVs are specified. Here, following expressions are taken for the achievements of EV_GET:

$$X_m = A_m B_m^{\ T}$$
$$X_m = \left(X^{Base}{}_m + X^{Nz}{}_m + X^{Pflow}{}_m + X^{Model}{}_m\right) \quad (12)$$
$$= \left(A^{Base}{}_m + A^{Pflow}{}_m + A^{Model}{}_m\right)\left(B^{Base}{}_m + B^{Pflow}{}_m + B^{Model}{}_m\right)^T$$

2.3 Predictive Factors

When NMF is used, Event matrix *X* in formula (1) is decomposed into two factor matrices such as *A* and *B*. Then we can consider the necessary attributes for prediction and the mechanism for constraints of dimension for the factorization. It is desirable for the factors that we can express the EV acquisition pattern intuitively.

$$\tilde{X}_{PURP} = \tilde{A}_{PURP} \tilde{B}^T_{PURP}$$
$$\mathrm{Get}(\mathbf{EV}_l) = \sum_{m=1}^{M} \mathbf{P}_m \quad (13)$$

Here, $\boldsymbol{P}_m$ means the purpose matrix which shows the multi-purpose in *mth* stage of the trajectory (trip) of a person for the lth EV in row vectors. The column vector means the time series changes in a schedule which is definitely defined in advance or simply, the past achievements. Then $\boldsymbol{P}_m$ has three types such as anticipated schedule $\boldsymbol{P}^S{}_m$, real time variation $\boldsymbol{P}^R{}_m$, and the past achievements $\boldsymbol{P}^P{}_m$. Usually, $\mathbf{P}^{\mathrm{R}}{}_{\mathrm{m}}$ is determined by $\boldsymbol{P}^S{}_m$, and the $\boldsymbol{P}^P{}_m$ database depending on the user's situation. Namely,

$$\mathbf{P}_m = Decision\left(\mathbf{P}_m{}^S, \mathbf{P}_m{}^R, \mathbf{P}_m{}^P, situation\right) \quad (14)$$

From the statistical points of view, most of all (about seventy to eighty percent) are recorded as "indefinite" as the past public inquiry shows in the PFLOW database. This is because the privacy problems or originally ambiguous or just it cannot be remembered.

Human sensing which can acquire the subtle difference of wind, temperature, common sense, view of values, prejudice, the images to the scene and way to the field (for example, there were many people who carries the suit case, so much crowded and twice of ever, so many people that I could not avoid them to go forward, there are some drastic changes on the rooms and walls of the department stores, there are many people standing on in the line of waiting to buy sweets, etc.) will not be displayed in a camera image. This is because the EV-GET property of situation dependence is working. Behaviors of the EV-GETTER depend on the events and surrounding situations.

This time LMs which are well accessed by the user are selected to form the prediction scheme such as parks, shopping centers, city offices, etc. are considered to for the categories. However, in the reservation behaviors, space configurations which can be comfortable to be accessed are also the important feature dimensions. Therefore, we consider the totally representative labels which can express the many event attributes which include the moving purpose, preference, etc. that can be accessed by EV when moving for surrounding landmarks would be better than that grouping with minor set of landmark categories.

Finally the users will move along the recommended trajectories which include the major EVs made reservation. However, these are the personal information and we cannot inquire it unless users are willing to disclose. To analyze and predict the next reservation at the high level of accuracy on the basis of the practical reason would be very difficult if the each moving purpose is the complexed result of the plural purpose and scheduling unit. Therefore this problem should be solved not by analytic means but by practical PFLOW and the empirical rule base. Namely the EV achievements should be supposed to be generated by the filtering results of plural time series wave are to be the final EV reservation statistically or probabilistically.

In a small scale system like EV_GET SYSTEM, it is required to predict the events, to improve and extend the system at the earliest level before the big data are accumulated. Then approximately analyzing system which use the NMF of NTF and the rule base which are based on human intuition and experience and sensing results to generate the hypothesis and to process the data assimilation will appropriately converge to the prediction results from the both sides.

Finally it is the problem that what trajectory the each use moved along and what purpose he has attained are user's personal information and we will not be able to inquire them unless the users actively disclose the personal schedules. And when the users analyze and predict at high accuracy the predictions would be very difficult if the each moving purpose is made of mixed reasons. On the other hand, it would be better to generate the rule base from PFLOW than solve them analytically from the EV reservation results. So we should suppose that the filtering process to real reservation based on the multi supervised waves of time series and the results are to be EV acquisition achievements.

EV_GET SYSTEM in the small level will be desired to have the prediction improvement and extension at the earliest stages before it needs big data. Then it needs to be appropriate to have the abilities to predict with NMF and NTF which does not depend on the learning amounts and the rule base which converge the predicted results from both sides of approximately analyzing process and the data assimilation process and hypothesis generating process on the basis of the human intuition and experience、then it becomes possible that the Intelligent time spending makes contribution to ITS.

2.4 Data Matrix

In *EV_GET SYSTEM*, it will need to set the landmark number in vertical axis, and event vectors for horizontal axis, that is *X*（*L*×*M*）, and the each Landmark acquisition achievements is described with M dimensional event vectors. Left six rows of *X* describe the reach time to the landmark and the leave time from the landmark, and the next *L* dimensions are the utilization information which corresponds to the landmark usage information.

2.5 EV Acquisition

Difference between holidays and weekdays are explicitly detected in EV_GET. PFLOW affects EV_GET and it will generate the EV extension with new PFLOW. Energy、Environment、Experience、Excursion are the good examples as follows: Energy is used by *GET_PAY* which means the acquisition behaviors by various currency. Environment is used by *GET_PAY* and will be enjoyed. Emotional values are consumed as music, cinema, art, etc. all of them are addressed as Experience values.

2.6 Ordinary and Extraordinary

When the extraordinary scene is expected in EV acquisition, once the situation turned to be ordinary, scene and EV will get degraded catastrophically. If a user is accustomed to it, everything will become ordinary. Does the culture hold the extraordinary property? When the city is changed to the compact city, the culture will be neglected and will be generic. What would be the extraordinary? When it becomes extraordinary, EV will be degraded if it changes to be boring. Therefore the users will need new stimulus or he can get no satisfaction.

Demand based PFLOW are modelled not by active movement but by recommendation and preset modelled AV route which are automatically set. Followings are the comprehensible examples:

Ex1) "It was very dull day, today. Now I am looking the night view of Nagoya station and thinking so. Next I started to go with taxi to see red leaves in Fall. It costed 960 yen, but it showed no return. Red leaves are not mature to be appreciated. Then I hit the big bell in the shrine of the main temple."

Ex2) "Because the sightseeing in this rural area is not so interesting, I decided to move to the center of the city. I have an impression that everything is boring. I can get no satisfaction"

In such situations, EV would be very low. New experiences will not inspire the user and the Environment is not excellent. It will take much money and it is not good for my sense of economy. In energy view, it takes much fuel to get there. All of these EVs are low. And what is worse, time consuming and the user has no room for being relaxed. Namely, the restriction from time and cost counts more and more. Then some questions would arise in the user's mind that "Does the every person have specific purpose to come here? Are there any great events to allure everybody?" These examples show that the logical reasons are not the main force to navigate the people flow but the fairy ambiguous decisions such as "As someone goes there, I am very much interested in the spot." Off course the nature of the person affects the movement. Also, whether the person can be patient with the situation alone or not affects the movement. Someone who envies other people may become the tracker of the trend.

Someone who wants to be always in outside tends to be moving by vehicles or trains. He does not want to go back home early but he wants to stay with his family. Such a person will need some specialized EV optimizations. Moving office, moving restaurants, moving library are the considerable solutions. Driving cars are once very good solutions, but today, it may not be safe if the surrounding people are not so conscious for the traffic situation. It will degrade the EV values to negative when the congestion occurs and the road condition is not good for driving. In addition to these conditions, it will take too much time to drive manually. Then the complete autonomous vehicles or public transportations would be better.

However the public transportations often give the bad environment and sometimes it will not afford the complete satisfaction. Then the autonomous moving library or office would be an ideal moving environment. Reading books and doing some works including operating PCs or doing some art will make the ADAS life highly convenient. Under the condition that "Time is the best priority", your car will not complain even if you use it every day for the commuting. But for the users, it is so much time consuming tasks if the driving repeats the same dull experiences of scene and congestions. In physical points of views, driving vehicles itself does not have good effects on your body especially for elderly people. Sometimes it will turn to be heavy traffic accidents.

When EV_GET of the extraordinary is the most valuable points, EVs which are easily predicted would not be convenient or useless. On the other hand, people like to hear the same music over and over again. Is this the special case of EV_GET? The experience activated by the sound is not unique but the images of the sound have common essence. To buy time by money would be the essential part of the EV business. The system can get the useful time for the user. Purchase pattern correlation subject to {Time, Money, Price, Health, Convenience, Life} includes the following examples:

- To experience parks which are not the same as the one you see every day.
- To experience different world which he has not ever experienced.
- Topic and season are the important factors for the buying behaviors

When expecting the extraordinary things and elaborating to get EVs, everything turned to be ordinary, scenes and EVs are catastrophically degraded in values, to what extent does the culture hold the ordinary properties ? When the extraordinary properties lose, the EV gets degraded if they are boring. Time is restricted and what does he select to do? What can he select during the time? The number of selection is not restricted to one. Originality will make positive EVs subject to {TIME, LIFE, MONEY}. Additionally, for example, in view of the preferences and the natures of users like below, they will change the EVs of the target landmarks. For example, questions for classifying the preferences are as follows:

- Does he have a patience to be alone?
- Does he have the obsession to be an expert or not?.
- Does he have a belief to be a professional expert?

Everybody surrounding a user who is not evil person may have the positive factors to enable the user to be cheer. The effects of friends will boost the effect of EVs. If the people surrounding the user are such kind of nature, user can elaborate more and more. If the user has anxiety, surroundings may be willing to hear the reason of that.

From the other points of views in EV, the reason to listen the music is as follows: To be absorbed in his own world, to be free from the time constraints. Also, the reasons to be secured with the comrades, to be secured with his family exist. Practically, the user's generation and the user attributes will increase the number of branch of selection. It is difficult to analyze and predict the user trajectory especially for the reason to select which way for what and when in high accuracy. Particularly when the plural moving purposes are complexed, it needs to be described by multi-variate prediction problems for multi object functions. This is the basic concept of the extended environment values in mixed space of virtual and real world. Deviation from human sense also makes the problems more difficult to solve. Therefore we firstly make the X by definition of purpose vectors and the related real landmarks in row dimensions.

2.7 Prediction

The predictive results obtained by the past results of factorization $\{A, B\}$ which is made by the constant matrix B of fundamental basis pattern of events. According to the above processes, matrix of the predicted values of EV is acquired by the next formula

$$\widetilde{X}_{Next\_Month} = \widetilde{A}_{Next\_Month}\widetilde{B}^{T}_{Next\_Month} \quad (15)$$

NMF and NTF are the approximately analyzing processes which are not depending on the learning amounts. In addition to this stage, rule base which can assimilate the targeted data to generate the hypothesis on the basis of the human intuition and the experiences are required. In NMF, we have verified that the representative LMs can be used for the factors which can include integrated geometrical positions of landmarks which can be accesses and users.

At this stage, machines cannot sense like human. The camera image is just making the data of pixels which can express only a single shot of the scene field. Therefore it will be very different from what a human can acquire from the scenes (spatio-temporal regions + confidence regions on the basis of the sensing results). Prediction will be attained by using some of effective factor matrices above, because A matrix has the basic pattern of changes introduced by NMF calculations.

$$X_{Purpose} = A_{purpose}B_{purpose} \quad (16)$$

3. People Flow

From the investigations and hypothesis above, the reasons why the people gather in the crowded town are considered as follows. Partly, these are related to the aging society including the deprivation in EV.

#1) peace of mind when being in the place where people gather

#2) peace of mind when keeping own space (negative factor of outside)

#3) peace of mind when acquiring the brand-new or the latest information

#4) peace of mind and view of values when getting environment values more than the threshold as the other people can do at the minimum level

#5) peace of mind in which he or she can maintain the own belief and the strength of own will.

3.1 Relation to the Generic Properties of PFLOW

EV which induces (namely, flows out and attracts) PFLOW can be modelled as follows:

$$PFLOW = f\left(\mathbf{P}(t_1), \mathbf{P}(t_2)\cdots, \mathbf{P}(t_N)\right) \quad (17)$$

PFLOW which actually get EEV will be modelled like below:

$$GET\_EV(PFLOW) = G\left[f\left(\mathbf{P}(t_1), \mathbf{P}(t_2)\cdots, \mathbf{P}(t_N)\right)\right] \quad (18)$$

Spatio-temporal trajectories which get EV is well organized to form PFLOW.

3.2 Correlation to the EV behaviors

How much of the members of the PFLOW will the target application take? This can be described as follows:

$$Correation(X_{PURPOSE}, X_{EV\_Landmark}) = X_{PURPOSE}X_{EV\_Landmark}^{T} \quad (19)$$

3.3 PFLOW of Multi Object Functions

PFLOW can display the effects of EV if the appropriate generic transform can be selected. If the one dimensional transform is selected, spatio-time correlation is simply calculated. Let r be a distance from LM which is the main source of PFLOW. (r,t,a) will form the NMF space. Then each NMF on the specified LM will be totally combined and will make the fundamental base of prediction on the basis of the factorization formula $X=AB$, where a is the most effective attribute component of the PFLOW. (r,t,a) will form the data matrix X. Shops around the LM will be the 2nd order of attractors when the source of the PFLOW is the station. The configuration of shops will change from time to time and the location will not be restricted other than the distance from the source LM.

3.4 PFLOW Model

In order to consider the practical model of PFLOW, firstly, we visualized the major landmarks from the past database. There are several attributes which will affect the EV-GET behaviors. From the human attributes of PFLOW, we can represent the example of purpose vector as follows;

$$P = (\text{eating}, \text{shopping}, \text{commuting}, \text{work}, \text{leisure})$$

The behavior models which can be reached from the human attributes of PFLOW are not completely applied to the EV demand temporary changes. But there will be some correlations between the EV and PURPOSE in view of stochastic variables. Then we can simply suppose that the moving purposes occurrence rates are proportional to the number ratio.

$$\widetilde{X}_P = \left[\mathbf{P}(t_1), \mathbf{P}(t_2)\cdots, \mathbf{P}(t_N)\right]^T = \begin{bmatrix} eating(t_1), shopping(t_1), commuting(t_1), work(t_1), leisure(t_1) \\ \cdots \\ eating(t_N), shopping(t_N), commuting(t_N), work(t_N), leisure(t_N) \end{bmatrix} \quad (20)$$

On the other hand, the purpose data matrix is also decomposed to the two factor matrices as follows:

$$\widetilde{X}_P = \widetilde{A}_P\widetilde{B}_P^T \quad (21)$$

Similar discussions are applied to the EV fields to yield the next formula:

$$\tilde{X}_M = \tilde{A}_M \tilde{B}_M^T \quad (22)$$

$$\begin{aligned} \tilde{X}_M &= [E_1 E_2 E_3 \cdots E_5] = \tilde{A}_M \tilde{B}_M^T \\ E_i &= (e_{i1} e_{i2} e_{i3} e_{i4} e_{i5})^T \\ \tilde{X}_P &= [P_1 P_2 P_3 \cdots P_5] = \tilde{A}_P \tilde{B}_P^T \\ P_i &= (p_{i1} p_{i2} p_{i3} p_{i4} p_{i5})^T \end{aligned} \quad (23)$$

Where,

$$\begin{aligned} p_{i1} &= Confedence\_Degree\_Of\_Eating \\ p_{i2} &= Confidence\_Degree\_Of\_Commuting \\ p_{i3} &= Confidence\_Degree\_Of\_Shopping \\ p_{i4} &= Confidence\_Degree\_Of\_Work \\ p_{i5} &= Confidence\_Degree\_Of\_Leisure \end{aligned}$$

E_i is factor vector which contains five dimensions of factors. These factors are describing Environment Values. Here, one factor of which is EV reservation. Other factors are describing fascinating natures of LM. For simplicity, this LM means the EV station. EV station can be decomposed to five factors such as commuting, shopping, eating, work, leisure. Therefore a single EV station has been supposed as the composite factors of fascination. On the other hand, P_j has the active nature of EV acquisitions. These will form the class type of users.

In order to simplify the comparison and analysis which will not be affected by the city and road structures, we considered to make the three dimensional expression of PFLOW such as time, distance from the basic point, and the demand vector (purpose).

Predicted form of factor matrix A is decomposed into two parts as follows:

$$\tilde{A}_{Next\_Month} = A^{Base}{}_{Next\_Month} + A^{Pflow}{}_{Next\_Month} \quad (24)$$

Then, predicted values of EV acquisition are described as below:

$$\tilde{X}_{Next\_Month} = \tilde{A}_{Next\_Month} \tilde{B}^T_{Next\_Month} \quad (25)$$

For example,

$\{festival,\ event,\ typhoon,\ construction,\ accident,\ congestion,\ bad\ weather, \cdots\}$

will make some classes. If any generic properties exist, they will be applied to other regions. Then the Spatio-temporal correlations between purpose space of PFLOW X_p and practically acquired data matrix of environment values X_{EV}, for example, EV reservation data at several stations will be affected by the class.

Age and work attributes will enable to estimate the event occurrence frequency. It will have generic properties which are not specialized for specified area. LM is described by the sources of PFLOWS and the attractors of PFLOWs. Final attractors of PFLOWs will change from time to time. But the sources of the PFLOW which leads to the final stage of LM are to be restricted by the public transportation facilities. Then the simple forms of the PFLOW features are described by the next formula:

$$\mathbf{EV} = \mathbf{EV}(r, t, a) \quad (26)$$

The distance r does not depend on the city structures and road structures but depends on the main features of a. t is the time. This EV is visualized like Figure1 for the Nagoya station area, one of the biggest sources of Tokai regions PFLOW. Then the simple form of EV is based on the generic transform of geometric constraints. Next, we can compute spatio-temporal correlation map based on PFLOW. Every PFLOW map can be converted to the same 3D feature space *RxTxA*. PFLOW of around the basic point of the landmark will generate the matrix of *RxTxA* which is simply described by *X*. Then the *X* will be decomposed by NMF to AB. Therefore we can analyse the mechanism of event generations and the roughly it is expected to the concentrated phenomena around the major attractors and sources. This will make possible to predict the new production of PFLOW with potential EV related wills. Figure 2 shows the results of *RTA* form of PFLOW

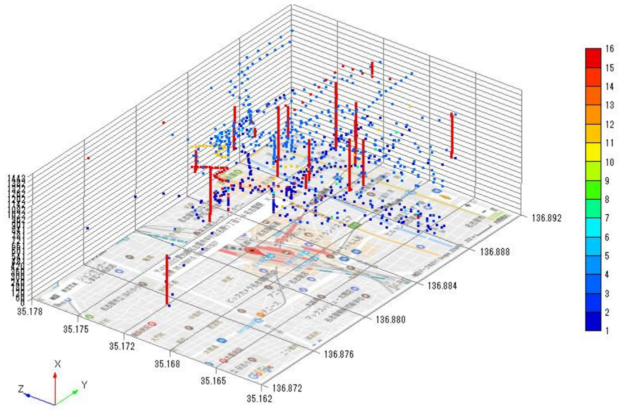

Figure 1 Purpose of PFLOW in Nagoya Station.

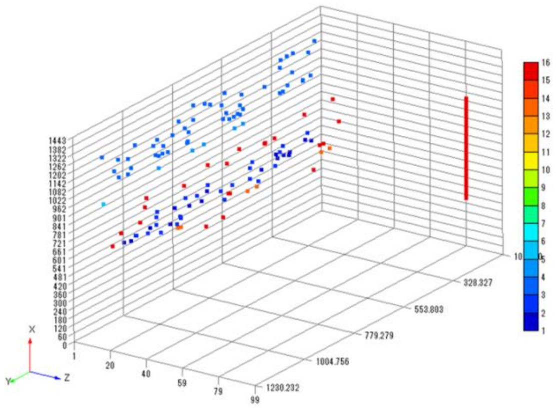

Figure 2 RTA form (Nagoya St.).

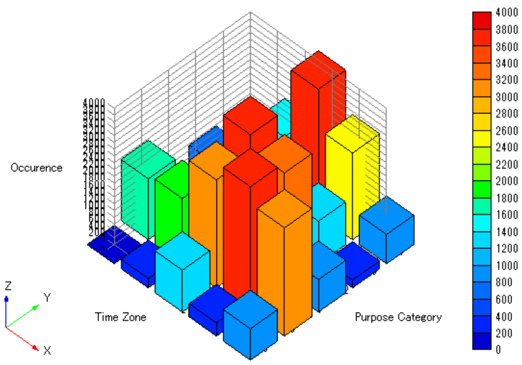

Figure 3 Purpose Occurrence (Nagoya St.).

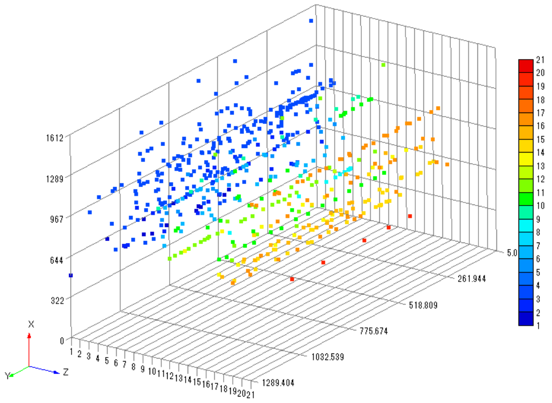

Figure 4 RTA form (Toyota city St.).

3.5 Experiments

Grouping of purposes into 5 categories is performed for making purpose data matrix. Also time zone is defined as shown by Table 1. And to make the EV achievements matrices, we have selected five landmarks near by the station.

Table 1

time zone No.	hour	purpose No.	category
0	5am–10am	0	eating
1	10am–12am	1	commuting
2	12am–3pm	2	shopping
3	3pm–6pm	3	work
4	6pm–5am	4	leisure

3.5.1 Correlation between two areas

Through the use of one dimensional expression of each landmark, we can compare the people flow at the same category which is not affected by the geometrical factors surrounding the landmark. This is based on the idea of generic transform of people flow. Figure 2 and figure 3 are showing one dimensional expressions of the distance from the source point (station) for a person trip for Nagoya station and Toyota city station respectively.

Secondly we can compute the numerical correlation factors between the PFLOW and the EV achievements database. This is made by the setting of data matrix in two categories, for example, purpose and EV Landmark Get reservations. Therefore we can get two data matrices X_{PURP} and X_{EV}. For simplicity, we made the row dimension of the matrices as the five time zones. Then we can compute the inner product based correlations between two matrices for the purpose vector space. Inner product correlation between purpose matrix of landmark A and EV achievements of landmark S is calculated as follows:

$$C_1 = COR\left(X^A_{PURP}, X^S_{EV}\right) = X^A_{PURP} {X^S_{EV}}^T \quad (27)$$

Inner product correlation between purpose matrix of landmark A and EV achievements of landmark B is calculated as follows:

$$C_2 = COR\left(X^A_{PURP}, X^B_{PURP}\right) = X^A_{PURP} {X^B_{PURP}}^T \quad (28)$$

Figure 3 shows the example of X_{PURP} in the 2km square area around Nagoya station. This has five time zones in row dimensions and five categories of purposes in column dimensions which are acquired from the people flow database of 11CHU (Chukyo database in 2011) including 140,000 person IDs for a holiday and 220,000 person IDs for a week day.

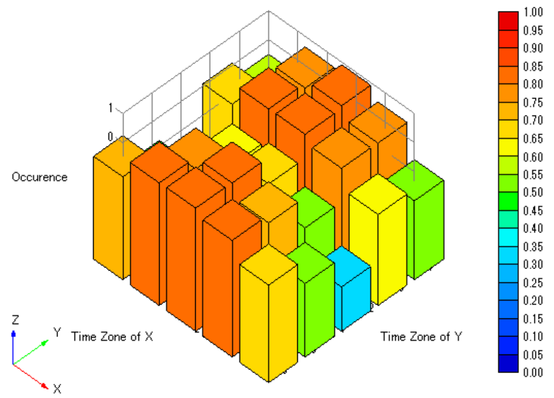

Figure 5 Correlation between Nagoya and Anjo.

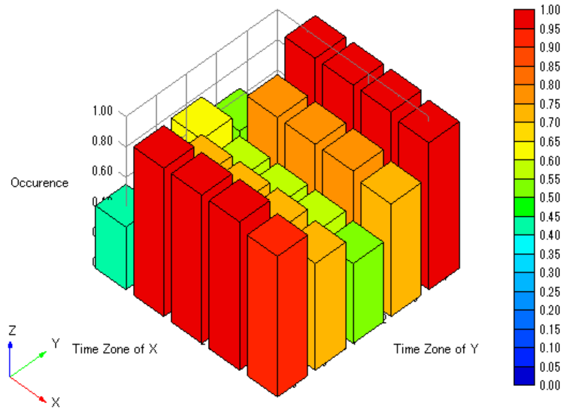

Figure 6 Correlation between Nagoya and Toyota.

In Figure 5 and Figure 6, averages of correlation values are 0.675, 0.734, respectively.

3.5.2 Prediction

Absolute difference AER_{ij} between predicted results of EV-Getter and the real achievements is calculated for EV in landmark LM_i as follows;

$$AER_{ij} = \left|\tilde{x}_{ij} - x_{ij}\right| \quad (29)$$

This is applied to all coverage of the evaluation and the average *AER* is taken to calculate evaluation value prate which is the average frequency of demanded EVs for Get start time and Get_Finish_Time which are predicted in advance. But this method does not hold for the dynamic range of predicted EVs to get *AER* which is uniformly evaluated.

3.6 Evaluation

For specified LM area S, X_{EV} exists and the value of C_1 is more than 0.9 for *A* which is equal to be *S*. As for $C_{2,}$ it showed around 0.7 for five LM areas in average of five time zones multiplied by five purposes. Maximum value of C_2 is more than 0.9.

As for prediction, NMF showed more than seventy percent of accuracy for share car optimization problems in a month records of reservations. And it also showed more than ninety percent of accuracy at the maximum level for a day by the time series prediction using the past data.

In view of data security problems and the cost, the real time acquisition data for EV sharing reservation cannot be disclosed. However, I have confirmed from the viewpoints of generic properties and specific properties of PFLOW that there is a possibility for this concept to be used for real prediction problems, especially in moving demands on the basis of purpose vectors occurrence field.

4. Conclusion

We have started the EV demand prediction on the basis of the multi-purpose interpretation of the human attributes of the PFLOW model, with landmark model to integrate totally the NMF + MVLR (Multi-Variate Linear Regression). This time the MVLR is simplified by using linear extrapolation and interpolation. Also the time series prediction is started on the basis of NMF. In order to relocate the target EVs, moving cost and energy, moving time, number of available EVs more than the demands of EV numbers, the possibility of reconfigure the potential demands, strategies from the viewpoints of campaign effects should be considered. New ideas including proactive navigation [2], data assimilation [3] is required. When comparing with the multivariate linear regression scheme, NMF can realize the prediction regardless of learning amounts. We would like to optimize the EV acquisition trajectories with the constraints of major landmarks.

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