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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 EVs and related city structures are described. Finally, NMF and PFLOW based EV optimization using the new concept of FFLOW (feeling flow) will be shown.

KEYWORDS:

Environment value, nonnegative matrix factorization, people flow, spatio-temporal trajectory, feeling flow

Introduction

In this article, we are going to newly propose the concept of the environment values (hereafter, EVs) 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 EVs above, we are investigating the people flow around the major landmarks (hereafter, LMs) 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 moving demand prediction with spatio-temporal trajectories and the EVs 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) [1][2]. Moreover, it is enabled by new model of PFLOW and demand prediction with land mark model. This is simplified by multi EV 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.

From the viewpoints of EV above, we are investigating the people flow around the major LMs 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 we focus on the PFLOWs which are supposed to be activated by the common situations even if they are the past data.

1. Environment Values

1.1. What are the Environment Values?

To get every valuable information and material along the spatio-temporal trajectory is considered as the 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 drive and feel.
(5) Economy: to get the special benefit of the LM (Landmark).
(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 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, diving, concert, skiing, buying the brand name products, going to the interesting LMs, 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 LMs 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.

1.2. Modelling 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.

$$X = AB^T = \left(\sum_{\forall a \in E\$} A_a \right) \left(\sum_{\forall b \in Q\$} B_a \right)^T \quad (2)$$

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

$$NMF = (a_1, a_2, \cdots)(NMF_1, NMF_2, \cdots)^T,\ NMF_i = A_i B_i^T\ (\mathrm{i}=1,2,...) \tag{5}$$

$$EV \approx EV\_Satisfactory = EV\max\ \text{-}\ Congestion\ \text{-}\ Crowdness + Weather \tag{6}$$

Sometimes, most effective EV is congestion like below.

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

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;

$$X = AB^T \tag{8}$$

Here, R describes the number of the factors.
Each component of A, B will be updated by the next formula:

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

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

$$X_m = A_m B_m^{\ T} \tag{10}$$

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

$$E_m = X - X_m \tag{11}$$

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

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

1.3. 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.

$$\tilde{X}_{PURP} = \tilde{A}_{PURP} \tilde{B}_{PURP}^T \tag{13}$$

$$\mathrm{Get}(\mathbf{EV}_l) = \sum_{m=1}^{M} \mathbf{P}_m \tag{14}$$

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, $\boldsymbol{P}^R{}_m$ is determined by $\boldsymbol{P}^S{}_m$, and the $\boldsymbol{P}^P{}_m$ database depending on the user's situation. Namely,

$$\mathbf{P}_m = Decision\left(\mathbf{P}_m^{\ S}, \mathbf{P}_m^{\ R}, \mathbf{P}_m^{\ P}, situation\right) \tag{15}$$

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 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. 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 purposes and scheduling unit.

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.

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 makes the predicted results converge from three sides that are the approximately analyzing process and the data assimilation process and the 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.

1.4. Data Matrix

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

1.5. 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.

1.6. 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." Of 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 LMs. 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 EVs 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 LMs in row dimensions.

1.7. 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

$$\tilde{X}_{N+1} = \tilde{A}_{N+1}\tilde{B}^{T}_{N+1} \tag{16}$$

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 LMs 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.

$$X_{Purpose} = A_{purpose}B_{purpose} \tag{17}$$

2. 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 EVs 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.

2.1. Relation to the Generic Properties of PFLOW

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

$$PFLOW = f\left(\mathbf{P}(t_1), \mathbf{P}(t_2)\cdots, \mathbf{P}(t_N)\right) \tag{18}$$

PFLOW which actually get EEV will be modelled like below:

$$GET\_EV(PFLOW) = G\left[f\left(\mathbf{P}(t_1), \mathbf{P}(t_2)\cdots, \mathbf{P}(t_N)\right)\right] \tag{19}$$

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

2.2. Correlation to the EV behaviours

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

$$Correation(X_{PURPOSE}, X_{EV\_Landmark}) = Normalize\left(X_{PURPOSE}X_{EV\_Landmark}{}^{T}\right) \tag{20}$$

2.3. PFLOW of Multi Object Functions

PFLOW can display the effects of EV if the appropriate generic transform [4] 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. Then (r,t,a) will form the NMF space $X=AB^T$ on the specified LM, where a is the most effective attribute component of the PFLOW. 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.

2.4. PFLOW Model

In order to consider the practical model of PFLOW, firstly, we visualized the major LMs 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;

$$\mathbf{P} = (eating, commuting, shopping, work, leisure) \tag{21}$$

The behavior models which can be reached from the human attributes of PFLOW are not completely

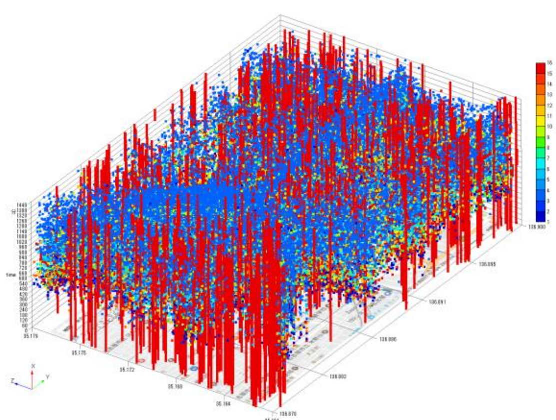


Figure 1 Moving purpose vectors of PFLOW.

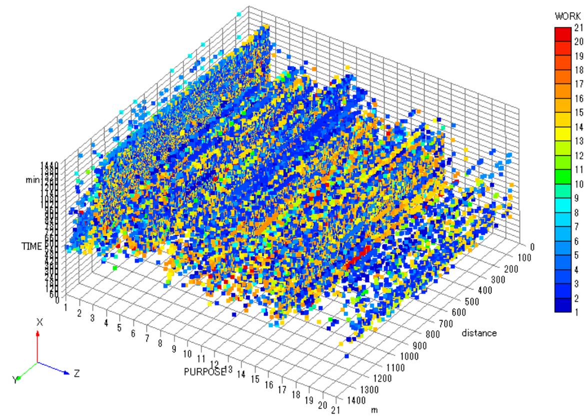


Figure 2 RTA form (Nagoya St.).

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.

$$\tilde{X}_P = [\mathbf{P}(t_1), \mathbf{P}(t_2), \cdots, \mathbf{P}(t_n), \cdots, \mathbf{P}(t_N)]^T = \begin{bmatrix} eating(t_1), commuting(t_1), shopping(t_1), work(t_1), leisure(t_1) \\ \ldots \\ eating(t_N), commuting(t_N), shopping(t_N), work(t_N), leisure(t_N) \end{bmatrix} \quad (22)$$

where, $\mathbf{P}(t_n)$ is a five dimensional purpose vector at time t_n (n=1,…,N).
This purpose data matrix is also decomposed to the two factor matrices as follows:

$$\tilde{X}_P = [P_1 P_2 P_3 \cdots P_5] = \tilde{A}_P \tilde{B}_P^T,\ P_j = (p_{jn} p_{jn} p_{jn} p_{jn} p_{jn})^T, (j = 1, \cdots, 5)(n = 1, \cdots, N) \quad (23)$$

where, p_{jn} means the confidence degree of purpose number j in Table1 at time t_n.

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

$$\tilde{X}_M = [E_1 E_2 E_3 \cdots E_5] = \tilde{A}_M \tilde{B}_M^T,\ E_i = (e_{in} e_{in} e_{in} e_{in} e_{in})^T, (i = 1, \ldots, 5)(n = 1, \ldots, N) \quad (24)$$

E_i is a confidence vector of event which contains five dimensions of environment factors at time t_n. These factors are describing EVs. Here, one factor of which is EV reservation. Other factors are describing fascinating natures of landmark (hereafter, 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:

$$\tilde{A}_{Next\_Month} = A^{Base}{}_{Next\_Month} + A^{Pflow}{}_{Next\_Month} \quad (25)$$

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

$$\tilde{X}_{Next\_Month} = \tilde{A}_{Next\_Month} \tilde{B}^T_{Next\_Month} \quad (26)$$

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 EVs 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

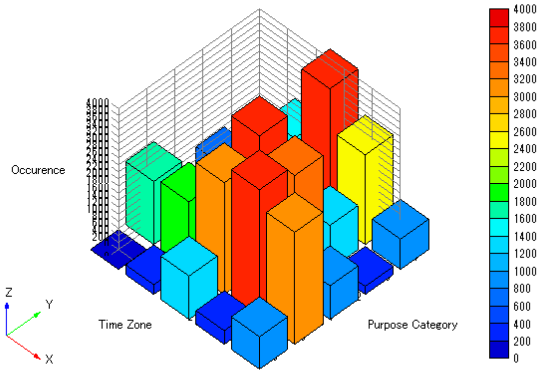


Figure 3 Purpose Occurrence (Nagoya St.)

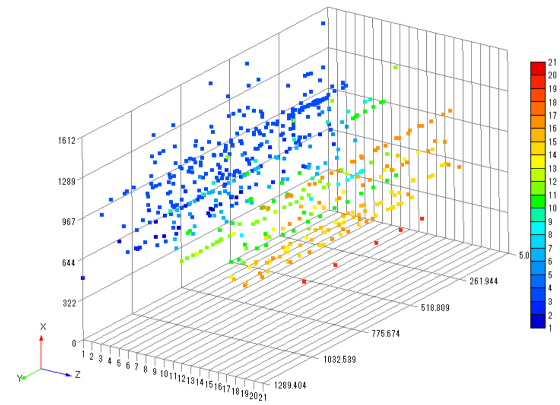


Figure 4 RTA form (Toyota city St.)

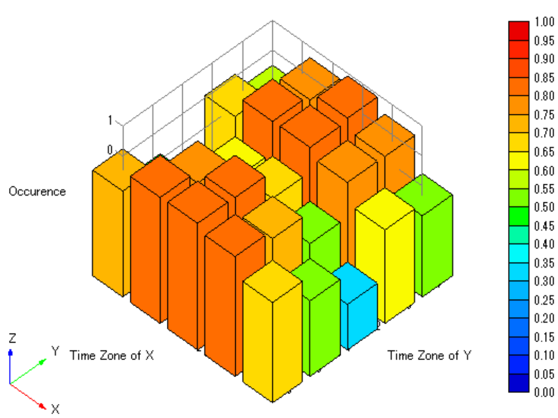
Table 1 Definition of time zones and purposes

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

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:

$$\mathbf{EV} = \mathbf{EV}(r, t, a) \tag{27}$$

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 LM 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



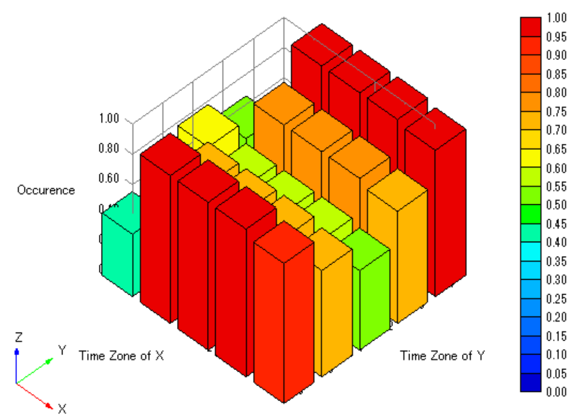


Figure 5 Correlation between Nagoya and Anjo. Figure 6 Correlation between Nagoya and Toyota.

make possible to predict the new production of PFLOW with potential EV related wills. Figure 2 shows the results of *RTA* form of PFLOW.

2.5. Experiments

Grouping of purposes into five 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.

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 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:

$$C_1 = COR\left(X_{PURP}^{A}, X_{EV}^{S}\right) = X_{PURP}^{A} {X_{EV}^{S}}^{T} \tag{28}$$

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

$$C_2 = COR\left(X_{PURP}^{A}, X_{PURP}^{B}\right) = X_{PURP}^{A} {X_{PURP}^{B}}^{T} \tag{29}$$

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

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;

$$AER_{ij} = \left|\tilde{x}_{ij} - x_{ij}\right| \tag{30}$$

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.

2.6. 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.

3. Extension to Feeling Flow

3.1. Feeling Flow

FFLOW includes so-called the notion of information flow, but that is not the new part. We consider the PFLWOW is activated not only by the information flow, but also by the “vague thinking of user” which is

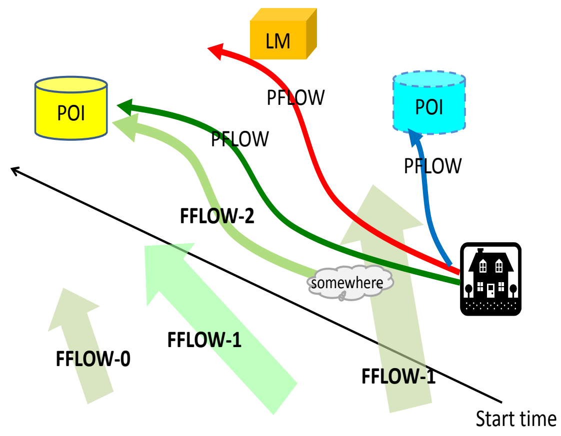


Figure 7 Three steps of FFLOWs.

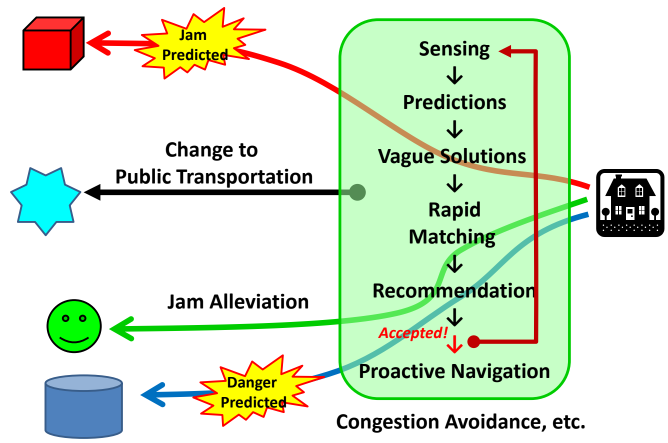


Figure 8 Prediction and recommendation.

usually called “image” or “feeling”. This will concretely begin the physical movement of the user in the real space. Moving means are not restricted to specified facility but which will include the new mobility and public transportation. FFLOW moves on the basis of the PFLOW, but these two FLOWs are not constrained to exit in the same spatio-temporal space.

Now we can define the PFLOW by using the formula (18) as follows:

$$PFLOW = f\left(\mathbf{P}(t_1), \mathbf{P}(t_2) \cdots, \mathbf{P}(t_N)\right) \tag{31}$$

where, $\mathbf{P}(t_n)$ expresses the attributes vector related to the human at the time of t_n (n=1,…,N). Some navigation function f(●) will generate the PFLOW, which is to be modeled by using some activation function G[●] which will acquire the environment potential EV.

$$GET\_EV(PFLOW) = G\left[f\left(\mathbf{P}(t_1), \mathbf{P}(t_2) \cdots, \mathbf{P}(t_N)\right)\right] \tag{32}$$

FFLOW is apparently expressed by the same formula as the PFLOW above. Namely,

$$FFLOW = f_F\left(\mathbf{F}(t_1), \mathbf{F}(t_2) \cdots, \mathbf{F}(t_N)\right) \tag{33}$$

FFLOW is structured by the following elements:

(a) Information regarding user’s moving demand
(b) Vague thought (feeling) of the user
(c) User’s emotion

These threes are expressed in confidence vectors and are to be stored in a common media (information bank, web, cloud, SNS, etc.) with position information. Therefore the FFLOW is described as follows:

$$\mathbf{F}(t_n) = \left(\mathbf{F}_{moving\_demand}(t_n), \mathbf{F}_{feeling}(t_n), \mathbf{F}_{emoton}(t_n)\right) \tag{34}$$

When POI is embodied, a user can begin the movement in real space. Moving means are not restricted. New mobility recently closed up and public transportations are also included. FFLOW usually moves with the physical body of PFLOW, but they do not necessarily exist in the same spatio-temporal space.

In FFLOW, temporal relations are ambiguous especially on the feeling component. Sometimes POIˆ in the virtual space which corresponds with the POI in the real space may be situated adversely along the time axis. Sometimes plural POIs in a virtual space may correspond to a single POI in a real space and vice versa. Also we can assume the same discussions regarding the categories of POI. PFLOW in a real world will encounter the POI as the result of the moving demands, but no restrictions are defined regarding the existence, numbers, places, categories, temporal relations on the user’s image. Then the POIs are situated in a virtual space and there exists no definite information for the configurations.

On the other hand, F_{moving_demand} corresponds with the FFLOW which is the nearest to the real flow just after the human decision. Then the feeling described above is the trigger image to make the real flows, which is the vague stage of the spatio-temporal designation such as “we would like to go somewhere like this image or feeling”. This time, we concentrate on this point. Namely,

$$\mathbf{F}(t_n) \cong \mathbf{F}_{feeling}(t_n) \tag{35}$$

On the other hand, the emotion is dominant when the negotiated results are changed on purpose.

On each time point, PFLOW and FFLOW corresponds with each other, PFLOW can be expressed as the time series of POI to include positional information. However, FFLOW has the POI in virtual world, so it does not always correspond to the time series.

3.2. When Feeling Flow Activates People Flow

A physical PFLOW is activated by the feeling flow based on human consciousness. On one hand, the FFLOW is affected by the PFLOW. For example, congestion and jam will introduce discomfort in FFLOW and soon, the FFLOW will change the PFLOW. Therefore, PFLOW and FFLOW will form the loop structure to change the PFLOW as the physical phenomena. On the other hand, FFLOW will not have space jam and congestion because the FFLOW itself does not physically exist. In turn, it easily be propagated from person to person and sometimes it generates the copy. The media is the sensing experiences generated by moving demands on the PFLOW including IoT devices and conversation, voice, weather, temperature, and other PFLOWs. Moreover, FFLOW will not be restricted by the physical restrictions and it sometimes will survive in a virtual spatio-temporal space.

We can consider the three steps approach to the activation of the PFLOW as shown by Figure 7.

Phase-0: when the problems definition of moving demands is ambiguous and the gap between FFLOW and PFLOW is large, the following "feeling" becomes dominant in the activation of the PFLOW. At this stage, vague images affects very much when seeing at the signage and advertisement.

Phase-1: the emotion intervenes with the feeling and more realistic images are effective in mind. At this stage, new sightseeing menu found in sightseeing 2.0 and pattern analysis and retrieval and the analogy of the past historical geographical events will be executable according to the machine information processing capabilities.

Phase-2: moving demand will become dominant more and more, accordingly, proceed to the stage just before the decision of PFLOW activation.

This time, although it is restricted to the moving demand, other decisions for moving requirements and the behavior occurrence will pass the stages like above. The common points are that the embodiment process of decision by using FFLOW by way of virtual world. Although these are the simulation of FFLOW and PFLOW by machine, when PFLOW is completed inside the machine, we can predict that it will provide the creation process by the artificial intelligence.

3.3. Feeling Flow Predicts People Flow

The conversion from virtual FFLOW to physical PFLOW is activated by the way of the matching operations above and navigation [2][3]. FFLOW timely matches to PFLOW on the basis of fluent moving means. FFLOW is appropriately modified by considering the cost, moving means, weather conditions, acquired information, schedules of accompanied persons, physical conditions which lead to the activation of the PFLOW on the spatio-temporarily deviated positions. Namely, it can be described as follows:

$$PFLOW(t,x) = FFLOW(t + \Delta U(t), x + \Delta V(x)) \tag{36}$$

When considering the arbitration of FFLOWs, we can suppose the spatial deviations are little and we have the assumption that $\Delta V(x)=0$. This enables the phenomena that PFLOW follows the FFLOW. It means that FFLOW is essentially the predicted results of PFLOW which will happen from now. On the other hand, when the POI related information of the moving target is very few, there is a high possibility that the vague solutions which the FFLOW of the vague users will introduce the large scale of spatial deviations from the corresponding real flow which is assumed. Therefore the computations to seek for the high accuracies at this stage will have the possibilities to be wasted in vain.

3.4. Control Of PFLOW

According to the scheme above, the output of decision will activate the physical PFLOW. Although the feedback from PFLOW to FFLOW exists, finally the above decision will control the PFLOW. In view of the natures of the PFLOW, the prediction backgrounds such as POI and LM related transition of time, trend will take too much time to form the big data. Therefore the quick and small computation system which uses the vague solutions will be desired.

3.5. Prediction And Arbitration Of FFLOW

If the machine can make decision as possible as the target user, we can assume the situation that LM^ is selected as the temporal vague solution. If the machine knows that the same LM^ is selected for the plural users through the use of some means (connected, etc.), the machine can predict the congestions at the target area as soon as possible. Machine verifies whether the moving demand exist or not at the considerable goals by using the least amounts of interactions. If the congestion is predicted as under the limit of acceptable level, the goal is selected as the final one without any discussion. If it is over the acceptable limit, it will recommend the LM (real world) which has second (or lower) order of EV values. Generally, we can define the comfort potential of moving demand on the basis of FFLOW as follows:

$$\dot{E} = COR\left(\dot{U}_D, \dot{U}_S\right) = \dot{U}_D \dot{U}_S{}^T = W\left(U_D, A_D\right) W\left(U_S, A_S\right)^T,\ W(U, A)_{ij} \equiv U_{ij} A_{ij} \quad (37)$$

where, U_D *[I×J]* means the user based comfort factor matrix which contains I user comfort feature vectors of *J* factor dimensions. Also, U_S *[K×J]* means the LM based comfort vector matrix which contains *K* LM feature vectors each of which has *J* factors. *W* means the special weighting function. Therefore *J* factors form the specialized confidence degree vector which we call MOVER considering the following attributes such as {time, cost, congestion, accessibility, hobby, culture, scenery, weather, smoking, restaurant, food, sports, taxi, shopping, walking, public transportations, user experience, repeater degree, the best ten priorities, the best three priorities, etc.}. A_D *[I×J]* and A_S *[K×J]* mean the weighting matrices which express the dynamic user models of current FFLOW, the static landmark models including the past user experience database, respectively. Then the machine can predict the FFLOW to generate the recommendations by some maximization processes of *E* which in turn can be directly decomposed to the two factor matrices U_D and U_S according to the NMF. These predictions can become highly accurate on the basis of the social collaborative filtering by trust [5] by using the connected car mechanism.

If the user accepts the recommended solutions, he can enjoy the LM which has no congestions and no jam comfortably before the departure. If the user hopes the other LMs at the sacrifice of time relocation tasks, the machine can recommend the new ones. Therefore the user can move to the recommended places by the confirmation behaviors without no stresses when the estimated results of FFLOW by the machine is very much close to the user's FFLOW, PFLOW will not arise the congestions. Then the PFLOW as the result will be reflected to the overall changes of FFLOW. If the congestions are predicted as the results of FFLOW estimation, the machine can divide the FLOWs to control the total PFLOW (Figure 8) by using the minimal numbers of stable-matching and recommendations of the vague solutions, no special problems will occur for the FFLOWs to activate the PFLOWs.

4. Conclusion

We have started the EV based moving demand prediction on the basis of the multi-purpose interpretation of the human attributes (MOVER) of the PFLOW and FFLOW with the LM models and user models. When comparing with the multivariate linear regression scheme, NMF can realize the prediction capability before the big data are accumulated. We are now trying to validate the recommendation scheme which focuses on sightseeing related moving demands and considerable comfort factors on vehicles. It is expected that the FFLOW prediction using the user experience database and the user generated contents will have the various kinds of possibilities especially in ITS related business models.

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