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An Instant Interest Oriented Recommendation Agent Based on SVDD and Schedule

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Abstract

In order to detect the instant interest in mobile commerce environments, an interactive recommender agent was proposed based on schedules and the algorithm of support vector data description. The agent residing in smart phones obtained the user's instant interest by comparing the current latitude, longitude and speed of the user's geographic positions with the preset schedule using support vector data description algorithm. If the current position was in the hypersphere or the tolerant hypersphere, the user were taken as be adherent to the schedule, otherwise, the user would be prompt to confirm whether he or she is adherent or deviated to the schedule. Based on the result of SVDD comparison, a process of determining the behavior states of the user was proposed. And some techniques of interaction between phones and the users were discussed based on vibrations, ringtones, and graphical interfaces. At last, an experiment was conducted to verify the proposed agent, and the result proved that the agent was effective.

Keywords: *SVDD, Schedule, Instant interest, Human-machine interaction, Deviated behavior*

1. Introduction

User interest model is critical to personalized information services such as network marketing and e-commerce recommendations [1]. It represents the user's personal preferences and is an important basis for personalized information services.

Currently, models of user's interests can be classified into two classes: (1) Static models on the structure of user's interests [2-3]; (2) Dynamic models on the formation and drift of user's interests [4-5]. But in mobile commerce environments, another kind of models—the instant models are needed, because that instant identification of user interests is important for us to instantly recommend products and services to users. Because many factors including habits, location, weather, work plans and other ambient factors impact the instant interests of the user [6], the identification of user interests is very complex. And what leads the identification more difficult is that the interests are completely personalized for a user, because that we can't learn one's interests on the empirical data of other users.

To solve the above problem, we would propose the interactive user interests agent model based on the Schedule and SVDD [7]. Where, the schedule will be used to assess user's state. SVDD will be applied to determine whether the user has deviated from the Schedule. And the human-computer interaction will be employed to solve the problem of the confirmation of instant personalized interests and the accumulation of empirical data. The proposed model is implemented through the built-in agent in mobile phones [8].

In the second part of this paper, we will describe the structure of users' instant interests and the main framework of the interest model. In the third part, the SVDD based classification

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algorithm will be described and used to distinct adherent behaviors from deviated behaviors to schedule. In the fourth part, we will have some discussions on the human-machine interaction and related techniques. In the last part, an experiment would be conducted to prove the proposed agent. And we will discuss the parameters of SVDD algorithm and the consumption of computation resources.

2. The Framework of the Proposed Model

The framework consists of two elements: the user's behavior states and the agent's reactions. The process is given as follows.

2.1. The process of the framework

The identification of a user's interests is implemented through an agent that resides on the user's phone. The agent first compares the user's behavior state and planned activities in the schedule, decides whether the actual behavior deviates from the plan, determines the interest of the current user, and provides the relevant information for the user's interest. The details are given in figure 1.

If the user is acting according to the schedule, the action status would be in normal, and the agent would provide the information that the user needs to perform related activities. And if the action deviates from the schedule, the action status would be in emergency, in normal or in leisure according to different reaction of the user, and then the agent would provide different information for different state.

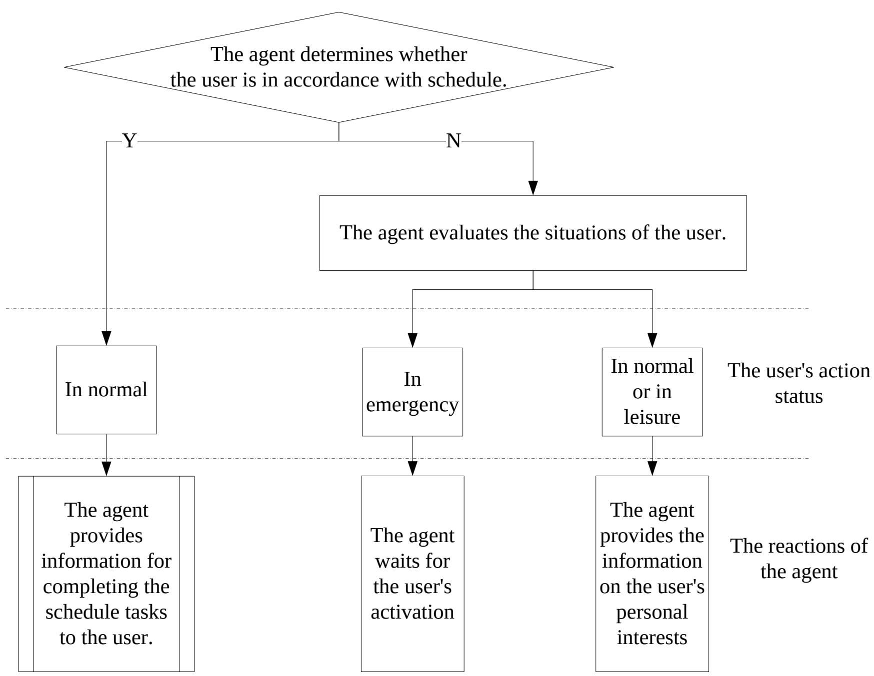


Figure 1. The Detailed Process of the Framework

2.2. The user's behavior states

The user would probably in three situations: in normal, in emergency and in leisure [9].

In the case of the user's situation in normal, the user has certain objectives, and he or she has plenty of time to obtain them. In this case, the muscle tension, blood pressure, glandular secretion, heart rate and respiratory are maintained at normal levels. And external stimuli can be communicated to the brain. In this case, things that are helpful for completing the current task will attract the attention of the user.

In this situation, muscle tension, blood pressure, glandular secretion, heart rate and respiratory system change dramatically. This state will make the regulation and control of the cerebral cortex weakened, thus subcortical nerve center ground alive. In this case, unless it is related to the current task that the user is currently focusing on, the behavior of the user will not go to comes to it. And external stimuli can be communicated to the brain at normal levels.

In leisure state, the user has no working objective in a short time, and thus has a lot of spare time. In this state, the muscle tension, the blood pressure, the glandular secretion and the heart rate of the user work at a lower level. In this case, anything related to the personal interests of the user will get into the range of demanding of the user.

2.3 The algorithm determining the behavior state of the user

The agent residing in the mobile phone needs to determine whether the current behavior of the user deviates from the schedule. It establishes a classifier based on Support Vector Data Description (SVDD). The classifier contains all the scheduled behaviors that can be recognized in a hypersphere, in order to distinguish them from the deviated behaviors. The input of the classifier involves time, address and speed. The output identifies that the behaviors are scheduled or deviated.

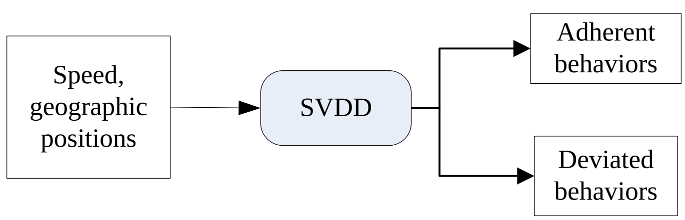


Figure 2. The Input and Output of the SVDD Algorithm

3. SVDD

Assume we have a dataset consisting of N "adherent behavior" multi-dimensional objects

$$\theta = \{x_1, x_2, \ldots, x_N\} \tag{1}$$

And a and R are respectively the central point and the radius of a hypersphere fitted on θ . To fit the hypersphere with the minimal volume, the optimal problem is given as

$$\min \quad L(R) = R^2 \tag{2}$$

$$s.t. \ R^2 - (x_i - a)(x_i - a)^T \geq 0 \tag{3}$$

where, $i \in \{1, 2, \ldots, N\}$. Based on equations (2) and (3), a Lagrange function is defined as follows

$$L(R,a,\Delta) = R^2 - \sum_{i=1}^{N} \alpha_i \left\{ R^2 - (x_i - a)(x_i - a)^T \right\} \tag{4}$$

where Lagrange multipliers $a_i \subset \Delta$,and $a_i > 0$. Solve the partial derivatives of equation (4) with respect to R ,and let it equal zero. Equation (5) is obtained

$$\sum_{i=1}^{N} \alpha_i = 1 \tag{5}$$

Combined with equation (5), the partial derivatives of equation (4) is solved with respect to a and equal zero, and then equation (6) could be obtained as

$$a = \sum_{i=1}^{N} \alpha_i x_i \tag{6}$$

substituting equations (5) and (6) into equation (4),the following optimization equation could be obtained

$$\max \quad L = \sum_{i=1}^{N} \alpha_i (x_i \cdot x_i) - \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j (x_i \cdot x_j) \tag{7}$$

$$s.t. \sum_{i=1}^{N} \alpha_i = 1, \quad \alpha_i \geq 0 \tag{8}$$

According to the Kuhn-Tucker Theorem, in equation (7), a large fraction of $\alpha_i = 0$ and a small fraction of $\alpha_i > 0$. The corresponding data objects with $\alpha_i > 0$, through which the boundary of the hypershpere passes, are called as support vectors (SV).

For the given Δ ,we can obtain the value of a by solving equation (6). Then the value of R corresponding to any support vector object x_s can be obtained by solving the following equation

$$R^2 = (x_s - a)(x_s - a)^T \tag{9}$$

The shape of the boundary given by the solution to optimization equation (7) is singly linear circular, which is not tight enough to eliminate the chance of accepting "deviated behavior" objects into the hypersphere. This problem can be solved by mapping the input data objects into a kernel based feature space H , using the kernel method (KM). Here we replace the inner product with a kernel function satisfying with Mercer conditions: $(x_i, x_j) \rightarrow K(x_i, x_j)$. Then the optimization equation (7) can be transformed into the following form

$$\max \quad L = \sum_{i=1}^{N} \alpha_i K(x_i \cdot x_i) - \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j K(x_i \cdot x_j) \tag{10}$$

the value of R corresponding to any support vector x_s could be given as

$$R = \sqrt{K(x_s, x_s) - 2K(x_s, a) + \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_i \alpha_j K(x_i, x_j)} \tag{11}$$

Specifically, Gaussian kernel function

$$k(x,y) = \exp\left(-\|x - y\|^2 / \sigma^2\right) \tag{12}$$

is chosen as the kernel function in equation (10). The value of σ could be fixed. Different values of σ have different boundaries of the hypersphere fitted on the same samples. The difference is shown in figure 4 and figure 8.

For the event dataset θ with N "adherent behavior" samples, its central point and its radius of the hyperspere in mapped feature space H are given in equations (6) and (11). The space between the $N+1^{st}$ sample and the central point a is given in the following equation

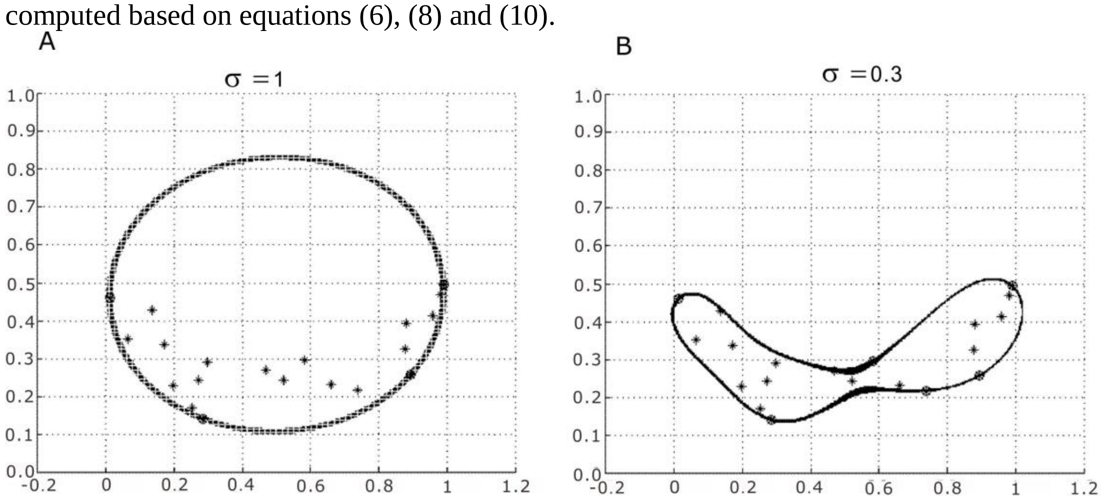
$$d\left(x_{N+1}, a\right)=\sqrt{K\left(x_{N+1}, x_{N+1}\right)-2K\left(x_{N+1}, a\right)+K\left(a, a\right)} \tag{13}$$

The following index is introduced

$$\lambda_{N+1}=\frac{d\left(x_{N+1}, a\right)}{R_s} \tag{14}$$

If x_{N+1}: the value of the data object, which represents the action status, is larger than 1, it would be taken as an object Z, which is "suspicious deviated behavior," $Z \subset (0,1,....)$ [12].

If λ_{N+1}<1, the data object Z would be a routine action status, which means we do not need to solve the optimization equation. Otherwise, the "suspicious deviated behavior" object Z would be decided through human-machine interaction, whether or not it is an adherent behavior object. If it was an "adherent behavior," both values of a and R would need to be re-computed based on equations (6), (8) and (10).



(a)The boundary of a hypersphere with $\boldsymbol{\sigma} = \mathbf{1}$ (b) The boundary of a hypersphere with $\sigma = 0.3$

Figure 3. The Boundary of a Hypersphere with Different σ

4. Interactions between the User and the Agent

Human-computer interaction is the technology of studying human, computer and the interaction between them. The technique is the passage of exchanging information between people and computers, is an important part of human-computer interaction systems.

4.1. The user state determination

Figure 4 shows (1) If the user does not have a schedule for this period of time, the user would be in a leisure state (in leisure); (2) If the user does not respond to the pop-up window while he deviates from the schedule, the user would be in a state of high tension (in emergency); (3) otherwise, the user would be in a general state of tension (in normal).

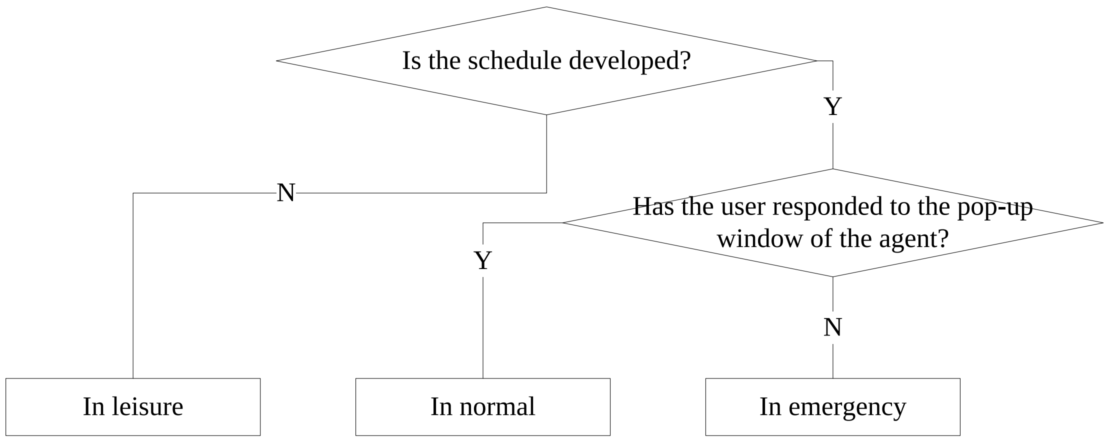


Figure 4. The User State Determination

4.2. Interactions

The agent in the mobile phone of the user communicates with the user through three ways: vibration, ring tones and graphics interface.

4.2.1. Vibration: While the phone is in contact with the user body or in a quiet environment, the phone vibration is one of the main ways for user to interact with the phone. In this research, we use the way of vibration as the default way of reminding the user.

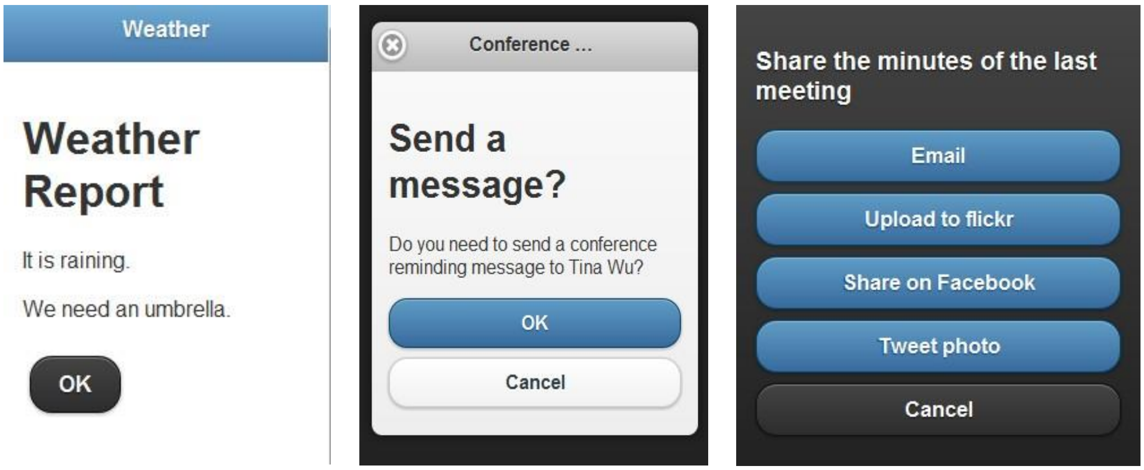
4.2.2. Ringtone: With the widespread popularity of mobile phones, all kinds of ringtones are endless, from the original single ringtone to chords and effects ringtones. And the quality of ringtones has improved much. But the proliferation of various tones pollutes the environment. Most users complain of the proliferation of ringtones. Therefore, we need to use different ringtone enabling policies on different occasions. Zhu distributed a questionnaire in a regional public place [11]. The contents of the questionnaire consist of personal information, phone using habits and ringtones preferences. Annoyance degrees of different people in different environment are shown in table 1.

In Table 1, degree of annoyance or preference of 2 represents that people is very annoyed about the ringtone. The degree of -2 represents the user likes the ringtone of mobile phone. Based on the above investigation, agents employ the ringtone to notify the users when the users are in shopping, in queuing, in driving and at home in leisure state. During the other time, phone vibration and graphical interfaces are used to notify the users.

Table 1. The Number of the Users with Annoyance and Preference to Ringtones in Different Environments

Degree of annoyance or preference	2	1	0	-1	-2
In shopping	6	9	112	2	1
In meeting	70	46	13	1	0
In working	22	48	57	3	0
In resting	57	41	30	1	1
In queuing	7	15	98	10	0
In driving	6	23	90	11	0
At home	3	20	88	13	6

4.2.3. Graphical Interface: As a communication tool between the agent and the user, graphic interface should be simple and convenient, optimizing operating steps to reduce the burden of user memory and to improve efficiency of the user. The user interface employs as far as possible the natural habits and ways of person operating the real-world objects. The commonly used operations, such as, pushing, pulling, rolling, twisting, pressing and toggling are used to reduce the costs of learning and using of the users. Figure 5 shows the commonly styles of the graphic user interfaces between the user and the agent.



(a) Weather reminding (b) Conference reminding (C) Share operating

Figure 5. The Commonly Used Styles of Graphic User Interfaces

5. An Experiment and Discussions

In this part, we will conduct an experiment and have some discussions on its setup parameters.

5.1 Experimental setup

In this experiment, the works of 20 days of one of the author from the morning to noon were used as examples. The agent the SVDD algorithm was employed to detect whether the user was deviated from the work plans. The activities in the work plans include the walk to the parking lot, car driving, parking in the school, having classes, finishing class and going to the parking lot, driving home and walking home.

5.2 Implementation of SVDD algorithm

The whole SVDD computation process involves three phases:

1) The setup phase

The first phase consists of the following steps and it is computed in the server:

(a) Choose early warning indicators and obtain the initial “adherent” behavior objects;

(b) Set the value of σ in equation (2).

2) Parameters computation phase

In the second phase, the algorithm of SVDD is employed to fit a hypersphere enclosing all "scheduled" data and the data outside the hypersphere is taken as "suspicious". The detailed process steps are:

(e)Compute $K(x_i, x_i)$ and $K(x_i, x_j)$ using equation (12);

(d)Compute α_i in Δ based on the optimization equation (10) and the constraints and compute the value of the center point of the hypersphere a ;

3) Detecting phase

(e)Compute the value of R_s for any x_s chosen from support vector objects using equation (11);

(f) Compute the value of λ based on equation (14);

(g)Decide whether the detected data object is "suspicious" by value of λ . If the value is larger than 1, it would be "suspicious", otherwise it would be "adherent"

4) Human-machine interaction phase

(h) In the fourth phase, the "suspicious" Z is decided by the person holding the mobile phone through interface shown in figure 5.

(i) If the "suspicious" data object is taken as "adherent", then it would go to phase 2),and the behavior states would be "in normal"; Otherwise, the action status would be "in emergency".

5.3 Accuracy of detecting behavior deviation

The seven activities: the walk to the parking lot, car driving, parking in the school, having classes, finishing class and going to the parking lot, driving home and walking home were detected. The input factors are longitude, latitude and time. The detecting accuracy is given in Table 2.

According to Table 2, the total detecting accuracy is 91.43%. The percentage of detecting error rate is lower than 10%, which is better than the expected goal.

5.4. Resources consumption of the interest agent on mobile phones

The instant interest agent is implemented and tested on Sumsung gt-i9228, which is based on Android 2.3.6. The agent process runs as a background service without impeding other tasks. Considering energy and memory efficiency is critical for mobile devices, besides the function testing of the usability and the reliability of this interest agent, we care more about its efficiency. Because the agent is implemented on CPU and memory-limited mobile platform, we tested the CPU usage, VSS (Virtual Set Size) usage and RSS (Resident Set Size) usage of the agent for specific operations including user register, login, schedule input, window pop-up, chords reminding , adherence confirmation, deviation confirmation, schedule delete and schedule modification, as illustrated in figure 6.

The most CPU, RSS and VSS consuming activity is the confirmation to the adherent behaviors. It's because that when the interest agent detected the deviation, it would prompt the user to confirm whether the activity is deviated. If the user confirms it is an adherence, then the agent would recompute the support vectors and the hypersphere that containing all the adherence activities.

Table 2. The Accuracy of Detecting

Activities	detecting time	Times of deviation from the schedule	Times of adherence to the schedule	Times of correctly detected	Accuracy (%)
walking to the parking lot	20	5	15	19	95.00%
car driving	20	6	14	18	90.00%
parking in the school	20	5	15	19	95.00%
having classes	20	1	19	20	100.00%
finishing classes and going to the parking lot	20	5	15	17	85.00%
driving home	20	3	17	19	95.00%
walking home	20	4	16	16	80.00%

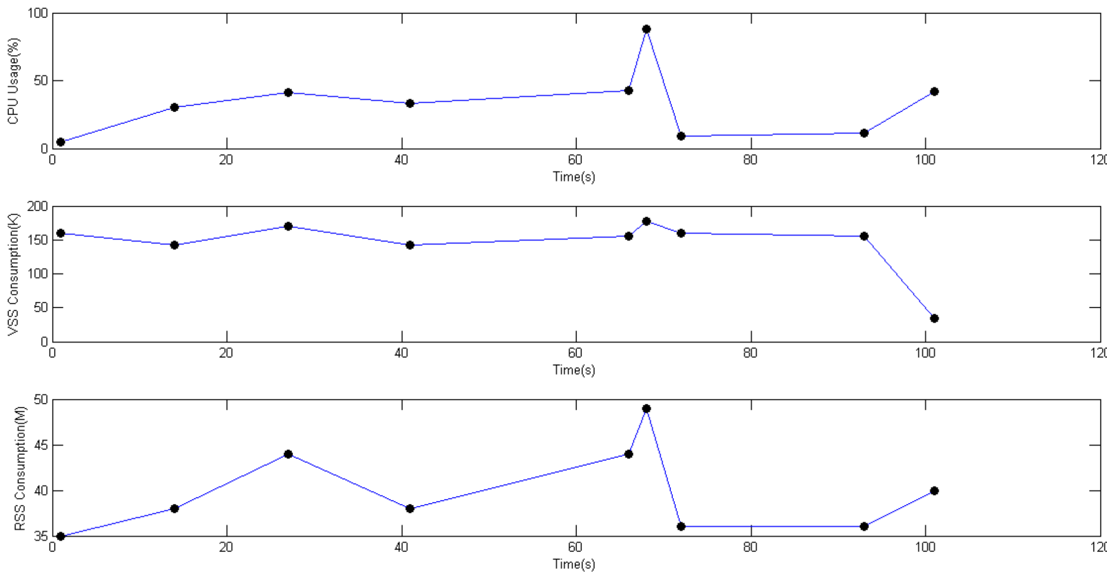


Figure 6. Cost Analysis of the Instant Interest Agent

5.5 Parameters setup

Three parameters are important for agent to effectively run. The three parameters are: (1) σ in Gaussian kernel function. It determines the complexity of the different hypersphere boundaries in the Figure 7 (a), (b), (c) and (d). In this experiment, we set $\sigma = 0.8$; (2) we set a degree of deviation tolerance for the SVDD deviation detecting, that is, when the behavior is beyond the hypersphere and within the boundary of deviation tolerance, we take that it is still an adherent behavior, reducing the number of re-computation of SVDD detecting, reducing resources consumption, and optimizing the speeds of agent responses; (3) detection interval time. Each detection operations are required to load and compute. If the detected interval is too short, the agent would work overloaded. If the detection interval is excessively long, the agent would not work efficiently. In this experiment, we set the detection interval to 3 minutes.

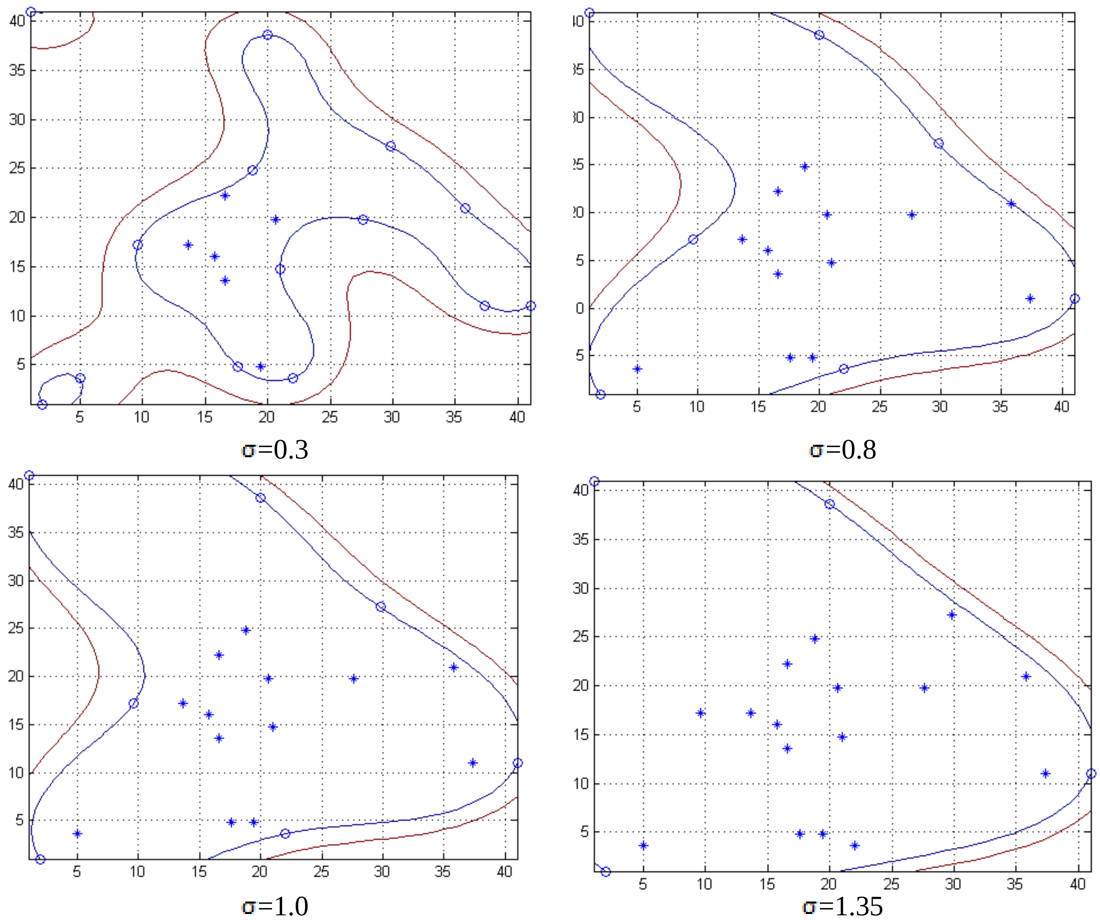


Figure 7 Different Support Boundaries and Tolerance Boundaries with Different Values of σ

6. Conclusions and Future Works

With the detection of instant interest getting widespread attentions of researchers and smart phones becoming popular, instant interest agent on mobile phones are becoming the interest focus of e-commerce researchers. In this research, SVDD algorithm was employed to compare the scheduled geographic positions and the current latitude and longitude of the user, and based on the results of comparison, the algorithm of user status was proposed to identify the user's instant interests the user status speculated process, and detect the user's immediate interest. The 90% detection accuracy in the conducted experiment proved the effectiveness of the proposed model.

In the future research, we will proceed to combine the geographic location with user interest to determine user's different interest in changing occasions and locations.

Acknowledgements

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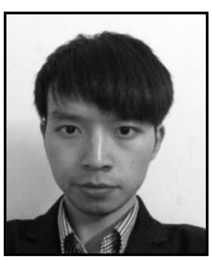

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