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5th Hyphotesis Consideration of UTAUT for IOT By Exploiting ACO based Classification

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Abstract – Internet of things (IoT) application needs to be evaluated to gain better improvement and innovation. The evaluation can be examined from user acceptance. The unified theory of acceptance and use of technology (UTAUT) can be used as a model to identify user acceptance in using technology, including IoT application. However, the ease of use of technology must be included, determining of easy of use from negative aspects must be included, so the 5th hypothesis of UTAUT (hindering condition) must be included. Before this hypothesis is formulated and included in evaluation by the user, obtaining data to identify the real condition of the user is performed using forensic analysis and ACO based classification. To evaluate this activity, this 5th hypothesis is measured by reliability and validity test, also hypothesis testing itself.

Keywords – hindering condition, internet of things, user acceptance testing, IoT evaluation.

1. INTRODUCTION

Similar with software engineering, internet of things (IoT) must be assessed properly to gain user satisfaction. But, in reality, it still less amount of research in user satistfaction assessment. This is important because user satisfaction correlated to enjoyment in using the IoT [1]. User satisfaction may impact to loyalty of the product. From perspective of technology and it's using, loyalti of product form customer may be indetified from easy of use that technology. It is not only seen from innovation of technology but also how the technology can be reflected from user when they use that technology.

How easy is one of the main questions when we want to identify user satisfaction, so we need user acceptance as our factor. Without user acceptance, technology innovation may face an obstacle to develop more advance [8]. User acceptance can be identified and measured using unified theory of acceptance and use of technology (UTAUT) model by Venkatesh et.al [11]. However, the state of the art of UTAUT has no hindering aspect to be identified, UTAUT aspect only consist of: (a) performance expectancy; (b) effort expectancy; (c) Social influence; and (d) facilitating condition. Although effort expectancy can be viewed as a factor that is correlated with easy use of a user at using the technology, but it is only focused on context of personal technologies and non-work place settings, not on negative aspects of technology that lead techno-stress on user [1]. Techno-stress may decrease user satisfaction [9] and can be categorized as work overload that leads to be a main stress from the use of innovative technology [10].

Hindering condition is the 5th hyphoteses of UTAUT as addition hyphoteses that proposed by Lee and Shin [1]. It aims to gain the understanding of user difficulty in using the technology. This kind of study is very advantage to evaluate the usage intention of IoT application [3], especially for our IoT application in our department. Implementation of hindering condition as the 5th hyphoteses can be useful for us to make improvement and innovation for our IoT application. But, before we decide to use this aspect, we would to measure the needment of this hyphotesis so this hyphotesis can be really included and useful to know more about our user satisfaction. In this paper, we first use forensic analysis to gain detailed condition about connection between user devices and sensor, it is really needed because a not-detected condition that is happened by user can make a stressfull in using the IoT application. So, we want to know if a not-detected condition has happened in majority of our user, if this condition really happens then we have to perform more scientifically approach to know detail of how many detected/not-detected condition happens in user, in this occasion we use ACO based classification that proposed by Jing Tian et.al [4]. What really user feels are our object to know the real condition in using our IoT application, so we perform third stage: formulating hyphotesis and its evaluation.

2. RESEARCH METHOD

This activity exploits Bluetooth low energy (BLE) as sensor and several devices with different brand and model supported BLE as experiment activity tools. Figure 1 shows our steps in this activity; before defining the 5th hypothesis, some stages are conducted to know more explicit about condition in IoT especially interaction between device and sensor that related to user satisfaction.

Figure 1. Consideration stages and hyphotesis evaluation

Our approach to determine user satisfaction is based on interaction between device and sensor because 5th hyphotesis of UTAUT is related with hindering condition that happens in user. Our activity consists of three stages: (a) forensic analysis; (b) classification data; (c) defining hyphotesis. Forensic analysis describes about data acquisition and examining of interaction between device and sensor, this section may result how hindering may happened to user.

2.1. Forensic Analysis

Data acquisition is performed by identification of no point reward added in user account. This condition is assumed as hindering condition which user does not get his/her point after trying to pair their device with sensor from log in server. This acquisition has limitation in logical acquisition and certain artifatcs of data. This acquisition can only obtain the equivalent of a logical acquisition of device and not all artifacts that created by Android operating system because some artifacts are resided in another areas of device.

Because our user object is younger generation so we have to perform preprocessing data, we have to exclude user who categorizes as baby bloomer generation. Our filter is just based on age value that has ben inputed in registration stage.

The finding of preliminary data is performed after the system is operated publicly. Several artifacts that are obtained can be useful to be investigated as hindering condition although only missing data record and data record about when and where the device being used are examined. It is possible to determine when connection between device and sensor is active.

Our approach follows Sablatura and Karabiyik [2] to perform forensic analysis in this stage. Examining data consists of several dump activities, in this paper we present the four result from different phone device with two dumps (dump 1 and dump 4) as sample, dump 1 focused on device and sensor connection and dump 4 is effect after recalibrating (as repairement in connection between device and connection). Any activity from device and sensor will be recorded to determine whether hindering condition will be formulated as hyphotesis or not. Comparison of those dumps will show realtion of use between device and sensor. By the result, it reflects how user may get a hindering condition while use this technology. This reflection can be used for a reason in need to use the 5th hyphotesis of UTAUT.

2.2. ACO based Classification

Unlike traditional ACO, ACO based classification exploits ant agent to collect a source of food then make group in that source area [4] using certain feature. Detection data from several devices that conducted in section 2.1 has role as food that be collected by ants. The kind food that collected by an ant is detection condition from interaction between sensor and device so every detected or not detected condition will be logged in server then collected by an ant. Ant movement is steered by detection condition in every device. This operation performs in two fields, the first field is classification in each sensor record, the second one is all data record.

For each nth iteration, an ant agent that is randomly selected moves from one node (represent device label(l) and detection condition (m)) to its neighbouring node (next device label(i) and detection condition (j)) for L steps. This movement follows:

$$p_{(l,m),(i,j)}^{(n)} = \frac{(\tau_{i,j}^{(n-1)})^{\alpha}(\varphi_{i,j})^{\beta}}{\sum_{i,j\in\Omega_{(l,m)}}(\tau_{i,j}^{(n-1)})^{\alpha}(\varphi_{i,j})^{\beta}} \qquad (1)$$

$\tau_{i,j}^{(n-1)}$ is value of pheromone that spreaded in every node, $\Omega_{(l,m)}$ is the neighborhood nodes of the node (l,m), α and β are defined as influence of pheromone matrix and heuristic matrix. The pheromone update consists of two kind: (a) the first one is update after each ant movement that is according to

$$\tau_{i,j}^{(n-1)} = \begin{cases} (1-p).\tau_{i,j}^{(n-1)} + p.\Delta_{i,j}^{(k)} \\ \tau_{i,j}^{(n-1)} \end{cases} \qquad (2)$$

The first criteria is a condition when *k*th ant visits *(i,j)*, $\Delta_{i,j}^{(k)}$ is determined by the heuristic matrix; and (b) second kind of update is performed after all ants make a movements

$$\tau^{(n)} = (1-\psi).\tau^{(n-1)} + \psi.\tau^{(0)} \qquad (3)$$

ψ is pheromone decay coefficient.

Classification is performed by considering normalized pheromone matrix using K-means with K = 2.

2.3. 5th Hypothesis Formulation

This section describes about a new variable of the hindering condition formulation in UTAUT. Hindering condition is one of the examples in negative aspects of technology which leads to anxiety or techno-stress for consumer. As we know that hindering condition is the 5th hypothesis and it is a negative effect of behavioral intention. According to Fishbein's theory [7], behavioral intentions are correlated significantly with potential behavior. Hindering condition is registered as the 5th hyphotesis after some trial in dump activities is performed and has shown some uncertain phenomenas in connection between device and sensor. Item hyphotesis statement is based on using activity, an unsuccessfull user when using this technology.

3. RESULTS AND DISCUSSION

In this activity, the user of this product is younger generations (y-generation, z-generation, and millenials) who study in Information Technology Department Politeknik Negeri Malang. Younger generation is more to adapt in technology than older generation (baby bloomers). Our IoT object is an electronic canteen payment which is implemented in our department. To attract user to fill the questionnaire, we use a generated online page using Bluetooth low energy that appear in their mobile app. It runs after they make a payment. User who fills the questionnaire completely will get a reward (5 points), that reward can be collected and exchanged to buy snacks in that canteen.

From forensic anlysis activity, we got several conditions that are logged in server. By sample, we show four dumps activity result (Table 1)

Table 1. Activities on Each Dump of The System

Data Dump Name	Activity	Notes
Dump 1	**Start:** 2 January 2020 10:15 a.m. **Location:** Basket 1 **Activity**: scanning device **Device**: Device 1: Xiaomi Mi Note 3 Device 2: Vivo Y93 Device 3: Redmi 6A Device 4: iPhone 5s **Frequency of trial**: 10 times	Device 1 and 4 are always detected Device 2 has six times detected successfully Device 3 just one time detected
	Start: 2 January 2020 01:25 p.m. **Location:** Basket 2 **Activity**: scanning device **Device**: Device 1: Xiaomi Mi Note 3 Device 2: Vivo Y93 Device 3: Redmi 6A Device 4: iPhone 5s **Frequency of trial**: 10 times	Device 1 and 4 are always detected Device 2 has four times detected successfully Device 3 just one time detected
	Start: 2 January 2020 04:15 p.m. **Location:** Basket 3 **Activity**: scanning device **Device**: Device 1: Xiaomi Mi Note 3 Device 2: Vivo Y93 Device 3: Redmi 6A Device 4: iPhone 5s **Frequency of trial**: 10 times	Device 1 has eight times detected successfully Device 2 has six times detected successfully Device 3 just one time detected Device 4 is always detected
Dump 4	**Start: 9** January 2020 9:15 a.m. **Location:** Basket 1 **Activity**: recalibrating sensor and scanning device **Device**: Device 1: Xiaomi Mi Note 3 Device 2: Vivo Y93	Sensor calibration is successed. Device 1 has eight times detected successfully Device 2 has nine times detected successfully Device 3 has five times detected Device 4 is always detected

	Device 3: Redmi 6A Device 4: iPhone 5s **Frequency of trial**: 10 times	
	Start: 9 January 2020 11:15 a.m. **Location:** Basket 2 **Activity**: recalibrating sensor and scanning device **Device**: Device 1: Xiaomi Mi Note 3 Device 2: Vivo Y93 Device 3: Redmi 6A Device 4: iPhone 5s **Frequency of trial**: 10 times	Sensor calibration is successed. Device 1 and 4 is always detected Device 2 has seven times detected successfully Device 3 has five times detected
	Start: 9 January 2020 02:15 p.m. **Location:** Basket 3 **Activity**: recalibrating sensor and scanning device **Device**: Device 1: Xiaomi Mi Note 3 Device 2: Vivo Y93 Device 3: Redmi 6A Device 4: iPhone 5s **Frequency of trial**: 10 times	Sensor calibration is successed. Device 1 and 4 is always detected Device 2 has nine times detected successfully Device 3 has seven times detected

In ACO based classification, we use $\tau_0 = 0.0001, \alpha = 1, \beta = 2, \psi = 0.3$. This kind classification forms unequal (spherical clusters of different volumes). That result may follow the concept of ACO based classification that separates different foods in different criteria (Figure 2), this condition shows that this approach identifies two clusters correctly. Same as Breaban and Luchian [5], we use Adjusted Rand Index (ARI) to make sure our approach works well and we get 1 for the result value., it means our index (food value or detected/not-detected condition) is similar with the expected index (standar for detected/not-detected condition). Based on this result, the 5th hyphotesis of UTAUT is included to our assessment.

Figure 2. Classification result where left side is detected condition and right side is not-detected condition

The questions and structures for 5th hyphotesis derived from Lee et al. [6] based on reverse engineering technique that we used in this activity. Items were reflected from characteristics of IOT.

Table 2. Survey Items of Hindering Condition

Item	Questions
HC1	The information of guidance in this technology confuse me
HC2	The more trying to use this technology, it seems harder to try
HC3	Technology Menu is confusing

In this activity, measurement of reliability uses Cronbach's Alpha test and the validity uses exploratory factor analysis (EFA) with five factors have 72,33% of total variance were extracted, based on table 3, the EFA results shows that this model is quite fit to the data by compare with another factors. Tabel 2 shows result of Cronbach Alpha test for 5th hyphotesis in this activity, it seems users have satisfied with the technology and to be confused with the use of technology (no hinder condition).

$$Cronbach's\ Alpha = \frac{n^2 * mean(COV)}{\sum(VAR/COV)} \quad (4)$$

Where n is number of items, VAR is variance, and COV is covariance.

Table 3. Cronbach Alpha for Hindering Condition

Alpha score	Mean	Number of items
.735	2.758	3

Table 3. EFA Result for Hindering Condition

Item	PE	EE	SI	FC	HC
HC1	-.003	-.215	-.097	-.003	.766
HC2	-.070	-.108	-.123	-.054	.785
HC3	.035	-.155	-.014	-.100	.821

Hyphotesis were analyzed by using SEM and major fit statictics. Major fit result shows that data is acceptable. As Table 4, hindering condition has negative value, it indicates that no difficulties in using of this technology.

Table 4. Hyphotesis Test Result for Hindering Condition (*p < 0.05)

Estimate	S.E	C.R.	p-value
-0.224	0.116	-1.652	.006*

4. CONCLUSION

Several dumps of activities show different condition of each devices when contact to sensor, detected condition has more appear than not-detected condition. ACO based classification with K-Means justifies this condition by showing the clusterization result and ARI value. When the 5th hyphotesis is tested, it shows that user has no difficulties in using of this technology. Comparing to Lee and Shin [1], our result is no different with them in conclusion, user does not have difficulties in using this IoT technology while Lee and Shin have greater impact value than ours. However, our activity is still limited only on detected/not-detected condition, but it does not cover more detail condition like detected with transaction, detected with no transaction, not detected, etc. So, our future work will use that kind of conditions. We will also improve our classification approach with more adaptive in data retrieving as consequence in using more detailed condition.

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