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PROBABILISTIC INTENTION CLASSIFICATION FOR HUMAN AUGMENTED COGNITION SYSTEM

Byunghun Hwang, Young-Min Jang and Minho Lee

Kyungpook National University, Daegu, South Korea, elecun@ee.knu.ac.kr, ymjang@ee.knu.ac.kr mholee@knu.ac.kr

Abstract: In this paper, we present a probabilistic human implicit intention classification using user's eye gaze data for human augmented cognition system. The Ultimate purpose of this method is to implement a human augmented cognition system which can provide a specific service to address the cognitive limitations of human brain. In order to partially overcome the cognitive limitations, the system should be able to control the flow of information. Therefore, a specific intention classification using a Naïve Bayes classifier can be used as useful tool for searching and retrieving specific information according to the human intention and situation.

Keywords: human intention, Naïve Bayes, human augmented cognition, system architecture

1. INTRODUCTION

Human augmented cognition can be regarded as enhancing and expanding human's cognitive capability. Many researches in psychology realm revealed the cognitive limitations and several marvelous phenomena of the mental system so that there is a basic notion that most of the cognitive psychologist agree with. The notion is the assumption of a limited capacity of the mental system. It means that the amount of information which can be processed by the mental system is constrained. George A. Miller introduced 'magic number seven' in 1956 [1]. In that paper, he proposed that the span of memory of young people was around seven chunks, regardless of the units. Other researcher, Nelson Cowan, has proposed that working memory has a capacity of about four chunks in a young person [2]. Based on those researches, we can infer that the performance of human cognitive process is strongly related to the limited capacity of working memory.

In order to alleviate the above limitations of the human brain by technical supports to expand the limited capacities, we consider the following two issues; First, memory capacity issue, which is a well-known psychological basis. In general, human has poor short term memory which can hold a small amount of information in mind, readily available states for a short period of time. This issue can be solved by using an electronic memory and/or recognition techniques. Second, remembering and retrieving the memories, basically we can realize that some of experiences which are not significant, interesting and not retrieved frequently may be removed or not being stored instinctively. Hence, our assistant system should try to store all recognized results regardless of user's intention to memory. However, retrieving issue is different from the memorizing because there is no way to know the correct human intention. It means that when our assistant system retrieves appropriate information from general or personal database, the system should be able to recognize the user intention. By doing so, the system can provide appropriate information to the user according to a situation. This paper focuses on the user intention recognition using eye gaze data to provide appropriate information.

This paper is organized as follows. Section 2 presents the human augmented cognition system. Section 3 presents human intention recognition for cognitive service. Section 4 describes the experimental result. Finally, Section 5 summarizes and discusses the studies and future research direction.

2. HUMAN AUGMENTED COGNITION SYSTEM

We have developed a glass-type human augmented system to assist in expanding the cognitive capability [3]. Glass-type platform has several merits, which is convenient rather than conventional handheld devices. In addition, communication-al distance is very close so that interaction between human and device is very rapid.

This system has a variety of functionalities such as face detection using bottom-up saliency map, incremental face recognition using a novel incremental two dimensional two directional principle component analysis ($(I(2D)^2PCA)$) [4], gaze point detection, speech recognition using Google API and information retrieval based on ontology, etc. By using these techniques, it can provide translation functions from the visual information to auditory information, or vice versa.

In order to select a single object which is salient among the surrounding objects, one of the cameras is mounted on the front side to capture the image of outward visual surroundings and the other is attached to the right side of the glasses for user's eye movement detection. A head mounted display(HMD) device is used for displaying the visual information about the recognized object.

3. HUMAN INTENTION RECOGNITION

In cognitive psychology, an intention refers to an idea or plan of what we are going to do. According to the theory of mind [5], human beings have a natural way to predict, represent and interpret user intention reflected implicitly or explicitly by the others. It is necessary to understand the human's intention for augmented cognition, particularly modulating information flow as well as human computer interaction. Intention recognition is a relatively new field that is being widely used in the web applications [6].

Some researches classify the user intention in web search as 1) informational, 2) navigational, and 3) transactional. In this paper, we redefine and present a comprehensive classification of human intention as [7]:

Navigational intent : refers to the human's idea to find some interesting objects in a visual input without a particular motivation.

Informational intent : refers to the human's aspiration to find a particular object of interest or to behave something with motivation.

For intention recognition we usually use several features related with intention such as fixation length and count, pupil size variation, etc [8]. Figure 1 shows the heat maps representing the fixation length of the eyeballs for the given visual scene. Right figure is the heat map of the navigational intent results and left one is informational intent results.

Figure 1. The heat maps of the human's eyeball movement analysis for visual stimuli. Navigational intent(top), Informational intent(bottom)

To retrieve information efficiently, user intention recognition should capture the starting and finishing points to provide appropriate intention information to the user. Our augmented cognition system can recognize user intention through eyeball movement pattern and pupil size variation. Human eyeball movements are not random and are known to be tightly related with human cognitive processes [9]. Therefore, the human's gaze contains richer and more complex information regarding a person's interest and intention.

Retrieving information can search useful information and provide appropriate information to the user. One of the most important points is that the information should not give rise to the distribution or distraction of user's attention when the system retrieves some information. It means that the information should be better fitted to the user's intention. Hence, the system for augmenting the cognition has to recognize the user's intention prior to retrieving the appropriate information.

In this paper, we used a probabilistic approach to recognize one of the predefined specific user intentions. By using the Naïve Bayes classifier [10], we try to recognize the user intention in a specific situation. The Naïve Bayes classifier is based on conditional probabilities. It uses Bayes's theorem with strong independence assumption, a formula that calculates a probability by counting the frequency of value and combination of values in the historical data. Equation (1) is described the Naïve Bayes classifier that we used.

$$\begin{aligned} & classify(o_1,\ldots,o_n) \\ & = \arg\max_{c} P(C=c)\prod_{i=1}^{n} P(O_i=o_i \mid C=c) \end{aligned} \quad (1)$$

Where $\{O_1,\ldots,O_n\}$ is n number of recognized results in the historical data and C is a predefined user intention. We want to select one of human intention which has maximum probability values among all of possible probabilities in the specific user intention.

4. EXPERIMENTAL RESULTS

In this paper, we use Naïve Bayes classifier to recognize user's specific intention. We obtain training data set from 6 subjects' eye-gaze data. The training data set consists of 4 classes which are 'eat noodle', 'drink coffee', 'drink beer' and 'eat bread' and the experimental image includes 12 objects. The included objects are noodle, coffee, knife, pot, gas range, beer, electric pot, water, goblet, bread, mug and wine. Figure 2 shows the images used in this experiment.

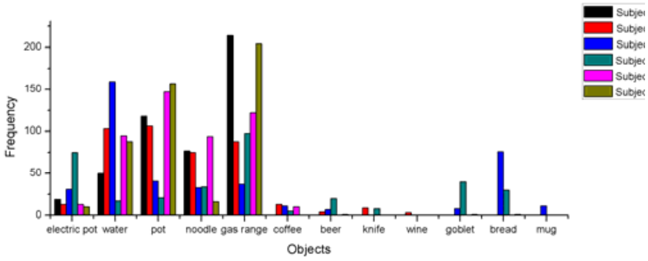
Due to the gaze point calibrator resolution, the objects location and distance are considered enough. We instruct each participant to look at the objects corresponding to given desired intention class. Then we measure the participant's eye-gaze data. Figure 3 describes the histogram of the seen objects corresponding to each class. As shown in Figure 3, we can realize that objects corresponding to given each specific informational intention are different. Thus, we can easily classify the user's intention by using a probabilistic method. The results of each intention classification performance are shown in Table I.

TABLE I. CLASSIFICATION PERFORMANCE

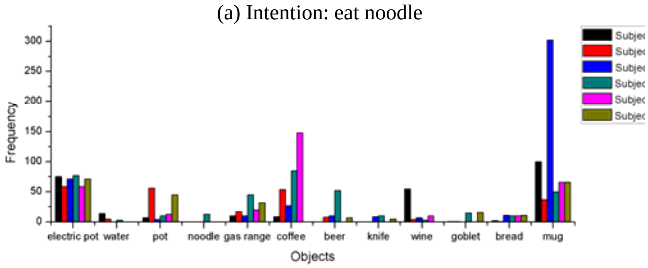
	Specific informational intention			
	Eat noodle	Drink coffee	Drink beer	Eat bread
Subject 1	100%	82.03%	83.53%	85.86%
Subject 2	97.33%	67.10%	80.65%	52.08%
Subject 3	84.14%	89.54%	13.66%	98.54%
Subject 4	100%	29.70%	66.89%	100%
Subject 5	100%	78.48%	61.07%	97.65%
Subject 6	100%	52.58%	75.71%	56.79%

Some of results have very low classification performance. It means that the subject's mind is scattering during the experiment so that the effect affected the results. Thus, the subject could not focus on the experiment at that time. Therefore, the low performance results are meaningful.

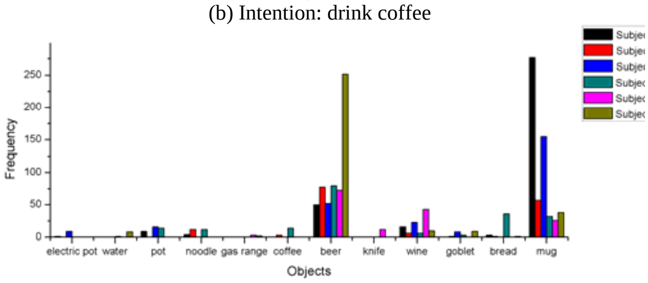
Figure 2. Experimental image



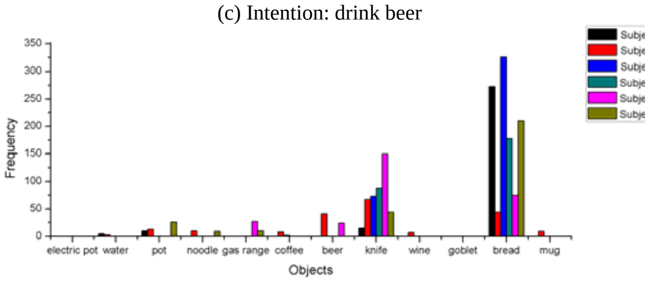
(a) Intention: eat noodle



(b) Intention: drink coffee



(c) Intention: drink beer



(d) Intention: eat bread

Figure 3. Hstogram of the seen object corresponding each intention class. (a) eat noodle, (b) drink coffee, (c) drink beer, (d) eat bread

5. CONCLUSION AND FURTHER WORKS

In this paper, we address the issues regarding the 'memory capacity' and 'remembering and retrieving'. Memory capacity refers to the quantities of semantic information which can be stored in short term memory at once. Remembering problem can be solved by adopting expansible and flexible database, but retrieving is perhaps difficult to solve due to the user's intention. Thus, user's intention may influence the process of information retrieval. Therefore, we adopted Naïve Bayes classifier to recognize user's intention so that the proposed glass-type human augmented cognition system can classify the user's intention in some specific cases.

We do not consider the so-called 'Rashomon' effect in intention recognition. If this effect can give a bias to prior knowledge of probabilistic model, the system can provide user-oriented specific information. Also, we would like to verify the importance of intention recognition for augmenting cognition in real environment. As a further work, cognitive phenomenon such as 'change blindness' will be considered for the purpose of human augmented cognition system.

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