

BAYESIAN BELIEF NETWORK FOR HUNGER DETECTION: PHYSICAL VS EMOTIONAL EATING

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ABSTRACT. *Intuitive eating is about gaining a deeper understanding of your body and responding to its internal cues. The ability to control ourselves not eating emotionally is a crucial aspect for our health. We present a simple and novel approach for detecting physical or emotional hunger using Bayesian belief networks and psychological aspects. A novel approach is proposed where the user asks whether he/she is thirsty, then some action should be done such as drinking and answering some questions, and the result and suggestion are then displayed. Bayesian belief networks use 3 nodes: thirsty, mood and social media to improve the accuracy of hunger prediction. A hunger and discovery scale concept as parameter of the output is used. This Android app is very useful for people to avoid emotional hunger. Based on the experiment, concept of physical and emotional hunger can apply the application able to show the prediction of his/her hunger.*

Keywords: Bayesian belief network, Emotional eating, Hunger detection, Intuitive eating

1. **Introduction.** Obesity is becoming a serious issue in many developing countries, especially in Indonesia. Over the past 20 years, obesity has increased remarkably in Indonesia across all population groups, including rural and low income strata. While income growth and urbanization foster this trend, poor and rural people are also affected. Changing diets and decreasing physical activity levels are important determinants of BMI (*Body Mass Index*) and these problems are particularly severe among women [1]. Besides, the culture in Indonesia, where many people show culinary on the social media makes this problem more complex called emotional eating. Emotional eating refers to the tendency of overheating in response to negative emotion [8].

Emotional eating is part of intuitive eating concept. Emotional eating includes extreme emotions, attitudes, and behaviors surrounding weight and food issues. It is serious emotional and physical problems that can have life-threatening consequences for females and males. Not many of us make the connection between eating and our feelings. However, understanding what drives emotional eating can help people take steps to change it.

Many life problems solved using psychology and combined with information technology such as [11] as Android apps. Research and development of application focusing on emotional eating such as “Bingo Eating Disorder Help” teach how to stop binge eating disorder forever, how to stop overeating or binging, cure emotional eating for life and learn the best food addiction treatment of the brain [2]. EmoTree [4] is one of mobile applications to provide feature such as tracking emotion and just-in-time intervention for emotional eating, and unfortunately the system was too complex for use in a normal situation. The current guidelines for “overweight” and “obese” individuals are to lose weight through lifestyle modification (involving diet, exercise and other behavior changes). This approach not only has been shown to be inefficient in maintaining long term weight

loss, but does not achieve the putative benefits of improved morbidity and mortality [16], that is our reason that the simple method for hunger detection is needed.

In this paper, we propose a novel approach, where factors for social media/friends, mood and thirsty are used as a probabilistic parameter for detecting whether someone in emotional or physical hunger uses Android apps. This is an initial study for intuitive eating measurement, using “Eating for Physical Rather Than Emotional Reasons”, one of the 4 dimensions of intuitive eating proposed by Tylka and Tracy [5]. Tylka and Tracy proposed the development and initial psychometric evaluation of the Intuitive Eating Scale (IES) with data collected in 4 studies from 1,260 college women. Exploratory factor analysis uncovered 3 factors: unconditional permission to eat, eating for physical rather than emotional reasons, and reliance on internal hunger/satiety cues.

We use Android for our platform, and our application named Intuitive eating v.2 is the first and the simplest hunger detection application at Google Play store. Android powers hundreds of millions of mobile devices in more than 190 countries around the world. It is the largest installed base of any mobile platform and growing fast – every day another million user’s power up their Android devices for the first time and start looking for apps, games, and other digital content [10]. Our application is very useful for someone to measure his/her hunger. The originality of this research is the implementation of Bayesian belief network for predicting the hunger and the simple Android application. Figure 1 shown is a real case in Indonesia, if we cannot control our eating.



FIGURE 1. A crucial case where a child in Indonesia got the obesity. His name is Arya Permana [17].

2. Intuitive Eating.

2.1. Physical hunger. Intuitive eating is about becoming more attuned to your body’s natural hunger and fullness signals. It is learning how to distinguish between physical feelings (hunger pangs, nausea, headache, or difficulty concentrating) and emotional feelings (disappointed, anger, sadness and anxious) [6]. Research conducted by Ganley identified that emotions influence the eating pattern [3]. The underlying premise of intuitive eating is that you will learn to respond to your inner body cues, because you were born with all the wisdom you need for eating intuitively. On the surface, this may sound simplistic, but it is rather complex [7]. Binge eating disorder (BED) is characterized by a loss of control over eating behaviors. The binge eater consumes unnaturally large amounts of food in a short time period, but unlike a bulimic, does not regularly engage in any inappropriate weight-reducing behaviors such as excessive exercise and taking laxatives [14].

Physical hunger, also known as stomach hunger, is a complex interaction between the digestive system, endocrine system, and the brain. Physical hunger signs begin when the body needs refueling and manifests as stomach rumbling or growling. When we eat, we feel better because our need for hunger is being met. Physical hunger cues can occur in 2-4 hours after your last meal. Many people eat for comfort, stress relief or as a reward. More

often than not, we are eating out of boredom or because food is available, not because we are physically hungry. The eating habits of our society have shifted from the need to eat for energy and survival to eating when stressed or to fill a void; leading to mindless eating and overeating. “Eat when you are hungry, stop when you are full” – this is a statement most people struggle with putting into practice. Many people are unaware of whether they are eating out of physical hunger or because they are under an emotional stress [13].

2.2. Emotional hunger. Emotional hunger comes on suddenly and craves specific comfort foods. Emotional eaters are people whose minds repeatedly move their hands toward food even when they are not at all physically hungry. Table 1 shows the difference between physical and emotional hunger.

TABLE 1. The difference between physical hunger and emotional hunger [13]

Physical hunger	Emotional hunger
Gradual and can be postponed	Sudden and feels urgent
Satisfied with any type of food	Specific cravings (cake, ice cream, pizza, fries)
Once full, you can stop eating	More than typical intake and feeling uncomfortably full
Feeling satisfied, no guilt	Feeling guilty and depressed after eating

Often, emotional hunger often leads to mindless eating. Some of factors are such as stress, stuffing emotions and social influences [8]. Besides, it is hard to find food that satisfies you. For this reason, you do not stop eating when you are full. You may find yourself scavenging for food or eating things you do not even like. Before eating, we should know our hunger scale, and ideally it should be at 3 or 4 as shown in Figure 2.

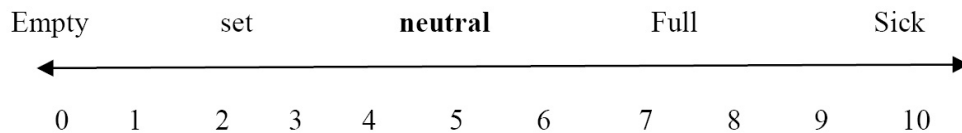


FIGURE 2. Hunger and fullness discovery scale [4]

Based on the concept of physical hunger, for testing whether we only thirsty or hungry, we should drink water, and after 15-20 minutes we can feel our hunger caused by thirsty or real hunger.

3. Materials and Methods.

3.1. Bayesian belief network approach. The Bayesian methodology is built upon the well-known Bayes’ Rule, which is itself derived from the fundamental rule for probability calculus.

$$P(a \wedge b) = P(a|b)P(b) \quad (1)$$

In Equation (1), $P(a \wedge b)$ is the joint probability of both events a and b occurring, $P(a|b)$ is the conditional probability of event a occurring given that event b occurred, and $P(b)$ is the probability of event b occurring. A Bayesian belief network (BBN) [4] is a directed a-cyclic graph (DAG) that provides a compact representation or factorization of the joint probability distribution for a group of variables. Bayesian network is widely accepted as models for reasoning with uncertainty.

The nodes in a Bayesian network represent a set of random variables, $\mathbf{X} = X_1, \dots, X_i, \dots, X_n$, from the domain. A set of directed arcs (or links) connects pairs of nodes, $X_i \rightarrow X_j$ representing the direct dependencies between variables, for example, a directed graph shown in Figure 3.

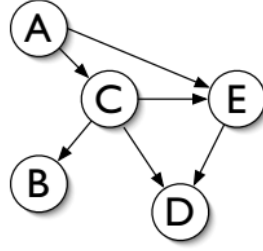


FIGURE 3. Directed graph example [15]

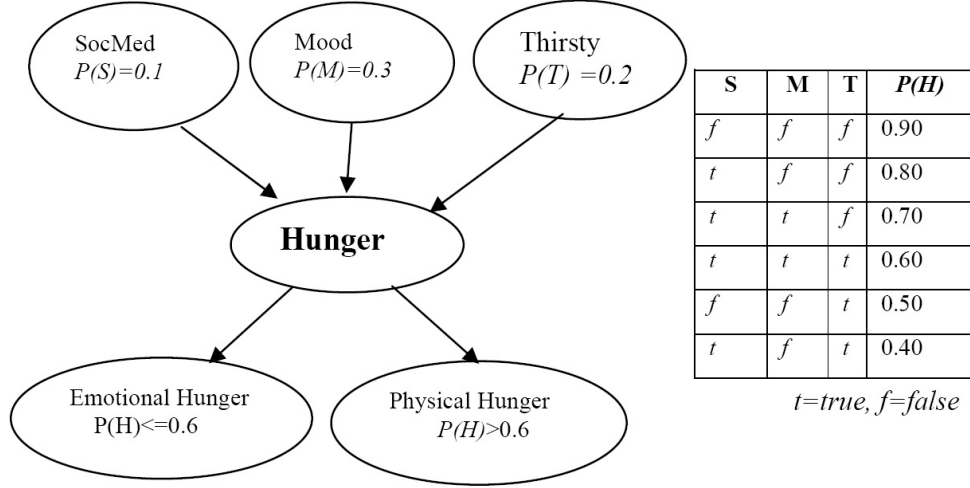


FIGURE 4. Bayesian belief network for measuring emotional or physical hunger

So, based on Figure 3, Bayesian networks can be used for calculating new beliefs when new information – which we have been calling evidence is available. General expression from Figure 3 is:

$$P(A, B, C, D, E) = P(A)P(B|C)P(C|A)P(D|C, E)P(E|A, C) \quad (2)$$

Assuming discrete variables, the strength of the relationship between variables is quantified by conditional probability distributions associated with each node. Consider a BN containing the n nodes, X_1 to X_n , taken in that order. A particular value in the joint distribution is represented by $P(X_1 = x_1, X_2 = x_2, \dots, x_n)$ or more compactly, $P(x_1, x_2, x_3, \dots, x_n)$. The chain rule of probability theory allows us to factorize joint probabilities so:

$$\begin{aligned} P(x_1, x_2, \dots, x_n) &= P(x_1) \times P(x_2|x_1), \dots, \times P(x_n|x_1, \dots, x_{n-1}) \\ &= \prod_i P(x_i|x_1, \dots, x_{i-1}) \end{aligned} \quad (3)$$

Recalling from Equation (3), that the structure of a Bayesian network implies that the value of a particular node is conditional only on the values of its parent nodes, this reduces to:

$$P(x_1, x_2, \dots, x_n) = \prod_i P(x_i|Parents(X_i)) \quad (4)$$

The relation between conditional independence and Bayesian network structure is important for understanding how Bayesian network works [9]. For Figure 4, Mood, Social Media and Thirsty are called as common effect for hunger. $P(S)$ is the contribution of Social Media which will make people think hungry. $P(M)$ is the contribution of Mood which will make people think hungry, and $P(T)$ is the contribution of thirsty which will make people think hungry. We set the values of $P(S)$, $P(M)$ and $P(T)$ based on the

discussion with the psychologist in Indonesia, which is based on the possibility of the people in Indonesia who will hunger. The output $P(H)$ is the final value of probability from 3 conditions (SocMed, Mood and Thirsty).

3.2. Architecture of the system. The Bayesian belief network is shown in Figure 4.

Eating emotionally is conditionally independent given friend and social media and mood. We propose the algorithm for hunger detection as shown below. This is the simplest and fastest algorithm that can be used for hunger detection based on the concept above.

Algorithm 1. Emotional Hunger Detection

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Start
Check whether user is thirsty or not
If answer == "thirsty" then
    display "Should drink a water and wait for 10 minutes"
    If the result is not thirsty then
        display "You only thirsty, not hungry"
    else
        set not thirsty
        go to next questions
Endif
If not thirsty then
    Input data from Social Media and Mood
    Calculate Bayesianbeliefnetwork for  $p(H)$ 
    If  $p(H) > 0.6$ 
        Display "Physical hunger"
    else
        Display "Emotional hunger"
    Endif
    Display suggestions for user
End

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We designed a use case diagram based on Whitten and Bentley [12]. We realized our algorithm using Android Studio and Samsung smartphone. The development of Android apps uses Android Studio 2.1. Android offers a unified approach to application development for mobile devices which means developers need only develop for Android, and their applications should be able to run on different devices powered by Android. Android operating system is a stack of software components.

4. Main Results. Experiments of this system have been tested for getting the prediction of hunger to 10(ten) people in our campus with the age between 19-40 years old. The system runs very well with the capability to calculate the hunger level based on Bayesian network as shown in Figures 5 and 6.

If the user is not thirsty, there are many possibilities that the user feels hungry, whether they smell any food, go to have a meal with friend, get stress at the moment, just got delicious picture of food or usually not in a good mood as shown in Figure 5(c). Hunger detection result is shown in Figure 6.

The physical hunger and fullness are often overshadowed by other body signals, habits, needs and emotions. Identifying and dealing with them appropriately are a huge step in the process of discerning true stomach hunger. Indonesian people usually eat rice 3 times per day, and this is a habit that should be changed for our healthy, but need a hard effort from community and government. Emotional eating can be overcome through treatment. So our apps should provide additional information for the effect of emotional

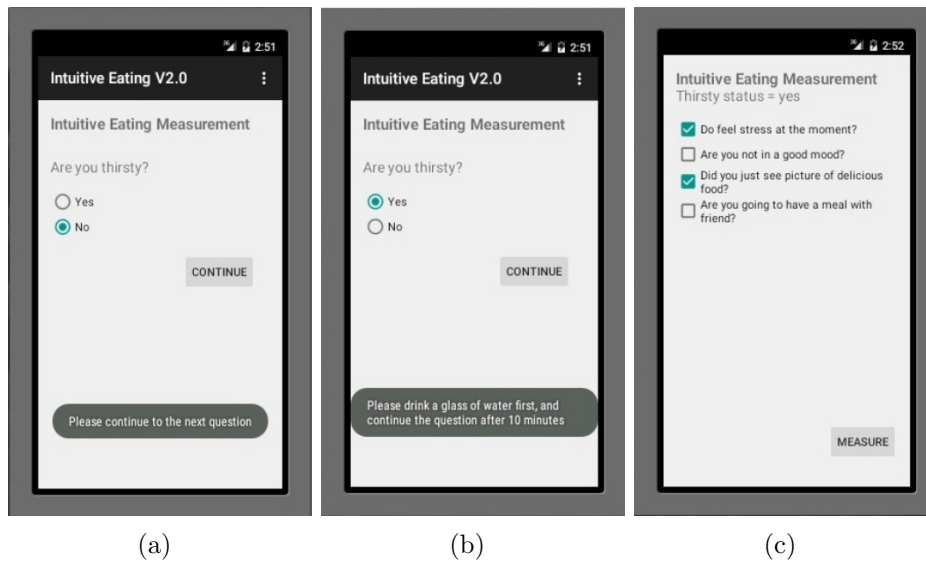


FIGURE 5. Screen shot of the application for making sure whether user is not thirsty (a) or thirsty (b) and the suggestion, and additional question (c)

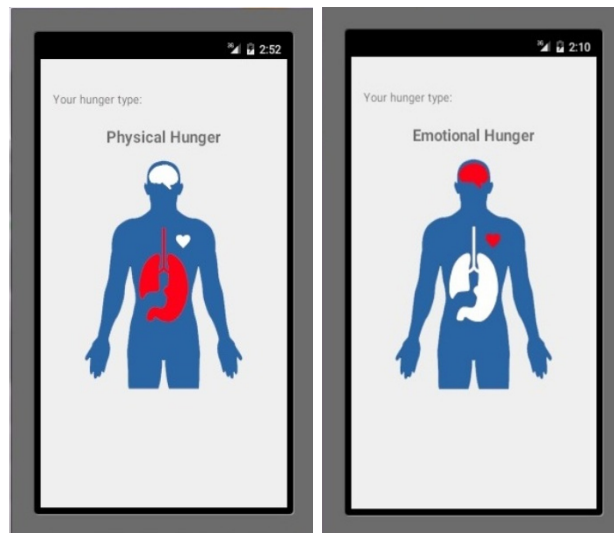


FIGURE 6. Screen shot application of the result of physical hunger or emotional hunger

TABLE 2. Result of the experiment

No	Description	
	Case	result
1	Thirsty	Drink a water
2	Not thirsty, not mood, not social media	Physical hunger
3	Not thirsty, not mood, social media	Physical hunger
4	Not thirsty, mood, social media	Physical hunger
5	thirsty, mood, social media	Emotional hunger
6	thirsty, not mood, not social media	Emotional hunger
7	thirsty, not mood, social media	Emotional hunger


eating. Table 2 shows the result of Android application for predicting the hunger based on the input from user; it shows a good result as expected.

After testing with 10 (ten) users, the result of user response is good enough based on feasibility aspects such as acceptance, interest and easiness.

5. Conclusions. This paper proposed an initial Android-based intuitive eating measurement using Bayesian belief network for hunger detection. Eating mindfulness is very important for us. Android application built with the proposed algorithm can help users to determine his/her hunger. Emotional eating can be overcome through treatment. Based on the experiment, this application is really useful and easy to be used. For future work, we will develop an apps for more complete evaluation of intuitive eating measurement.

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