Activity-Based Context-Aware Model

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Abstract. Context awareness is an important part of mobile and ubiquitous computing research. Most of the existing studies have concentrated on technical implementations. There is a considerable gap between systems context-aware actions and human expectations. We made an Activity-based Context-Aware Model based on Activity Theory and human situation awareness theories. Activity-based Context-Aware Model based on Activity Theory describes human context awareness within activities, which could offer more accurate understanding of human context awareness and help the development of context-aware technology. This paper defines the Activity-based Context-Aware Model based on Activity Theory, and presents a case study of shopping activity, which initially verifies the validity of the model.

Keywords: Context-aware, Activity Theory, Situation awareness, Activity-based Context Awareness Model.

1 Introduction

Just like a friend who knows certain things about you and can offer assistance when in need, a context-aware computer can gather contextual information and then provide 'right services' for people at the 'right time' and 'right place'. According B. Schilit, 'Context-aware systems adapts according to the location of use, the collection of nearby people, hosts and accessible devices, as well as to changes to such things over time. A system with these capabilities can examine the computing environment and react to changes to the environment.'[1]. Research on context-aware computing have been carried out in context information acquisition, context modeling, context reasoning and systems architecture [2], in the fields of education, health care, tourism, smart home, shopping, entertainment among others.

The majority of context-aware system design and implementation are based on a more technical point of view. The most common and the simplest services powered by context awareness are location-based services (LBS). Most of the LBS can obtain fairly accurate location data by GPS or CellID, but positioning techniques indoors still have many of limitations for wide usage. Some context-aware systems can integrate many sensors, such as Myexperience, a context-aware experience sampling tool, that can take advantage of multiple device and sensory multimedia data, calendar, Bluetooth, GPS etc., but the users have to predefine the sensors as in what information is to be collected and in what conditions [3].

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If an ideal context-aware system should be like a friend, with similar abilities as humans do, a major problem within current context-aware systems is the gap or mismatch between people's expectations and context system behaviors. This affects user's trust, acceptance and user experience of context-aware systems [4]. Thus, reducing this gap or mismatch is an important issue for research within context awareness. There are two main reasons for this problem. As already mentioned, the majority of existing studies in context-aware systems design and implementation are focusing on technical implementation, and there is a lack of understanding of human context awareness, as in how do we form our awareness of context. It is a combination of perception, memory and experience, which gives us the ability to make decisions in complex situations. This mental process is very complex, and it makes the context-aware systems design and implementation a challenge.

The design and implementation of context-aware systems should try to reduce the awareness mismatch between the user and the system. For reducing the gap, a thorough and systematic understanding of human context awareness, and models and methods for describing it are needed. This paper explores the characteristics of human context awareness and looks for ways to improve the user experience of context-aware systems. Based on human activities and related context elements, we propose our Activity-based Context-Aware Model (ABCAM). We have preliminary verified the validity of the model by a case study examining human shopping activities in a supermarket for analyzing the process of human context awareness.

This paper is organized as following. The second part describes the related theories; activity theory and theories of human situation awareness. In the third part, the ABCAM is proposed and introduced in detail. The fourth part introduces the case study of human context-aware processes of shopping activities. The last part describes the research conclusions and our future work.

2 Related Theories

ABCAM is built on activity theory and theories of situation awareness.

2.1 Activity Theory

Activities are fundamental components of human's daily life. Soviet psychologist Vygotsky proposed activity theory as a common conceptual framework to understand and analyze human activities in 1920s[5]. Activity theory describes the basic elements of an activity including subject, object, tools, community, rules and division of labor. The basic structure of activity theory is show as Fig. 1.

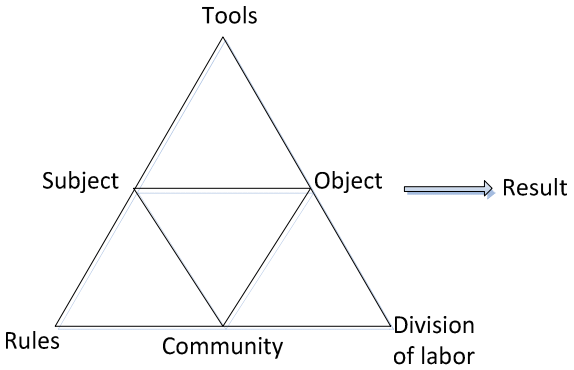

Fig. 1. Activity Theory diagram

An activity is the basic analysis unit in activity theory. An activity has three levels; purpose, functionality and reactivity. An activity is determined by subject's motivation and composed by actions. Actions are goal-directed and conscious. Different actions are executed by operations. Operations are unconscious or automatic. When some conditions are met, operations could be completed. Activities, behaviors and operations could change and transfer to each other dynamically. (As Fig.2)

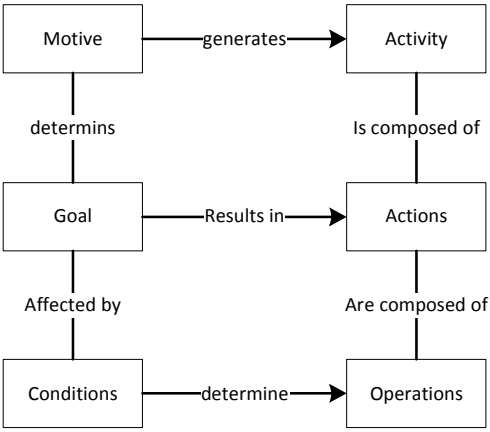

Fig. 2. Activity hierarchical structure

2.2 Theories of Situation Awareness

An important aspect of human cognition is situation awareness. Some of the earlier studies on human situation awareness were carried out on the industries related with aviation and control, emergency response, military command, and fuel and nuclear management. The tasks for the people operating in these industries are usually high on accuracy and time pressure, which demands good situation awareness to deal with some complex operations.

Endsley studies the human situation awareness process from the perspective of information processing. He defined the human situation awareness mechanism as [6]: "perception and comprehensive understanding of certain elements of the environment within a range of time and space t, and predict their subsequent status changes." According to situation awareness model proposed by Endsley in Fig.3, situation awareness process is divided into perception, comprehension and prediction. In the stage of perception, targets, events, human, system and environmental factors, and the related state, properties, and changes are perception elements; Comprehension is a process of pattern recognition, interpretation and evaluation on perceived elements; Prediction is the highest level of situation awareness, it is a comprehensive judgment according to states and properties to forecast future situation events.

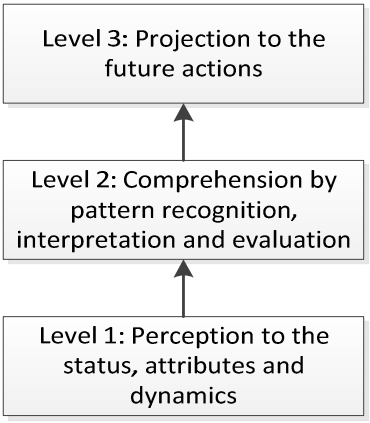

Fig. 3. Three levels model of situation awareness

The other two major situation awareness theories are the interactive sub-systems theory and the perceptual cycle theory. The model of interactive sub-systems is a theory of activity proposed by Bedny and Meister, which is composed of eight function blocks, and is a directed behavior function model [7]. Situation awareness is not the processing of perception, memory, thinking and behavior; but a process according to the nature of the mission and goals. The key components are conceptual model, goals and individual subjectivity. The perceptual cycle proposed by Neisser claims that the way people are thinking is closely related to the environment. In a particular environment, existing knowledge might lead to some expectations for the information and direct some behaviors of choosing and explanations of information [8].

3 Activity-Based Context Awareness Model

A system that is context aware should consider abundant contextual information and relations between them, and therefore we need methods to construct context awareness models describing the complexity [9] [10]. For to guiding the human situation awareness research, we propose a model of context awareness based on human

activity, which describes and analyses human activities and human context awareness. The Activity-Based Context-Aware Model is based on combining the human situation awareness theories and activity theory, describing activities and contexts and the relation between them. According to activity theory, human activities can be divided into different behavioral phases and each behavioral phase is formed by several operations. Contextual factors related to subject, tool, physical environment, social environment and operation objects are included in an activity. A behavioral phase determines what context factors are active within the phase. The active context factors can be matched under rules and trigger behaviors when certain conditions are fulfilled or operations have occurred, as shown in Fig. 4. Subject, tool, object and environment related context elements exist within a specific activity (perception). A specific activity could be decomposed into different action phases, and each action phase is composed of several operations. Different action phases also have different active context elements and different trigger rules (comprehension); when these rules are satisfied, they may trigger behaviors (projection).

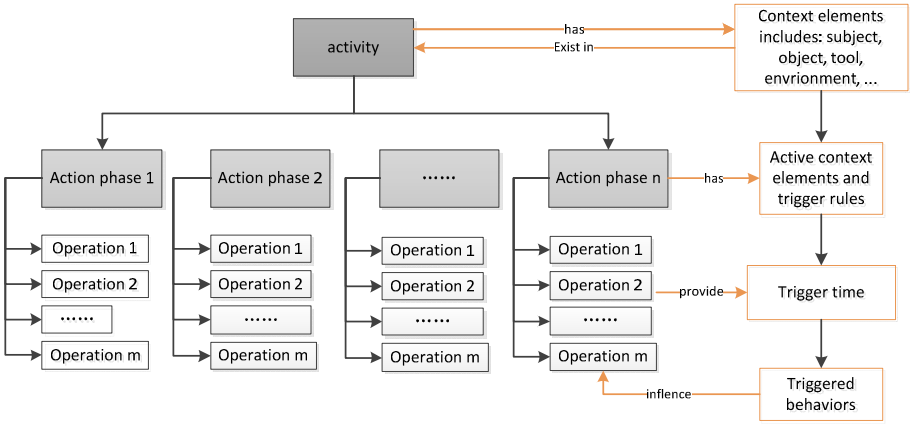

Fig. 4. Activity based context-aware model (ABCAM)

4 Case Study

A study to verify this model was conducted by examining normal supermarket shopping activity. We describe shopping as an enjoyable experience and an activity where customers can make decisions about what to buy. We think that if new technologies are introduced into the activity related to shopping, the purpose of them should be to make the experience more enjoyable rather than interruptive [11].

For confirming our activity-based context-aware model in a supermarket scenario, we needed to find out about and understand shopping activity. We did this by using activity theory by analyzing different behavioral phases of activities. The next thing we need to identify was the corresponding active context factors in different behavioral phases. After these steps, we analyzed the condition of active context factors and triggered actions. We then examined the process of human situation

awareness within shopping activity in a supermarket including the division of action phases, active context factors in different behavioral phases, trigger rules and triggered actions.

Normally shopping behavior includes phases like planning, choosing and buying. We conducted field observations in a supermarket, and by using our Activity-Based Context-Aware model, we defined six action phases within shopping activity as plan, search, evaluate, compare, exchange and confirm. The operations within phases included look, touch, hold, release etc.

4.1 Experiment Design

Based on the normal customer behaviors and our field observation of active context factors in each behavioral phase, trigger rules of active context factor and triggered actions, we formed two basic hypotheses about action phases within shopping activity in a supermarket. The two basic hypotheses were:

H1: active context factors are different in different action phases of shopping activity in supermarket.

H2: active context factors have different trigger rules and triggered actions in different action phases of shopping activity in supermarket.

To test these hypotheses, we used a method of combining video analysis with semi-structured interviews. We recorded a video of shopping activity, in which the customer purchased some basic commodities like a hair dryer, toilet paper, shampoo, toothpaste, washing powder and cookies. The video included all of the shopping activities as defined from our observations: plan, search, evaluation, comparison, exchange and confirm. 16 participants were shown the video and interviewed about the shopping activities as they saw them. We instructed them to think of themselves as a friend or a companion as if they were there together with the person in the video. We collected their answers and suggestions of how they perceived the activities and then analyzed the active context factors, context factor trigger rules and triggered actions.

4.2 Results of the Experiment

1. Different action phases have different active context factors. (As Fig. 5)

Context factors can be divided into three categories in a shopping activity: purchaser-related, commodity-related and circumstance-related context factors. Commodity-related context factors include production attributes (brand, weight, material quality, level, etc.), sales attributes (price, sales volume, etc.) and use attribute (date of manufacture, packaging, etc.). Purchaser-related context factors include personal characteristic (gender, age, family, etc.), lifestyle (income, hobby, value, etc.) and purchase preference (brand or price preference, requirements for quality, etc.). Circumstance-related context factors include physical environment around (season, promotion, etc.) and social environment (friends experience suggestions, news reports, etc.)

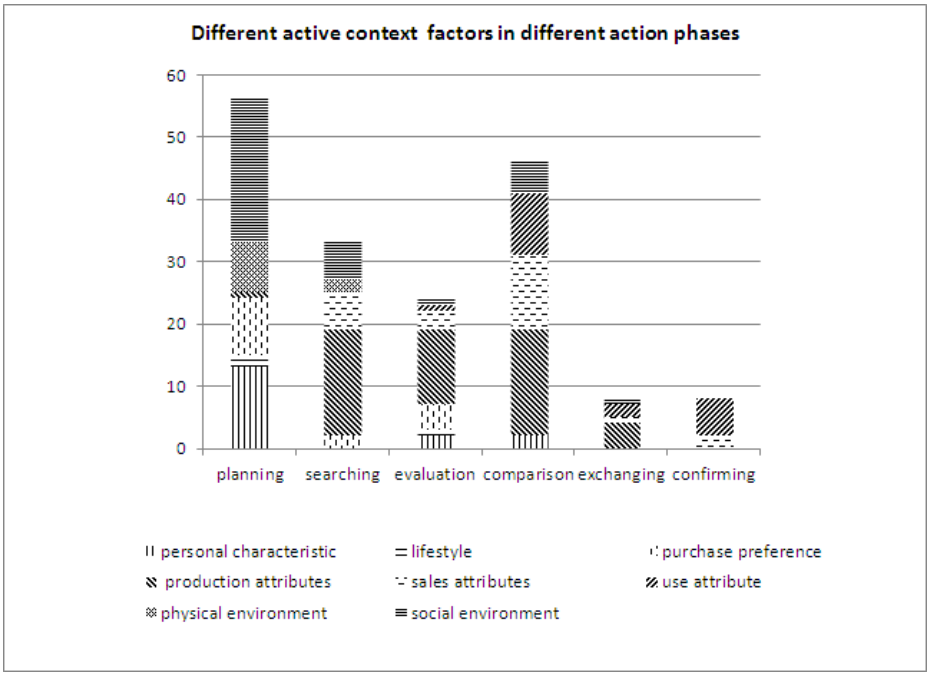

Fig. 5. Different active context factors in different action phases

2. As a shopping companion, the participants of the experiment suggested to offer different kinds of assistance to the person in the video or talk about different topics in different action phases.(As Fig. 6)

In the planning phase, the participants would provide advice or one's own shopping experience, including reminding about promotion information that could be suitable, offer sales information of a commodity or recommend brands according to the customers' preferences etc.

In the searching phase, the participants suggested to help finding commodities to match the needs of the customer.

In the evaluation phase, the participants suggested to evaluate the selected commodity and talk about whether it is suitable for customer preferences.

In the comparison phase, the participants suggested comparing two or more commodities and talk about which one is better or more suitable for the customer.

In the exchange phase, the participants suggested selecting a better one for the customer, and to get more detailed information about the preferences.

In the confirming phase, participant suggested paying more attention to the shelf life (expiration dates etc.) of a commodity and package, and to make sure about the price.

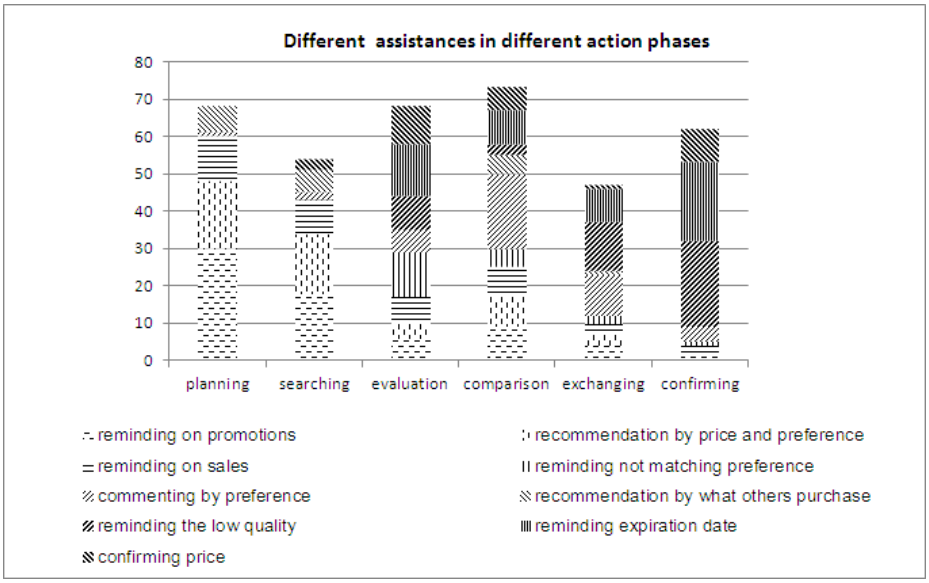

Fig. 6. Different assistances in different action phases

4.3 Findings

The result of this experiment verified our model of activity based context awareness. In a shopping activity, context factors can be divided into three parts: purchaser-related, commodity-related and circumstance-related context factors. In different action phases of shopping activity, there are different active context factors to help purchaser make decisions. The participants were aware of the different activities and suggested different assistance in different action phases. Through this experiment, the six action phases defined from the field observations were verified indirectly. The experiment was an initial test of accuracy and effectiveness of the Activity-Based Context-Aware Model.

5 Conclusion

Understanding human context awareness is a key point in designing context-aware system. This paper proposes our Activity-Based Context-Aware Model, which is based on activity theory and theories of human situation awareness. We have initially confirmed the rationality and validity of this model through field observation, video analysis and semi-structured interviews about shopping activity. Based on this model and experiment, our future work will seek to further optimize the model, and to continue to design and evaluate context-aware systems.

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